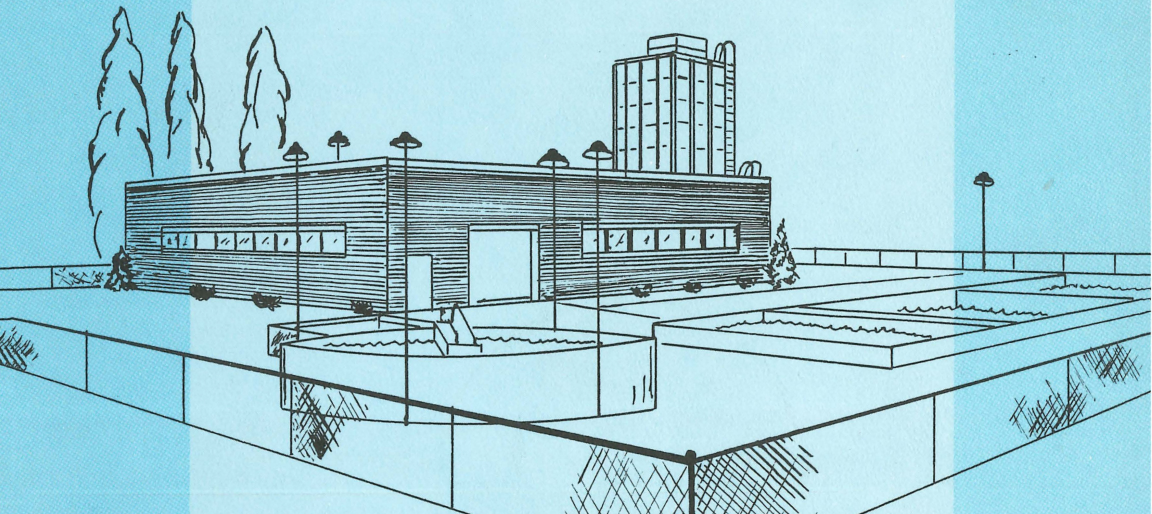
selected papers from the ninth missouri

AIR AND WATER POLLUTION CONFERENCE

Lindon J. Murphy, P.E. Editor

November 19, 1963



UNIVERSITY OF MISSOURI

COLUMBIA, MISSOURI

University of Missouri Bulletin

ENGINEERING EXTENSION SERIES BULLETIN NO. 3

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CONTENTS

WATER RESOURCES DEVELOPMENT IN MISSOURI

Clifford L. Summers, Executive Director, Missouri Water Resources Board, Jefferson City, Mo.

The early development of Missouri, as with most of the nation, followed the major watercourses and the sites of early settlements were influenced largely by the availability of water transportation routes. It is interesting to note that the earliest settlements are situated on the bluffs overlooking the alluvial planes of the Missouri and Mississippi Rivers. Early sketches of these settlements show the more permanent structures of the community to be located above the flood plains. This common sense approach to flood plain zoning unfortunately has not been followed in the later development.

As migration occurred inland, we find communities locating on the ridges or at the heads of valleys, and while the availability of water was not of prime consideration in locating these communities, sufficient water was available from springs or from shallow depth wells to meet domestic needs. As the population density of the state increased, we find a tendency of community effort in manipulating water resources in the benefit of mankind. The earliest efforts involve the construction of impounded water supplies and the drilling of deep wells to serve municipal needs.

Later community attempts were made to control floods and to drain land through the mechanics of levee and drainage districts. The exact number of these special benefit districts that have been formed in Missouri is not known since current county records reflect only those districts which are now or which in very recent years have assessed a maintenance tax on the lands within the district. A complete search of all county court records and all circuit court records would be necessary to establish an exact number for the levee and drainage districts which have been formed under the laws of the state. There is little doubt that such districts have formed a useful purpose, even though in many instances improvements designed to protect one area adjacent to the river often resulted in adverse affects on either upstream or downstream land owners. It is significant to note that the development of municipal water supplies and the work carried out by the levee and drainage districts constitute the majority of water control accomplished by Missourians with their own resources and funds.

In our complex society of today, many more water uses and benefits to be derived from water and its use have been recognized. In addition to flood control, drainage and water supply, the need for improving and extending the inland waterway navigation system; the water requirements of fish and wildlife and of recreation; and the need for augmenting stream flow for the purpose of affording dilution for natural occurring and man made wastes are recognized as justifiable uses of water. Power and agriculture uses are also recognized.

Each of these interests is represented by individuals or organizations of a voluntary nature and often by state agencies which have been established to pro-

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tect or to regulate water for certain uses. Within the State of Missouri there are thirteen agencies of government having some degree of responsibility in the development of water resources. The most recent of these agencies, the Water Resources Board, was created in 1961 for the purpose of devising a long range comprehensive plan for the development of the state's water resources in the interest of the social and economic betterment of the state. The Board is also charged with the coordination of data collection by the several state agencies and with the collection and classification of information dealing with water resources. The Board has been designated by the Governor to represent the interests of the state in regard to water resource planning by federal agencies and also represents the Governor on several inter-agency river basin committees charged with coordinating regional water resource development.

As with any newly organized group, the Water Resources Board has experienced a great degree of difficulty in first, grasping the importance of each facet of society that might benefit from water resource control and second, in assuring these many interests of the Board's desire to honestly appraise and consider each water use in devising and presenting a plan for the state. Additional difficulties are encountered since local improvement works, and Corps of Engineers and Soil Conservation Service projects and studies progress simultaneously with the development of an over all plan for the state.

The Board has established general areas to be considered in the development of this resource, has established communication channels with other state and voluntary agencies, and has asked for advisory assistance from all interests through creation of a state Inter-Agency Advisory Committee on Water. To expand on these activities, the Board is of the opinion that the development of the surface water resources in Missouri must include: first, the upland treatment of land through terracing, flood control structures, and other construction practices as promoted by the Soil Conservation Service, U. S. Department of Agriculture. Second, the Board believes in the development of intermediate flood control reservoirs with multi-purpose features where possible in order that water resource benefits may accrue to those areas above the main stem of any controlled stream. Third, the Board believes in the use of multi-purpose impoundments where such use is economically justified and does not interfere with the historical, geological or other intangible benefits associated with a free flowing stream. Fourth, the Board believes consideration should be given to drainage and protective works in the lower extremities of streams where such works contribute to the economic betterment of the area. When the four above mentioned means of controlling water are not feasible, and flood plains will continue to exist, the Board is of the opinion that flood plain zoning should be considered as a means of protecting life and property.

The Board initially held one meeting with all the interests involved in water resource development and solicited their thinking and assistance in initiating the policies and procedures to be followed by the Board. Continued meetings have been held for the purpose of assuring these agencies and voluntary groups of the Board's continued interest in their problems. In June, 1963 the Board published and distributed Phase I of the Missouri Water Plan entitled, "Development".

This publication outlined channels of communication and established a general scheme for determining priorities for river basin development. An Advisory Committee was established to assist the Board in analyzing the needs of the state with particular emphasis on the social and economic needs. At present the Board is studying the structure of state government as it is related to water and is attempting to determine the reasons for the lag in water resource development in the state.

Although the Board is the first water resource planning agency recognized by the legislature, it is actually the fourth such group to attempt the development of Missouri's water resources since the mid 30's. A Missouri Water Plan was published in 1938 under the auspices of Works Project Administration. This plan was fairly complete and strangely enough incorporated many of the features currently considered in approaches to comprehensive river basin planning. The plan was not implemented probably due to the fact that it was federally sponsored with the additional interference caused by World War II. In 1945 and again in 1954 attempts were made to develop a Missouri plan through committees appointed by the Executive. The magnitude of work involved was not supported by the legislature through appropriations with the result that both attempts were abandoned prior to completion.

In addition to this failure to act on its own initiative, the State of Missouri has further failed in establishing a uniform front in either support or opposition to projects proposed by the Corps of Engineers under the Authorization Act of 1938 or the Flood Control Act of 1944. A review of the correspondence and statements supposedly reflecting the position of the state illustrate conflicting desires among the several state agencies and a complete failure to resolve differences of opinion on the project between local interests. Approximately ¾ of the State of Missouri is located in what is considered the lower portions of the major drainage basins. The control of water usually begins in the upper reaches of the drainage basins. This might account in part for Missouri's failure to obtain water resource developments within the state.

While Missouri has received extensive benefit from the construction of the main stem reservoirs on the Missouri River and from the flood control impoundments constructed on its tributaries in Wyoming, Montana, North and South Dakota, Kansas and Nebraska, it has not received direct benefit which today is most noticeable to the average citizen; that is, the benefits derived from recreation on large reservoirs and the economic impact which results from a tourist attraction afforded by such reservoirs. The reservoirs completed in the White River Basin, Bull Shoals and Table Rock have demonstrated to other areas of the state the importance of a water impoundment to the local economy. Voluntary promotional groups have sprung up in the Osage, Chariton, Salt, Meramec, Grand and Platte Basins each interested in obtaining for their areas a reservoir sufficient in size to attract tourist trade from St. Louis, Kansas City, Des Moines, even Chicago. The need for outdoor recreational areas cannot be denied. However, it is extremely difficult to provide for water supply storage, flood control, flow augmentation, power and other benefits derived from manipulation of water elevations, when the primary backers of the project are demanding a stabilized shoreline during the recreation season.

Explaining the many benefits to be derived through multiple use of our water and reconciling each interest to its proportionate share is one of the largest problems faced by the Water Resources Board. Of almost equal importance is resolving the equitable use of the lands surrounding an impoundment of water. Under current federal land acquisition policies, all land including a 300 ft. buffer strip above the flood pool are acquired in fee unless the lands are not needed for operation of the project; unless they are remote from the site of the project, unless it is more economical for the federal government to acquire easement in lieu of fee, and unless the lands are of no substantial value for fish and wildlife or outdoor recreation. All four of these conditions must be met before consideration can be given to obtaining the land by easement. This acquisition policy is, of course, extremely popular with conservation groups and with those interested in outdoor recreation. It is not popular with those interested in the commercial development of the shoreline of the reservoir, or with those located in the upper reaches of the reservoir area where the economic impact resulting from federal purchase of land will be noticeable. Here again, we have a situation where several agencies of government and several local groups are expressing opinions which are often taken to be the official position of the state.

Our failure to resolve our own differences of opinion has in the past necessitated the determination of what Missourians will receive by an agency of federal government or by the Congress itself. This is a shortcoming which we hope is in the process of being eliminated. The Board believes that with a reasonable degree of understanding and with a willingness to give and take, all interests in the water resources field can be served and that a uniform front can be presented when dealing with the federal construction agencies and congress. No mention has as yet been made of Missouri's ground water resources.

Generally water of an acceptable quality can be obtained from the alluvial deposits in our river basins. The Ozarks region generally south of the Missouri River, has to the best knowledge of the State Geologist adequate supplies of ground water. North of the Missouri River and in the West-Central portion of the state highly mineralized water is often encountered. Fresh ground water in these areas is usually found in pockets of glacial drift or in preglacial stream beds. These deposits are usually not recharged with fresh water at a sufficient rate to permit reliable production of water for municipal and industrial purposes. Limited records of ground water conditions are available throughout the state. In some areas where voluntary reporting by well drillers has been forthcoming there exist now sufficient data for projecting ground water availability. In other areas, however, the logs of wells are not located at close enough intervals to permit availability projections. The Division of Geological Survey and Water Resources has recommended for many years a cooperative ground water program with the United States Geological Survey. At present only a token program has been initiated and even if expanded to the desired level, it will be many years before sufficient data have been collected to determine the course of ground water development. The Water Resources Board assumes that eventually sufficient ground water data will be available. In the interim, the development of surface water is given prime consideration with the thought that adjustment can be made when a ground water plan can be developed.

It is expected that many in attendance at this meeting will be interested in the status of current water resource development by the federal agencies. First, the status of Public Law 566, Watershed Projects, includes two completed watersheds, four watersheds are under construction and nineteen are in the application or planning stage. For the most part, these watersheds are located in the Northwest section of the state, although interest has been expressed in the Eastern and Southern portion of Missouri in the past two years. There are currently fifty-three counties having been organized into Soil and Water Districts. The watersheds projects previously listed are in effect subdistricts of the county organization. Development in the subdistricts is accomplished at federal expense exclusive of easements and right-of-ways and maintenance activities. The subdistricts or small watersheds are empowered to levy taxes for maintenance purposes.

Corps of Engineers projects in the state include the completed Wappapello, Clearwater, Northfork, Bull Shoals, Table Rock and Pomme de Terre Reservoirs. The Stockton Reservoir is under construction and the Kaysinger Bluff and Joanna Reservoirs are in the planning stage. The Corps of Engineers, St. Louis District, is now completing the resurvey of the Meramec Basin and will propose the construction of several reservoirs on the Bourbeuse, Meramec and Big Rivers. The Kansas City District has completed and forwarded to higher authority a report on the Grand River Basin which includes the recommendation of seven multi-purpose impoundments, channel straightening and levee work. This office is also completing a report on the Platte River Basin and has completed a report on the Chariton River Basin which is now ready for congressional consideration.

The Missouri River agricultural levee program is proceeding and is now under construction to a point below the mouth of Fishing River in Lafayette County. Of extreme importance to the future economy of the State of Missouri is the recent acceptance by the House Appropriations Committee of the proposal to increase the depth of channel for the Missouri River to Kansas City. Tonnage transported on the river should increase materially over 2,250,000 tons reported in 1962 when the nine foot channel is completed.

This paper has attempted to review briefly the history and the current status of water resource planning and development in Missouri. The Water Resources Board is hopeful that it will be able to serve the best interests of all of the people in guiding and planning the development of water. Every effort will be made to consider all interests and to serve each of the varied interests in the best possible manner. It is further hoped that a firm understanding of water and its importance to our civilization can be realized and that the citizens of the state will adequately support the Board in is efforts to develop water resources for all beneficial purposes. Moral support and more important, financial support, must be forthcoming if water conservation, distribution, quality control and multiple use are to be realized.

PLANNING FOR COMPREHENSIVE DEVELOPMENT OF A RIVER BASIN

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Water is becoming more and more a concern to people of the Nation both as to quantity and quality. I believe that early in our history water was generally accepted as abundantly available and of good quality. Shortly, concern was expressed as to quantity, particularly in some areas. In fact, some areas are now definitely water short. As concentration of population occurred pollution of water supplies resulted and in recent years the problem of water quality has also become of considerable concern in planning the Nation's future. This has been recently highlighted by the report of the Senate Select Committee reporting on water supplies over the entire Nation which indicated probable shortages by 1980 for some regions and, for much of the country, around the year 2000. Quality of water was also referred to as being of importance.

The water resources use and development in the Missouri Basin can be traced to shortly after Lewis and Clark exploration in the early 1800's. The first indication of Federal interest was the undertaking of clearing and snagging in the Missouri River for navigation in 1838. Shortly thereafter, bank revetment works were constructed at the principal landings. These works were extended upstream because of loss of early work due to erosion. The present navigation project along the Missouri River was authorized in 1912. Shortly after people began settling in the Missouri Basin floods became a problem. Early measures were undertaken by local people to provide some protection against floods. Although there had been certain flood control works undertaken by the Federal Government it was not until 1936 that the Federal Government expressed an interest and concern generally in flood control. Irrigation development in the Missouri Basin can be traced back to the early 1860's when there was irrigation in Colorado. The Federal development for irrigation started with the creation of the Reclamation Service in 1902. Federal interest in agriculture and watershed development stems from the creation of the Soil Conservation Service in 1923.

Most all of the early interest and concern with water resource development was for single purpose development, usually in preventing damages from floods or providing a supply of water, particularly for agricultural use.

In 1927 the Congress directed the Corps of Engineers to undertake a comprehensive study of many of the rivers of the Nation, including the Missouri, for the then primary interests of navigation, flood control, irrigation, and power. These studies carry the general nomenclature of the "308 Reports," referring to the House Document which was the basis for Congressional authorization. In the Missouri Basin the 308 Reports were prepared by the Corps of Engineers between 1928 and 1934. They came up with extensive studies of various water resource developments and recommended the adoption of a general plan of development for the Missouri River Basin—not, particularly as a Federal undertaking, because most of the developments were of a type considered, at that time, to be in the nature of private undertakings. However, some of the developments in the Missouri Basin can be traced back to the 308 Reports.

In 1943, as a result of major floods along the main stem of the Missouri River, the Corps of Engineers prepared an extensive report, outlining a plan for the control of floods. This report is often called the Pick Plan. In this undertaking it was found that local protection works alone would be insufficient to provide a desirable degree of control. Reservoir control of the main stem of the Missouri River above Sioux City and reservoirs on the principal tributaries in the lower basin were recommended, not only for flood control, but particularly in the case of the main stem reservoirs, for multiple uses of flood control, conservation, irrigation, navigation, and hydroelectric power.

The Bureau of Reclamation, in 1944, prepared a report, the so-called Sloan plan, covering the Missouri Basin, recommending extensive irrigation developments on the tributaries of the Missouri River. These two reports were coordinated by the Departments concerned, and the Congress, in the 1944 Flood Control Act, adopted the comprehensive plan for the Missouri Basin, which is referred to as the Pick-Sloan Plan. This basin plan includes over 100 reservoirs, with about 110 million acre-feet of storage capacity; 27 power plants, with 2½ million kilowatt installed capacity; 143 irrigation projects which will provide irrigation for nearly 3½ million acres of new land and supplemental water supply to around 700,000 acres of land that have insufficient water supply; it would provide flood protection to 3,670,000 acres of agricultural land and has 50 local flood protection projects which would provide protection for municipalities with population well over a million people.

During the twenty years since authorization many things have been happening:

The Nation and this area have been progressing.
The economy has changed.
Some of the needs, especially for water, have changed,
There have been technological changes.
Governmental policies have changed.
Additional projects planned and authorized.
We have completed much of the program envisioned in 1943 and 1944.
With respect to the latter—

We have completed: 37 reservoirs with storage capacity of about 90 million acre-feet; 10 hydro-power plants with an installed capacity of about 2 million kw; 5,607 miles of transmission lines; 286,747 acres have been placed under irrigation; 37 local flood protection projects have been completed, protecting areas of concentrated values; a degree of flood control has been given to 3 million acres; and 24 watersheds have been provided with a sound management situation.

This latter has been another of the changes which have come about since 1944. In 1954 the Congress passed the Watershed Protection Act, providing a basis for this important facet of land resource development to become a part of overall basin development. Considerable progress has been made but there is still much to be done.

Another function which has been coming to the fore in recent years is recreation. In 1944 it was generally Federal policy that recreation development would largely remain a responsibility of local government or the State. The exception was the National Parks and Monuments which were considered as a proper function for the Federal Government protecting outstanding natural areas and areas of historical importance for future generations. However, the demands of the people for recreational opportunities have brought a response and the Federal Government is beginning to take cognizance of this demand and is beginning to modify its policies to fit current needs. An indication of the current importance of recreation is the 12.3 million visitor days attendance at reservoirs in the Missouri Basin last year.

Another facet which has been gaining in importance and concern to the people of the country is clean streams. Again, early responsibility was local; States then slowly took over responsibility. In 1948 Congress adopted the Water Pollution Control Act which gave the Public Health Service certain responsibilities in working with and assisting the States in trying to clean up our streams. Subsequently Congressional action in 1956, 1960, and 1961 increased Federal interest and responsibility and provided Federal funds to assist States in their activities and funds to assist municipalities in providing pollution abatement by sewage treatment works. It directs the Public Health Service to develop comprehensive programs for eliminating or reduction of pollution, for gathering basic water quality data, and for water quality investigations. The Federal Water Pollution Control Act also allows the Public Health Service to initiate actions to correct pollution in those cases where pollution from one State adversely affects others in a downstream State. Support of State activities has been greatly increased. One can readily see the improvements that have been accruing at a steadily increasing rate over the years. There is still considerable to be done, and with the mounting concern of our water resources and the knowledge that we will require them unimpaired for future use, I believe we can look forward to continued improvement.

As an adjunct to providing pollution abatement, which cannot do the entire job, the Federal Water Pollution Control Act authorized the Public Health Service to cooperate with the Corps of Engineers and the Bureau of Reclamation to determine the need for storage in federally built reservoirs for providing releases to improve the quality of water. This cannot be in lieu of proper sewage treatment, but supplements it. Storage can also now be provided in Federal reservoirs for municipal water supply needs, not only currently, but for the future. In such cases local governmental agencies are required to give assurance that the cost of use of such service will be repaid.

Policies with respect to many other facets of water and related land resources have been modified. So, we find ourselves with a plan largely fit to old standards. Although the Missouri Basin Development is not now fully responsive to current needs and requirements and, although the individual projects are changed to meet current requirements at the time they are placed under construction, it is not always practicable to make all the desirable changes without taking the time necessary for restudy and reauthorization.

As water is getting more attention and concern is growing over proper development, control, and operation, it is understandable that more Federal Agencies are becoming involved and that State and local interest is more apparent.

To update the general planning to make it fit current policies and to make it more responsive to current needs, General Seedlock, then Chairman of the Missouri Basin Inter-Agency Committee, proposed that the Committee, which has representation of the ten basin states, Missouri, Kansas, Colorado, Iowa, Nebraska, Wyoming, Minnesota, South Dakota, North Dakota, and Montana, and the seven Federal agencies, besides the Corps of Engineers, the Department of Interior, Department of Agriculture, Department of Health, Education and Welfare, Department of Commerce, Department of Labor, and Federal Power Commission, undertake jointly a comprehensive basin study.

It was the consensus of the members that such an undertaking would be desirable and a Subcommittee has been established to outline the studies which would be required. It appears that one of the first undertakings will be an economic study which will include projections of those economic indicators which can be translated into future needs for water and land. Then, a hydrologic study of water availability and its quality will be undertaken.

The latter part of this study may be somewhat difficult to accomplish. It is hoped not only to obtain information on present quality of water, but also to project to probable future conditions, both as to pollutants in the streams and the requirements for future needs to determine the type of action required to provide water of adequate quality. Undoubtedly much of this job can be done by adequate treatment, but it is anticipated also there may be requirements for regulation to supplement low quality flows to improve their quality. It is recognized that differing requirements on the various reaches of the stream will result from the potential uses and whether they are for irrigation, other agricultural uses, municipal uses or industrial uses. There are also studies being made of land availability, including estimates of the conversion of agricultural areas to other uses, such as municipal and highway, recreation, and similar uses. From these factors future needs will be forecasted and an attempt will be made to indicate a plan for water and related land resource development to meet these future requirements.

In conclusion I wish to call attention to one fact which I think is outstanding. In this forthcoming study all facets of water resource development are being considered, looking into the future to the best of our ability. There is a considerable change from past practice which was essentially to take an existing problem and work out a solution to it, which frequently resulted in piece-meal development that was not coordinated and did not consider the future adequately. It is our sincere hope that the forthcoming study and plan can guide developments in the future with specific delineation of requirements over the next 10-20 years to meet the needs and bolster the needs and bolster the economy of this great region.

DANGERS TO WATER SUPPLY FROM INCREASING NITRATE POLLUTION

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There is probably nothing that could be more important to the welfare of man and his animals than a dependable and wholesome supply of water. The rise and fall of civilizations have been dependent upon just this one thing, alone. Often, it has been the *mismanagement* rather than the management of existing water resources which contributed to the downfall of a given civilization. Often, the water supply vanished because of mismanagement and abuse of land and forest resources. History, written and unwritten, is full of such instances of the rise and fall of organized human society.

This paper does not plan to discuss the natural disasters of history which were probably beyond the scope of human influence. What we will discuss today are the common everyday practices which individuals and groups can be responsible for.

While some of the examples might be handled more effectively by larger organized groups such as the state or nation, most of them fall into the category that can best be handled by one person who is living on the farm or ranch. Nearly every example in today's presentation represents an error of omission rather than a deliberate effort to bring about trouble of one kind or another. Many instances, true enough, are illustrations of neglect of one or more basic principles of good, common sense on the part of someone. The person suffering the most doesn't necessarily have to be the one responsible for the error.

The pollution or contamination of water supplies was first recognized by such pioneer veterinarians as James Law (10) and N. S. Mayo (11) well before the present century but in rather special circumstances in which the nitrate (and hence, nitrite) source was thought to be closely associated with drainage from barnyards, decomposing hay and straw stacks, and similar situations. Mayo was perhaps the first American veterinarian to recognize the significance of long established legume fields as a potential source of pollution of shallow flood plain wells with nitrate and nitrite.

Metzler and Stoltenberg (12) followed Mayo by half a century with a comprehensive review in which they again stressed the possible paths by which nitrate pollution of groundwater occurs. They were among the first to warn of the Public Health significance of such nitrate pollution, especially as it affected human infants by producing methemoglobinemia (infant cyanosis) which had long been blamed on other factors until Comly (3) recognized nitrate as the etiological factor in Iowa. In addition to the Kansas and Iowa workers, Missouri, Illinois, Minnesota, North Dakota, South Dakota, Nebraska, and perhaps other areas have reported instances of infant cyanosis due to excessive nitrate (and hence, nitrite) in formulas (12). The condition never became widespread until the modern prepared infant formulas came into common use about 25 years ago. About the same time, extensive use of chemical fertilizers also became popular.

Within the past 20 years, numerous reports of excessive nitrate in water supplies for domestic animals have appeared. Case (6, 7), Campbell et al. (4), Muhrer et al. (15), Hueper et al. (9), Nupson and Henry (16), Bosh et al. (2), and perhaps others have reported on one or more aspects of excessive nitrates in animal water supplies. The various reports have given analysis results which range from the low levels which cause *interference phenomenon* to such high levels that acute nitrite intoxication and death resulted (5, 6, 7).

If one compares the earlier reports such as the Kansas, Iowa, and Illinois surveys with recent reports, it appears that the problem of nitrate contamination of wells is either becoming more widespread or it is now being recognized. The correspondence with veterinarians and owners indicates that this problem is becoming more serious over wide areas of the North Central U.S.A. and adjoining Canadian provinces (3) (4). Dairy cattle, beef cattle, swine, horses, and sheep as well as small animals (puppies) and human beings may be harmed by too much nitrate in the water, the forage and hay, or both, with the domestic animals, must also be considered when working with problems which involve excessive nitrate or nitrite (5, 6)

It is very important that anyone working with this problem knows that the nitrate represents the parent substance for nitrite. Nitrite is fully ten times as toxic as nitrate. In working with water supplies, and wells in particular, one should also be sure to test for nitrite as well as nitrate. It is entirely possible for enough nitrite to be present to cause interference syndromes in animals when the nitrate level may be quite low. This is very true of the shallow sandpoint wells of the intensively cultivated floodplains where corn, cotton, rice and soybeans are grown.

In the Canadian wells reported by Morrow, nitrate was present in very high levels with virtually no nitrite. Such wells are also shallow, generally located within a barn, and probably represent seepage or percolation of "oxidized manure water" (3).

It is almost impossible to recommend minimum standards because of the very wide range of such things as individual animal tolerance, the amount of conversion of nitrate to the more toxic nitrite ions, the amount of compensatory capacity of the ration, and many other factors difficult or impossible to evaluate.

Herrick (8) recently emphasized that there is considerable confusion among Iowa farmers concerning the terms which are in use concerning analysis reports and how various laboratories report them. He correlated those given by Case (6) with those in common use in Iowa and set forth some guide-lines for general interpretation. In Iowa, as elsewhere, there are many instances of poorly constructed, unsealed wells in or near a barnyard, feedlot, by a silo or in other locations where surface drainage and seepage from piles of manure, old hay and straw stacks and other places naturally high in nitrogenous substances.

Lowering of the general resistance to environmental stresses is one of the most important effects of excessive nitrates whether in the water, feed, or both.

Nitrate is not the only mineral ion which can produce interference syndromes in animals. Well known are selenium and fluorine, and there are others.

The very young animal, the pregnant female, and debiliated animals are more susceptible to the action of the nitrite ion. The hungry, depleted animal in a poor state of nutrition is also much more susceptible to the action of the nitrite ion.

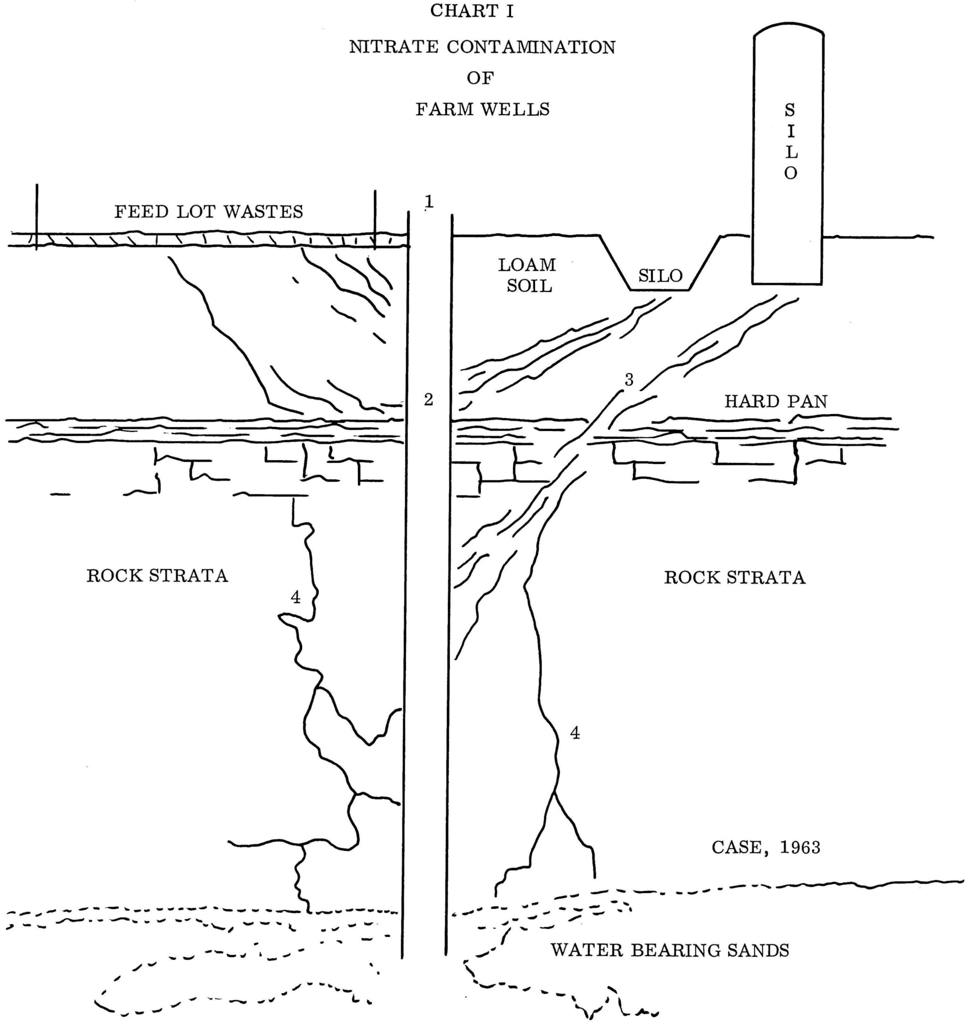
It is probable that the Public Health maximum permissible amounts for human water supplies, set at 10 ppm NO_3-N is a good mpa for animals, too. Minnesota workers (2) have given 20 ppm as a more practical mpa. Experience

CHART I

NITRATE CONTAMINATION

OF

FARM WELLS



(1) UNSEALED TOP.
(2) SEEPAGE THROUGH SOIL.
(3) DRAINAGE THROUGH FAULTS AND SOLUTION CHANNELS IN ROCK.
(4) CONTINUATION OF (3) TO DEEP WATER BEARING SANDS, (5).

CHART II

POSSIBLE EFFECTS OF NITRITE ON SWINE

(Interpretation of NO_2, NO_3, and NO_3-N in Water in P P M)

NO_3 (PPM)	NO_3-N (PPM)	REMARKS*
0-45	0-10	Approved. MPA for SPF Piglets.
45-135	10-30	Doubtful. Can be Off-set
135-225	30-50	Risky. Interference syndromes.
225-450	50-100	DO NOT USE / Interference.

(CASE, 1963)

* Nitrate serves as the parent substance from which nitrite is derived. It is the nitrite ion that causes interference syndromes in the lower amounts and either acute or chronic toxicity at the higher levels of contamination.

CHART III

NITRATE CONTAMINATION OF PONDS, LAKES AND STREAMS

(1) Drainage from barnyards, feed lots, silos, stacks of decomposing organic materials.

(2) Legume fields which have grown for years in shallow well areas where sand-point wells are used.

(3) Heavily fertilized cash crop lands in same situation as (2)* rice, corn, cotton, & soybeans.

(4) Drainage from tiled agricultural lands ot type (3).

(5) Actual wash-in from heavily fertilized fields during very heavy rains.

(6) Industrial and municipal wastes - raw sewage, major streams. Also, effluent from sewage lagoons under certain circumstances.

CASE - 1963

at Missouri indicates that interference syndromes may occur at levels between 20 and 50 ppm as NO_3-N. Of course, the higher levels bring on the interference syndrome in much less time.

The possible danger of increasing pollution by nitrates, and hence nitrite, to human and animal health ranges from the mild, scarcely recognized *interference phenomenon* to the very real possibility (at high enough levels) of acute intoxication and sudden death. When human infants happened to be involved, headlines appear in the regional and nation-wide news media (1) but the hazards to animals, if recognized, are usually known by just a few persons, and are often not reported even on a statewide basis. Facts are difficult to obtain, and even more difficult to evaluate (Chart II). As indicated by nearly every reference used in this paper, much remains to be learned about the why, where, and when concerning nitrate pollution of domestic water supplies (Charts I, II). This is as true of wells as of any other water source. (Chart III)

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AN INDUSTRIAL PLANT WASTE REDUCTION PROGRAM

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Western Electric came to the Kansas City area about five years ago. Operations began in a rented building with approximately 150,000 square feet of floor space. This initial pilot plant operation was located at Grandview, Missouri. The purpose of the original plant was to train employees and assemble equipment so that production operations need not be stopped when facilities and personnel were transferred to the new plant at Lee's Summit, Missouri. Starting in May of 1961, production facilities were installed in our main plant.

The plant is located on 345 acres of land approximately two miles northeast of downtown Lee's Summit. The main plant has approximately 1,500,000 square feet or 30 acres of production and office space. Production is limited to the manufacture of electronic devices and wired equipment for the Bell Telephone System.

These electronic devices include transistors, diodes, triodes, rectifiers, thermistors, mercury vapor rectifiers, and planar triodes. The wired equipment section builds radio bays for RF transmission of TV and telephone channels, and carrier and repeater equipment for the transmission of voice communication.

The plant employs over 4,000 persons at this time, 75 per cent of which are women.

All of the plant's industrial waste waters are discharged eventually into the Little Blue River with two exceptions and they are the cyanide and chromic acids which are removed from the plant by scavenger service. The chromic acids are collected at the use point. Spent acids are pumped into an epoxy-lined tank mounted on wheels. This trailer-tank is then moved to the chemical storeroom dock. A scavenger service transfers the concentrated acids from the trailer to a tank truck for removal from the plant.

We would not be helping the over-all pollution problem of our state if we were not assured the chemical contractor would treat our acids in such a way as to make them harmless before discharging them into a public stream. In this case, the scavenger company adds ferrous sulphate to reduce hexivalient chrome to the trivalient state then adds caustic to precipitate chromous hydroxide.

Concentrated cyanide is collected in a separate drain system which terminates at the Waste Treatment Plant. The cyanide is pumped from the cyanide basins and removed by scavenger service. The scavenger company destroys the cyanide by acidulation and by air stripping in a packed column.

In electronics manufacture, the surfaces of component parts going into tubes and transistors must be very carefully cleaned and prepared or the finished product will be unstable, performance wise.

The spent acids and salt baths used in preparing these surfaces are discharged into our collection grid system which is located in the basement of our electronics manufacturing building. We have a full basement beneath our electronics building which makes it convenient to make changes in our process piping and drain systems. This basement encompasses an area of approximately 12½ acres with a 10-foot ceiling height. This is of great benefit when a modification of drain facilities is necessary.

The acids used in etching and electropolishing are nitric, sulphuric, acetic, and hydrofluoric acids. For cleaning operations we use mainly hydrochloric acid because it leaves no residue on the parts being cleaned. For passivating surfaces we normally use chromic acid. Bright dipping operations utilize mixtures of acetic, nitric, and sulphuric acids. At Western Electric we use approximately 100,000 gallons of deionized water per day. The regeneration of these deionizer resin beds utilizes large quantities of hydrochloric acid and sodium hydroxide. We have many plating operations which used cyanide baths.

For control of our waste reduction program, samples are collected and sent to the Chemical Laboratory on a weekly schedule. This analysis indicated that an acid holding tank was needed to reduce the ionic content of certain elements in our waste waters. Such a holding basin with its connecting pipe running the width of the electronics building has recently been completed and is ready for service. The segregated waste acids will be collected in the basin until approximately 4,000 gallons have accumulated. A waste chemical contractor will remove the acids by pump and transfer them to their plant for treatment. There is some savings to our Company in this operation. The more acid that is removed, the less has to be neutralized so that some return may be expected from this new facility.

All acids and caustics which can be rendered colorless, odorless, and harmless are passed to the Waste Treatment Plant through our acid drain grid system. The acid collection system in the basement of the electronics manufacturing building consists of five drain lines running the width of the building. These tie together at the east end of the building and are connected to the Waste Treatment Plant by a six-inch PVC line. The wired equipment Metal Finishing Area is connected to the same transfer piping system. All the acids from the wired equipment section go into a sluiceway covered with metal grating and drains to the Acid Waste Treatment Plant. All feed lines to the Waste Plant are gravity fed.

The waste acid drain discharges into two epoxy-lined basins. Each of these basins has a holding capacity of 50,000 gallons. They are agitated in order to obtain as much neutralizing effect as possible from the waste liquid itself before treatment is begun. The pH of the mixture will vary from 1 to 12. Since we normally handle 200,000 gallons per day through our plant, this means the operators are quite busy, especially during the day shift. We have one operator assigned to the plant on the day shift with operators from the Gas Plant next door filling in on the second and third shifts.

Industrial waste water is pumped from the holding tanks to the flash mixer where it is mixed with enough acid or base to neutralize it. These pumps have an average operating time of ten hours per day. From this point the water passes into the solids contact basin or clarifier where, due to the very slow motion of the waste water through the 40-foot diameter basin, the solids in the waste water settle into a layer about three feet below the water surface. This layer of solid particles, called floc, acts to filter liquid passing through it. At our normal pumping rate of 400 gallons per minute, the maximum rise rate is 0.67 gallons per minute per square foot of area. The floc layer can be increased in weight by the addition of ferric sulfate to the water in the solids contact basin. This addition results in a clearer effluent passing into the launders and down the storm sewer. Normally, the total solids passing into the launders will be less than fifty parts per million by weight.

The operation of the equipment at the plant should be classified as semi-automatic. Pumps are turned on manually from the main control panel but are automatically shut off when the tank reaches a certain preset level. PH controllers automatically control the amount of sodium hydroxide or sulphuric acid pumped into the flashmixer by adjusting the stroke length of the chemical pumps. We also have a lime system which can be put into operation when our usage of sodium hydroxide shows it to be feasible. The problem that arises in using lime is one of an additional labor requirement to keep the plant in operation.

Effluent from the clarifier is discharged through a 33-inch storm drain line to the lagoon for further dilution and settling. The overflow from the three-acre lagoon passes into Little Cedar Creek and from there to the Little Blue River. This river also receives the effluent from the treatment lagoons of three suburban cities. The result is a constant flow rate stream which is used for irrigation and fishing as you will see in the slides to be shown.

The system that has been installed at Western Electric is quite trouble-free and dependable. The use of scavenger services to dispose of cyanide and other troublesome chemicals in concentrated form helps to keep operating costs low and our operation in control. As our production and use of chemicals increase, the waste water system installed at Western Electric can easily be expanded to handle larger volumes of liquids. You can be sure that the policy of the Western Electric Company will always be one that favors uncontaminated public streams and safe, healthful water facilities.

AIR AND WATER POLLUTION AS RELATED TO SOLID WASTE DISPOSAL PRACTICES

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All the Papers that have been presented so far are on water pollution; therefore, before discussing the subject that has been assigned, it might be useful to discuss air pollution in general.

What is the Extent of the Air Pollution Problem?

It has been estimated that at least 308 urban places in the United States with a population of 2500 or more have a major air pollution problem. About 24% of the nation's population live in these areas. About 15% of the nation's population live in about 850 areas with moderate problems of air pollution. Together, these people constitute 58% of the urban population of the country. Including the people who live in communities of less than 2500 population that have air pollution problems and those in all sizes of places with minor problems, it is estimated that about 7300 places are confronted with an air pollution problem of one kind or another. About 107,000,000 people live in these communities; 60% of the nation's population.

These figures are from the paper presented at the 55th Annual Meeting of APCA, May 1962, by Jean Schueneman. (1)

What are the Costs to Society?

There have been some very rough estimates of the cost of air pollution in terms of dollars. These estimates are very rough indeed. In 1950-1951, it has been estimated that the cost per inhabitant of the United States was about $10.00 per person per year. At the 1958 National Conference on Air Pollution and repeated at the 1962 conference, the figure of $65.00 per capita per year was used. Either one is a tremendous amount of money when multiplied by the population. (2, 3)

This cost in terms of dollars, of course, does not include the health problem. It is very hard to analyze the hazards that air pollution creates for human health. However, we do know about the experiences of the Belgian Meuse Valley in 1930; Donora, Pennsylvania in 1948, and London in 1948, 1952, 1956, and 1962, in which people died as a result of air pollution during episodes under certain meteorological conditions. In Donora, Pennsylvania, there were 20 deaths and about one-half of the population was ill during one episode in 1948. In London, during one week in 1952, between 4,000 and 5,000 more people died than would be expected under normal conditions (2).

There may be other episodes during which people have been made ill or have died, but these have passed unnoticed because the machinery for identifying excessive deaths or disabilities is too insensitive to identify small disasters.

The sources of air pollution are many and varied. In some areas, the major problem may be industrial and in others the automobile. S. Smith Griswold, in his address at the National Conference on Air Pollution December 1962, said

"In Los Angeles, 80 per cent of our problem is motor vehicle emissions; 20 per cent comes from industry and other sources. In neighboring San Francisco, the problem is approximately 60 per cent vehicular and 40 per cent industrial." (3) In other cities, the major problem may be from the fuels used. However, today we are to discuss one of the sources that may contribute to the problem in many communities; that is, the solid waste disposal practices.

In the United States today there are approximately four pounds per capita per day of solid waste produced. Solid waste as used in this discussion refers to the useless, unused, or discarded materials resulting from normal community activities. This includes such materials as garbage, rubbish, ashes, street refuse, dead animals, and solid industrial waste. Therefore, our urban population is producing approximately 400,000,000 pounds of solid waste every twenty-four (24) hours. This must be disposed of by incineration, dumping on land, grinding and disposal with sewage, or reused by one or more reclaiming processes. (4) The disposal practices for discussion are incineration and dumping on land, which includes the sanitary landfill and the open dump.

How Serious is the Problem of Air and Water Pollution from the Practices of Disposal of Solid Waste by Incineration, Sanitary Landfill, Open Dumps, or Various Combinations of These Methods?

In 1955, Louis Garber, in his paper "How Serious is the Air Pollution Problem in Missouri" (5), ". . . noted, that municipal operations such as city dumps and sewage treatment plants have been implicated almost as often as industrial operations . . ."

Mr. Jean Schueneman, in 1962, before the Air Pollution Control Association in Chicago (1), stated that "burning dumps cause air pollution problems in about 25% of the urban communities in our country, according to data collected in state-wide air pollution surveys."

The three state-wide air-pollution surveys (6, 7, 8) that have been conducted in Region VI of the Public Health Service have also shown that solid waste disposal practices were among the air pollution sources most frequently recognized.

The Kansas report says "The greatest number of complaints encountered during this survey were those related to the disposal of solid waste material." This included not only odor and smoke from open dumps, incinerators, and "so called" sanitary landfills, but the practice of burning automobile bodies at salvage yards.

The South Dakota report states "At this time (1961-1962), air pollution from improper refuse disposal poses the greatest threat to the State's air resources." The report goes on to say that 75 per cent of the communities visited during the survey used open dumps that were characterized by intermittent burning and continuous smoldering and at some of the sanitary landfills refuse was being burned instead of buried. Indiscriminate backyard burning was also found in all but one of the 25 communities visited.

The Minnesota Survey indicated that refuse dumps were the source of complaints in 24 communities and incinerators in three others. This was in answer to a questionnaire sent to local authorities of all the Minnesota communities.

The composition of solid waste from the American communities has notably changed since World War II. This change is an indication and result of our changing mode of living. The modern housewife now discards paper and plastic wrappers from frozen ready-to-cook foods and oven-ready meats. This is an example of the change from the pre-war years when vegetable stalks and tops, poultry entrails, meat trimmings, and other similar materials were discarded. As a result, the solid waste of today is lighter, drier, bulkier, and higher in combustiles. The pre-war waste composition was estimated to be 50 per cent garbage and 50 per cent rubbish and trash. Today, about 85 to 90 per cent is rubbish and only 10 to 15 per cent garbage. (9) This change may be one reason for more burning and, in turn, more air pollution.

Solid Wastes are also a Recognized Source of Water Pollution.

When solid waste is deposited in a sanitary landfill or in an open dump, there is a potential problem of the surface waters or subterranean aquifers being polluted.

From an open dump the waste can be washed directly into the creek and rivers by runoff. If the waste is not washed directly to the surface streams, there is still the problem of leaching of the material both to the surface and ground water.

From the sanitary landfill there is the potential of leaching that may cause pollution to the surface or ground waters or both, if the site is not selected to prevent this from occurring.

Invesigations of leaching from sanitary landfill have shown that ground water in the immediate vicinity can become grossly polluted and unfit for human and animal consumption or industrial and irrigational use. This was shown by the classic investigations conducted in early 1950 by the University of Southern California (10, 11) and reported in the California Water Pollution Control Publications. In their Publication No. 10 was included a summary of conclusions as follows:

"1. A sanitary landfill, if so located that no portion of it intercepts ground water, will not cause impairment of the ground water for either domestic or irrigational use.

"2. A sanitary landfill, if so located as to be in intermittent or continuous contact with ground water, will cause the ground water in the immediate vicinity of the landfill to become grossly polluted and unfit for domestic or irrigational use. Local increase of mineral elements to concentrations varying from 20 times those found in the unpolluted ground water of the area in the case of common minerals up to 10,000 times in the case of ammonia nitrogen are possible.

"3. It may be expected that continuous leaching of an acre-foot of sanitary landfill will result in a minimum extraction of approximately 1.5 tons of sodium plus potassium, 1.0 tons of calcium plus magnesium, 0.91 tons of chloride, 0.23 tons of sulfate and 3.9 tons of bicarbonate. Removals of these quantities would take place in less than one year. Removals would continue with subsequent years, but at a very slow rate. It is unlikely that all ions ever would be removed.

"4. Dissolved mineral matter, entering a ground water as a result of intermittent and partial contact of a sanitary landfill with the underlying ground water will:
   (a) have its greatest travel in the direction of flow,
   (b) undergo a vertical diffusion to a limited extent and, where the aquifer is of appreciable thickness (100 feet or more), the bottom water will probably remain unimpaired.
   (c) be subject to dilution, the result of which will be a minimizing of the effect of the entering pollutant ions.

"5. Where the pollutional load of a ground water is light by reason on a sanitary landfill being in intermittent and partial contact with the underlying ground water, the most serious impairment of the ground water as little as a half-mile downstream from the landfill will be an increase in hardness, and then only in the upper portions of the aquifer.

"6. Rainfall alone in this area will not penetrate a 7.5 foot thick landfill sufficiently to cause entry of leach into the underlying ground water.

"7. Compared to the hardness entering the ground water with leach from a sanitary landfill, the additional hardness which might result from the dissolution of calcium carbonate by carbon dioxide produced within the fill is negligible, unless the aquifer is of a calcareous nature.

"8. Anaerobic conditions with production of combustile gas will exist within a sanitary landfill in approximately one month following deposition of the fill. The composition of the gas at that time will be approximately 70 per cent methane and 30 per cent carbon dioxide.

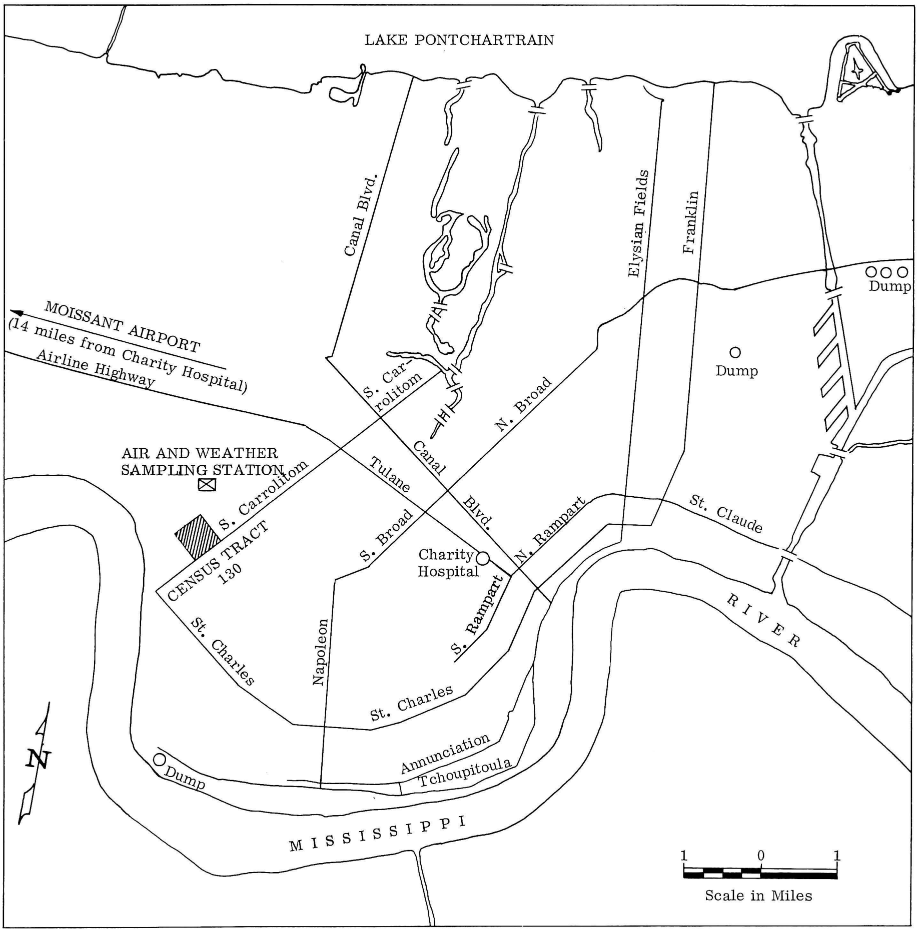
"9. The production of methane and carbon dioxide from solid fill materials results in increased pressure, and gas diffuses out of the fill. Low content of limestone in an aquifer will limit the diffusion of carbon dioxide into the water, and all but a negligible amount of the gas formed will escape into the atmosphere."

These studies were conducted in the relatively dry climate of Southern California where the rainfall averaged only 9.5 inches per year for the two years during which the studies were conducted. Therefore, Conclusion No. 6 may not be valid for Missouri, where the rainfall averages from 30 to 60 inches per year.

The Sanitary Landfill-Ground Water Study conducted by the Wichita-Sedgwick County Department of Public Health in 1957 (12) concluded that the landfill appeared to be causing some increase in the mineral concentrations in the ground water in the immediate vicinity and downstream in the direction of the ground water flow. This was indicated particularly by the increase in hardness and BOD concentrations. These studies prove that leaching from solid waste to a shallow aquifer occurs when the water intermittently comes in contact with the waste. There is a question as to how deep this pollution will travel. The answer to this is not necessarily clear-cut. The geological formations obviously are important.

Probably the most Striking Example of Pollution from Solid Waste Disposal is the Air Pollution of New Orleans which seems to cause what is called today "New Orleans Asthma." (13)

Figure 1. Location map, New Orleans, La.



As a result of an outbreak of asthma with three deaths in New Orleans in 1958, an investigation was started. A preliminary report—"Air Pollution and New Orleans Asthma" (13) was published in the Public Health Reports, Volume 77, No. 11, November 1962. This report is the result of a series of investigations carried out by Tulane University under contract with the Public Health Service to determine the source and nature of air contaminants which produce asthma in New Orleans.

Analysis of data from the emergency clinic at Charity Hospital which pertained to asthma and of data from the U.S. Weather Station disclosed that asthma outbreaks were most commonly associated with winds of low speed from the south and southwest. Occasional outbreaks occurred with winds from the north or northeast. Figure 1 is a location map of New Orleans and shows the dump in the south and northeast sections of the city.

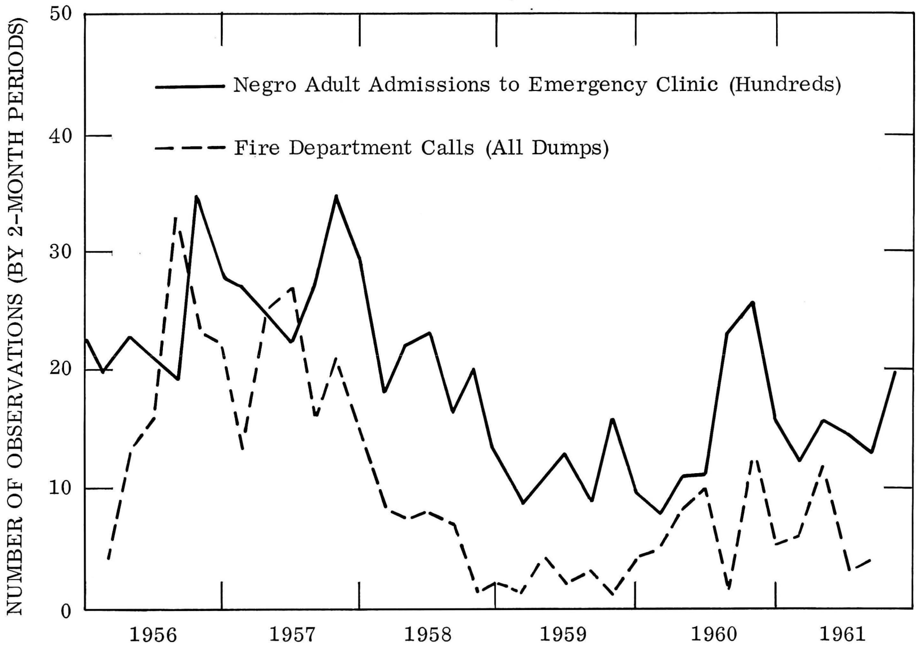
A number of air pollutants were collected and analyzed and their prevalance was compared with the prevalance of asthma outbreaks. A statistically significant relationship was found between the daily asthma admissions at Charity Hospital Emergency Clinic and the prevalance of *one* (1) air pollutant. This was a poor-combustion particle with associated silica. No relationship was shown between concentrations of other pollutants and the number of reported asthma attacks. It would appear either that the poor-combustion particle with associated silica produces asthma or the asthma-producing agents travel in consort with this *one* air pollutant. This particle could arise from combustion processes in which siliceous material is present and burning is inefficient. All possible sources of this material were not examined; however, large quantities of this particle were found in samples taken from one dump in the summer of 1961. Figure 2 shows the relationship between asthma and dump fire calls, 1956-61, received by the New Orleans Fire Department.

An added note to this report states that there was an episode in New Orleans in October 1962 in which it was reported that more than 200 people sought treatment and nine asthmatic deaths occurred during one week.

This investigation is continuing but so far it has shown that there is probably a relationship between the emissions from burning dumps and the asthma outbreaks.

So far, this discussion has been mainly about air and water pollution from dumping of solid waste on land or sanitary landfills and open dumps. However, incineration of solid waste has been found as a source of air pollutions in many reports. One state report on municipal incineration (14) said that most of the units do not operate efficiently from the standpoint of total refuse reduction and/

Figure 2. Relation between asthma and dump fire calls, 1956-61, New Orleans, La.



or air and water pollution control. This report concluded that over two-thirds of the municipal incinerators needed improvements to prevent the discharge of fly ash to the atmosphere and that all dumps associated with incinerators should be given close scrutiny in regard to water contamination.

What can be done about the Pollution of Air and Water From Solid Waste Disposal Practices?

The answer to this is obvious. Solid waste should be disposed of by a method that will not create an air or water pollution problem.

The open dump should be abandoned. Of course the closing of these dumps should include the destruction of the rodents and covering the area to leave it in a sanitary condition.

All sanitary landfills should be properly engineered and satisfactorily operated. This will include the selection of a site that will not contaminate the surface or ground water and operated without burning the waste.

All incinerators should be designed and constructed by competent engineers and operated efficiently. Since incinerators have a long life, the operating capacity should be designed according to population growth expected, and sized to handle the variations in solid waste received. The design should include the needed air pollution control equipment. The incinerator should be efficiently operated at all times to completely reduce the garbage and refuse to ash, without creating an air pollution problem.

In conclusion, it is evident that solid waste disposal practices are potential sources of air and/or water pollution. Data now available indicates that this is a true statement. However, with good engineered sanitary landfills and incinerators and proper operation, this waste can be disposed of without public health hazards or nuisances.

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AIR POLLUTION STANDARDS*

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Standards are either voluntary or mandatory. The primary voluntary standards are those adopted as association standards by organizations solely devoted to broad spectrum standardization. In a secondary category are standards adopted by trade associations or professional societies. Association standards frequently become mandatory in some localities by being incorporated into law or regulation either directly or by reference. Incorporation by reference has the pitfall that revision of the referenced standard leaves the law or regulation obsolete.

Mandatory Standards

Mandatory standards are those appearing in law or regulation. The so-called "office" standards of regulatory agencies have a quasi-mandatory status when they are used by regulatory officials to guide their interpretation of laws or regulations which do not themselves contain standards. In general, standards are classified as design, emission, or air quality standards. Planning and zoning professionals give the name "performance standard" to either emission or air quality standards when they appear in zoning ordinances or regulations. The zoning ordinance equivalents of design standards are construction standards.

Relations between Standards

An air quality standard sets a limit on the amount of the pollutant in the air—more specifically, at a representative point near ground level. An emission standard is a limit on the amount of a pollutant emitted from a source and is intended to bring the ambient air within air quality standard limits. Design standards are specific limits on dimensions, construction methods, fuel or material specification, input rates, temperatures, or pressures, intended indirectly to bring the affected effluent within emission standard limits. It would appear from these definitions that no emission standard could be set until the air quality standard for the pollutant had first been established, and that no design standard could be set until the emission standard for the pollutant had first been set. Actually, this has not been so in practice. Engineers studying processes and process equipment have first learned the economically practicable changes which will decrease process emission, and subsequently have used this knowledge to establish design standards, regarding these as essential before emission limits could rationally be set. They have likewise been able to rationalize emission standards from source and equipment performance data before air quality standards have become available. Thus, the development of most present standards has been empirical rather than theoretical.

*Condensed with permission of the publisher from the author's chapter on "Air Pollution Standards" in the book "Air Pollution" (Edited by A. C. Stern) Vol. II pp. 451-498—Academic Press (1962).

Design Standards

The first standards to be used extensively in air pollution ordinances and regulations were design standards. The incorporation of such standards led to the requirement of the submission of plans and specifications for approval, i.e., for checking for compliance with design standards. Proponents of this approach have argued that it has been the only practical preventive in the absence of air quality standards. Design standards must therefore be sufficiently restrictive so that this hypothetical eventuality will never occur. Opponents also have held that design standards stifle engineering ingenuity by preventing designs which contravene the standards but which achieve the desired result in terms of emission or air quality. To avoid this, design standards should never be used as a strait jacket on design, but rather as a guide to good design, and appeals procedures should be provided to allow fair consideration for nonstandard designs.

Design standards for stationary fuel-burning equipment relate to such factors as heat release per unit furnace volume, furnace refractory placement and arch design, chimney cross-sectional area and height, stoker setting, fuel oil viscosity, and preheat temperature, etc. Being specific to the characteristics of the fuel used, which differ from region to region, such standards are perforce local and not universal. Design standards tend to become obsolete as technology changes, and therefore should not be incorporated into legislation or regulation that is difficult to amend. Even design standards for chimney height and distance from a chimney in which any specific land use is prohibited are subject to better definition as our knowledge of the behavior of staff effluent improves.

Emission Standards

The setting of emission standards may be approached (a) directly, (b) forward from the design standard, or (c) backward from the air quality standard. The direct approach asks the question, "What are the emissions from the best constructed and operated plants in this category?" and then rationalizes that this performance should set the standard for all such plants. Alternatively, the question may be asked with respect to "well constructed and operated plants" rather than "the best" ones.

In the approach from the design standard basis, the first step is to determine for a range of plants from best to worst the pollutant loading of gases leaving the process at a point prior to their passing through any emission control equipment such as dust separator or gas scrubber. The next step is to compute what the emission from each would be if treated by an appropriate unit of commercially available emission control equipment. The result will depend upon the collection efficiency assumed for the control equipment. The old adage in air pollution that "one can have as much control as he is willing to pay for" becomes the test in setting the assumed efficiency high or low. A good combination for such computation is to assume control equipment of better than average efficiency applied to a plant of average control equipment inlet loading.

The approach from the air quality standard basis is the ideal that all people concerned with standard setting hope to adopt but seldom have succeeded in following. Where an air quality standard has been adopted (or even assumed for the purpose of developing therefrom an emission standard), an emission standard can be computed by the use of some modification of one of the diffusion or dispersion formulas.

An opacity standard is applicable only when an emission contains sufficient concentration of solids or liquids to make it at least partially opaque to the passage of light. One major drawback is that mere water vapor in the emission can condense to cause opacity at or not far from the point of emission but evaporate before the plume has traveled very far from its point of emission. Therefore, opacity measurement must distinguish between water droplets and other dispersoids. Knowledge of the process causing the emission will usually provide this distinction. In addition, experienced observers can distinguish water vapor by the characteristic feathery appearance of the edge of the plume at the point where the vapor evaporates.

Gravimetric emission standards are expressed as weight of emitted pollutant per unit volume or unit weight of carrier gas. Standards on a "per unit volume" basis must be further specified as to the gas temperature and pressure to which volumes are to be reduced. Unless otherwise noted, pressures are presumed to be reduced to 30 in. Hg. and temperatures to 60°F. To account for incidental, accidental, or deliberate dilution with air prior to measurement, it is customary with cumbustion effluents to specify also either the per cent excess air or the per cent CO_2 to which gas quantity must be reduced.

There are very few emission standards for gaseous pollutants in the United States. Of 111 regulations reviewed, 3 restricted SO_2 to 0.2% by volume in the emitted gases. The Bay Area Air Pollution Control District, California, regulations for incineration and salvage operations set an emission standard of 50 p.p.m. each for hydrocarbons (C_2 and higher) and for carbonyls (as formaldehyde).

The state of California has adopted volumetric motor vehicle exhaust emission standards. These are based upon proportional and "rollback" procedures.

Air Quality Standards

Deficiencies in air quality adversely affect animate and inanimate things with a wide spectrum of response. Thus, sulfur dioxide between 0.01 and 0.1 p.p.m. may manifest itself in its presumed role in atmospheric photochemical reactions which by creating aerosols decreases visibility. Between 0.1 and 1 p.p.m. SO_2 will also damage plants and materials. Between 1 and 10 p.p.m. it will, in addition, be irritant to people. Between 10 and 100 p.p.m. it will cause symptoms in experimental animals. At levels above 100 p.p.m. it becomes lethal to all forms of life.

At any one level of SO_2, there is a wide response variation with respect to duration of exposure, species resistance and individual susceptibility. Thus the level required to protect all plants of all species will be much lower than that to protect most plants of all species or all plants of most species.

The cost damage attributable to a pollutant goes up as the ambient concentration in the community's air. Conversely, the cost of controlling a pollutant to a set level goes up inversely as that level. There is thus a level of lowest community cost—that at which the sum of the cost of damage and cost to control becomes minimum. However, this optimum economic level may not satisfy community esthetic and ethical values. Thus the esthetic sensibilities of the community may demand an extent of atmospheric transparency or the ability to grow types of plants which require an air quality standard lower than that based solely upon readily measurable costs.

Lastly, there are ethical values, impossible to measure in dollars, such as those associated with the aged and infirm in the population. An air quality level which will not harm them may be very expensive for the rest of the community to maintain, and difficult to rationalize because of both the small number of such persons and the small fraction of their total health risk attributable to this portion of their total stress. After all, there are cultures which for economic and sociological reasons kill their infirm and drive out their aged. In these matters, each community must search its collective conscience.

Standards and the Community

Air pollution standards are promulgated as the result of study of available information on sources, transport, and effects of pollutants. Our ability to measure all three of these factors is rapidly improving. These factors also change with time. This combination acts to make standards obsolete. Information used for standard setting must therefore be periodically brought up to date, studied and used for revision of standards.

Emissions, transport, and effects are also subject to geographic variation. Since they vary between localities, so also may the standards based upon knowledge of these pertinent factors. The resultant standards may thus reflect differences among communities in meteorology, topography, latitude, longitude, sources, and receptors. An invariant standard covering a large number of such communities, and intended to protect each of them, must be as stringent as would be required for the least favored of the communities. Thus the feasible way for a community to have less stringent standards than some other community is by local adoption of standards. In theory, state, regional, or county standards can contain standards of several levels of stringency applicable each to designated political subdivisions. In practice, it is difficult to define the basis for categorizing these subdivisions with respect to these levels in a manner that truly reflects all the factors variant among them.

The one sure thing that can be said by way of summary is that as population, urbanization, and energy utilization all increase in future years, air pollution standards regardless of whether they be national, state, regional, or local, must of necessity grow progressively more restrictive.