PROCEEDINGS OF THE FOURTH ANNUAL WATER RESOURCES DESIGN CONFERENCE

Sponsored by

DEPARTMENT OF CIVIL ENGINEERING

With Cooperation of

ENGINEERING EXTENSION

Iowa State University
of Science and Technology
January 19-20, 1966
Ames, Iowa

Proceedings of the Fourth Annual WATER RESOURCES DESIGN CONFERENCE

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1966 Proceedings

Water Resources Design Conference

Preface:

The Water Resources Design Conference of the Iowa State University has a statewide objective of bringing new concepts and information in planning and design to engineers and administrators. It is aimed primarily at water resources design problems in Iowa and serves to fulfill part of the continuing education role of the University.

The technical role of this conference is contained in the preface to the 1966 conference:

Topic: Economic Evaluation and Legal Concepts in Planning; Specifications for Construction; Estimating, Assessments, and Financing

This fourth conference continues with the engineering studies which arise in designing water resource projects. Economic evaluation and related legal and statutory concepts are a pertinent aspect of every engineering study in water resources development. Thorough coverage is offered of various alternatives, and in several water uses. Construction specifications complete a phase which began a year ago with the design of rolled earth fill dams. Estimating construction costs is important in financing as well as in project evaluation. Assessing project costs among the benefited interests is another important consideration in water resource projects A new method of financing recreation projects with bond issues offers new alternatives to many counties.

The conference is aimed toward the technical role. It offers you an opportunity to keep abreast of the latest technical information and procedures in planning and designing water resources projects.

The support and cooperation of the engineering profession in Iowa, including engineers and administrators in private practice, public agencies, and education are both appreciated and welcomed

Merwin Dougal
Assistant Professor
and Conference Supervisor

PROGRAM

1966
WATER RESOURCES DESIGN CONFERENCE
Memorial Union
Iowa State University
Ames, Iowa

WEDNESDAY, January 19

Topic: Economic and legal concepts of water resources projects

MORNING PROGRAM, Gallery
Presiding: John L. Cleasby, Professor, Civil Engineering, ISU

8:30 a.m. REGISTRATION ~~AND COFFEE~~ Gallery

9:15 WELCOME
Dr. Carl E. Ekberg, Jr., Head Civil Engineering, ISU

9:30 MUNICIPAL WATER SUPPLY PROJECTS
Mr. Leo L. Cunningham, Partner, Burns and McDonnell Engr. Company, Kansas City, Missouri

10:30 EVALUATION OF RECREATION--BUREAU OF OUTDOOR RECREATION CONCEPTS
Mr. Evan Haynes, Assistant Regional Director, Lake Central Region, Ann Arbor, Michigan

11:30 Lunch, ~~through Cafeteria line to [illegible] Room~~

AFTERNOON PROGRAM, Gallery
Presiding: David B. Palmer, Assistant Professor, Agricultural Engineering, ISU

1:00 p.m. P. L. 566 WATERSHED DEVELOPMENT, WALTER'S CREEK WATERSHED PLAN FOR MULTIPURPOSE USES
Mr. Martin Meyer, Agricultural Economist, River Basin Survey Party, Soil Conservation Service, Des Moines, Iowa

2:00 BEAVER WATERSHED DRAINAGE DISTRICT PROJECT, WEBSTER COUNTY
Mr. Glen H. Miller, Consulting Engineer, Fort Dodge, Iowa

2:45 Coffee Break ~~in Gallery~~

3:00 URBAN FLOOD CONTROL PROJECTS, LOCAL FLOOD PROTECTION WORKS
Mr. Raymond Stearns, Engineering Economist, Planning and Reports Branch, Rock Island District Corps of Engineers, Rock Island, Illinois

4:00 LEGAL ASPECTS OF OUR STATE LAWS--POLICIES AND PROGRAMS PERTAINING TO WATER AND RELATED LAND RESOURCES
Mr. Clifford L. Peterson, Deputy Water Commissioner, Iowa Natural Resources Council, Des Moines, Iowa

6:30 DINNER MEETING, ~~Cardinal Room Memorial Union~~
Presiding: Burl A. Parks, Assistant Professor, Landscape Architecture, ISU

THE COMPREHENSIVE STATEWIDE PLAN FOR RECREATION IN IOWA--PLANNING, EVALUATION AND FINANCING
Mr. William Brabham, Director of Planning and Coordination, State Conservation Commission, Des Moines, Iowa

THURSDAY, January 20

Topic: Specifications for construction, estimating, assessments and financing water resources projects.

MORNING PROGRAM, Gallery
Presiding: Wilfred T. Hezmer, Associate Professor, Civil Engineering, ISU

8:30 a.m. CONSTRUCTION SPECIFICATIONS FOR ROLLED EARTHFILL DAMS
Mr. Kenneth Cornforth, State Conservation Engineer, Soil Conservation Service, Des Moines, Iowa

9:15 a.m. CONSTRUCTION SPECIFICATIONS FOR CONCRETE--SPILLWAYS, CONDUITS, AND MISCELLANEOUS STRUCTURES
Mr. Orwin Keifer, Jr., Materials Engineer, Foundations and Materials Branch, Omaha District, Corps of Engineers, Omaha, Nebraska

10:00 Coffee ~~break in Gallery~~

10:15 CONSTRUCTION SPECIFICATIONS FOR RECREATIONAL FACILITIES
Mr. William Randolph, Engineer, State Conservation Commission, Des Moines, Iowa

11:00 DESIGN AND CONSTRUCTION OF DRILLED WELLS
Mr. Robert D. Reckert, Partner DeWild, Grant, Reckert, and Associates, Rock Rapids, Iowa

12:00 Lunch, ~~through Cafeteria line to [illegible]~~

AFTERNOON PROGRAM, Gallery
Presiding: Gerald Smith, Associate Professor, Industrial Engineering, ISU

1:15 p.m. ESTIMATING CONSTRUCTION COSTS--TECHNIQUES, RECORDS, APPLICATIONS
Mr. Paul R. Lilly, Lilly Engineering, Construction Engineers, Boone, Iowa

2:00 ASSESSMENTS AND LAND RECLASSIFICATION IN DRAINAGE DISTRICTS
Mr. W. C. Otto, W. C. Otto Engineering Company, Consulting Engineers, Sac City, Iowa

2:45 FINANCING COUNTY RECREATION PROJECTS WITH BOND ISSUES
Mr. Wendell Cornwall, Member and Mr. Jack Fisher, Secretary Boone County Conservation Board Ogden, Iowa

3:30 ADJOURNMENT

ECONOMIC CONCEPTS OF MUNICIPAL WATER SUPPLY PROJECTS

Presented at
WATER RESOURCES DESIGN CONFERENCE
IOWA STATE UNIVERSITY

January 19, 1966
by
LEO L. CUNNINGHAM
BURNS & McDONNELL ENGINEERING COMPANY

Any economic study of source for municipal water supply must consider the complete process of treating and delivering finished water to the user. It does not necessarily follow that the lowest cost of development of a raw water source will produce the best value in finished product. In order to establish a basis for comparison, certain guidelines as to quality, quantity and pressure must be established.

First, we must produce a quality product. The water, as delivered to the user, must be bacteriologically safe. It must be palatable, having no objectionable taste or odor and a satisfactory temperature. It must have a pleasing appearance, clear and sparkling and free from color. It must be chemically stable to prevent corrosion within the distribution system and resulting "red water." Ideally, the water, as delivered, should not be excessively hard, although hardness in itself is a matter for further economic study. The degree of hardness which is acceptable is basically a matter of the desire of the user. However, the hardness should be considered when comparing potential sources having dissimilar hardness.

We must realize that it is generally impossible to produce water in which the foregoing characteristics are all uniform from day to day. Nor would we expect two plants on the same source to produce identical results. Rather, acceptable limits have been established and must be maintained to produce quality water. These limits are constantly being revised to upgrade the quality, and any comparison should be based on current standards.

With regard to quantity, the water source or sources must be capable of supplying every user with all the water he is willing to pay for, and at sufficient pressure to make it available to him. Here the location of the source must be considered from the standpoint of pumping head required, and the distance the water is to be transported.

Of course, we might say that any source can be treated to provide potable water. Certainly we are aware that in emergencies some very questionable sources have been utilized. We know that ocean water can be treated for human consumption. A classic example is the recycling of the effluent of the sewage treatment plant through the water treatment plant at Chanute, Kansas from October 1956 to March 1957. Extreme drouth made this necessary and it is estimated that the water was recycled from 8 to 15 times. The water was constantly checked for compliance with health standards. As the recycling advanced, the water developed a yellow color, musty taste and odor, and foamed when agitated. About all that can be said of this supply is that it was wet and safe. Certainly, we would not intentionally set out to develop such a source for a continuing supply of quality water. The quality of the source may not be purely a matter of economics, but it is a major consideration.

It is readily seen that any economic study of source for municipal water supply must consider quality of finished water and all the steps required for its production and transmission.

The preceding statements can probably be best illustrated by reference to the development of some specific projects as a result of economic considerations. The first municipal project to be discussed is Little Rock, Arkansas.

The original Little Rock water treatment plant was located on a bluff overlooking the Arkansas River from which it obtained its supply. While the Arkansas River was never a very desirable source, its quality deteriorated as its drainage area became more populated and oil field wastes were discharged from it. Auxiliary wells were drilled to provide water at times when the chloride content of the river was high. However, the well water was extremely hard and required softening. Following are some characteristics of the two supplies as determined by raw water analyses.

	Arkansas River (Nov., 1936)	Auxiliary Wells (July, 1936)
Chlorides	425 ppm	8 ppm
Total Hardness	208	432
Total Dissolved Solids	587	500

Mean turbidity for the year was 700 ppm with a range from 10 to 15,000.

At the end of 1935, the City purchased the water system and immediately began development of a new source of supply and treatment plant. A number of impoundment sites had been investigated and evaluated with the Lake Winona site being determined as most feasible. The new filtering and pumping facilities were located at the site of the original plant since it was the focal point of the distribution system and the elevation of the site was advantageous for gravity service to most of the system. It was also feasible to continue to use the existing settling basins and clearwells.

Lake Winona is at such elevation as to provide gravity flow to the treatment plant and supplies raw water of excellent quality as evidenced by the following averages for analyses performed in 1962.

	ppm	
Chlorides	1.6	
Total Hardness	12.0	
Total Dissolved Solids	30.00	
Mean Turbidity	5.0	(Range 3.0 to 8.0)

One might well wonder why such a desirable source had not been tapped long before. The reason: A pipeline 33 miles long was required to transport the water from the lake to the plant. However, the reduced treatment cost and elimination of pumping, together with the advantage to the users of having soft, iron-free water made the project highly desirable and feasible.

The Little Rock area experienced rapid growth in the two decades 1936-1956 during which the population served grew from 102,000 to 209,000 and the average day pumpage from 6.7 to 18.6 mgd. By the early 1950's, it became apparent that a continuation of the growth trend would see the demand approaching the safe yield of Lake Winona sooner than had been visualized 20 years earlier. Further investigation and evaluation of potential sources led to the development of Lake Maumelle beginning in 1956. The quality of water is comparable to that of Lake Winona. Although Lake Maumelle is considerably shallower, it impounds five times the capacity of Lake Winona (68 bg to 14 bg). Lake Maumelle is only 15 miles from the treatment plant, however, its elevation is such that the water must be lifted 350 feet. Naturally, under these circumstances, Lake Winona water is being utilized insofar as possible.

By 1960, it was time to consider development of additional treatment capacity. A good share of the City's growth has been to the west in the direction of Lake Maumelle. The growth area, being at higher elevation than the downtown area, required a rapidly increasing demand for water at boosted pressure. Economic study of a new plant location resulted in its being constructed along the Maumelle transmission line. The new plant will serve the areas requiring boosted pressure. This will, in effect, serve to increase the existing plant's ability to serve the direct system since it will be relieved of service to most of the higher ground. Study also revealed that it would be economically advantageous to create an intermediate booster district to be served by the new plant. Therefore, water will be delivered at two pressures from the new plant . The economic comparison recognized the cost of operating two plants 10 miles or so apart. However, the need for additional miles of transmission main required in conjunction with expansion of capacity at the original plant site and increased capacity of booster system feeders from the old plant were eliminated.

Some economic considerations in connection with development of the new plant might be of interest. Water which has been used to backwash filters is collected in a holding basin and returned by low head pumps to the plant influent at a regulated rate. This makeup replaces water which otherwise would require 350 feet of pumping head, eliminates discharge of filter wash water through a high class residential area, and aids settling by adding some turbidity to the raw water. The filters are open sand beds rated at 3 gpm per square foot. However, the plant piping is designed to handle 7.5 gpm per square foot so that the filter capacity may be increased considerably by the substitution of high-rate filter media for sand. This appears desirable in light of the trend to use of high-rate media, and original installation of such piping capacity is much less costly than future modification. In general, the development of the Little Rock system has been in line with a master plan. However, it is usually not possible to accurately forecast the rate of growth or location of water demands in the distant future. Therefore a master plan must be flexible and choices based on economic considerations are constantly encountered.

Generally, economic considerations are affected to some degree by factors external to the water system. This was found to be the case at Ottumwa, Iowa where a study in the early 1950's revealed that the water treatment plant fell short of meeting modern standards to such an extent that the City's supply did not have State approval. The plant had been flooded in 1947 and for a period of 25 days the City was without filtered water. As a result of the study, a new treatment plant was recommended at a new site somewhat upstream from the existing plant. The new site would permit construction of the complete new facility without interference with production of water. Actually, the cost comparison between the cost of overbuilding in stage construction and the cost of extending feeding mains to connect to the proposed site was very nearly a toss-up. In view of the fact that the Water Works owned sufficient property at the old site to accomodate the new plant, and since the old site was more convenient to the hydro-electric plant also owned and operated by the Water Works, the decision was made to proceed with the construction of a new plant in stages at the old site.

In the meantime, the City Council authorized a study for a program of local flood protection. Ottumwa had suffered extensively from the 1947 flood. Although construction of Red Rock Dam on the Des Moines River by the Corps of Engineers had been authorized, there remained some 950 square miles of drainage area below the dam and upstream from Ottumwa for which the dam would have no control of runoff. The study was based on protection against a river discharge of 135,000 cfs and included channel straightening and cleaning and the construction of some seven miles of levees and floodwalls.

The proposed channel straightening was in the locality of the water plant where the Des Moines River channel makes a large oxbow bend. In the early 1930's, the Water Works constructed a hydro-electric plant of 4200 horsepower capacity at the lower end of the oxbow. The hydro plant was served by a 200-foot wide headrace connecting the two ends of the oxbow. The hydro pool was created by a fixed diversion dam at the upper end and four Tainter gates each 25-feet wide at the hydro plant. The river improvement plan proposed damming off the oxbow to create a lake and widening the headrace to a width of 700 feet to accommodate the design flood flow of the river. The straightened channel would reclaim several hundred acres of land laying within the oxbow which had been consigned to flood plain. Protection of this land would permit its use for a portion of the limited access highway being proposed within the City.

With this development, the matter of source of the municipal water supply was up for re-examination. It had been determined earlier that the Des Moines River was to be the source, with water to be withdrawn from the headrace. Now there were three possible means of obtaining Des Moines River water to be considered. A run-of-the-river intake with a low head fixed dam, collector wells in the former flood plain, or construction of a new movable dam capable of passing the design flood flow. At an estimated cost of 1-3/4 million dollars, the movable dam could not be justified from the standpoint of impounding water supply. However, opening the channel would mean abandonment of the hydro-electric plant which had been a profitable operation. The economic study revealed that when hydro-power production was considered on the basis of operating records with allowance for the guaranteed minimum release from Red Rock Dam and the benefit of the larger storage pool, the construction of the movable dam was feasible. The dam as constructed is equipped with 8 Tainter gates each 60 feet long and one bascule gate 75 feet long. The City has benefited from the impoundment as recreational area and the Water Works has the advantage of a practically unlimited water supply. The water treatment plant has been completed at the site of the previous plant with an intake located on the straightened channel immediately adjacent to the plant.

In this case, the final determination of the municipal water source depended upon an economic study of a plan of City-wide benefits including flood protection, power production, highway development, land reclamation, recreation, and city beautification in addition to water supply. The citizens of Ottumwa are proud of the fact that their City now has a State-approved water supply and are pleased that the City kept dry last April when the river reached its second highest crest in recent years. It is unfortunate that we do not more often have the opportunity to mesh the final planning and economics of water supply with other major municipal projects as was the cas at Ottumwa.

Recently I visited a small midwestern city having a population of 7500 and the amazing average annual water demand of nearly 600 gallons per day per capita. The city has several industries with high water demands. The city is supplied by nine wells ranging in capacity from 350 gpm to 1800 gpm. The city is remote from any sizeable water source and the surrounding terrain does not make impoundment practicable, therefore an alternate source is not feasible. Although the well supply is abundant, it is not of good quality. Hardness averages about 350 ppm. Iron is present in all wells and hydrogen sulfide is present to an objectionable degree in at least two wells. The wells are scattered over the city at one-half to one mile spacing. No treatment is provided by the city, each well delivering directly into the distribution system. One industry treats its usage of approximately one mgd by Zeolite softening and filtration. Because there are no costs involved for treatment or repumping, the water rates are extremely low, the city's average revenue being 18¢ per 1,000 gallons. Average revenue from domestic sales is 60¢ per 1,000 gallons.

The city is considering treatment for softening, iron removal and hydrogen sulfide removal. From the economic standpoint, such a study poses some very interesting questions:

1. How can the required treatment be most economically provided? A central treatment plant would require transmission mains from wells to plant and, probably, extensive system reinforcement to distribute the treated water to the users. On the other hand, treatment at each well would require higher capital investment for equipment and higher operating costs.

2. What affect will the higher rates attendant to treatment have on revenue? The industry that presently softens and filters its supply would undoubtedly be happy to dispense with these operations and continue to use the same quantity if the city's rates make it economically feasible for them to do so. But, how about the industry that currently buys two million gallons per day and provides no treatment? Can it be expected to continue to purchase the same quantity at the higher rate? Or, will it curtail its purchase by reducing water consumption or by reuse? Or, might the industry develop its own supply?

After the most feasible means of treatment and the costs therefor are determined, a rate schedule must be determined which will cover cost of production, distribution, and amortization of capital outlay. However, the rate schedule must be based on anticipated revenue which can be greatly affected by the actions of a very few industrial users. No great change would normally be expected in the domestic usage of 65 gpd per capita. The domestic user could afford to pay considerably more for soft, iron-free water, particular since many of them own or rent home softeners.

Although this instance is not one dealing directly with alternate water sources, it is a good example of the application of economic determinations, first of the feasibility of an undertaking, and, second, the most economical means of performance.

In the case of Water District No. 1 of Johnson County, Kansas, as in many growing communities, increased demand brought about the development of a new source of supply. The District serves some 15 cities in northeast Johnson County. Growth of the area has been rapid and is expected to continue at the rate of 1,800 new customers per year. A study made in 1961 reccommended increasing production facilities from 15 mgd to 36 mgd. The treatment plant is located near the Kansas River a few miles upstream from its confluence with the Missouri River. Water was obtained from 21 wells located on the flood plain of the river. During peak demands, plant production was augmented by the purchase of treated water from Kansas City, Kansas and Kansas City, Missouri.

For the development of 21 mgd additional supply, more wells were considered as was the construction of river intake. Analysis of the well field sites, based on test wells, revealed that 35 additional wells would be required and that they would be located on the far side of the river. Water from both potential sources is hard and would require softening. While the well water is of more uniform quality and free from turbidity, it is harder and would require more chemicals for hardness reduction. The construction of 35 wells with land rights, connecting piping and river crossings represents a large investment. The maintenance and operation of 56 wells is also a considerable factor. Also to be considered was the fact that the well field could be developed in increments and the capital investment therefor spread over a number of years.

A suitable site for a river intake was located about two miles upstream from the plant. The supply was found to be adequate. Existing and proposed impoundments on tributaries to the Kansas River serve to improve low flow conditions. Because of seasonal high turbidities of the river, presedimentation facilities were considered as part of the river supply scheme. In making the comparison, the intake structure was sized for handling 100 mgd and equipped for 50 mgd. Two presedimentation basins were planned for immediate construction with land made available and yard piping arranged for the future addition of two basins. Because sludge disposal is difficult from the plant site, an economic study revealed the advantage of locating the presedimentation basins at the intake site. Heavy sediment would be removed and returned to the river and the pre-settled water piped to the treatment plant by gravity flow.

When the two sources were compared on the basis of first cost of source facilities and transmission mains and the costs of labor, power, and chemicals, the river supply was found to be the more feasible. And, as we look further down the road beyond the development of 36 mgd, the river supply looks even better. The river intake and pre-sedimentation basins have been recently completed. The existing 21 wells will be maintained as an emergency supply. Well water will be available for blending with river water when desirable for quality or temperature adjustment.

It can readily be seen that the economics of this particular study are greatly affected by:

1. Rate of growth in demand.
2. How far in the future are we justified in planning for?
3. What is the projected growth pattern, and is another source available in the direction of anticipated growth which might be feasible eventually?

The City of Omaha, Nebraska has in the past obtained its water supply from the Missouri River. A master plan study conducted in 1955-56 recommended the development of further supply of 60 mgd from wells along the Platte River south of the city. The existing Missouri River facilities are at the north end of the city. A second source at the opposite end of the city serves to increase the overall reliability of the system. New facilities in the area of anticipated industrial growth would relieve the present distribution system of transporting large industrial demands. Although a river supply at the south end of the city would serve the same purpose, such a source was not recommended because it would be immediately downstream from the city where a high degree of contamination can be expected. Such a consideration is usually encountered in river cities and requires that the surface supply be obtained upstream from the city. Omaha is now proceeding with development of a supply from the Platte River source.

The foregoing examples serve to point out that the application of sound economics is an integral component of good engineering. With modern technology, materials, and construction methods, we can design and build almost anything; and, certainly, economics play an important part in these operations. However, good design and efficient construction can seldom make the most feasible project out of a plan that is ill-conceived or inadequately considered. The development of a dependable and economical water source rests on thorough consideration of many factors during the investigation and planning stages.

<u>Some Economic Considerations in Recreation Planning for Reservoirs</u>

Speech delivered before the Fourth Water Resources Design Conference, Iowa State University, Ames, Iowa, on January 19, 1966, by Evan A. Haynes, Assistant Regional Director, Lake Central Region, Bureau of Outdoor Recreation, Ann Arbor, Michigan

It is a privilege to represent our Bureau before you today. As you might know, we are a very young organization and have arrived on the scene at a most interesting period in American life.

During the past decade or two, outdoor recreation has assumed tremendous proportions in the social and economic life of our country. It constitutes today a major use of our land and water resources and is on an equal basis with other demands upon these resources. In many instances, it has become a predominant or priority use of such resources.

Largely as a consequence of this new dimension in outdoor recreation, Congress in 1958 created an Outdoor Recreation Resources Review Commission. The commission was directed to estimate the needs for outdoor recreation for our citizens in the future, determine the resources available to meet those needs, and to recommend the policies and programs to achieve these objectives.

After three years of study, the commission transmitted its report to the President and the Congress. This was almost exactly four years ago. This report entitled Outdoor Recreation for America contains some 50 specific recommendations. Foremost among these recommendations, to myself and my fellow workers at least, was the recommendation to establish the Bureau of Outdoor Recreation.

Some of the major responsibilities outlined in the organic act which established our Bureau are:

1. Prepare a comprehensive nationwide outdoor recreation plan.

2. Prepare a system for classification of outdoor recreation resources.

3. Engage in research relating to outdoor recreation.

4. Provide technical assistance to Federal departments and agencies.

5. Coordinate Federal plans and activities generally relating to outdoor recreation.

6. Provide technical assistance to the states, political subdivisions, and private interests with respect to outdoor recreation.

7. Administer a program of financial assistance to the states for planning, acquisition, and development of outdoor recreation resources.

8. Serve as staff assisting the President's Recreation Advisory Council. A word of explanation is necessary to explain this Recreation

Advisory Council. It consists of representatives, ordinarily at Cabinet level, of the Departments of Defense, Commerce, Agriculture, Interior, Housing and Urban Development, and Health, Education, and Welfare. The council considers problems of Government-wide importance and is established to provide broad policy advice to the heads of Federal agencies on all important matters effecting outdoor recreation resources and to facilitate coordinated efforts among the various Federal agencies.

This Bureau cooperates with the Federal water construction agencies in recreation planning at water and related land resource development projects. In short, it makes recommendations for recreation development and use in both river basin studies and individual project studies. Federal water development reports are submitted to us for review and comment by the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service. Non-Federal public and private reservoir developments and development proposals subject to Federal license are likewise submitted by the Federal Power Commission to us for appraisal.

The Bureau's participation in both comprehensive river basin planning and individual project planning is consistent with its general responsibilities to promote the coordination of Federal plans and activities generally relating to outdoor recreation and its specific responsibility to cooperate with and provide technical assistance to Federal departments and agencies.

The Bureau's investigations and reports relate to the total recreation aspects of water and related land programs and projects. Consideration is given to all outdoor recreation activities (including hunting and fishing) which are dependent upon public and private water and related land resources. The scope and detail of the Bureau's studies are keyed to the requirements of the agency for whom the study is being undertaken. In certain instances, the importance of preserving a segment of river in its natural state can supersede any plans for an impoundment, and we so state.

In comprehensive river basin planning, the Bureau formulates and evaluates the recreation component of such comprehensive river basin plans.

The Senate Select Committee on national water resources in its report of January 1961 established the goal that comprehensive plans for the use and development of water and related land resources be formulated by 1970 for all major river basins in the United States. The Department of Interior, through the Ad Hoc Water Resources Council, is a party to, and has adopted, a coordinated interdepartmental program to attain this goal.

Two general types of comprehensive studies are underway. Type I studies are general in nature and are referred to as framework studies. Examples of type I studies being undertaken in our office are the Upper Mississippi and the Ohio River region.

Type II studies are more detailed. Our regional office, which covers nine states, is responsible for the Grand River basin study in Michigan, the Wabash River basin study in Illinois and Indiana, and the Big Muddy River basin study in Illinois. Bureau studies are conducted with a view toward determining present and future outdoor recreation needs in the basin, the most feasible means of meeting the recreation needs, and the determination of that portion of the action which should be taken by Federal, non-Federal public, and private interests.

In undertaking individual project planning, the Bureau formulates and evaluates the recreation component of selected water and related land resources projects.

Many individual projects are frequently planned independently of the comprehensive river basin planning schedule. Most of these projects have recreation significance. Those who relate recreation to water resource projects often refer to a "bible," known more specifically as Senate Document 97 which was issued under the direction of the President's Water Resources Council in 1962. Entitled Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, it is a specific guide to all agencies involved in such work. Let me describe some of the guidelines it promulgates. The document states:

> National economic development and development of each region within the country is essential to the maintenance of national strength and the achievement of satisfactory levels of living.

> Water and related land resource development and management are essential to economic development and growth through the following concurrent provisions: (1) adequate supplies of surface and ground waters, (2) water quality facilities, (3) water navigation facilities, (4) hydroelectric power, (5) flood control or prevention measures, (6) land stabilization measures, (7) drainage measures, (8) watershed protection and management measures,

(9) outdoor recreation and fish and wildlife opportunities, and (10) any other means by which development of water and related land resources can contribute to economic growth and development.

The document goes on to discuss preservation and states that:

Proper stewardship, in the long term interest of the Nation's natural bounty, requires in particular instances that:

(1) There be protection and rehabilitation of resources to insure availability for their best use when needed,

(2) Open space, green space, and wild areas of rivers, lakes, beaches, mountains, and related land areas be maintained and used for recreational purposes, and

(3) Areas of unique natural beauty, historical, and scientific interest be preserved and managed primarily for the inspiration, enjoyment, and education of the people.

The document gives this strong emphasis by stating:

> The well-being of all the people shall be the overriding determinant in considering the best use of the water and related land resources.

Let us assume, now, that we are going to apply some of these considerations to an actual river basin. I have selected some examples in the Wabash basin in Indiana (somewhat to the east of Iowa) to illustrate some economic aspects of recreation planning. Please remember that this a so-called type II study and that a type I is less detailed. Also, these are not tested or refined methods and illustrate considerations more than established methods.

The basin is almost void of natural lakes, does not border on the Great Lakes, and only a relatively few streams have sufficient water year around to support more than minor amounts of recreation. Also, the basin is generally lacking in extensive woodlands. It naturally follows that substantial amounts of recreation can only be satisfied by impounding water and developing adjacent lands.

It appears that the greatest amount of demand in the Wabash basin is latent. It will probably remain latent until sufficient resources are provided for full expression.

Here are some basic assumptions made in this planning effort:

1. The reservoir (the water itself) is the basic attraction of the project for recreation.

2. Two reservoirs of approximately equal size should have the same drawing power in terms of distance from the site, otherwise called the market area or recreation market area (RMA).

3. The larger the reservoir, the larger the RMA. At present, we are using RMA's as follows:

Recreation Pool (acres)	Radius (miles)
Under 400	10
400 to 1,800	25
1,801 to 3,500	35
3,501 to 7,000	50
7,001 to 18,000	60
18,001 to 25,000	75
Over 25,000	Special consideration

4. Within reasonable limits, it appears that the more recreation areas that are available, and the nearer they are to a person's home, the more that person will participate in recreation. Thus, a person whose only opportunity to swim or boat is at a single point 50 to 75 miles distant is not likely to pursue these activities to any great extent. However, if that person has the opportunity to recreate at more places and also nearer home, he may be

expected to increase his participation accordingly. Although there must be a point of diminishing returns, this point is still far out of sight in most of the Wabash basin.

The following is the procedure we follow in determining the visitation at a reservoir:

1. Circumscribe a circle on a good highway map with (1) the center at the center of the reservoir and (2) the length of radius determined by the size of the reservoir.

2. Transpose this circle on the map in the <u>1960 Bureau of Census - Numbers of Inhabitants</u>.

3. Population within the circle is calculated to the nearest one-quarter township. Where the circle bisects a large metropolitan area, the population is determined to the nearest named suburban portion of the city for which the Bureau of Census has established a population calculation.

4. Basically, it is assumed that there will be recreation visitation at the initial period of 1.0 times the population within the circle. Let us assume that the initial period is 1975 when the reservoir is constructed and facilities are complete. The basic factor of

1.0 assumes an average condition. Since no reservoir is completely average, the basic factor of 1.0 is modified up or down according to the probable effects of several qualifying factors. In this regard, a great deal of personal judgment is involved.

Qualifying factors being used as a basis of judgment are:

1. Size of reservoir as compared to the range of reservoir sizes for a given radius. A 5,200 acre reservoir is the midrange size (between 3,501 to 7,000 acres) for a 50 mile radius. A qualifying factor of up to ±.25 is applied to reservoirs as their size may differ from the midrange size.

2. Locality of major population centers within the circle. Up to ±.25. This pertains to the location of, not existence of, large cities within the RMA. Thus, the nearer a large city is situated to the reservoir, the higher the probable visitation.

3. Large population centers within close proximity of the outside of the RMA. Up to ±.50. This makes allowance for the obvious effects of larger cities which are situated just outside the RMA.

4. Roads. Up to ±.15. Generally, the existing or probable early future road network is not considered to effect more than the initial visitation.

5. Relative urbanization of the population within the RMA and the forecasted future trend. Up to ±.10.

6. Site quality

    a. Shoreline ±.40

    b. Ponded area ±.40

The shoreline and ponded area are most important qualifying points. The shoreline and adjacent lands determine not only the attractiveness of the area but also the ability to serve recreation. A short shoreline, or one too steep or not sloping sufficiently, greatly affects the usefulness of the area. A reservoir with underwater topography too steep for beach development, too flat for beach development, or with extensive shallow flats likely to be overly turbid detracts from the area.

7. Fluctuation of reservoir pool during major recreation season. This is largely ignored in preliminary evaluation because of lack of information concerning operation. In detailed report, up to ± .25.

8. Pollution (domestic - industrial - farm). This is largely assumed to have little effect over the life of the project except where present pollution is considerable, and the likelihood of remedy in

the reasonably near future appears improbable. From past experience, it appears that, even when pollution is greatly reduced, the stigma of the past is hard to erase, and visitation may be expected to be effected.

All these qualifying factors are applied to the basic factor of 1.0. On the five reservoirs on which reports are now in preparation, the final factors will vary from about .35 to 1.55.

This factor is multiplied by the projected population for the year 1975 and is the initial visitation estimated mentioned above. We have assumed that if studies and authorization progressed steadily that the projects could be completed about 1970, and initial visitation figures are provided for the fifth year following completion, or 1975.

We assume that the population within the RMA of one reservoir will eventually be within the RMA of one or more additional reservoirs (some large and some small). Therefore, we cannot assume that the population within any one RMA will utilize their full per capita future recreation demand at one location. We have assumed our per capita demand would increase by about .5 at the ultimate period, i.e., where we use a factor of 1.0 times the 1975 population for initial visitation, we use 1.5 times the 2020 population for ultimate visitation. Where we have used an initial factor of .75, we have also used an ultimate factor of 1.25 (an increase of .5 per capita). This is something that could change as we progress, but I see no reasons for a change at present.

The projected ultimate visitation becomes the basis for determining the quantity of lands needed for recreation for the eight activities which we analyze. These activities are swimming, boating, water skiing, picnicking, camping, nature walks, hiking, and sightseeing. Where circumstances dictate (such as inability to secure the required quantity of lands near the reservoir), some of the land acreage needed for recreation may be made up from the flood control pool. In most cases, we will attempt to keep our outer boundary of recreation lands to within a mile of the reservoir.

Our general land-for-recreation policy is that (1) it should be sufficient to meet the needs for the eight activities for the projected ultimate period and (2) that it should be the best land. Best land may involve one or more of the following considerations: developability, scenery, topography, access, public control, and administration. Regardless of the other features of the area, public control and economic administration may prove to be the most important considerations, particularly since it appears that entrance charges and activity fees are becoming more necessary.

A supplement to Senate Document 97 issued in 1964 gives some monetary uuit values for tangible benefits for water and land resource projects. For a recreation day visit involving standard or conventional activities, a range of $0.50 to $1.50 per day is assigned per visitor. For specialized activities, a range of $2 to $6 per visitor is assigned.

This is another area of considerable personal judgment. The eight activities we analyze are considered general forms of recreation activity and, as such, fall into the $0.50 to $1.50 range per day evaluation, the average being about $1.

The estimate of visitation for the selected target years gives us recreation days. The value of a recreation day is determined as explained above, falling in a range of $0.50 to $1.50 per recreation day. Multiplying the number of recreation days by the value per recreation day results in an estimate of recreation monetary benefits for each target year

The following is a procedure to determine the design load for a proposed reservoir. The design load is the maximum number of people expected to use an area at any one time on a normal summer Sunday, for which facilities would have to be provided.

1. Design load for an activity is derived by multiplying the expected visitation figure by the design load factor for that activity.

Design load for an activity = Visitation estimate x Activity percentage rate (participation rate ÷ sum of all participation rates) x Number of activity days per recreation day (2.5) x Proportion of visitation expected in the summer (.65) ÷ Capacity days for an activity (42-water based) (53-others) x Turnover factor (from 1.5 to 10)

2. To determine acreage requirements using the design load calculations for the eight activities, we use this procedure:

a. The developed acreage required for an activity is calculated by multiplying design load for that activity by the respective activity acreage factor:

Acreage = design load x acreage factor

Acreage factors are derived in accord with generally accepted standards of land (or water) per user. Example:

Camping $\frac{\text{1 acre}}{\text{24 people}}$ = .041667 (activity acreage factor)

For the water based activities (swimming, boating, and water skiing), two acreage factors are used--one each for water and land.

b. Total the derived land acreage and multiply by 10. This allows for a 90 percent buffer factor for the whole recreation area.

c. Total the derived water acreage.

3. To determine facility development costs for a proposed reservoir, we use this procedure:

Eight activities are provided for in terms of facility development: swimming, boating, water skiing, picnicking, camping, sightseeing, nature walks, and hiking.

For each activity, two design loads have been calculated--for the 5th and 50th years after project completion. For the present reports, these years are defined as 1975 and 2020.

In general for a particular activity:

Cost	=	Design load per activity	x	Estimated cost of one unit of this facility	÷	Number of people to be served by this one facility unit during one day

Cost estimates are derived for the target years in this manner for each type of facility to be provided.

Recreation costs for facility development, replacement, operation and maintenance, and land are calculated on an annual equivalent basis in order to place benfits and costs on a similar annual basis for the selected target years 1975 and 2020. These two cost estimates are then used to derive an average annual cost for recreation over the 50 year study period.

Here, I have presented some of the mental gymnastics we go through in recreation planning. Thus, you see our basic considerations and the manner in which we compute visitation estimates, recreation benefits, design load, acreage requirements, and facility development costs. Our responsibilities are broad, but I felt it would be of value to you to review this portion of our work in detail.

I appreciate the opportunity to be with you today and to discuss some aspects of outdoor recreation.

4th Water Resources Design Conference
Iowa State University, Ames, Iowa
January 19, 1966

P. L. 566 WATERSHED DEVELOPMENT, WALTER'S CREEK WATERSHED PLAN FOR MULTIPLE-PURPOSE USES

by
Martin H. Meyer
Agricultural Economist, Upper Mississippi River
Basin Planning Party, U. S. Soil Conservation Service
Des Moines, Iowa

I. Introduction

The Watershed Protection and Flood Prevention Act, commonly referred to as Public Law 566, as amended, authorizes the Secretary of Agriculture to cooperate with local organizations in planning and carrying out works of improvement for flood prevention or for conservation, development, and disposal of water in watershed areas.

The Act provides authority to the Secretary of Agriculture to assist local organizations in carrying out a program for the development, use, and conservation of the Nation's soil and water resources. It provides for technical, financial, and credit assistance by the Department of Agriculture to local organizations representing the people living in small watersheds. It also provides a basis for coordinating such locally undertaken upstream watershed improvements with water-resource development projects on major rivers of the Nation.

The Act provides for a project-type approach to soil and water resource development, use, and conservation. Unlike older project-type Federal public works programs in this field, it requires that full initiative and maximum responsibility for any undertaking be exercised by local people through their local organizations. Firm commitments are required from local organizations for sharing the costs of installation, for assuming operation and maintenance responsibilities, and for meeting other requirements as a condition for Federal financial assistance in carrying out the improvements. Congress made it clear that the additional authority provided under the Act would be used to supplement both our present agricultural soil and water conservation programs and programs for development and flood protection of major river valleys. This program was designed to bridge the gap between these two types of programs and greatly enhances the ultimate benefits of both.

Congress further stated that Federal help under the Act would be available only to assist local organizations to plan and install needed water-management and flood prevention measures that could not feasibly be installed under other current Federal conservation programs.

II. Multiple-Purpose Objectives

All watershed projects should have multiple purpose objectives. They will provide for proper land use and treatment in the interest of soil and water conservation as well as other purposes such as: flood prevention, irrigation, drainage, recreation and fish and wildlife developments, municipal water supply, or other phases of water management.

The watershed project with which we will be primarily concerned today, Walter's Creek, includes four of the multiple purposes. They are: proper land use and treatment, flood prevention, recreational development, and municipal water supply.

III. P. L. 566 Projects in Iowa

As of December 31, 1965, four P. L. 566 projects have been completed in Iowa. These involved 13,165 acres. Construction has been authorized on 26 projects which involve 487,565 acres. Some of these projects are in the drawing-board stage and some are well on their way to completion. Authorization has been received from our Washington Office to plan seven additional projects which include 136,939 acres. And approval of applications for 25 more projects has been given by the State Soil Conservation Committee, the authorized representative [illegible] of [illegible] watershed projects. These [illegible] projects involve 240,700 acres.

The majority of our projects involve problems of gully erosion and are located in the west central and [illegible] part of the state. These loessial hills are subject to severe gully erosion problems because of the [illegible] erodibility of the soils. Perhaps a half-dozen [illegible] have additional problems of floodwater damage [illegible] pastures. Two watersheds have a problem of [illegible] water problems. [illegible] of these projects include multiple-purpose features of either flood prevention, recreational development, and municipal water supply.

We have made progress in Iowa in solving many of the problems which take place within the [illegible]. However, we have a long way to go before great effects will be realized from our program.

II. Economic Appraisals—Data, Framework, and Standards

Before we get into analyzing the Walter's Creek Watershed Project, I would like to dwell for a moment on some of economic appraisals. Being an economist, I would feel derelict in my duty if I did not expose you briefly to the economic principles of project [illegible] formulation.

The measurement of benefits and costs is an essential part of the process of formulating and evaluating project purposes that will be economically sound and give the best possible combination of eligible measures to meet project needs and objectives. In the formulation stage, it is necessary to consider existing and probable future economic conditions, the need for project development, the physical possibilities for project action, and the most practical means for realizing the desired objectives.

In a broad sense, the process of project formulation and evaluation, within the framework of legal and policy constraints, is largely a problem of weighing alternatives. The overall planning objective is to select the measures or combinationof measures that will meet the watershed needs and yield the greatest possible gain at the least cost.

Some of the important legal restraints are: (1) Limits on the size of watersheds(250,000 acres), (2) size of floodwater retarding structures (not more than 25,000 acre-feet total capacity), and (3) flood prevention storage capacity in individual structures (just recently increased from 5,000 acre-feet to 12,500 acre-feet). These and other legal restraints are contained in the Act, as amended.

One of the most important policy restraints that influences project formulation is that land treatment measures, such as terracing, contouring, waterways, and such, are the basic element of any watershed project and shall be considered the nucleus or initial increment for project formulation. All other measures shall be justified for inclusion in the project on the basis that the land treatment measures scheduled for completion in the watershed work plan have been installed.

Project formulation requirements are: (1) The least costly system of structural measures needed to achieve the project objectives will be developed to supplement the land treatment measures. (2) We must evaluate the benefits that will accrue to the system. (3) If the sponsoring local organization and the Soil Conservation Service agree that it is desirable, increments may be added to the basic system to the extent that they produce benefits in excess of their costs.

A ratio of benefits to costs of greater than one is regarded as an indication that the proposed work is economically desirable. Authorized purposes may be included in a watershed project only if they are economically justified. Careful economic analysis is needed to make sure that no purposes are included that lack economic justification.

Walter's Creek Watershed Project

After this introduction to P.L. 566, let us get to the task of reviewing the Walter's Creek Watershed project.

Walter's Creek watershed is located in Adams County about 2 miles north of Corning. It contains 31,580 acres or 49.3 square miles. The watershed is long and narrow being about 18 miles in length and 4 miles wide at its widest point. Walter's Creek is a right bank tributary of the East Nodaway River and flows in a southwesterly direction.

The land use in the watershed is cropland 65 percent, pasture 27 percent, woodland and wildlife 4 percent, and other use such as roads, farmsteads, and idle land, 4 percent.

The major problems in the watershed are gully erosion and floodwater damage to agricultural lands and crops. Highly productive or potentially productive land is subject to flooding. A 50-year frequency flood is estimated to inundate 957 acres. The bottomlands are not farmed as intensively as would be possible with reduced flooding. Many farmers cannot plant their crops in a timely manner because of wetness. They are reluctant to apply the optimum amount of fertilizer and will not risk planting the more profitable [illegible]

[illegible]

[illegible] land [illegible]

and [illegible] land depreciation [illegible] the productive capacity of other areas in a farm unit, especially those areas adjacent to the gully areas. The gullies range in width from 15 to 150 feet and in depth from 4 to 10 feet.

The city council of Corning, Iowa, which has a population of 2,041, and local civic groups and organizations indicated great interest in obtaining a reliable source of water supply for municipal uses. In recent years, Corning has experienced critical water shortages during severe drought periods. City officials consider the present water supply inadequate for the expansion of existing industries, for the development of new businesses and industries, and to provide sufficient water for future predicted normal increases in domestic uses.

The local sponsoring organizations, several civic groups, and local residents were concerned with the lack of adequate water-based recreational opportunities in the immediate area. Four parks with limited water-based recreational opportunities lie within a 50-mile radius of the area. One is a county-operated park and

[illegible]

[illegible] 100 acres in size, and local people were very interested in water skiing and speed boating opportunities.

As a result of the interest in municipal water and recreation, these purposes were included in the design of structure M-1-A in addition to the flood prevention purpose.

Just a word about the project and how many structures are included. Project formulation indicated a need and justification for 37 grade stabilization structures. These are drop inlet type structures, drop spillways, concrete chutes, and inlets to existing road culverts. The multiple-purpose structure for municipal water, recreation, and flood prevention, as mentioned before, was also included. In addition, two single-purpose floodwater retarding structures were included. There are additional areas in the watershed where gully erosion damage to land is a problem. However, these areas did not lend themselves to economic justification because of poor quality soils and non-cropland uses. In other words, the benefit-cost ratio was not favorable.

[illegible] (justification), and cost sharing of the purposes included in multiple-purpose structure [illegible]. As was mentioned before, this structure includes three purposes: flood prevention, recreation, and municipal water.

There are two separate steps involved in analyzing the financial sharing of a multiple-purpose structure. One is allocation of costs to purpose served and the second is cost sharing the costs of a multiple-purpose improvement.

It is important that one recognizes and remembers the distinction between cost allocation and cost sharing. Cost allocation pertains to works of improvement serving more than one purpose. It is the process whereby the cost of the structure is divided equitably among the purposes served. Cost sharing is the division of the cost allocated to each purpose to the financing agencies or groups involved.

To allocate the costs of structure M-1-A, the Use of Facilities Method was used. This method, in its simplest terms, allocates costs based on the required storage assigned to each purpose.

It was determined that [illegible] acre feet, or [illegible] percent of the total storage was provided for flood prevention, [illegible] acre feet, or about [illegible] percent was provided for public recreation; and 560 acre feet, or 7 percent was provided for municipal water.

After costs have been allocated to purposes, it is then necessary to determine the costs to be borne by either P. L. 566 or local funds. Cost-sharing criteria is set by policy and varies by purpose.

P. L. 566 cost sharing may not exceed 50 percent of the construction costs plus the full cost of engineering and other services for the water resource improvement allocated to the recreation purpose. The P. L. 566 cost sharing for the construction costs of minimum basic facilities for recreation will not exceed 50 percent.

The local organization will be expected to provide engineering and architectural services without Federal cost sharing from its regularly employed staff. If the local organization does not have a regularly employed staff and private consulting engineering and architectural services are required, the P. L. 566 cost sharing will not exceed 50 percent of the payments made for such services.

Minimum basic facilities may include:

1. Roads and trails
2. Parking lots
3. Public water supply
4. Sanitary facilities including toilets and garbage disposal
5. Power facilities

(continued next page)

6. [illegible]

7. Boat docks and ramps

8. Permanent-type picnic tables and fireplaces, and

9. Other similar or related permanent-type facilities needed for public health and safety, access to, and use of the recreational development.

Cost sharing not to exceed 50 percent will be provided only for the cost of land rights acquired by the sponsoring local organizations for public recreational purposes and for associated floodwater detention. When capacity for other purposes, such as municipal water, is included in a multiple-purpose reservoir, local interests must bear the entire cost of the land required for that purpose.

No cost sharing will be provided for the engineering, legal, or administrative costs incurred by the local organizations for acquiring the land rights.

All costs of including the municipal water supply purpose in the structure must be borne by the local sponsoring organization. These include the cost of the structure allocated to water supply, the portion of the land required to store the water, the engineering and related services required for the water purpose, and their proportionate share of administering the contract.

Some of the more pertinent details of the [illegible] are as follows: A [illegible]-inch drawdown pipe and [illegible]

[illegible] will be raised to [illegible] unit. The gate will be manually operated to draw down the water level for the purpose of controlling undesirable aquatic growth and rough fish. The detention pool, dam, and spillway will occupy 1,000 acres of land. The surface area of the water available for recreational use is 700 acres. Land provided for basic recreation facilities at the locations adjacent to the water and including areas for picnicking, camping, boat launching, parking, and other facilities is 610 acres.

The total storage capacity for all purposes is 14,300 acre feet. The volume of fill is 225,000 cubic yards with a maximum height of dam of 55 feet. The total drainage area above the structure is 23 square miles or about 18,000 acres.

It was estimated by the Bureau of Outdoor Recreation that the annual visitor-day attendance to the recreation development will be 90,000. This estimate was based on a population base of 74,947 persons residing in six counties in the primary zone of influence and [illegible] in two counties in the secondary zone.

With the total project installed, evaluated floodwater damage to crops and pasture will be reduced 24 percent. Floods of less than a 5-year frequency will be [illegible]

Gully erosion damage reduction benefits will accrue to 108 of the 215 farms in the watershed. Adams County will also realize damage reduction benefits to roads and bridges.

The City of Corning will be assured of an adequate and dependable municipal water supply for present and future needs.

Recreation enthusiasts will be able to pursue water-based recreational activities. Fishing, swimming, boating, water skiing, camping, picnicking, and hunting will be available to the estimated 90,000 annual visitors.

Farmers will be able to apply better management to the very productive bottomland soils because of reduced flood hazards. More intensive use of this land will permit less intensive use of the highly erosive upland soils.

VI. National Impact of P.L.566

Just a closing word about the national impact of P.L. 566 as of January 1 of this year. Of the 2,408 applications approved by state governments and forwarded to the Soil Conservation Service for assistance, 1,172 have been authorized for planning assistance. Also as of January 1, 712 projects have been approved for operations. Of these 286 include multiple purposes as project objectives.

[illegible] wildlife purposes in 20, and recreation in [illegible] trend toward multiple-purpose projects is [illegible]

Of the 712 projects that have been approved for operations, both structural measures and planned land treatment measures have been completed on 85 and structural measures on another 49.

Thank you for permitting me to tell you about Public Law 566.

BEAVER WATERSHED PROTECTION AND AGRICULTURAL WATER MANAGEMENT PROJECT
WEBSTER COUNTY, IOWA

DRAINAGE DISTRICT NO. 47A

by

Glen H. Miller, Consulting Engineer
Ft. Dodge, Iowa

Description of Work

Installation of new and relief tile mains in the Beaver Watershed (Webster County Drainage District No. 47A).

Project is planned for construction under authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666) as amended. This is the first tile line construction project in the State of Iowa to be built under authority of Public Law 566. Other construction in Iowa, under this law, has been types different from relief tile lines.

Engineering work for construction of the project has been given to a local consulting engineering firm. In the future, there probably will be many similar projects throughout the State where private firms will be selected to do the engineering work on construction.

Agencies

Watershed Work Plan was prepared by the Webster County Soil Conservation District and Webster County Board of Supervisors (Sponsoring Local Organization) with technical assistance by the Soil Conservation Service, United States Department of Agriculture.

Project Agreements, etc.

1. Application for Planning Assistance.
2. Board of Supervisors to acquire any necessary land for the project.
3. Board of Supervisors to acquire such water rights as may be required under State law.
4. Agreement for Construction of Structural Measures by Contract.
5. Appointment of Contracting Officer (Local drainage attorney).
6. Operation and Maintenance Agreement.
7. Agreement for Engineering Services Performed by the Contracting Local Organization. (Engineer to submit statement of standard charges and estimate of engineering costs.).

Basis of Cost Sharing for Drainage Improvement Construction Cost

Costs allocated to drainage will be paid 38.6% by P. L. 566 funds and 61.4% by local organization (Drainage District No. 47A).

Costs of all necessary land, easements, right of way and administration will be provided by local funds.

Engineering cost on construction will be paid 100% from P.L. 566 funds.

Certain other extra costs, such as repair of existing tile branches cut by new tile, will be paid from P. L. 566 funds.

Cost of assessing lands for benefits will be paid by the drainage district.

Works of Improvement - Structural Measures

Drainage consists of 6.95 (7.72) miles of public outlet tile drains. Most of these tile will add needed capacity to existing tile system. Plan calls for construction of a tile system consisting of :

36" Extra Quality Drain Tile	8,9[illegible]'
34" " " " "	1,3[illegible]'
32" " " " "	1,100'
26" " " " "	752'
24" " " " "	[illegible],900'
22" " " " "	[illegible],800'
20" " " " "	[illegible],550'
18" " " " "	3,3[illegible]'
16" " " " "	5,6[illegible]'
14" " " " "	[illegible],722'
12" " " " "	1,52[illegible]'
10" " " " "	600'
8" " " " "	2,314'
6" " " " "	60'
34" 1500-D Drain Tile	300'
32" " " " "	900'
26" " " " "	1,400'
24" " " " "	60'
22" " " " "	[illegible]
36" Reinforced Concrete Culvert Pipe, Class III	100'
30" " " " " "	40'
24" " " " " "	[illegible]
15" " " " " "	[illegible]
12" " " " " "	[illegible]
	[illegible]

[illegible]

[illegible] the work quantities listed above with existing Drainage District [illegible] these quantities shown as follows:

28" Drain Tile	[illegible]
26" " "	[illegible]
24" " "	[illegible]
22" " "	[illegible]
18" " "	[illegible]
15" " "	[illegible]
14" " "	[illegible]
12" " "	[illegible]
10" " "	[illegible]
8" " "	[illegible]
7" " "	[illegible]
6" " "	[illegible]
	[illegible]

Plan

Attached plat of Drainage District No. 47A, Webster County, Iowa [illegible] shows the location pattern of existing tile lines and new relief lines.

Design (Information from SCS Work Plan Report)

Topography is a series of depressed areas which require one-half inch [illegible] drainage coefficient. Upstream portions were designed on a one-half inch [illegible] up until the contributing drainage area was about 500 acres. As the drainage [illegible] increased from 500 to 1200 acres, the drainage coefficient was decreased [illegible] from one-half to three-eighths inch. A drainage coefficient of three-eighths [illegible] used to design all the tile drain mains with a contributing drainage area over [illegible] acres. These design criteria were established in consideration of the [illegible] of the lateral tile versus the main and the timing of peak flow events. The design of structural improvements was based on applicable Soil Conservation Service criteria and design procedures. These include Service Washington and State Engineering Handbooks as well as the Iowa Drainage Guide and other engineering material.

Economic Investigation

Information from farm plans and local Service technicians was used to [illegible] cropping patterns and rotations used both with and without the project.

[illegible] yield studies were made using Special Report No. [illegible], "Estimated [illegible] on Iowa Soils", April 1960, developed jointly by Iowa State University and [illegible] Conservation Service, yield records of farms in the watershed and local [illegible] [illegible]. These crop yields [illegible] the basis for [illegible] [illegible] with and without adequate tile [illegible]. The crop yields [illegible] [illegible] as follows:

[illegible]

[illegible]

Crop	Without Project	With Project
Corn	55 bu.	80 bu.
Soybeans	20 bu.	30 bu.
Oats	30 bu.	50 bu.
Hay	1.8 T.	3.0 T.
Pasture	85 cpd	120 cpd

The net per acre income was then determined. The percent distribution of the various categories by soils were determined and weighted economic returns were computed to a composite acre net return with and without the project. The weighted net income per acre with adequate tile drains was found to be [illegible] and without adequate tile drains $27.40, giving a net benefit of $24.40 per composite acre.

Associated costs of the farm tile drains were deducted from the gross per acre benefits. These costs, amortized at 3 percent for a 50-year period, were [illegible] per acre. The net annual benefits are $20.51 per acre before discounting.

About 2,000 acres of existing cropland will benefit from project measures. Of these 1,000 acres are presently tiled but will realize immediate relief through increased outlet capacity. The remaining 1,000 acres will benefit from installation of new farm tile lines which cannot be installed without project improvements.

All benefits that will accrue from tile drains installed during the 15 years following the 10-year project installation period were discounted using the straight line method as shown in the SCS Economics Guide, Appendix A. The net annual value after discounting, is $19.40 per acre.

Local secondary benefits that will accrue within the immediate zone of influence of the project were considered in computing the benefits accruing to the project. These were estimated to be about 13 percent of the direct primary benefits. Secondary benefits benefits from a national viewpoint were not considered to be pertinent to the economic evaluation.

Costs incurred for installation of land treatment farm tile drains were considered associated costs. Associated costs are those costs incurred which are not associated directly with the installation of the structural measures, but are necessary to realize the benefits claimed for the structural measures.

The costs of the land, easements, and rights of way were computed for the area disturbed by tile installation. It was estimated that two acres of cropland per mile of tile would be disturbed during the year that these lines were installed [illegible]. The value of the crops lost was based on present land use and [illegible].

[illegible]

[illegible]

Primary benefits together with secondary benefits were used in computing benefit-cost ratios of structural measures.

Cost

Estimated cost from SCS Work Plan Report:

Land Treatment Measures	$ 49,290.00
Structural Improvements	140,760.00
Total	$190,0[illegible]

Works of Drainage Structural Improvements:

Estimated cost of labor and materials	($106,497.5[illegible]
Cost of Labor and materials per letting Sept. 8, 1965	105,237.[illegible]

Engineering

Estimated cost	$ 17,000.00

Extra Work

Estimated cost	$ 5,000.00
Total present contract work	$132,23[illegible]

Cost to Drainage District No. 47A	$ 67,068.[illegible]
Cost from P. L. 566 Funds	65,165.[illegible]
	$132,23[illegible]

Recapitulation of Income Per Acre From Economic Investigation Above

Net income per acre with adequate tile drains	$	[illegible]
Net income per acre without adequate tile drains		[illegible]
Benefit	$	[illegible]
Less associated costs		[illegible]
Net annual benefits per acre before discounting	$	[illegible]
Net annual benefits per acre after discounting	$	[illegible]

Assessment of Cost

Original assessment for existing District tile system	$ [illegible]
Average cost per acre .... $ [illegible]	
[illegible]	[illegible]
Average cost per acre .... [illegible]	

[illegible]

Assessment for current project (estimate)................ $ 70,000.00
Average cost per acre.........$ 24.83

Assessment Plat

Attached, for your information, is plat of the District under discussion showing amount of original assessment for each tract of forty acres or less and also amount of assessment of each tract for cost of the current work. Beaver Watershed work assessment is figured upon the same basis as the original assessment.

How much drainage assessment can a 40-acre tract of land stand? The amounts of assessments shown for lands of the Beaver Watershed are good examples of drainage costs which are apparently acceptable to the owners.

End

This completes one story of the Beaver Watershed.

Review of the Urban Flood Control Project
at Dubuque, Iowa

by

Raymond Stearns
Engineering Economist
Planning and Reports Branch
U.S. Army Engineer District, Rock Island

Reference Document for Dubuque local flood protection works:
House Document No. 450, 87th Congress, 2nd Session.
Mississippi River, Urban Areas from Hampton, Illinois to Cassville, Wisconsin. Interim Report, referred to Committee on Public Works, June 25, 1962.

THE ECONOMICS OF URBAN FLOOD PROTECTION

The economic analysis principles used in planning flood protection for urban areas must conform basically to those principles laid down by Congress in the Flood Control Act, Public Law No. 738, 74th Congress, adopted 22 June 1936. This legislation states "that the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected." This Congressional legislation recognized that flood control on the nation's rivers and streams is a proper activity of the Federal Government in cooperation with States, their political subdivisions, and localities thereof to provide protection for alleviating flood damages in urban and rural areas.

A community having a recurring flood problem has two avenues of approach in seeking Federal assistance in a flood control program. The large metropolitan area having a widespread recurring flood problem usually must work through their elected representatives in Congress. A resolution calling for the Corps of Engineers to make a study of a designated community or a river basin is introduced in the Public Works Committee of the House of Representatives or the Senate. The resolution if voted out by the Committee is considered by the Congress for adoption, or it may be contained in a River and Harbor Bill passed by Congress.

The smaller community, wherein the cost of providing a project is usually of a lesser magnitude because of its size, may receive consideration for a Federal study under Section 205 of the 1948 Flood Control Act. Although these respective legislative acts do not specify population or area as a criteria for consideration, the latter, Section 205 authority, known as the Small Flood Control Act, specifies that the maximum amount of the Federal expenditure may not be in excess of $1,000,000. A large city having only a limited flood problem may then be eligible also under this authority. Pursuant to the small flood control Act, officials of a community may direct a letter to the District Engineer, of a Corps of Engineer District in which they are located, requesting a study of this problem. It must be stated at this point that either of the above legislative procedures for flood control studies, available to the Corps of Engineers, are applicable to rural agricultural areas, as well as urban communities.

Upon receipt of authority and allocation of survey funds the District Engineer proceeds on a program of engineering and economic investigations. The extent of these studies is dependent upon the nature and the complexity of the problem. At the outset, a reconnaissance and a discussion with local interests is usually held by personnel of the District office. Under other conditions, as in the case of a river basin study wherein several communities or rural areas are to be considered, the District Engineer usually initiates the study by holding a public hearing at one or more localities in the basin. By these procedures the District office obtains preliminary information on the extent of the study effort required to arrive at a solution.

Flood control plans include the consideration of earthen levees, concrete flood walls, channel straightening or enlargement, channel diversion or a dam with a reservoir for temporary storage of flood run-off. Usually one of these methods is adopted as the final plan, or a combination of one or more of the features may be found to be the most economic plan.

The extenet to which local interests are required to participate in Corps of Engineers projects is determined at the time of project authorization. However, the 1936 Flood Control Act prescribes basic policies. These include:

(a) provide without cost to the United States, all lands, easements and rights-of-way necessary for construction of the project,

(b) hold and save the United States free from damages due to construction work, and

(c) maintain and operate the project after completion.

There may be other terms of local cooperation requirements imposed on a project, depending upon the nature of the individual study, such as the cost of relocation of utilities, enlargement of highway bridges, etc.

Experience of the Rock Island District has included studies for flood control projects for a small community involving a relatively small channel rectification project costing about $125,000, to the protection for a large metropolitan area wherein the over-all plan included a multi-million dollar program consisting of a combination of levees, flood walls, interior drainage and a large control reservoir.

The preceding discussion has been general in nature and intended to set forth basic policies under which the Corps of Engineers proceeds on studies of urban flood protection plans. In accord with the theme of this days conference, the remaining portion of this paper will treat the economic studies procedure of an urban flood protection project authorized by the Congress in the 1962 Flood Control act and presently under preconstruction planning stage in the Rock Island District office. The economic data presented is that contained in the survey report completed in 1960. These data for the study presently in progress have not as yet been finalized.

The project selected for this paper is located at Dubuque, Iowa, population 56,606, situated on the Mississippi River in the northeast section of the State. The problem area of this city is outlined on this aerial photo and also (Slide #1, Aerial Photo of portion of the city of Dubuque) reveals the extent of development of the flood plain area. This flood plain within the Dubuque city limits covers about 1,100 acres. The area has been developed for industrial, commercial and residential purposes. There are some 175 commercial and industrial properties, including a major meat packing plant, a sash and door works, two large machine tool works, one pump manufacturing concern, a large chemical fertilizer plant, several important grocery warehouses, a cold storage and locker service and several large bulk petroleium storage tank farms. In addition, there is located in the flood plain, the city water plant, a large steam electric generating plant and main line traffic arteries of three railroads and Federal and State routes carrying highway traffic. There are some 1,500 residential units located in the bottom land areas.

The first step in the economic study of an area is to collect flood damage data experienced during past flood events. During the course of past damage investigations of Mississippi River floods, Corps of Engineer personnel had made surveys in Dubuque - obtaining these data for the floods of September 1938, May 1944, April-May 1951, April-May 1952, and April 1954. The procedures followed in such surveys are to make contact with all interests known to have been affected by the respective floods and obtain an estimate of the damages caused to their properties. Items of damage include the monetary cost of repair or replacement of physical property such as buildings, furnishings, equipment, stocks, etc., cleanup, rehabilitation, loss of business, loss of wages, cost of emergency work, evacuation, overhead expenses, cost of rerouting traffic, repairs of streets and utilities, etc. The results of these damage survey investigations for the floods covered, revealed that actual flood damages experienced in Dubuque amounts to:

1938	$ 364,000
1944	258,200
1951	2,347,900
1952	2,472,400
1954	41,500

At the time of the investigation for the survey report, all properties that would be affected by a flood of recurrence frequency of 200 years was tabulated and data on type and occupancy of each building were recorded. From these data and based on interviews with management personnel of industrial and commercial properties, estimates of possible damage to the property were made in the event that a flood of such magnitude would occur.

The second step in the damage study is the plot of the total damage caused by the flood event with the coresponding stage or elevation of the water level. This relationship was prepared for the entire flood plain area and for smaller reaches of the flood plain for purposes of coordinating the engineering plan with the economic study.
(Slide #2 - Graphs - Economic Analysis)

The analysis of the damages, including the annual flood loss, constitutes the outstanding problem of the economics of flood control in which benefits must be weighed against costs, as set forth in the 1936 Flood Control Act. This is the objective of the economic analysis and on this comparison depends:

(1) whether or not any protective meausres are justified;
(2) to what extent protection may be given; and
(3) in part, what kind of works may be provided.

The methods used in evaluating the annual flood loss is the development of data which represents the economic risk of such damage. The intermittent and sometimes heavy cost of floods may be reduced to an annual basis in accordance with the mathematical expectancy as expressed by the formula $A = pD$, in which A is the annual flood loss, p the probable number of floods per annum, and D the damage caused by the flood. The number of floods per annum can be taken from the frequency curve which is computed from the record of flood discharges. (1) The procedure used in the computation of annual flood damage may be portrayed graphically as has been done in the case at Dubuque and shown on Slide No. 2. This is done by inter-relationship of the graphs, stage to damage, stage to discharge and discharge to frequency. Values of the abscissa are the number of expected floods per year, expressed in percent, and on the ordinate scale is the damage caused at the corresponding stage, obtained through the discharge relationship. The area under the curve then represents the total annual expected loss from uncontrolled floods. This annual damage for the entire flood plain area for the city of Dubuque was determined to be $345,800. For analysis purposes the flood plain area was divided into three reaches to obtain the feasibility of the extent of economic protection.

The next procedure of an economic study is the determination of the flood control benefits that will accrue to a proposed plan. These benefits may be defined as the flood damages that can be prevented. The determination of the amount of these benefits is accomplished in a manner similar to the method described for determination of annual flood damages.

In planning a flood project of an urban area that involves protection of people living in the flood plain, it is essential that an adequate degree of protection is considered, to preclude a false sense of security. A monetary value of a human life is difficult to evaluate in terms of project benefits. It is highly desirable in such cases to provide protection against a flood of infrequent occurrrence. However, on the other hand, there remains the basic policy of economic justification that must be met. Once it has been determined that a project is economically feasible, based on preliminary cost-benefit analyses, it then follows that the most economic project for the area, be developed. The scope of this development is determined through a project formulation analysis. The general objective of project formulation is to maximize net economic returns from the economic resources used in a project. This requires that a project should be so designed as to include each separable segment or increment of scale of development which will provide benefits at least equal to the cost of that segment or increment. Throughout the process of project formulation the physical effects of each plan or proposal must be measured and translated into benefits for comparison with costs of the plan. As a starting point for analysis purposes, it is usually necessary to analyze a specific initial proposal. After the initial proposal of development has been selected for analysis and its benefits and costs measured, consideration can be given to scales of development greater or less than the selected plan. This study procedure will develop the optimum scale of development at which point the net benefits are maximized. The net benefits are maximized if the scale of development is extended to the point where the benefits added by the last increment of scale are equal to the cost of adding that increment.

The plan of protection for Dubuque consisted of a system of levees and flood walls as shown on this slide.

(1) "Evaluation of Flood Losses and Benefits" by Edgar E. Foster, Transactions American Society of Civil Engineers, Volume 107, No. 2149, 1942.

Slide No. 3 - Plan of Protection for Dubuque

The project formulation study for this project developed an estimate of project costs and project benefits for levee structures to withstand three flood levels - the 50-, 100- and 200-year frequency. For purposes of benefit determination it can be said that levees will eliminate all flood damage caused by inundation up to the stage at which they are overtopped. Beyond that stage the loss is as great as if there were no protection. Therefore, the annual benefits will equal the annual losses below the design flood elevation of the levee or wall.

Slide No. 4 - Graph - Economic Analysis

Slide No. 4A - Graph - Benefit Analysis

Referring again to our graphs of annual flood damage determination, it is only necessary to enter our damage-frequency curve at the 50-, 100- and 200-year protection level and determine the annual damages to be prevented at these scales of project development. The results of this formulation study with consideration for anticipated future development in the flood plain are as follows:

Protection Level	B/C	Project Annual Benefits	Project Annual Charges
50-year	1.23	$182,100	$148,200
100-year	1.54	253,500	164,800
200-year	1.32	291,400	221,000

A plot of these data will show the trends of the scope development from which is determined the point at which project benefits are maximized. These data can be

Slide No. 5 - Table Project Formulation Studies

further developed to arrive at the final point of the formulation study to optimize the degree of protection as portrayed in the tabulation shown. The curve data, developed from this table

Slide No. 6 - Project Formulation

show the increment of benefits added for an increment of cost of enlarging t he project attains a 1:1 ratio at a point of flood occurrence somewhat less frequent than once in one hundred years. One additional plot can be made of theamount of excess of benefits overproject cost (net benefits) for the studied frequency points to establish this point, which is found to be equivalent to a flood of about 110 year frequency. However, in order that an added safety factor may be provided the protected area, wherein a large number of human occupants reside, a degree of protection of 200-year frequency was recommended for construction.

Finally, upon selection of the scope of project development a detailed estimate of cost of the project is set forth and forms the basis for authorized project costs allocated to the Federal Government and to local interests, as follows:

Estimates of costs - Dubuque

Feature	Amount Federal		Non-Federal
Lands and damages	$ -		$ 62,000
Relocations	124,000		79,300
Levees and flood walls	4,004,000		-
Pumping Plants (3)	257,000		-
Total land and constr. cost	$ 4,385,000		$141,300
Engineering and design	465,000		-
Supervision and administration	500,000		-
Engineering and Supervision	-		8,700
Total first cost	$5,350,000		$ 150,000
		$5,550,000	
Total annual charges	200,900		20,100
		$ 221,000	
Total annual benefits		291,400	
Ratio - Benefits to costs		1.3:1.0	

IOWA STATE LAWS, POLICIES AND PROGRAMS pertaining to Water and Related Land Resources

By

Clifford E. Peterson
Assistant Director
Iowa Natural Resources Council
Des Moines, Iowa

Notes from talk given at 4th Annual Water Resources Design Conference, Iowa State University, Ames, Iowa, on January 19, 1966.

* * * * * * * * * * * * * *

State laws, policies and programs pertaining to water and related land resources are contained in the state constitution and statutes (principally statutes relating to specific state departments, to counties, cities and towns, and to the formation and management of special purpose districts) and in the decisions of the Iowa Supreme Court interpreting and applying pertinent provisions of the constitution, statutes and common law.

State and local governmental programs in the field of water resources in Iowa are subject to the usual constitutional restrictions embodied in the concepts of due process of law,[1] equal protection and uniform application of the laws[2] and just compensation for the taking of private property

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1. Iowa Const. art. I, Sec. 9

2. Iowa Const. art. I, Sec. 6

for public use.[3] A 1905 amendment authorized the General Assembly to pass laws permitting the construction of drains and levees across the lands of others, to vest proper authorities with power to construct and maintain such drains and levees, to finance same by special assessment of specially benefited property, and to provide for condemnation of su lands as are necessary to the construction and maintenance thereof.

The constitutional sanction against special laws are sometimes ob viously, but apparently quite legally, circumvented. For example, con sider the so-called 'little old lady' bill enacted by the 60th Genera Assembly in 1963.[4] It seems the 'little old lady' owned a small tract of land in the center of a commercial lake development, planned and de veloped by private interests for private gain. The legislature passed the bill permitting condemnation of land for such purposes. Without de bating the public purpose of condemnation for such uses, consider the method by which application of the law was limited to the county in which the coveted land was located - - application of the law was limi to counties without a county conservation board and to counties over 70 miles from any border of the state.

STATUTES

Any listing of significant Iowa statutes would certainly include following:

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3. Iowa Const. art. I, Sec. 18

4. Iowa Acts, 60 G. A. ch. 106 (1963)

1. The long standing laws providing for protection of public water supplies and review of water supply plans by the Department of Health.[5]

2. The 1965 law creating the Iowa Water Pollution Control Commission.[6]

3. Fish and game laws, state parks and preserve laws, motorboat safety law administered by the State Conservation Commission.[7]

4. Laws providing for basic data collection, interpretation and reporting by the Iowa Geological Survey.[8]

5. The mill dam law.[9]

6. Laws creating the State Soil Conservation Committee and providing for State Soil Conservation Districts.[10]

7. The 1949 law creating the Iowa Natural Resources Council - 1957 amendments incorporating the Iowa Water Rights Law - 1965 amendments dealing with comprehensive planning and flood plain regulation.[11]

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5. Principally Iowa Code ch. 135 (1962)

6. Iowa Acts, 61 G. A. ch. 375 (1965)

7. Iowa Code ch. 106-109, 111, 111A, 112 (1962)

8. Iowa Code ch. 305 (1962)

9. Iowa Code ch. 469 (1962)

10. Iowa Code ch. 467A (1962)

11. Iowa Code ch. 455A (1962)
See also, Iowa Acts, 61 G. A. ch. 60, 372, 373, 374, 375 (1965)

8. The public utility regulation laws, insofar as they affect water service.[12]

9. The eminent domain laws insofar as they affect condemnation for water supplies, sewer systems, water power generation, flood control works and related water resources interests.[13]

10. The authorization for cities and towns to provide water and sewerage services and to finance these improvements by various means.[14]

11. The authorization for cities and towns to construct, maintain and operate flood control systems and to finance same[15] and to create water recreational areas.[16]

12. Laws authorizing formation of benefited water districts[17] and sanitary districts[18] within counties.

13. The levee and drainage district enabling law and other drainage laws.[19]

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12. Iowa Acts, 60 G. A. ch. 286 (1963)

13. See Iowa Code ch. 472 (1962) for procedure generally. For specific powers of condemnation, see the statute setting forth the specific powers of the governmental unit concerned or the statute referring specifically to the purpose for which condemnation is sought.

14. Iowa Code ch. 368 (1962) and amendments thereto,
Iowa Code ch. 391, 391A, 397, 398, 398A, 399, 420 (1962) and amendments thereto.

15. Iowa Code ch. 395 (1962)

16. Iowa Acts, 60 G. A. ch. 106 (1963)

17. Iowa Code ch. 357 (1962)

18. Iowa Code ch. 358 (1962)

19. Iowa Code ch. 455 (1962)
See also, Iowa Code ch. 456 - 467 (1962)

[illegible] in terms of [illegible] [illegible] purposes prescribe a [illegible] coordination [illegible] between agencies and governmental units.

These statutes thus comprise the main thrust of the will of the legislature, insofar as the legislative will is expressed, with regard to the water and related land resources of the state.

The executive branch of the government, in many instances supplementing these statutes through adoption of detailed rules and regulations, administers the statutes and supplemental rules.

When conflicts arise, the third branch of our system of government, the judiciary, resolves these conflicts through interpretation of the statutes and rules involved and the application of constitutional precepts to the case at hand.

Most of the statutes just discussed, including the water use and permit system, the floodway encroachment - flood plain regulation provisions and the water pollution control law, have never been tested in the Iowa courts on any basis, constitutionality of such regulation generally, adequacy of the particular statute, or the reasonableness and [illegible] of a particular administrative act or order. Although scholars [illegible] at length regarding the progressive trends in technical [illegible] thinking in such matters and arguments favoring the constitutionality and adequacy of such laws often can be buttressed with [illegible] facts reflecting the changing situation and needs, the final [illegible] only opinion that really matters is that of the court of last resort holding the particular law constitutional, adequately drawn and properly administered. This is not to say that these theories, opinions, facts, and authoritative writings are of no value. Judicial decisions are often influenced or based on the same considerations first enunciated by experts totally concerned with problems in the area in question. The construction placed upon a statute by the administering agency and the apparent successful administration of a statute of considerable public importance over a substantial period of time is also considered by the courts.[20] Once enacted by the legislature, a particular statute normally is presumed to be constitutional and is administered as enacted until overturned by the courts.

JUDICIAL DECISIONS

Recognizing then that many of the most recent and perhaps most important statutes pertaining to water and related land resources have not been tested in the courts, it might be well to consider expressions of the Supreme Court of Iowa with regard to such resources - rendered prior to enactment of the statutes

USE FROM STREAMS

Two systems of law prevail in the U. S. governing use of water from streams - the doctrine of riparian rights which prevails in the 31 Eastern

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20. John Hancock Mutual Life Ins. Co. v. Lookingbill, 218 Iowa 373 (1934)
State v. Standard Oil Co. of Indiana, 222 Iowa 1209 (1937)

States - the doctrine of prior appropriation which prevails in the 17 Western States.[21]

The doctrine of riparian rights centers on the general proposition that the owner of land adjacent to a stream is entitled, as an incident of ownership of such land, to have the stream flow through or past his land undiminished in quantity and unimpaired in quality. He may use as much of the water in the stream as is needed for household and other domestic purposes even to using the entire flow.[22] He may also use the water for other purposes provided that he does not by such use unreasonably affect the rights of an upper or lower riparian proprietor. Owners of non-riparian land and members of the public generally have no right to make consumptive use of the water.[23]

The doctrine of riparian rights has always prevailed in Iowa, attaching to any natural watercourse, a term which has been defined very broadly by the Iowa Supreme Court. Where water naturally and habitually follows a certain general path, within reasonable limits as to width, the line of flow is a natural watercourse.[24] It need not have a definite channel or banks, a swale may be a natural watercourse.[25] It need not be entirely natural but may be aided by the hand of man,[26] as by deepening or

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21. 56 Am. Jur., Waters, sec. 273-322

22. 56 Am. Jur., Waters, sec. 273-276

23. 56 Am. Jur., Waters, sec. 283

24. Hinkle v. Avery, 88 Iowa 47 (1893)

25. Hunt v. Smith, 238 Iowa 543 (1947)
Stouder v. Dashner, 242 Iowa 1340 (1951)

26. Falcon v. Boyer, 157 Iowa 575, (1913)

[illegible] of nature.[27] An artificial ditch, or a drainage ditch, may become a natural watercourse by lapse of time (10 years) as between private individuals on principles similar to the creation of an easement by prescription[28] but such rights may not be urged against the public.[29]

Generally, riparian rights accrue only to the smallest abutting tract held under one chain of title leading to the present owner.[30] Land outside the watershed of a stream or which is separated from the stream by a highway or railroad right of way is not considered riparian.[31] The Iowa Supreme Court apparently has not ruled on the various possible interpretations of the extent of the land to which riparian rights attach. In the only opinion located that is pertinent to this question, the court stated that a riparian owner is one 'whose land abuts upon a river'.[32] Owners of land riparian to a navigable or meandered stream own only to the ordinary high water mark, the State retaining title to the bed and banks.[33] The court has defined the ordinary high water mark as the limit of the bed which the water occupies sufficiently long and continuously to wrest it from vegetation and destroy its value for agricultural purposes.[34]

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27. Logsdon v. Anderson, 239 Iowa 585 (1948)

28. Nixon v. Welch, 238 Iowa 34 (1946)

29. Droegmiller v. Olson, 241 Iowa 456 (1949)

30. 56 Am. Jur., Waters, sec. 277

31. Cook v. City of Burlington, 30 Iowa 94 (1870)

32. Peck v. Olsen Construction Co., 216 Iowa 519 (1933)

33. Shortell v. Des Moines Electric Co., 186 Iowa 469 (1919)

34. Merrill v. Bd. of Super's. of Cerro Gordo County, 164 Iowa 325 (1914)
Solomon v. City of Sioux City, 243 Iowa 634 (1952)
Wilcox v. Pinney, 250 Iowa 1378 (1959)

On many occasions, the Iowa court has recognized the right of a riparian owner to have the water in a stream flow by or through his property in its natural state subject only to the right of other riparian owners to make reasonable use of the water.[35] In determining whether a particular use is reasonable the Iowa court has enumerated several criteria - what the use is for; its extent, duration, necessity, and its application; the nature and size of the stream, and the several uses to which it is put; the extent of the injury to the one proprietor, and of the benefit to the other; climatic conditions; the uses and customs of the neighborhood; convenience in doing business, and indispensable public necessity of cities and villages for drainage, and all other facts which may bear upon the reasonableness of the use.[36]

One may not embank against the natural flow of a stream when the effect is to cast increased water on the lands of others to their substantial injury.[37]

Although the Iowa court has experienced little difficulty enunciating and applying the classic riparian doctrines regarding uses of water which do not diminish supplies or impair quality, consumptive uses of

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35. Harp v. Iowa Falls Electric Co. 196 Iowa 317 (1923)
Watt v. Robbins, 160 Iowa 587 (1913)
Gibson & Kloppenstein v. Fischer & Orton, 68 Iowa 29 (1885)
Decorah Woolen Mill Co. v. Greer, 49 Iowa 490 (1878)

36. Gehlen Brothers v. Knorr, 101 Iowa 700 (1897)

37. Allely v. Fickel, 243 Iowa 105
Falcon v. Boyer, 157 Iowa 745 (1913)
Rock v. Vonghause, 127 Iowa 529 (1905)
Downey v. Phelps, 201 Iowa 826

water courses were precious and doctrine concerning such uses is much less certain. The court has in such cases distinguished between "natural" and "artificial" uses.

Natural uses have been defined by the court as use for domestic purposes, including household uses, such as cleansing and washing, and supplying an ordinary number of horses or stock with water. A riparian owner may take all of the water needed for this purpose even if all of the water in the stream is thereby consumed.[38]

All other uses of water are "artificial" and are always subordinate to the natural use.[39] Any riparian owner putting water to an artificial use must do so in such manner as not to interfere with its lawful use by others above or below him on the same stream.[39] The rights of all proprietors on the stream to use water for "artificial" purposes are equal.[39] Use of water for irrigation has been described by the Iowa court in dictum as an artificial use.[39] The distribution and sale of water by a municipality is an artificial use under the riparian doctrine.[39]

As well as being a criminal offense under statue law,[40] pollution of the water of a stream is also an interference with private riparian rights actionable in damages[41] and sometimes to injunctive relief.[42]

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38. Willis v. City of Perry, 92 Iowa 297 (1894)
    Spence v. McDonough, 77 Iowa 460 (1889)

39. Willis v. City of Perry, 92 Iowa 297 (1894)

40. Iowa Code ch. 657 (1962)

41. Vogt v. City of Grinnell, 133 Iowa 363 (1907)
    Ferguson v. Firmenich Mfg. Co., 77 Iowa 576 (1889)

42. Newman v. City of Grundy Center, 246 Iowa 916 (1955)
    Spence v. McDonough, 77 Iowa 460 (1889)

UNDERGROUND WATER

In general, riparian rights attach to underground streams which flow in a well-defined channel capable of being distinctly traced the same as if they were flowing on the surface.[43] Principal exceptions to the surface stream rule arise due to the difficulty of returning water underground. Consistent with generally accepted knowledge and theories regarding such phenomena, however, ground water is presumed to be percolating water until it is proved that the water is flowing in a definite channel.[44] Apparently the only restriction on the landowners right to use percolating water is that he not waste it if such diversion and waste injures another and prevents the latter from devoting such water to a beneficial use.[45] Pollution of percolating water by another is an interference with the private right of the owner of the overlying land and is actionable in a lawsuit for damages or in equity for injunctive relief.[46]

"Surface waters" (as defined by the Iowa Supreme Court) are defined as "diffused waters" in the Iowa Water Rights Law; that is, water of a vagrant or temporary character arising by precipitation or snow melt

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43. Willis v. City of Perry, 92 Iowa 297 (1894)
Burroughs v. Saterlee, 67 Iowa 396

44. Barclay v. Abraham, 121 Iowa 619 (1903)

45. DeBok v. Doak, 188 Iowa 597 (1920
Barclay v. Abraham, 121 Iowa 619 (1903)
Hougan v. Milwaukee & St. Paul Ry., 35 Iowa 558 (1872)

46. Iverson v. Vint, 243 Iowa 949 (1952
Payne v. Town of Wayland, 131 Iowa 659 (1906)

and not yet part of stream or watercourse.[47] An owner of land has an absolute right to such water on his land and may use it as he wishes.[48]

Riparian rights are appurtenant to the land to which they attach, passing with the land from owner to owner without specific mention in the deeds.[49] Such rights can be condemned and can be severed from the land by express conveyance.[50] They are not lost by mere non-user but can be lost by prescription or adverse user.[51]

STATE DEPARTMENTS

State departments directly concerned with the administration of a statute or statutes pertaining to water and related land resources are the Iowa Geological Survey, State Conservation Commission, State Soil Conservation Commission, State Department of Health, the new Iowa Water Pollution Control Commission, and the Iowa Natural Resources Council. The Commerce Commission in connection with the regulation of pipeline and underground gas storage and the regulation of water service utilities[52]; the Highway Department in the construction of bridges and road

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47. Hunt v. Smith, 238 Iowa 543 (1947)
    Iowa Code, sec. 455A.1 (1962)

48. 56 Am. Jur., Waters, sec. 66

49. 56 Am. Jur., Waters, sec. 252, 254, 287

50. 56 Am. Jur., Waters, sec. 253, 288

51. Fennema v. Menninga, 236 Iowa 543 (1945)
    Shortall v. Des Moines Electric Co., 186 Iowa 469 (1919)
    Trudo v. Pratt, 148 Iowa 195 (1910)
    Marshall Ice Co. v. LaPlant, 136 Iowa 621 (1907)

52. Iowa Code ch. 490 (1962)
    Iowa Acts, 60 G. A. ch. 286 (1963)

grades[33]; the Department of Agriculture in the regulation of certain processing and marketing activities,[34] and the Development Commission in connection with its planning and advisory functions,[35] also have an interest in such resources. The two state universities are also actively concerned with such resources, Iowa State University through the Engineering and Agricultural Experiment Stations and the Cooperative Extension Service, the University of Iowa through its Agricultural Law Center, and both institutions through their cooperative administration of the Iowa Water Resources Research Center founded and funded through the Federal Water Resources Research Act. Both universities are also represented on the State Coordinating Group for Comprehensive Planning of Water Resources.

In addition to its duties with regard to fish and game, the State Conservation Commission has proprietary jurisdiction over the beds and banks of meandered streams, administers statutes and programs relating to state parks and preserves, stream access areas, state owned artificial and natural lakes, and has primary responsibility for formulating and implementing state plans for recreational developments, including the supervision of County Conservation Boards and Water Recreation Areas.[36]

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33. See Iowa Code ch. 306 (1962) for general duties of Commission

34. Iowa Code ch. 170, 192 (1962)

35. Iowa Code ch. 28, (1962)

36. Iowa Code ch. 106-109, 111, 111A, 112 (1962)
Iowa Acts, 60 G. A. ch. 106 (1963)

The expanding role of recreation generally and water-associated activi-
ties specifically at the national level is also reflected at the State
level in the funding and functions of the Commission.

The Iowa Geological Survey is concerned with the collection, in-
terpretation and reporting of basic data including stream flow, ground
water and geologic data.[57]

The State Soil Conservation Committee[58] function of directing the
organization of Soil Conservation Districts is now completed as Iowa is
now completely organized into 100 districts. District boundaries coin-
cide with county boundaries except for the two Pottawattamie County
districts.

Principal functions of the Committee now are to assist District
Commissioners; maintain liason between Districts; coordinate programs
between Districts; maintain liason with U. S. Soil Conservation Service
and other state agencies; disseminate information regarding activities of
Districts; render certain financial aid to Districts; and to represent the
Governor and State with regard to P. L. 566 watershed applications.

The State Department of Health, Division of Water Supply, inspects
water supplies and directs their method of installation and operation
and administers a new law[60] requiring certification of operators of pub-
lic water supply and sewage systems. The newly created Division of Wa-

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57. Iowa Code ch. 305 (1962)
    See also Iowa Acts, 60 G. A. ch. 84 (1963)

58. Iowa Code ch. 467A (1962)

59. Iowa Code sec. 135.11(7) (1962)

60. Iowa Acts, 61 G. A. ch. 162 (1965)

Pollution Control within the Department of Health provides the services of Technical Secretary to the Iowa Water Pollution Control Commission and conducts investigations and studies under the Pollution Control La

The Iowa Water Pollution Control Commission[61] was created in 19 with the power and duty to supervise administration and enforcement of all laws relating to water pollution; to develop comprehensive plans an programs for the prevention, control and abatement of new, increasing, potential, or existing pollution of waters of the state; to cause in- vestigations to be conducted regarding alleged pollution; to adopt, am or repeal reasonable quality standards for waters of the state; to re- quire the submission of plans and specifications for disposal systems, and to direct the State Department of Health to issue, revoke, modify, or deny permits for the discharge of sewage, industrial waste or other wastes or for the installation or operation of disposal systems or part thereof. The Commission has thus succeeded to the duties formerly as- signed to the Health Department under the Stream and Lake Pollution title of Code Chapter 135 and has been delegated much broader jurisdic- tion and authority.

Activities of the new Commission and the Health Department in the area of water pollution will have to be closely coordinated since the Commission will function as a policy making body with all field work conducted by personnel of the Health Department. This operating re-

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61. Iowa Acts, 61 G. A. ch. 375 (1965)

responsibility is provided for in the statutes and in appropriations to the two agencies. The Commission is presently involved in investigations of specific instances of water pollution in various areas of the State and in study directed towards the establishment of water quality standards.

The Iowa Natural Resources Council was created in 1949 as the State agency to establish and enforce an appropriate comprehensive state-wide program for the control, utilization and protection of the water resources of the State.[62] The specific powers and duties delegated in the initial Act centered upon review of plans for flood control works and other projects which might affect the efficiency or capacity of the floodway.

The Act establishing the water use permit system was enacted in 1957 as an amendment to Code Chapter 455A with administration thereof by the Resources Council. This Act declares that all waters within the State are public waters and public wealth of the people of the State and are subject to regulated use for beneficial purposes. With a few exceptions, a permit from the State Water Commissioner is required for all uses of water in excess of 5,000 gallons per day.[64]

Statutory provisions pertaining to comprehensive planning of water resources were clarified by 1965 amendments[65] to Chapter 455A at which time a new flood plain regulation section was added.[66]

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62. Iowa Acts, 53 G. A. ch. 203 (1949)

63. Iowa Acts, 57 G. A. ch. 229 (1957

64. Iowa Code sec. 455A.25 (1962)

65. Iowa Acts, 61 G. A. ch. 373 (1965)

66. Iowa Acts, 61 G. A. ch. 374 (1965)

Regulation of use of the flood plain is a relatively new approach to flood damage prevention. Historically, man has tried to reduce flood damages through the _exercise of control over the river_ in time of flood. Dams and reservoirs, levees, dikes, flood walls, and channel improvements have been constructed at great cost, principally by Federal, State and local governments. The steady increase in flood hazards and damages despite the expenditure of billions of dollars in tax funds has led to a new approach to the reduction of these hazards and damages. The _exercise of control_ over the land lying adjacent to the river through the planned management and development of flood hazard areas.

Regulation of flood plain use can be carried out by a variety of means - encroachment lines, zoning ordinances, subdivision regulations, and modifications or additions to building codes. Park and open space developments, evacuations, urban renewal, flood proofing, tax reduction, and warning signs are other methods which may be helpful, particularly in special localized areas.

Flood plain regulation involves the establishment of legal tools with which to control the extent and type of development which will be allowed to take place on the flood plains. There are two basic objectives of such regulation. _The first is to assure the retention of an adequate floodway for the river,_ floodway being defined as the channel and those portions of the adjoining flood plains which are reasonably required to carry and discharge flood flows without unduly raising upstream water surface elevations. _The second objective of regulation is to_ encourage sound land use consistent with the flood hazard and the community land use needs.

Zoning is the legal tool used by cities, towns and counties to control and direct the use and development of land and property. The zoning ordinance is used to implement and enforce the comprehensive plan which has no legal status. Flood plain zoning is not a special type of ordinance but merely another set of provisions which can be incorporated into the comprehensive zoning ordinance so that flood damage can be minimized.

These considerations led the 1965 Iowa Legislature to enact the flood plain regulation Act. Under the Act, the Council may establish and enforce regulations for the orderly development and wise use of the flood plains of any river or stream within the State, and alter, change or revoke the same. The Council shall determine the characteristics of floods which reasonably may be expected to occur and may by order establish encroachment limits, protection methods, and minimum protection levels appropriate to the flooding characteristics of the stream and to reasonable use of the flood plains. The Council may cooperate with and assist local units of government in the establishment of encroachment limits, flood plain regulations and zoning ordinances relating to flood plain areas within their jurisdiction.

Flood plain information studies are completed or underway for several areas of the State. Reports have been prepared and published by the U. S.

Corps of Engineers for streams at Cedar Rapids[67] and Davenport.[68] A study of the Iowa River at Iowa City was made by the Resources Council in 1960[69] and regulations based on the study and governing use of the floodway and flood plains were adopted in 1962 by the City as part of its comprehensive zoning ordinance.[70] The ordinance permits only open type uses in the floodway area and, in those flood plain areas not needed for conveyance, permits development consistent with the adjoining use district provided the area is filled to a specified elevation.

COUNTIES

Counties may acquire, develop, and maintain public parks, preserves, parkways, playgrounds, recreational centers, county forests, wildlife and other conservation areas and make same available to inhabitants of the county. Management of such areas shall be vested in a five-member County Conservation Board created by favorable vote of the people of the county and appointed by the Board of Supervisors to five-year staggered terms. The approval of the State Conservation Commission must be obtained for the acquisition of land and all general development plans and programs

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67. Corps of Engineers, U. S. Army Engineer District, Rock Island, Illinois, "Flood Plain Information Report, Indian and Dry Creeks, Linn County, Iowa," 1964.

68. Corps of Engineers, U. S. Army Engineer District, Rock Island, Illinois, "Flood Plain Information Report, Duck Creek, Scott County, Iowa," 1965.

69. Iowa Natural Resources Council, Des Moines, Iowa, "A Study of Flood Problems and Flood Plain Regulation, Iowa River and Local Tributaries of Iowa City, Iowa," 1960.

70. City of Iowa City, Iowa, "Zoning Ordinance," July, 1962. (Article VI - Flood Plain Use Regulations)

71. Iowa Code ch. 111A (1962)

[illegible] may be paid from funds appropriated by the Board of Supervisors from the general fund or the Board of Supervisors may cause the levy of a special annual tax of not more than one mill on the assessed valuation of all real and personal property to be collected and paid into a separate and distinct county conservation fund. Bonds may be issued in anticipation of this annual tax.[72] The bond issue must be approved by at least sixty percent of the vote on the specific proposition at a special election thereon. The bonds shall mature in not more than 20 years, shall bear interest at a rate not exceeding five percent, shall be payable as to both principal and interest from the special one-mill tax levy, and the aggregate amount of bonds issued shall not exceed one million dollars in any single county. As of January 1, 1966, conservation boards had been created and organized in 81 of Iowa's 99 counties and a multitude of projects, some quite ambitious, were underway. Elections are planned in about ten additional counties during 1966.

Counties, through their Boards of Supervisors, may regulate use of land and structures thereon within the county and outside the corporate limits of cities or towns.[73] The enabling law was amended in 1965 to specifically include safety from floods as a proper objective of zoning, to make any flood plain regulation apply to farm land and buildings, and to require approval of the Resources Council for any flood plain regulation or variation or exception therefrom prior to adoption by the

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72. Iowa Code sec. 111A.6 (1962)
Iowa Acts 61 G. A. ch. 136 (1965)

73. Iowa Code ch. 358A (1962)

Board of Supervisors.[74]

CITIES AND TOWNS

General powers delegated by the legislature to cities and towns include power and authority to provide drainage systems for flood and other surface waters, sewer systems and disposal plants and to require and regulate connection thereto; to establish, purchase, maintain and regulate the use of parks, playgrounds and recreational facilities.[75]

Other statutes grant specific power to cities and towns to establish water and sewer systems,[76] flood control systems,[77] park commissions,[78] river-front improvement commissions,[79] and municipal zoning commissions.[80]

SPECIAL PURPOSE DISTRICTS

Levee and drainage districts,[81] benefited water districts,[82] soil conservation and flood control districts,[83] and sanitary districts[84] may

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74. Iowa Acts, 61 G. A. ch. 374 (1965)

75. Iowa Code ch. 368 (1962)

76. Iowa Code ch. 391 et. seq. (1962)

77. Iowa Code ch. 395 (1962)

78. Iowa Code ch. 370 (1962)

79. Iowa Code ch. 372 (1962)

80. Iowa Code ch. 414 (1962)
Iowa Acts, 61 G. A. ch. 374 (1965)

81. Iowa Code ch. 455 et seq. (1962)

82. Iowa Code ch. 357 (1962)

83. Iowa Code ch. 467C (1962)

84. Iowa Code ch. 358 (1962)

THE COMPREHENSIVE STATEWIDE PLAN FOR RECREATION IN IOWA

Planning Evaluation and Financing
William C. Brabham
State Conservation Commission
Des Moines 8, Iowa

It is indeed a pleasure to take part in the Fourth Water Resources Design Conference. This is my first active participation in the design conference and I must say it has been most enlightening.

Planning in Iowa is not new. The Iowa State Planning Board in their progress report of 1934 pointed out that when the great opportunity came through the Civilian Conservation Corps (CCC) in 1933 a plan previously prepared by the landscape architect, Board of Conservation, Fish and Game Commission was at hand and no time was lost in getting construction underway. In one year some phases of the twenty-five year program had been advanced to a degree equivalent to ten years of normal growth and development. This experience is a practical demonstration that "it pays to plan."

Added emphasis to statewide planning for outdoor recreation was set forth following an act passed by the 88th Congress of the United States known as Public Law 88-578--The Land and Water Conservation Fund Act, signed September 3, 1964, which became effective January 1, 1965, thus enabling the Federal Government, the states and their political subdivisions to participate cooperatively in a program under the supervision of the Bureau of Outdoor Recreation. Prior to the passage of this very important legislation, planning was carried on principally by the individual subdivisions of our state without the benefit of a completely coordinated statewide plan. There was coordination between the County Conservation Boards and the State Conservation Commission. However, very little emphasis was placed on the needs of the urban areas of Iowa and the role of the private sector.

The concept of the County Conservation Board system in Iowa is one of the most remarkable advances in the promotion of recreational facilities in recent decades. It affords an opportunity at the county level to acquire and develop areas of local and regional interest that provide for untold recreational experiences that could not be accomplished by any other means.

Thousands of people now enjoy various outdoor activities at little or no expense right at their back door. The County Conservation Boards have been established in 83 of our 99 counties. All are actively engaged in outdoor recreation projects and to date some 502 projects have been completed or are underway. It is expected that over four million will be spent by the County Conservation Boards in 1966. These projects are well distributed over the state and add immeasurably to the outdoor enjoyment of people.

Cities and towns and other political subdivisions of the state have spent millions in the construction and maintenance of fine parks, golf courses, gardens, swimming pools, tennis courts, camping and picnic areas and other facilities for outdoor recreation. Perhaps nowhere is the need as great for public outdoor recreation as in our urban areas where people live under crowded conditions with limited opportunity to enjoy natural surroundings. The great masses of people that do use the generally overcrowded urban public facilities attest to the need of expansion of these areas.

Recreation provided by the private sector is far greater than most of us realize. About 97 percent of the total land in Iowa is privately owned and a good share of this is potential hunting ground for upland game. Farmers and landowners continue to play hosts to thousands who enjoy their sport on private lands. More than 30,000 farm ponds have been built on private land and large numbers of these are suitable for fishing. Private shooting preserves, camp sites, lake sites, picnic areas, vacation farms, golf courses, ski lifts, gun clubs, boat marinas and numerous other facilities have been established. Outdoor areas are being expanded at a rapid rate with private capital and this will be increased as demand dictates in the future.

Colleges and universities and some high schools and elementary schools are establishing outdoor laboratories, classrooms and other facilities for instruction purposes and to study the phenomenon of nature.

All Federal Agencies are cognizant of the needs for outdoor recreation and have adjusted programs to allow the development of outdoor recreational facilities some by grants-in-aid, loans, services and technical assistance.

What this all boils down to is the fact that outdoor recreation is big business and nearly everyone is in the picture. Millions are being spent and millions more are needed if we are to keep up with public demand. The problem of more and more leisure time must bemet and in the judgment of many, no better way presents itself than programs involving the out of doors. The 60 to 80 hour work week of yesterday has given way to the 40 hour week of today and already serious consideration is being given to 30 and 20 hour work weeks for the future.

In Iowa and for that matter throughout the nation, water oriented areas are most attractive to the largest number of people. Unfortunately, Iowa was not blessed with thousands of natural lakes. It is essential therefore that we preserve the lakes we have and create new lakes for recreation. This is expensive, but serves the twofold purpose of providing excellent recreation and increasing the economic base of the community by the expenditure of money by those who use the facility. Streams must be protected and preserved for they provide unlimited recreational opportunity for our people.

With the problem of urban expansion, highway systems, intensive farming, private development and industrialization of our land and water shorelines, our most urgent need today is the acquisition of sufficient existing areas best suited for recreational purposes to enable us to provide for future recreational development and expansion. Development of these areas can be accomplished as funds become available for this purpose. It is paramount therefore that these diminishing areas be acquire before it is too late.

With this brief backlog of needs and planning, let's get into the subject of participating in the Land and Water Conservation Fund Program. This program is founded on the principal that adequate outdoor recreation can be provided only if all levels of government share in the task to assist the furtherance of outdoor recreation at the local level. In other words the land and water conservation fund act is a people's act and a share of the responsibility for providing outdoor recreation must rest with the political subdivisions of the state. The first responsibility of the local units of government in outdoor recreation is to plan to meet the local needs utilizing federal assistance if necessary and available.

In Iowa, Governor Hughes appointed the Iowa State Conservation Commission to act as the state coordinating agency and the Director of the Commission, Mr. Everett Speaker, to serve as the liaison officer between the Commission and Bureau. The act requires that each state prepare a comprehensive statewide outdoor recreation plan. This plan must meet the approval of the Bureau of Outdoor Recreation before the state is eligible to apply for grant-in-aids for planning, land acquisition and development projects. Planning projects will not be available to the local units of government.

I am happy to report at this time that the rough draft copy of Iowa's interim comprehensive plan has been reviewed by the regional office, Bureau of Outdoor Recreation, and that we are now in the final stages of revision and printing. We anticipate the formal presentation to the Bureau of Outdoor Recreation for their approval in early February. This plan covers a five year period to 1970; however, we do not expect approval for this entire period. Statewide planning will be a continuing process.

The comprehensive statewide outdoor recreation plan is not a composite of individual plans but rather it is a broad plan based on supply, demand, need and implementation. This plan consists of four basic factors.

1. An inventory of existing and potential supply of outdoor recreational facilities at all levels of government including the private sector of our state.

2. The determination of the present and projected demands for all types of outdoor recreational facilities.

3. A determination of the present and projected need for additional areas and facilities by relating the supply to the demand.

4. The formulation of a program of implementation to meet these needs.

The above mentioned four main ingredients of the statewide plan sound rather simple. However to compile the facts and to arrive at definite determinations takes considerable time and cooperation. We have found that we lack some information at this time - This was pointed out in the plan. Let's briefly take each item by itself and discuss some o the things that really apply to sound recreational planning in our state.

1. The inventory of existing and potential supply of outdoor recreational facilities. We were extremely fortunate in most instances however from many areas we have had little or no response. The inventory of federal areas in Iowa, the state areas of the State Conservation Commission and the County Conservation Board areas was a matter of tabulation. On the other hand the survey of the municipalities of Iowa presented problems as did the survey of this private sector.

We had excellent response from the larger municipalities in Iowa. There are some of the towns in our states who have never answered a questionnaire sent them by the State Conservation Commission. In this regard we have 946 cities and towns and questionnaires were submitted to all of them. The first survey of the cities and towns of Iowa was conducted in 1962.

The percentage of participation in that survey is as follows:

Less than 1,000 population	31%
1,000 to 5,000	86%
5,000 to 10,000	91%
10,000 to 20,000	75%
20,000 to 50,000	80%
50,000 to 75,000	100%

In 1965 an additional survey was made of the cities and towns. We received replies from less than half of the total urban areas in Iowa; however, from the date secured in the 1962 survey and that secured in 1965, we did have information from the citieis and towns of 10,000 population and over. We are lacking information from the cities and towns of 10,000 and under. As a result, it was necessary for us to use averages by classes to determine what recreational facilities existed in the smaller cities andtowns.

The 1962 survey also gave us information of a general nature including information about budgets, millage rates, and acreages which when applied to populations gave data on average expenditures per person and average number of persons per acre of park. This data indicated that as the size of a town increased there was a general increase in the number of persons per acre of recreational area. This ranged from 55 persons per acre in towns of less than 1,000 to 141 persons per acre in Des Moines.

Millage rates and average expenditures per person generally increases as the size of the cities increased.

This is no doubt due to the demand for more varied and sophisticated types of facilities in the larger cities. The importence of city parks in the larger cities is emphasized by the fact that all cities larger than 20,000 have park boards or a few cases park commissioners.

The census of the private sector was secured from a survey of the soil conservation district through the cooperation of the state soil committee and the soil conservation service.

2. The determination of the present projected demand for types of recreational facilities. Iowa's population in 1960 was 2,757,537. It is expected in 1970 to reach 2,879,570 people and 3,141,463 people in 1980 or a 13 percent

increase in 20 years. The rural population has been declining and at a fairly rapid rate with 79 of the 99 counties recording lower rural populations in 1960 than in 1950. Much of this is due to economic factors which have resulted in consolidation of farms. In 1961 there were 177,172 farms in Iowa, a decrease of 37,995 farms from the all time peak of 215,167 in 1939. As I recall an article the other day, the farm's total is now approximately 161,000.

There is another population change going on in much of Iowa while many people are leaving rural areas some cities are in effect moving to the country. Even the smallest urban settlements are intimately related and connected through trade functions with their surrounding rural areas but the large urban centers have even greater spheres of influence.

The main feature of this pattern concerns the large metropolitan centers and central cities for places over 50,000. These centers plus the surrounding country or counties are interdependent with the center forming a metropolitan complex. These metropolitan complexes contain approximately 1/3 of the state population and account for all Iowa's population growth during the last decade.

The shift of population from rural to urban as well as the general population growth is certain to increase the demand for outdoor recreation since urban residents seem to feel a more urgent need to get out of doors than do rural residents who are already there. State park attendance in Iowa has increased since World War II amounting to 258 percent between the years of 1947 and 1964. Camping attendance exhibited at even more spectacular upsurge during that same period with an increase of 5,030 percent. There is no indication that demand for camping will level off in the near future although total attendance may level off unless additional facilities are provided.

Some of the definite activities were adjusted to portray the situation in Iowa Most of these activities were those which could be based upon concrete evidence, mainly that of license sales, attendance figures, etc., and included such activities as hunting, fishing, camping and boating. We did not, however, have information on such things as outdoor games and sports, sightseeing, swimming, horseback riding, sledding or tobogganing, and attending outdoor concepts and dramas to name a few To determine a demand factor for these activities it was necessary that we utilize the ORRRC study reports for this region and apply those to Iowa. We recognized the fallacy of the application of these demand factors as they pertain to Iowa in our plan

However, this was the only information which we had available and as a consequence, it was our only means of making a determination at this time

I am happy to report that the Forestry Department at Iowa State University will be conducting a survey of these particular outdoor recreational activities, as they apply to Iowa. With this information we can accurately update the plan by activity for Iowa.

3. A determination of the present and projected needs. Theoretically this portion would normally be a comparison of the supply to the demand. However, in our particular instance, we did lack information both in supply and demand and as a consequence, this is the one portion of our plan which will need updating first following the completion of definite studies.

In this regard we did take the most obvious needs from a statewide level and incorporate them as a definite part of the plan. Our only other alternative to determine the needs was to pass on the responsibility to the other political subdivisions of our state to provide the informaticu as a part of the project both the supply and demand information. The lack of definite information further points out the need of our local units of government to put more emphasis on planning to determine exactly where they fit now and exactly where they fit now and exactly where they must go with the outdoor recreational activities in their local area.

As an example, following are some of the projections of total participants by activity which we do feel will be indicative of need:

Projected Participant Increases
From 1960-1980

1.	Driving for Pleasure	119,122
2.	Picnicking	96,648
3.	Swimming	94,400
4.	Sightseeing	78,665
5.	Boating	71,939
6.	Walking for pleasure	71,922
7.	Attending outdoor events	67,427
8.	Outdoor games and sports	60,686
9.	Fishing	51,695
10.	Hunting	40,455
11.	Nature study	33,717

12	Ice Skating	26,971
13	Sledding or Tobogganing	24,723
14.	Camping	18,279
15.	Bicycling	17,979
16.	Water skiing	13,486
17.	Horseback riding	11,239
18.	Miscellaneous	11,237
19.	Hiking	8,991
20.	Attending outdoor concerts, dramas	6,744
21.	Snow skiing	4,496

Trap - Scuba - Rock Hunting

4. The program of implementation to meet the needs was determined specifically for projects of statewide significance. We took advantage of all programs which were available and used them to the utmost. It is anticipated that by using these funds with anticipated appropriations the State Conservation Commission will be carrying on an 18 million dollar program. We did not attempt to point out specific means of implementation at the local level. We did indicate general programs which might be used.

Our commission has designated that 50 percent of the land and water conservation fund monies will be made available to the political subdivisions of Iowa. At the present time we have worked up a tentative formula for this projection based on population. This awaits the approval of our commission prior to making this information available.

We do recognize, however, that there are many federal programs that are available to urban areas which are in reality identical to the land and water conservation fund program in matching grant-in-aids. If Iowa is to reach the total maximum recreational area and facility needs in the future, it will be necessary that our political subdivisions take advantage of these programs. In all cases it is a prerequisite that a plan be formulated. This is no undue burden whether it applied to the lands and waters conservation program or to other governmental programs as well.

In summary I would like to point out several facts that are recognized in the plan.

[illegible]

[illegible] to the state.

3. Although the demand for such activities as driving and riding for pleasure, sightseeing and bicycling is high, the need for facilities is apparently [illegible] for such activities as outdoor games and sports, swimming, picnicking, camping and [illegible].

4. Multiple use recreation areas located adjacent to or accessible to water bodies are highly desirable.

We must formulate sound and practical programs at all levels of government to determine where we stand today in the recreational picture and what we must do for tomorrow to meet the need for outdoor recreational opportunities.

Construction Specifications
for Rolled Earthfill Dams

by

Mr. Kenneth Cornforth
State Conservation Engineer
Soil Conservation Service
Des Moines, Iowa

Note:

Review and discussion of SCS-Midwest constuction specifications for excavation and construction of earth fills. Attached are the construction specifications reviewed.

Iowa State University
Ames, Iowa

January 19 & 20, 1966

CONSTRUCTION SPECIFICATION

6. EXCAVATION

1. SCOPE

The work shall consist of the excavation of all materials necessary for the construction of the work.

2. CLASSIFICATION

Excavation will either be designated as unclassified or be classified as common excavation or rock excavation in accordance with the following definitions:

> Common excavation shall be defined as the excavation of all materials that can be excavated, transported, and unloaded by the combined or separate use of heavy ripping equipment and wheel tractor-scrapers and pusher tractors or that can be excavated and dumped into place or loaded onto hauling equipment by means of excavators having a rated capacity of not more than one cubic yard and equipped with attachments (such as shovel, bucket, backhoe, dragline or clam shell) appropriate to the character of the materials and the site conditions.

> Rock excavation shall be defined as the excavation of all hard compacted or cemented materials the accomplishment of which requires blasting or the use of excavators larger than defined for common excavation. The excavation and removal of isolated boulders or rock fragments larger than one cubic yard in volume encountered in materials otherwise conforming to the definition of common excavation shall be classified as rock excavation.

The class of excavation will be determined by the Engineer on the basis of his determination of the character of the materials to be excavated and the prevailing site conditions.

The presence of isolated boulders or rock fragments larger than one cubic yard in size will not in itself be considered sufficient cause to change the classification of the surrounding material.

For the purpose of this classification, the following definitions shall apply:

> Heavy ripping equipment shall be defined as a tractor-mounted, heavy duty, single-tooth, ripping attachment mounted on a tractor having a power rating of at least 200 net horsepower (at the flywheel).

Wheel tractor scraper shall be defined as a self-loading and unloading scraper having a rated load capacity of at least 12 yards.

Pusher tractor shall be defined as a track type tractor having a power rating of at least 200 net horsepower (at the flywheel) equipped with appropriate attachments.

3. UNCLASSIFIED EXCAVATION

Items of excavation designated as "Unclassified Excavation" shall include all materials encountered regardless of their nature or the manner in which they are removed. When excavation is unclassified none of the definitions or classifications stated in Section 2 of this specification shall apply.

4. USE OF EXCAVATED MATERIALS

To the extent that they are needed all suitable materials removed from the specified excavations shall be used in the construction of the specified earth or rock filled portions of the permanent work. The suitability of materials for specific purposes will be determined by the Engineer. The contractor shall not waste or otherwise dispose of suitable excavated materials.

The Contractor shall control the rock excavation operations to produce the size gradations specified for other parts of the work, if the rock is designated by the Engineer as suitable for use.

5. DISPOSAL OF WASTE MATERIALS

All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the locations shown on the drawings.

6. SPECIAL REQUIREMENTS FOR STRUCTURE AND TRENCH EXCAVATION

The side slopes necessary to maintain the stability of excavated surfaces may not necessarily coincide with the pay limits specified for structure excavation or trench excavation. Such works shall be so excavated, braced and supported as to safeguard the work and workmen, to provide that ground adjacent to the excavation will not slide or settle and to prevent damage to adjacent existing improvements. When such bracing and supporting is required the width of the excavation shall be adjusted to allow for the space occupied by the sheeting, bracing or other supporting installations. The Contractor shall furnish, place and subsequently remove such supporting installations.

Such excavations shall be completed to the specified elevations and to sufficient length and width to include allowance for forms, bracing and supports, as necessary, before any concrete or earth fill is placed or any piles are driven within the limits of the excavation.

7. BORROW EXCAVATION

When the quantities of suitable materials obtained from specified excavations are insufficient to construct the specified fill portions of the permanent works, additional materials shall be obtained from the designated borrow areas. The Engineer shall designate the extent of borrow pits within the limits of the designated borrow areas and the limits of the depth of cut in all parts of the borrow pits.

Borrow pits shall be excavated and finally dressed in a manner to prevent the creation of residual hazards or unsightly conditions by reason of steep or unstable side slopes.

8. OVEREXCAVATION OF STRUCTURE SUBGRADE

Excavation in rock beyond the limits of the specified cross sections and elevations shall be corrected by filling the resulting voids to the specified contours and elevations with portland cement concrete, Class 2500 or better.

Excavation in earth beyond the limits of the specified cross sections and elevations shall be corrected by filling the resulting voids to the specified contours and elevations with approved compacted earth fill.

9. DIVERSION AND REMOVAL OF WATER

The Contractor shall furnish, install, maintain, operate and subsequently remove all temporary facilities and equipment necessary to divert or impound surface water and remove ground water from the site of the work in accordance with the provisions of Construction Specification 25.

10. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the volume of each type and class of excavation will be measured within the specified limits and computed to the nearest cubic yard by the method of average cross-sectional end areas. Regardless of quantities excavated, the measurement for payment will be made to the specified pay limits.

Method 1. The pay limits shall be the neat lines and grades shown on the drawings.

Method 2. The pay limits shall be defined as follows:

a. The upper limit shall be the original ground surface as it existed prior to the start of construction operations except that where excavation is performed within areas designated for other previous excavation the upper limit shall be the modified ground surface resulting from the previous excavation.

b. The lower and lateral limits shall be the true surface of the completed excavation.

Method 3. The pay limits shall be defined as follows:

a. The upper limit shall be the original ground surface as it existed prior to the start of construction operations except that where excavation is performed within areas designated for other previous excavation the upper limit shall be the modified ground surface resulting from the previous excavation.

b. The lower and lateral limits shall be the neat lines and grades shown on the drawings.

Payment for each type and class of excavation will be made at the contract unit price for that type and class of excavation. Such payment will constitute full compensation for all labor, materials, equipment, and all other items necessary and incidental to the performance of the work. No compensation will be made for the removal and disposal of materials that may come into an excavation from outside the designated limits for any reason.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 11 of this specification.

CONSTRUCTION SPECIFICATION

5. EARTHFILL

1. SCOPE

The work shall consist of the construction of all earth fills necessary for construction of the works.

2. MATERIALS

All fill materials shall be obtained from required excavations and designated borrow areas. The selection, blending, routing and disposition of materials within the various fills shall be subject to approval by the Engineer.

Fill materials shall contain no sod, brush, roots or other perishable materials. Rock particles larger than the maximum size specified for each type of fill shall be removed from the material prior to compaction of the fill.

The types of materials to be used in the various parts of the permanent works are listed and described in the construction details and drawings.

3. PLACEMENT

Fill shall not be placed until the required excavation and preparation of the underlying foundation is completed and inspected and approved by the Engineer.

The fill shall be so constructed that the distribution of materials throughout each specified zone will be essentially homogeneous and free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation from the surrounding material in the zone. No fill shall be placed upon a frozen surface nor shall snow, ice or frozen material be incorporated in the fill.

Embankment fill shall be placed in approximately horizontal layers extending the entire length and width of the embankment. Unless otherwise specified, the elevation of the embankment surface shall be increased at approximately the same rate at all points regardless of the number of zones or types of material being placed, except that: (1) the boundary surfaces of drain fill shall be protected as specified in Construction Specification 7, and (2) during construction the surface of the fill shall be maintained with a crown or cross-slope of not less than 2 percent to insure effective surface drainage. Where sectional construction is authorized the additional requirements specified in Section 6 of this specification shall apply.

The thickness of each layer of fill shall be not greater than that required to achieve the specified compaction and in no case shall exceed that specified for the designated type of fill.

Materials placed on the fill by dumping in piles or windrows shall be spread uniformly to not more than the specified thickness prior to compaction.

Adjacent to structures fill shall be placed in a manner adequate to prevent damage to the structure and to allow the structure to gradually and uniformly assume the backfill loads. Hand compacted backfill shall be placed in layers not thicker than 4 inches. The height of the backfill shall be increased at approximately the same rate on all sides of the structure during placement.

4. CONTROL OF MOISTURE CONTENT

The application of water to the fill materials shall be accomplished at the borrow areas insofar as practicable. Water may be applied by sprinkling the materials after placement on the fill, if necessary. Uniform moisture distribution shall be obtained by disking, blading or other approved methods prior to compaction of the layer.

Material that is too wet when deposited on the fill shall either be removed or be dried to acceptable moisture content prior to compaction.

If the top surface of the preceding layer of compacted fill or the abutment surfaces in the zone of contact with the fill become too dry to permit suitable bond they shall be scarified and moistened by sprinkling to an acceptable moisture content prior to placement of the next layer of fill.

During placement and compaction of fill, the moisture content of the materials being placed shall be maintained within the specified range.

5. COMPACTION

The Contractor shall furnish and operate the types and kinds of equipment necessary to compact the fill materials in the specified manner or to the specified density.

For the purpose of this specification, compaction requirements are classified as follows:

a. Class A compaction is the compaction of the fill to such a degree that the fill matrix attains a density at least equal to the specified percentage of the maximum density obtained in compaction tests of the fill matrix. The fill matrix is defined as that fraction of the fill material having a maximum size equal to that used in the compaction [illegible] may be specified for the type of fill. The [illegible] and [illegible] the percent compaction required [illegible] of the work are specified in the construction details and drawings.

b. Class [illegible] compaction is the compaction of the fill by four passes per layer of fill of a pneumatic tired roller weighing at least 50 tons (static service weight).

c. Class S compaction is the compaction of the fill by either (1) the routing of the hauling and spreading equipment over the fill in such a manner that every point on the surface of each layer of fill will be traversed by not less than one tread track of the loaded equipment traveling in a direction parallel to the main axis of the fill; or, (2) equivalent methods approved by the Contracting Officer.

d. Class T compaction is the compaction of the fill by means of a tamping roller. The characteristics of the roller, the number of passes per layer of fill and the towing speed shall be as specified in the construction details.

e. Class V compaction is the compaction of the fill by four passes per layer of fill of a smooth-wheel vibrating roller at least 72 inches wide, weighing at least one ton (static service weight) per foot of width and capable of exerting a dynamic impact of at least 20,000 pounds at the rate of at least 1200 times per minute.

f. Class X compaction is the compaction of the fill by either: (1) four passes per layer of a crawler-type tractor weighing at least 40,000 pounds; (2) two passes per lift of a smooth-wheel vibrating roller at least 72 inches wide, weighing at least one ton (static service weight) per foot of width and capable of exerting a dynamic impact of at least 20,000 pounds at the rate of at least 1200 times per minute; or, (3) two passes of a pneumatic tired roller weighing at least 50 tons (static service weight).

The compaction equipment shall traverse the entire surface of each layer of material the number of times required to accomplish the specified compaction.

Adjacent to structures, compaction of fill shall be accomplished by means of hand tamping or manually directed power tampers or plate vibrators. Heavy equipment, except vibrating rollers, shall not be operated within 2 feet of any structure. Vibrating rollers shall not be operated within 5 feet of any structure.

The passage of heavy equipment will not be allowed: (1) over cast-in-place conduits prior to 14 days after placement of the concrete; (2) over cradled precast conduits prior to [illegible] days after [illegible]

[illegible] backfill [illegible] compacted above the top surface of the structure to a height equal to one-half the clear span width of the structure or pipe or 2 feet, whichever is greater.

Compaction of fill adjacent to structures may begin after the expiration of the following minimum time intervals after placement of concrete:

Walls and counterforts	10 days
Conduits, cast-in-place (with inside forms in place)	7 days
Conduits, precast, cradled	2 days
Conduits, precast, bedded	1 day
Antiseep collars and cantilever outlet bents	3 days

6. SPECIAL REQUIREMENTS FOR SECTIONAL CONSTRUCTION OF EMBANKMENTS

When sectional (or phase) construction of embankments is authorized, the work shall be accomplished in the following manner:

Each section of the embankment that is constructed in the first phase shall be so placed that a slope not steeper than 3 feet horizontal to 1 foot vertical is maintained at the end of the embankment section adjacent to the gap in construction or closure section.

Prior to placement of the closure sections the surfaces of completed fills and excavations that will be in contact with the closure fill shall be stripped of all loose material, scarified, moistened and recompacted as necessary.

During placement of the closure fill each layer shall be spread in a manner that will insure good bond between the two sections of fill when the new fill is compacted.

7. REMOVAL AND REPLACEMENT OF DEFECTIVE FILL

Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the specifications shall be reworked to meet the requirements or removed and replaced by acceptable fill. The bottoms of such excavations shall be finished flat or gently curving and at the sides of such excavations the adjacent sound fill shall be trimmed to a slope not steeper than 3 feet horizontal to 1 foot vertical.

[illegible] from the surface of the excavation [illegible] fill [illegible]. Replacement of fill shall be accomplished to the [illegible] for the closure section in Section 6 of this specification.

[illegible]. TESTING

During the course of the work, the Engineer will perform such tests as are required to identify materials, to determine compaction characteristics, to determine moisture content, and to determine density of fill in place. These tests performed by the Engineer will be used to verify that the fills conform to the requirements of the specifications. Such tests are not intended to provide the Contractor with the information required by him for the proper execution of the work and their performance shall not relieve the Contractor of the necessity to perform tests for that purpose.

Densities of fill requiring Class A compaction will be determined by the Engineer by the methods prescribed in ASTM Designation D 1556 (or by equivalent methods), except that the volume and moist weight of included rock particles larger than those used in the compaction test method specified for the type of fill will be determined and deducted from the volume and moist weight of the total sample prior to computation of density. The density so computed will be used to determine the percent compaction of the fill matrix.

9. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the volume of each type and compaction class of earth fill will be measured within the specified zone boundaries or limits and computed to the nearest cubic yard by the method of average cross-sectional end areas. In embankments, no deduction in volume will be made for embedded pipe conduits less than [illegible] inches in diameter.

Method 1. The quantity of earth fill will be measured as the computed volume of fill placed between the measured surfaces of the specified excavations and the specified neat lines of the fill surface.

Method 2. The quantity of earth fill will be measured as the computed volume of fill placed between the specified pay limits of excavation and the specified neat lines of the fill surface.

Payment for each type and compaction class of earth fill will be made at the contract unit price. Such payment will constitute full compensation for all labor, materials, equipment and all other items necessary and incidental to the performance of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 10 of this specification.

Construction Specifications for Concrete --
Spillways, Conduits and Miscellaneous Structures

by

Mr. Oswin Keifer, Jr.
Materials Engineer
Foundations and Materials Branch
Omaha District
Corps of Engineers
Omaha, Nebraska

presented at

4th Water Resources Design Conference
Iowa State University
Ames, Iowa

January 20, 1966

Manuals

Mr. Reifer discussed the pertinent aspects of concrete specifications as contained in the following manuals of the Corps of Engineers. These manuals contain specific information concerning concrete production and placement.

(1) EM 1110-2-2000 Standard Practice for Concrete

(2) Handbook for Concrete and Cement, prepared by the U.S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Abstract

"The Corps of Engineers places much importance on the writing of specifications and the engineering profession as a whole is beginning to take this same attitude. One prime objective of all concrete specifications is to insure that 'good concrete' is produced. Good concrete in this case is defined as uniform concrete. The Corps of Engineers makes use of the various types of cement available, as conditions warrant, even on small jobs. Water-reducing set-retarding admixtures are being used more and more to meet specific concreting requirements, especially in the precasting field. Specifications for major civil works jobs require that concrete aggregates be furnished from approved sources which have been thoroughly tested prior to the time specifications are issued. The Corps makes their own mix design studies for all but the smallest civil works jobs, and is in some instances employing the statistical evaluation procedures recommended by the A.C.I. for determining the required design strength level of the concrete. Batch plant requirements are based in part on the criteria published by the Concrete Plant Manufacturers' Bureau. Preparation of joint surfaces to receive the next concrete placement and thorough, effective curing are two concreting items which are emphasized in Corps of Engineers specifications and operations."

CONSTRUCTION SPECIFICATIONS FOR CONCRETE
SPILLWAYS, CONDUITS AND MISCELLANEOUS STRUCTURES
BY

OSWIN KEIFER, JR.
MATERIALS ENGINEER, FOUNDATIONS & MATERIALS BRANCH
OMAHA DISTRICT, U. S. ARMY CORPS OF ENGINEERS

presented at
FOURTH WATER RESOURCES DESIGN CONFERENCE
IOWA STATE UNIVERSITY
20 January 1966

1. INTRODUCTION

My subject is entitled "Construction Specifications for Concrete-Spillways, Conduits, and Miscellaneous Structures." Although the construction activities of the Omaha District range from the largest structures to the smallest, I will in general confine my remarks to civil works projects involving medium and smaller size concrete flood control structures. I will point out the Corps of Engineers attitude and procedures on various aspects of concrete specifications, particularly on those items we consider especially important or those on which we may take a slightly different approach than some other organizations.

When it comes to specifications, I sometimes think of the story about the man who saw a camel for the first time and asked the owner what it was. "Well, we call it a camel but actually it is a horse that we assembled according to a set of engineering specifications." I hope the engineering profession never gets to such a sad state.

Seriously, the preparation of specifications is every bit as important a part of engineering design as preparation of the plans. In the past, there has at times been an attitude throughout the profession to relegate specifications to a back seat, to treat the specification writer as a poor relative, or to make specification writing a last-minute assignment for the structural designer to finish as a slap-dab job after there isn't time for complete thought on the subject. We, in the engineering profession, are beginning to take a different attitude toward specifications. We are beginning to realize that the specification writer should be as highly trained, as well experienced and with as much responsibility and authority as the structural designer, with whom he must work in close cooperation. One thing that has brought about a change of attitude in the past few years has been the formation of the Construction Specifications Institute, and its untiring efforts to upgrade specifications and upgrade the quality of one preparing specifications. The Corps of Engineers places much importance on the writing of specifications and we attempt to tailor each set of project specifications to the actual structure being built. We, of course, cut down the size and complexity of concrete specifications for smaller structures, the same as we cut down the complexity of the plans. However, even then we try not to compromise the quality requirements contained therein. At times it may seem that our concrete specifications become too voluminous. However, we feel that spelling out exactly the materials and procedures required is essential. Essential not only to obtain the materials and finished structures that are desired, but also essential in fairness to the contractors in order to eliminate disputes arising out of misunderstandings that could be prevented by more clarity and more detail.

[illegible] procedures, [illegible] application of [illegible] procedures by the field inspector and the [illegible] the work. Some unknown engineer once made the comment "Good concrete is made of quality aggregates, tested cement, water and approved admixtures. Poor concrete is usually made of the same materials." This platitude, of course, has its exceptions. However, it stresses the fact that production of high quality in-place concrete is a continuing process involving the need for high grade materials, properly combined, mixed, conveyed, placed, consolidated and cured. Any weak link in this chain of operations will produce an inferior end product.

We, I am sure, are all in agreement that our objective is to produce good concrete. However, to define what we mean by good concrete is something else again. In one application it could mean high strength concrete and yet, as truly in other cases, this would not be a particular consideration. It could mean concrete free from cracks, concrete of high durability, concrete of high wear resistance or it could mean impermeable concrete. However, one definition that everyone should agree with and that is most important, is "good concrete is uniform concrete." Uniform from batch to batch and uniform from place to place in the structure. All work in the preparation and enforcement of specifications, is, or should be, aimed at securing uniform concrete in each particular project.

To get to actual specifications, as the first item to consider we normally think of materials. Cement is a logical material to head the list.

1. MATERIALS

a. Cement. There are five types of Portland cement available:

Type I - Normal

Type II - Modified

Type III - High Early Strength

Type IV - Low Heat

Type V - Sulfate Resistant

All five types can be obtained as "low-alkali" cements for which the total content of the minor alkalies, sodium and potassium oxides, is limited to 0.6 percent.

(1) Corps of Engineers specifications require Portland cement to conform to Federal Specification SS-C-192g, which is essentially similar to ASTM Standard C-150. On small jobs type I, normal, Portland cement is often permitted. However, on most civil works projects in the Omaha District, type II, modified, cement is required. Type II cement has both low heat of hydration and sulfate resistance qualities but to a lesser degree and at a lower price than type IV and type V cements. Type IV, low heat, and type V, sulfate resistant, are both relatively high priced cements and are used only in special situations. In many places in the Omaha District, particularly in the Dakotas and eastern Montana, sulfate soils and sulfate waters prevail. [illegible] for concrete construction [illegible] type II cement [illegible]. Type II cement is also required for structures in which massive

[illegible] used in the larger dam structures, [illegible] portland cement, in order to limit the heat of hydration. Because of these features, type II cement is usually specified for all construction concrete projects in the Omaha District, the attitude being that it is a product superior in quality to type I cement and is obtainable at only slight increase in cost. Type III, high early-strength, cement is seldom permitted on civil works projects except for use in precast and prestressed products. Type III cement presents more of a problem insofar as heat generation is concerned as well as increasing shrinkage and cracking problems. Regardless of the type of cement used, almost all project specifications prepared in the Omaha District require use of "low alkali" cement to insure against alkali-aggregate reaction. There are few locations in the Omaha District where there is assurance that reactive aggregates will not be encountered, one exception being parts of Iowa. However, low alkali cement is often specified even in areas known to be free of reactive aggregates, partly as a safety factor and partly, again, because low-alkali cement tends to be a higher quality cement with several desirable qualities, including higher strength producing characteristics, and is obtainable at only slight increase in cost. We also usually specify that all cement meet the requirements for control of false set, contained as an option in Fed. Spec. SS-C-192. This is included because in recent years there have been problems during construction due to false setting characteristics of some of the cements obtained in the Omaha District.

(2) Normally Corps of Engineers specifications provide for Government testing of the cement from samples taken at the mill. In the past sampling and testing have been performed by the National Bureau of Standards but, commencing this year, three Corps of Engineers laboratories have been assigned the duties of sampling and testing cement used by all Government agencies. On smaller jobs cement is accepted on the basis of certification of compliance from the cement mill or, more often, on the basis of certified results of tests performed by the mill laboratory.

(3) In recent years use of pozzolans as cement replacement materials has become more common in Corps of Engineers concrete construction for large structures. The main advantages obtained by using pozzolans are economy, some degree of control of alkali-aggregate reaction and control of heat rise and subsequent cracking. In this area flyash is the most commonly used pozzolan and is obtained from the steam power plants in the Chicago area. However, pozzolans are not particularly applicable for use on the smaller jobs since they require a more elaborate batching plant to handle the additional material. The Corps attitude is that economy should be the main reason for using a pozzolan even though there are other advantages to using it. Pozzolans are required to conform to Corps of Engineers Specification CRD-C262. When use of a pozzolan as a replacement for part of the cement is permitted by Corps specifications, it is always included as an option to the use of straight portland cement. If the contractor selects the pozzolan option, the Government makes extensive mix design studies since the percentage of cement replaced by the pozzolan can in some instances be quite critical.

b. Admixtures. [illegible]

(1) The most common admixture used in the Corps is air-entraining agents. The Corps of Engineers uses air-entrained concrete in almost all civil works construction regardless of exposure conditions. It is, of course, a necessity for exposed concrete in this part of the country and is used in most other concrete for better workability and ease of placement. Air-entraining agents must meet the requirements of Corps of Engineers materials specification CRD-C13 which is somewhat similar to the ASTM specification. We are rather particular about testing air-entraining agents because past experience has shown a high percentage of failures.

(2) The Corps of Engineers has been rather conservative about adopting water-reducing set-retarding admixtures for use in concrete construction, but we find that we are using them more and more now particularly for concrete requiring special qualities and for prestressed concrete. Our specifications state that these admixtures must meet the requirements of ASTM Standard C-494. When water-reducing admixtures are used, we always require special mix-design studies because of the possible variation in the performance of each admixture with different cements and different aggregate combinations. We require that special provision be made when batching a water-reducing admixture in order to prevent its mixing with the air-entraining agent until both are in the mixer because many such combinations are incompatible. Once the two admixtures are in the mixer and are in contact with the alkaline cement and water mixture there is no problem.

(3) The Corps of Engineers permits the use of calcium chloride as an accelerator for cold-weather concreting operations in some instances but we do require quite rigid controls in its use. Never do we allow more than 2% by weight of the cement. When calcium chloride is used there is a greater tendency for shrinkage cracking and also for problems related to alkali-aggregate reaction.

c. Aggregates.

(1) Corps of Engineers specifications for major civil works projects list approved aggregate sources from which all or nearly all material is accepted rather than listing limits for deleterious materials and test results in the specifications. The reasoning behind this method of specifying aggregates is, to quote from our "Standard Practice for Concrete": "The quality of aggregate is not controlled by specifying limits on properties such as sulfate soundness, organic impurities, Los Angeles abrasion, specific gravity and absorption. It is intended that at each project the aggregates used will be the best economically available." In other words, it is the intent of the Corps of Engineers to use the best construction materials, including concrete aggregates, locally and economically available to any construction project. On major civil works jobs we evaluate aggregates available in the general area during the design stage. The aggregate sources containing material considered of sufficiently high quality to warrant it are sampled and tested. The results are compared one against the other as to quality, taking into consideration the price or economic availability of the material under consideration. This approach to aggregate acceptance requires a thorough investigation and testing program for each general area where construction is planned. This, of course, is expensive and precludes its use for smaller projects.

on small projects where it is not considered economically justified to make the thorough aggregate investigation required for the use of standard specifications are prepared listing limits for permissible amounts of deleterious materials and limits on the results obtained in standard tests on the aggregates. When we do use a limit type specification for aggregates, we quite commonly reference Fed. Spec. SS-A-281b as the standard of quality. The requirements contained in it are nearly the same as those in ASTM C33.

(2) One of the main advantages of concrete that makes it so valuable as a construction material is the fact that a high percentage of the finished product is made up of materials, aggregates, which are in most instances readily available in the general area of the construction site. If the project is sufficiently large to warrant it, a wide range of aggregate gradations can be accommodated by means of suitable processing and variation of mix proportions. The old Roman engineer Vitruvius commented on this in his writings. Some people say Vitruvius was the first engineer able to write intelligently; there are others that say he was also the last. Anyway, he commented concerning concrete production, "I do not decide what ought to be the materials for walls, because we do not everywhere meet with such as are most desirable; but we must make use of such as we can find." A prime example of this idea of adapting to the materials available is our use of so-called "sand-gravel" with limestone coarse aggregate addition instead of the usual type of aggregates. This situation is encountered in extreme western Iowa and throughout much of Nebraska. The use of these materials is based on economy since they are the materials locally available. "Sand-gravel" is the local term applied to natural coarse sand treated with a minimum of processing to produce a fine aggregate with a maximum size of 1 inch, with 5 to 25 percent retained on the No. 4 sieve, and with an overall gradation coarser than that commonly used for fine aggregate. This material was originally accepted for use years ago because it was available and the minor processing used added very little to the cost. Later when the Corps commenced work in the area this material was accepted for use since it was the only material readily available and the service record of concrete made with this has been reasonably good. However, most of this sand-gravel aggregate is quite reactive and, to counteract this, 30 to 50 percent limestone course aggregate "addition" is required to be used with the sand-gravel. There is no agreement as to how this limestone counteracts the reaction, but experience has shown that it does. Again, the Corps goes along with local practice in this.

(3) Regardless of laboratory tests made on concrete aggregates it is still felt that the best criteria for evaluating an aggregate is its service record in actual concrete construction in the area under consideration. It is felt that the best laboratory test for evaluating an aggregate is the rapid freezing and thawing test of concrete specimens. We use all the standard tests on concrete aggregates including the elementary tests such as determination of deleterious materials, including shale particles, light weight pieces, chert, soft particles, iron manganese concretions, and other deleterious materials peculiar to any particular area; magnesium sulfate soundness test; freezing and thawing in concrete specimens; freezing and thawing of the aggregate both with water and with alcohol and water; Los

Angeles abrasion, bulk specific gravity, absorption and alkali-aggregate reaction both by mortar bar and quick chemical tests and those for organic impurities. In addition, the Corps makes extensive use of petrographic examination to evaluate aggregates. Normally the Corps of Engineers itself performs all testing of aggregates. For some projects with minor amounts of concrete the contractor may be required to have the aggregate tested by an approved commercial testing laboratory and to submit test results for approval.

3. PROPORTIONING

For all but the smallest Civil Works projects the Corps of Engineers itself makes the concrete mix design studies, normally in the Division Laboratory. On some small Civil Works projects the specifications require the contractor to hire an approved commercial testing laboratory to make the mix design studies. Often for these small jobs a fixed cement content is specified instead of a required compressive strength and there is no separate pay item for cement. Where the Corps makes the mix design studies, normally there is a separate pay item for cement. Normally the beginning mix design is based on achieving a compressive strength, 15% greater than the required "minimum" strength. Then when strength results of 28-day jobsite test specimens become available, the mix design is adjusted to reflect the results of field testing.

a. In the last few years we are leaning more to the approach recommended by the American Concrete Institute for statistical evaluation of results of tests on compressive strength specimens and have used similar evaluation and control methods for several important projects. This is the approach that says it is unrealistic to specify a "minimum" strength since by operation of the law of averages there will always be an odd specimen now and then which will test excessively low, regardless of the average strength designed for. Instead of giving an absolute minimum strength, there is the requirement that a certain percentage of the test specimens must be above some minimum strength. To be effective this approach must be combined with the requirement that the contractor furnish the cement as a part of the concrete without separate payment. This then furnishes an incentive for the contractor to control his operations carefully so as to keep the coefficient of variation of concrete tests at a low point. This permits use of a lower average strength and in turn a lower cement content which is money in the contractor's pocket.

4. BATCHING AND MIXING AND CONVEYING

Semi-automatic batching plants are required for medium sized jobs. For the smaller jobs we allow manual batching plants. However, regardless of the type of plant used we insist that the plant conform to the requirements of the Concrete Plant Standards of the Concrete Plant Manufacturer's Bureau and that the plant be in good operating condition. It is required that the plant be checked at regular intervals and that the delivery of materials to the mixer within the following limits of maximum error:

[illegible]

Cement
Water
Aggregates
Admixtures

For most medium and smaller Civil Works projects we allow the use of stationary mixers, truck mixers and the new high-speed turbine mixers. Due to the greater chance of variability in concrete produced and also in order to insure that we do not exceed the maximum allowable water-cement ratio, when truck mixers are used we require that all materials, including water, be batched through the Central Batching Plant.

We find that on most of our medium to small size projects we usually are furnished ready-mixed concrete delivered in truck mixers. The acceptance of truck mixers by the engineering profession has changed within the last 20 years from the former attitude of a reluctance to whole-heartedly accept ready-mixed concrete as the equal of job-mixed concrete to the point now where we expect and usually get continuously high quality ready-mixed concrete. This is due to improvements by the ready-mix companies, particularly better communications between the placing site and the batching plant, and also to more experience in the handling and control of ready-mixed concrete. We do limit the time that concrete is allowed to remain in a truck mixer particularly in hot weather. We do allow the use of nonagitating equipment for hauling concrete but require that it be constructed with a body which will dump without causing segregation. For conveying concrete at the placing site we usually prohibit the use of belt conveyors and the indiscriminate use of chutes since both of these have a high tendency to cause segregation of concrete. We do encourage the placing of concrete by means of wide-opening bottom-dump buckets and on all but the smaller jobs require this method. All concrete is required to be consolidated by means of high-frequency mechanical vibrators.

5. JOINTS, FINISHING AND FORMING

Horizontal construction joints, particularly those in hydraulic structures, must be properly treated before the next lift of concrete is placed thereon. Normally the requirement is that the joint be either wet sandblasted immediately before the placement of the succeeding lift or that the joint be air-water cut at the proper time just before the surface concrete completely hardens in order to expose part of the surface aggregate and provide a good bonding surface for the succeeding lift. Even when air-water cutting is used, however, it is required that sandblast equipment be maintained available at the job site for further cleanup if at any time it is considered desirable. This surface cleanup has been found by tests to be the one most important factor in producing a sound joint between succeeding lifts of concrete. Immediately before the next lift of concrete is placed the surface of the joint is coated with a thick grout of portland cement, sand and water. This joint preparation is very important and should never be neglected in a hydraulic structure.

a. *Finishing.* Type specifications require that the finishing of unformed surfaces be the minimum necessary to produce the type of surface desired and that the surface concrete be handled no more than absolutely necessary. Never is a trowel finish permitted unless the plans or specifications require it. This is in line with the often expressed feeling that we build slabs upside down - the best concrete at the bottom - and that the more we handle the concrete, the worse we make it. Never during finishing operations is use of any type of dryer such as portland cement or fine sand permitted since this very greatly detracts from the quality of the concrete surface.

b. *Forming.* Normally in the smaller hydraulic structures the type of finish required for exposed concrete surfaces is our so-called 'Class B" finish. This finish permits the use of any of the following form materials, tongue and groove lumber, shiplap, plywood, concrete form board or steel. Steel lining on wood sheathing is not permitted. This requires that irregularities in the finished surface must be limited to the following: Abrupt irregularities not over 1/4-inch, gradual irregularities not over 1/2-inch in 5 feet. Any imperfections in the formed concrete surface must be repaired immediately after forms are stripped. This refers to cone bolt holes and actual imperfections such as rock pockets, grout leaks, etc. These must be patched with a damp pack mortar. For permanently exposed surfaces this must have sufficient white portland cement mixed with the standard Portland cement to provide a color matching the adjacent surface.

6. CURING AND PROTECTION

Curing and protection of freshly placed concrete is considered to be one of the most important items of concrete construction. Since appropriate conditions of moisture and temperature are necessary for hydration of the cement and since tests have shown that not more than half the cement grains ever completely hydrate even under ideal long-time curing conditions, it can be seen why appropriate curing and protection procedures are essential to produce top quality concrete. Although rate of gain decreases rapidly, gain of strength in concrete is continuous as long as appropriate curing conditions prevail. The need for curing is even more important in order to produce impermeable concrete.

The standard against which all other curing methods are evaluated is of course, moist curing, either by ponding or by covering the concrete with burlap or cotton mats kept continuously moist. The essential requirement is that the curing material and the concrete under it be kept continuously moist during the entire curing period. The second method of curing concrete is by preventing the evaporation of the mixing water by means of watertight sheeting covering the concrete, such as polyethylene sheeting, waterproof kraft paper, etc. The prime requirements here are that the joints between sheets be completely sealed, that the material fit tightly against the concrete on all exposed surfaces, and that the material be applied while the concrete is still in a thoroughly moist condition. The third method of curing concrete is by means of a membrane forming curing compound sprayed onto the surface of the concrete. Here, of course, the [illegible] satisfactory [illegible] but that it [illegible] the entire [illegible] of the curing period. The Corps of Engineers uses such curing compounds and where possible requires that the curing compound be a pigmented white or gray material both to provide reflectance of the sun's rays and thus prevent heating of the concrete and also to visually indicate if there is a complete seal present. However, for aesthetic reasons, this white pigmented curing compound is often not desired since it leaves a rather spotty appearance for a period of time as it weathers off. Hence, in structures exposed to the public view, clear type curing compound with a "fugitive" dye that disappears a few hours after application is required. The Corps of Engineers is very particular about testing curing compounds since past experience has shown a number of failures. Under normal conditions of temperature, the Corps of Engineers requires that concrete containing type III cement be cured for three days, concrete containing type I cement be cured for seven days and concrete containing type II cement be cured for 14 days. If type IV or V cement is used or if a pozzolan is used the concrete must be cured for a minimum of 21 days.

During cool weather the concrete must have protection from the low temperature. We use a number of different specification requirements depending on the situation involved. One common requirement is: "The air and forms in contact with concrete shall be maintained at temperatures above 50 degrees F. for at least the first three days and at a temperature above freezing for the remainder of the specified curing period. The temperature protection equipment, the curing water and the removal of forms shall be handled in such a manner that the surface concrete will not be subjected to a temperature differential of more than 25 degrees F."

7. STEEL REINFORCEMENT

Corps of Engineers specifications concerning steel reinforcement are pretty standard. We specify that steel must conform to the various classes covered by Fed. Spec. QQ-B-0328 rather than to ASTM Standards, although the requirements are similar. We are quite particular about any welding involving reinforcing steel especially the hard grades. Any welding of the harder grades of steel must be done in strict conformance with the requirements therefor specified by the American Welding Society. Improper welding techniques on the hard grade steels can cause them to become quite brittle and subject to easy breakage.

8. CONCLUSION

I have pointed out to you some of the special requirements contained in concrete specifications prepared by the Corps of Engineers and some of the items that we think are particularly important. I wish to again emphasize that we, the Corps of Engineers, feel that preparation of specifications is an extremely important subject, equally important with preparation of plans for a project. Further, the administration of the specifications by the field forces, and the use made of the specifications by contractors are prime factors in determining whether or not high quality concrete structures are built.

CONSTRUCTION SPECIFICATIONS
for
RECREATIONAL FACILITIES

by

Wm. Randolph, Engineer
State Conservation Commission
Des Moines, Iowa

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The topic of construction specifications for recreational facilities will be presented in two general categories. The First, Design Requirements, are presented here because the requirements of recreation are generally much different than are those of highways, office building, industrial complexes etc. The second category, the Specifications for the control of the work, are very similar in structure, and often interchangeable with, specifications for the above mentioned projects. It is the intent of this presentation to outline in general terms those requirements which are peculiar to outdoor recreation as we know it in Iowa.

In the development of a design for an engineering project there are many factors that must be considered by the designer before a decision is made as to the general concept of the master plan. This certainly holds true in the field of recreation planning. The master plan shows the relationship of any one facility to all other facilities along with the topography of the park or proposed development. By laying out these facilities in their respective positions, and to a reasonable size scale, it is possible to provide an orderly, functional recreation area without the inherent hodge-podge of an unplanned development. It may be proper to draw the analogy that the master plan is to the development of a reacreation area what a city or county zoning plan is to the orderly development of a city or county. Since this plan is prepared early in project conception, later and more detailed information may dictate some changes in the plan. This would be considered proper updating of any plan.

Over the years we have developed a sequence of operations that have proven useful to us in our engineering work. It is not the intent of this presentation, however, to set maximum or minimum standards or procedures for any other organization interested in recreational development.

When a new project is contemplated, a feasibility study and report is prepared by the Engineering Section, which delineates the feasibility from an engineering standpoint only. Economic feasibility, biological feasibility, etc. are determined by others in the Conservation Commission. This preliminary report includes: a hydrologic and hydraulic study, particularly where lakes or marches are involved; a preliminary features map and a preliminary master plan, along with a set of very preliminary plans for the engineering construction and a rough cost estimate. No specifications are written at this stage of the project planning. The particular requirements of recreation are considered during the preparation of the master plan, and all subsequent designs.

DESIGN REQUIREMENTS

Roads

We are all familiar with the design criteria of our primary and secondary roads as set forth by the Iowa Highway Commission. These standards, however, are based on conditions almost totally foreign to those experienced in park roads. One of the basic departures from primary and secondary designs is the factor of speed. Park roads are slow speed roads leisurely winding their way from one point of interest to the next. It is rare indeed when a design speed in excess of 30 m.p.h. is used. Horizontal curves make up a very high percentage of the total length of the road and long tangents between curves are definitely discouraged. The degree of curvature may approach or exceed 60 degrees without adverse effect but should not occur following two or three 10 degree curves where traffic speeds could build up toward maximum. Grades of 12% are not uncommon; however, the designer should keep in mind that roads to camping areas will have trailer traffic that cannot comfortably negotiate too long an excessive grade.

Site distance of 700 feet is certainly not necessary. More often than not, a site distance of 200 feet would satisfy the conditions encountered on a park road. For purposes of safety, apprcach segments to pulloffs, entrances to parking lots or picnic areas, etc. should be tangents of approximately 100 feet or more. With reasonable care in the selection of the road alignment these tangents can usually be increased well beyond the point where safety is threatened.

The road ditches are designed in pretty much the conventional manner with one major exception. No snow storage factor is considered since these roads are generally summer roads and, with few exceptions are not kept open during winter. This criteria, of course, does not apply where traffic to the custodial residence or winter sports area is to be expected.

Our operating section, Parks, has indicated that it is desirable to provide a single access to a park complex and that this access should pass directly adjacent to the custodian's residence. Whether the residence establishes the road location or the road location determines the residence locations would seem immaterial at this point.

The matter of surfacing for park roads can best be determined by conventional standards. Economic considerations may be the most influential one factor to consider although few park patrons appreciate the dust inherent to gravel surfacing.

Wherever possible, trails should be provided for pedestrian and horse traffic rather than using the vehicle roads for such purposes. This, however, is not always possible and added top width must be provided where the dual purposes are involved. Usual top widths are 26' with 20' of surfacing for vehicle roads.

Camping Areas

Camping is becoming a popular form of recreation. We have experienced a 100% increase in camping units in the last 3 years with some form of wheeled vehicle showing the most rapid growth. The camper today is a far cry from the primitive tenting of the W.W. II era, and modern conveniences are almost mandatory. The wheeled vehicle, whether mounted in a pickup or towed behind a car, requires a substantial flat area on which to park the vehicle and around which the family unit can set up housekeeping.

In the selection of an area to be used for camping, it is desirable to select, insofar as practicable, an area which is divorced from the other principal uses. Campers desire a quiet atmosphere away from the hustle of the more athletic recreation indulged in by many of the park patrons. A reasonable view of the lake, or other special attraction, is also quite desirable. Tent camping is generally located nearer the lake than the trailers because of the lower silhouette presented by the tents thus permitting trailer occupants to see over the tents. Sixteen camping units per acre, a space 50' x 50', is considered optimum. Topography, gullies, trees, etc. will influence the shape of the unit, and to some degree, the density of the campers.

Modification of the natural topography will usually be necessary to provide the "flats" for the campers. In an effort to avoid a major grading program in the camping area which would be necessary if the entire area were to be modified, it is acceptable, and generally desirable, to treat each camper site as an individual unit. Small cuts and fills will often suffice and still permit a minimum of clearing of natural timber. Seldom is it possible to develop a camp site without modifying the natural surface drainage pattern. The use of terraces to direct surface runoff into safe outlets should not be overlooked. Small ponds and marshy areas in or near camping areas should be drained.

Shower Buildings & Toilets

Early in the development of a master plan a decision must be reached regarding the extent to which modern sewer and water facilities are going to be developed. Where primitive camping is contemplated, it is not uncommon to provide a vault type latrine without a water supply. A tap for drinking water may be a mile away and patrons will need to provide their own means of transporting their water needs. When it is anticipated that camping density will be such that modern facilities are economically feasible, a shower and toilet building is constructed. These buildings can be expected to serve a radius of 300 feet and should the camping area extend much beyond this limit a second unit should be constructed.

In the design of the building, every effort should be made to provide adequate light and ventilation. Dark, poorly drained, hard to clean corners and recesses should be avoided in the interest of sanitation. Concrete block, or any other porous finish material, used as an interior finish must be smoothed and sealed. Glazed block interiors are most satisfactory from the standpoint of sanitation and ease of cleaning. Self closing faucets and shower heads will conserve water. Our experience has indicated that China fixtures are subject to a high mortality and more durable material is indicated.

Hot water for showers, etc., is a major problem. There is always the matter of how much hot water is needed for a shower and how many people will take a shower. We have not provided as much capacity in our shower buildings as would be supplied in a commercial installation of comparable size or serving a comparable number of patrons. We have found that 50 gallon high recovery water heaters are a very minimum for our standard shower building with 4 shower stalls and 4 lavatories.

Picnic Areas

In the average recreational park about 50% of the attendance will be using the picnic facilities at any one time. The other 50% will be using the beach, lodge, camping facilities, etc. Overcrowding can be avoided by providing an acre of area for each 60 picnickers. Where terrain is favorable, with little unusable area, the density can be increased. Poor terrain, gullies, dense trees, steep slopes, etc., would dictate a lower population density. Every effort should be made to take advantage of existing shade trees in setting up the initial picnic areas. One or two table areas should not be overlooked. Vehicle parking immediately adjacent to the table is not necessary, but, in some cases, is quite possible and even desirable. Adequate refuse containers must be provided for the public if litter is to be avoided. The collection of refuse is expedited when the picnic areas are not too widely scattered throughout the park but always keep in mind that people come to parks to get away from the congestion of the apartment or housing development.

Water supplies into picnic areas are most desirable and may be in the form of hydrants and fountains connected to the distribution system or wells with hand pumps. Should hand pumps be used, the pump head should be equipped with a packing gland around the pump rod to eliminate contamination of the water in the pump. Compliance with all the requirements of the Department of Public Health is mandatory.

The use of redwood or cypress in the construction of picnic tables has not proven satisfactory in state areas principally because of the hard service given the tables. A stronger, more durable, wood such as Douglas fir or most of the pines will give much longer service. The life of the table is usually not determined by its resistance to weather and rot - but rather by resistance to shock. Annual painting of the wearing surface is a must.

Beaches & Appurtenances

The location and design of the beach area is a very important facet in park planning. Slopes, under the water, should be quite modest and all sharp dropoffs must be eliminated. A point is generally less subject to stagnation and accumulation of surface debris than is a bay. Retaining walls, above the water line, can be used where natural slopes are excessive. Sand for the beach should be clean, washed and screened to the extent that all plus 3/8" size is removed and no more than 2.5% of minus 200 remains. At least 40% should fall between #8 and #30. Some flexibility is necessary in the selection of suitable beach sand to make use of readily available supplies in the interest of economy. A 6" depth of sand is about minimum.

The size of the beach is determined by providing approximately 30 square feet of beach per bather. A portion of the swim area should be roped off for small children and non-swimmers since wading pools are generally not feasible. We have used wooden, cork, and plastic floats for the life line with about equal success. Anchorage for the life line should be in the form of a block of concrete, etc. as opposed to a post of any type driven into the lake bottom, since ice will dislodge almost any light post that would otherwise be stable enough for the life line.

Bathhouse facilities very with each installation. High use beaches are generally provided with a bathhouse rather than change booths that are popular at low use beaches. Bathhouse designs range from very simple two wing change booths to quite elaborate concessionaire operated structures. The availability of sewer and water will make a pronounced impact on the basic design and will determine to a large degree just how elaborate and formal the facility can be. Whether the architecture is modern or rustic is a matter of choice of the owner and would not effect the functional aspects of the basic design. If food service is contemplated, something more than candy bars and pop. it is imperative that sewer and water be incorporated in the design. As was previously mentioned in the discussion os shower buildings, the use of self-closing faucets and shower heads will conserve water, more particularly hot water. The use of stainless or porcelain coated cast iron fixtures will generally be more economical in the long run than China fixtures.

In determining the physical location of the bathhouse in reference to the shore line it is good practice to ascertain that the bathhouse will be above any surcharge elevation that the lake could attain. This generally does not present a problem, however, we have one installation where the bathhouse floor is only 2.8 feet above lake crest. When the spillway was reconstructed recently, this limiting surcharge factor made it necessary for us to design a much longer weir crest length than would have been necessary had we had available more surcharge storage. Savings in the cost of the spillway reconstruction would have been substantial.

Water & Sewer

Early in the development of the Master Plan, the problem of water and sewer must be considered. The widely scattered development add to the cost of supplying these services, yet having these services, yet having the various development concentrated into a congested area defeats the concept of outdoor recreation.

Several wells scattered throughout the park may well be the most desirable solution to the water supply problem particularly in that portion of the State where ground water is readily available. Where ground water is a problem, the treatment of lake water and usually lengthy distribution lines will provide the needed water supply. The design and construction of drilled wells will be discussed by others at this meeting and consequently will not be needed here. Service pumps range all the way from inexpensive hand operated pumps to complete automatic systems. Where automatic systems are to be used, we have found that it is possible to use the lower capacity pumps and large volume storage tanks to good advantage. Peak water usage in recreational areas occurs at three specific times during the day. A peak occurs in the morning in the camp area when the campers first arise. The usage then drops off until about noon when most other facilities - beaches, picnic areas, etc. enter the water use period. Another peak occurs during mid-afternoon with the maximum peak occurring during the supper hour when almost all facilities are used at their maximum. The large storage volume is depleted during these high use periods and is subsequently replaced during the low use periods. With the exception of our very high use parks we have been quite successful with pumps of 20 g.p.m. and less by taking advantage of these off periods to replenish the storage.

Where surface water is to be treated in a central plant and distributed to the ultimate use area the selection of the plant site is most important. In the interest of economy, the plant should be located where minimum distribution lines will be needed. A location where the best quality water is available must also be considered. These arenot necessarily the same location. Within reason, quality raw water is the controlling factor. In regard to the plant itself, several package units are on the market that are designed to perform specific treatments to varying degrees of success, and all arenot satisfactory. Care must be exercised in the selection of a package plant. Surface water treatment is a delicate thing and the services of a professional in this field should be secured.

We have used practically all types of water pipe for underground distribution and probably no single material is completely satisfactory under all circumstances. Some soil conditions are such that copper pipe will deteriorate in two years and must be replaced. Gophers and other burrowing animals will eat holes in plastic pipe. Rigid pipes are subject to breakage from shock or freezing. The selection of the proper material for a specific location is best made by determining the long range economics of the various materials available.

The treatment of sewage falls strictly into the category of domestic sewage as opposed to industrial sewage. In low usage isolated areas, small picnic areas, launching ramp areas, etc., a well constructed vault latrine will serve the purpose. These must be kept clean and free of flies and the vault cleaned annually. We have used several different chemicals for fly and odor control in our vault latrines. An enzyme product, now avilable, does an excellent job of digesting solids and controlling odors; however, a fungus or bacterial black stain appears on the walls of the latrine, giving the appearance of poor maintenance. As yet we do not have a solution.

The introduction of the sewage stabilization lagoon concept of sewage treatment has made possible, in many cases, a pronounced reduction in the cost of sewage treatment in parks. The conventional treament plant, with all of its mechanical devices and operating costs, is eliminated. Effluent discharge lines to outfalls of one type or another are not necessary when a lagoon is designed for total storage. The size of the lagoon is determined by balancing the inflow volume to the expected net evaporation from the liquid surface. Since parks are generally operated only during the summer, when evaporation is high, the balance is much more easily determined. An operating depth of 2.5 to 4.5 feet is optimum. Loadings of 20 pounds B.O.D. per acre per day has been acceptable for park insallations.

Standard practices of sewer design apply to park sewers as well as city sewers. Approval of the State Department of Public Health must be secured for both the water supply and sewage treatment systems.

DESIGN & CONSTRUCTION OF DRILLED WELLS

Robert D. Reckert

A paper presented on January 20, 1965, at the Fourth Water Resources Design Conference, Iowa State University, Ames, Iowa, by Robert D. Reckert, Partner; DeWild, Grant, Reckert & Associates, Company; Consulting Engineers; Rock Rapids Iowa.

Wells have been used as devices for obtaining water from the ground to supply the needs of cities and towns, industries, and irrigation districts for countless generations.

Wells may be classified into types according to their method of construction as dug, bored, jetted, driven, and drilled. Each has certain advantages based on ease of construction, volume requirements in terms of capacity, storage, mechanical limitations on the types of formations and depth that the equipment can penetrate, and economics. The first four are generally reserved for shallow (less than about 50 ft.), low capacity requirement installations. The fifth type, drilled wells, are constructed by portable drilling machines, either percussion or rotary.

Wells drilled with rotary equipment will be the subject of this paper. In order to describe procedures, design, and construction in the most practical manner, a hypothetical problem will be stated and certain assumptions made as to the depth and geological classification of the aquifer existing in the locality in which the water is required. With these factors stated, the paper will outline the procedures recommended and required to carry the project through to a satisfactory conclusion.

Outline of the Problem and Conditions

Let it be assumed that a new industrial plant will be constructed which will require process water capacity from ground water sources of 1,200 gallons per minute. (gpm)

Storage requirements, service factors, and water treatment are all matters which must be investigated in a real problem, but are considered beyon d the scope of this paper and will not be discussed.

A written request to the Iowa Geological Survey for a Geological Forecast of ground water conditions in the vicinity of the proposed construction site results, in part, in the following comments:

"Formation	Thickness (ft.)	Depth Range (ft.)"
Quaternary System		
Pleistocene Series (glacial drift clay, containing a few interbedded sand and gravel layers)	100 - 150	0 - 150 ±
Cretaceous System		
Undifferentiated shale & sandstone	50 ±	150± - 200±
Dakota Sandstone	100 ±	200±-- 300±
Pre-Cambrian System		
Undifferentiated basement rocks (igneous &/or metamorphic)		900 ±

"All of these depth estimates may have to be modified considera-ably owing to local variations in the structure and thickness of the beds."

"Thin interglacial sands are widely used as source beds for domestic and stock wells in this area, but are not expected to yield large supplies of water such as needed by industrial consumers."

"The City of __________ wells located 2½ miles northeast of the proposed site are completed in the Dakota sandstone formation at a depth of 210 feet and provide reported yields of about 500 gpm each."

"The Dakota Sandstone seems to be one of the most promising sources for reasonably large quantities of ground-water based on hydrologic data from this part of Iowa. However, the aquifer conditions are not uniform, and at some wells the results are less favorable. The sandstone commonly is very fine-grained and poorly cemented which often leads to serious pumping troubles."

From the Geological Forecast, the Dakota Sandstone aquifer, located approximately 200 feet to 300 feet below the ground surface, appears to offer the best possibility for obtaining the quantity of water needed at the least depth.

Design and Specification Requirements

At this point the engineer must decide whether he has or can obtain adequate information to proceed with design and specifications for the construction work in one unit price contract or whether he must first obtain additional information about the aquifer through exploratory test drilling and test pumping in order to be able to prepare the design and specifications for the construction work as a second step in the procedure.

From the Geological Forecast, the factors that are known or verifiable are listed below:

1. Dakota Sandstone, of water-bearing character, probably occurs at a depth of from 200 feet to 300 feet below the ground surface and is about 100 feet in thickness. The sandstone is probably very fine-grained and poorly cemented.

2. Existing City-owned wells located within 2½ miles of the proposed site reportedly produce about 500 g.p.m. each which can be verified in the field in which case, if correct, it will probably be necessary to construct two new wells, properly spaced, in order to supply the industrial plant requirement of 1,200 g.p.m.

3. From the existing City wells, the static water level, pumping water level, and mineral quality of the water in the aquifer can be obtained.

With this information, using good judgment and making provisions in the contract specifications for obtaining specific information on the unknown factors, it is feasible to design and prepare specifications for the proposed construction in a single unit-type contract.

Some of the information that must be provided for and obtained through the specifications is listed below:

1. Number of wells required; yield per well; spacing of wells.

2. Pump bowl diameter; pump suction level setting; diameter of well casing.

3. Type of well construction through aquifer; open hole through aquifer or screened aquifer; natural or artificial gravel envelope; diameter of well drill hole; construction materials and requirements.

4. Construction procedures; quality control and evaluation.

5. Pumps and auxiliary equipment.

Obtaining Technical Data for Specifications.

Since two existing wells, constructed in the proposed aquifer, are located reasonably close to the proposed site, the engineer should obtain as much information as possible regarding their depth, construction and performance. Simple measurements will determine diameter, depth, and static water level. Since they are municipal wells, permission can generally be obtained to run a short duration pumping test. From this the pumping level can be obtained, and with suitable measurements, estimates of aquifer coefficients (transmissibility, storage, etc.) can be computed. A water sample can generally be obtained for mineral analysis and a log of the existing well and well construction details will probably be available from the City, the State Geological Survey, or State Department of Health.

The engineer cannot assume that conditions will be the same at the proposed site as those prevailing at the existing wells but may use the information obtained as a guide in preparing the design and specifications for the proposed wells.

Let it be assumed that the investigation of the existing wells reveals the following information:

Ground elevation at wells -	1,000 ft. (above M.S.L.)
Depth of wells -	210 ft.
Diameter of wells -	12" casing x 24" bore diam.
Generalized log -	0'-100' (glacial till & sand. lenses)
	100'-140' (shales & lenses of sandstone)
	140'-210' (Dakota sandstone)
Static water level -	30' below ground surface
Type of aquifer -	artesian (Figure No. 1-A).
Pumping level after 12 hrs. @ 500 g.p.m. -	55' below ground surface
Specific Capacity -	20 g.p.m. per ft.
Coefficient of Transmissibility -	50,000 gals.per day per ft.
Drawdown (interference) at well used as observation - well after 12 hrs. pumping of pumped well @ 50 g.p.m. -	4 ft.

Results of mineral analysis indicate water in formation to be slightly corrosive.

Number of Wells Required; Yield per Well; Spacing; Depth

From examination of the existing wells, it can be assumed that two new wells will be required at the industrial site, that it is reasonable to assume that the wells will each produce 600 g.p.m., and that to avoid excessive interference between wells during pumping over a period of years they should be located approximately 1,000 ft. apart. A level network run to the new site indicates the average ground level is about 1,050 ft. above Mean Sea Level. It can be assumed that the aquifer at the new location will be relatively level with the elevation at the existing aquifer. Therefore, the new wells will probably be about 260 ft. deep and the static water level and related functions about 50 ft. deeper than in the existing wells.

In the event that any or all of the above assumptions prove to be incorrect, because of the use of a unit price contract, modifications and corrections can be made in the actual well construction during the construction of the first new well.

Pump Suction Level Setting; Pump Bowl Diameter; Well Casing Diameter

At this point in design it is necessary to determine the approximate pump suction level setting, pump bowl diameter and the well casing diameter.

In order to determine the approximate pump suction level setting, it is necessary to estimate the approximate pumping level in the well after pumping both wells at the required capacity for a period of about 10 years. This can be roughly determined by projecting the data obtained in the pumping test on the existing well field and includes the following:

1. Static water level in well.

2. Self-caused drawdown of pumped well.

3. Drawdown caused in pumped well from pumping of adjoining well.

4. Drawdown caused in pumped well from pumping of City wells located 2½ miles distant.

Although these projections may not be precise, any corrections required can be made after conducting the pumping test on the first new well from which actual aquifer coefficients can be determined and prior to ordering of the permanent pumping equipment. Since most ground waters are relatively cold (45° F - 60°F) it is usually not necessary to consider net positive suction head requirements if using vertical centrifugal (turbine) pumping equipment. Net positive suction head in a vented well is the sum of the barometric pressure plus the static suction head minus friction head-loss in the suction piping and the vapor pressure of the water, all expressed in feet of water. As long as the pump bowls are submerged, cavitation will generally not occur. For design and specification purposes it is assumed that the pump suction level setting will be as follows:

1. Static Water Level	80 ft.
2. Self-caused Drawdown	50 ft.
3. Drawdown from Adjoining Well	12 ft.
4. Drawdown from City Wells	3 ft.
Estimated Pumping Level	145 ft. below ground surface

The presence of any aquifer boundary conditions and efficiency of the well can be evaluated after conducting the pumping test on the first well and the pump level setting for the permanent equipment adjusted accordingly.

In order to estimate the pump bowl diameter required, the pump capacity, total dynamic head, and approximate specific speed of the pump must be known. The pump capacity required is 600 g.p.m. The total dynamic head is the sum, in feet of water, of the pumping level to surface (145 ft.), losses through the pump (estimated to be 5 ft.), friction head losses in discharge piping and fittings (estimated to be 30 ft.), and head to which the pumped water must be raised as to an elevated storage tank or pressure system (estimated to be 110 ft.), or a total dynamic head of 290 feet. The specific speed (N_s), of a given pump is determined from the formula,

$$N_s = \frac{(g.p.m.)^{1/2} \times RPM}{h^{3/4}}$$

, where N_s = specific speed, g.p.m. is gallons per minute being pumped, RPM is revolutions per minute of the impellers, and h is head per pump stage in feet of water. Suction lift is also related to specific speed. In most cases, a vertical centrifugal pump with a specific speed, N_s, of about 2,500 will provide the most economical and efficient pumping equipment. It is considered beyond the scope of this paper to discuss the factors that determine this, which include ratio of final impeller wheel diameter to inlet diameter, shape of impellers,,impeller trim, etc., but numerous field tests have proven this to be generally true. From the following Figure No. 1-B, assuming 600 g.p.m. flow, 1,750 RPM pump, and 50 ft. of head per stage; it appears that an 11½" O.D. impeller will be adequate. The same general information can be obtained by checking pump characteristic curve data available from pump manufacturers.

Major factors affecting the well casing diameter are entrance velocities of water entering the well from the aquifer and diameter of the pump bowls. High entrance velocities may change the chemical properties of the water (through release of dissolved gases) causing corrosion or incrustation problems. However the apparent aquifer thickness (about 70 ft.) is such that, if even a portion of it is screened with a well-designed screen, entrance velocities should be very low. The diameter of the pump bowls is probably the major factor in determining the well-casing diameter in this hypothetical project. A 12" I.D. well casing would probably be the minimum requirement but plumbness and alignment of the well casing would be very critical. A 14" diameter well casing is a better choice and will permit reasonable tolerances for plumbness and alignment errors which might otherwise make it difficult to install, maintain, and remove the pumping equipment. In the past, there has been a misconception by many people, including some engineers and well drillers, about the relationship between well diameter and yield from a given formation. The statement which is now only occasionally heard - "double the diameter and the yield will double" - is far from true. Many variable factors affect this relationship, but if the formation is homogenous and isotropic, doubling the diameter of a well from 12" to 24" will generally provide only about a 10% - 15% increase in yield, as shown on Figure No. 2.

Type of Well Construction; Open-Hole or Screened Aquifer; Natural or Artificial Gravel Envelope; Diameter of Well Drill Hole

The major types of drilling equipment used today are percussion, direct rotary, and reverse hydraulic. Each has advantages and disadvantages and although the construction procedures and materials differ somewhat for each a contract specification can be written which will permit the use of any of the three. For brevity and simplicity in this case, it will be assumed that the two test holes required will be drilled with direct rotary equipment and the drilling required for the actual well construction will be performed with reverse hydraulic equipment.

It may be assumed that the Dakota sandstone in the area is very fine-grained and poorly cemented. Open-hole wells (that is, wells without screens) have been constructed in the Dakota sandstone formations; generally, though, they have been notorious sand pumpers. The major reasons for installing screens in wells are to prevent structural collapse of the aquifer and to act as a sequential portion of a filter designed to prevent excessive intrusion of fine particles from the formation into the well. Because of the probable fineness of particle size and poorly cemented character of the Dakota sandstone aquifer, a screen should be used.

Aquifers which have particles that vary from coarse to fine in relatively large sizes seldom require artificial gravel envelopes to provide the filter effect required. Better wells can generally be constructed and developed in these circumstances at less cost through proper development of the natural sands and gravels in the aquifer and through judicious selection of the screen slot openings. The Dakota sandstone aquifer, though, has particles which are so fine-grained and uniform in particle size that it is difficult and impractical to construct a well in it that will not pump excessive quantities of sand without the use of an artificial gravel envelope.

Having determined that an artificial gravel envelope is required, the thickness of the envelope must be decided which will determine the diameter of the well drill hole. Theoretically, the thickness of the artificial gravel envelope required is that which will exclude those particles of the aquifer that are coarser than a certain desirable portion removed during development. K.E. Hill of the College of Mining, University of California, has conducted investigations which indicate that the thickness of an artificially placed sand envelope need be no more than one-half inch, provided the filter sand is of the proper size. This thickness was found to provide adequate control over a wide range of flows when the particle size of the artificial sand filter media was less than 3/16 inch. However, from the drilling contractor's view point, it is impractical to attempt to drill a bore hole several hundred feet below the surface which is uniformly ½-inch greater in radius than the radius of the screen; the diameter of the artificial gravel placement tremie or tube required is such as to make this impossible. As a practical matter, artificial gravel envelopes should be not less than two nor more than about nine inches thick. The thicker the gravel envelope the more difficult it becomes to penetrate through the envelope with development equipment to remove the thin skin of relatively impervious solids which become plastered on the formation face during drilling operations. It is assumed that the thickness of the gravel envelope for the proposed wells will be four and one half inches. The diameter of the well drill or bore hole will therefore be 14" plus 4½" plus 4½" or about 23" nominal diameter. A 24" diameter bit would probably be used.

In order to be effective, the gravel envelope must not restrict the flow of water into the well; the gravel envelope material must therefore have a high permeability compared to the formation it controls. Theoretical studies of this factor by Edward E. Johnson, Inc., of St. Paul, Minnesota, indicate that a gravel envelope material which has a permeability twenty times that of the controlled formation will result in negligible resistence to flow. High permeability of the envelope material is assured by using a carefully graded material with a low uniformity coeeficient. The uniformity coefficient is a numerical expression of the degree of uniformity of particle sizes for any particular material, determined from sieve analysis by calculating the ratio between the sieve size retaining forty per cent of the material by weight and the sieve size retaining ninety per cent. For optimum results, the uniformity coefficient of envelope material should be limited 1.7 for control of very fine sands, and a value of 1.5 or less, is even more desirable. Although there is some disagreement regarding the importance of selection and sizing of the envelope material gradation it is generally recognized in the industry that the envelope material and screen slot size should be designed in accordance with the standards accepted for design of rapid sand filters. Laboratory experiments and field experience have indicated that proper stabilization of formation sand is achieved when the effective size of the envelope material is not more than about eight times the effective size of the formation sand particles. The effective size of a particular sand is determined by sieve analysis and is taken as the size of the sieve opening which retains ninety per cent of the sample. An alternate method of filter media selection is to select the size corresponding to the sieve which retains fifty per cent of the formation sand in establishing a size ratio. In this case, the ratio of the sizes should be between four and six. This is usually satisfactory for formations having uniformity coefficients of two or less but may lead to erroneous results if lesser degrees of uniformity exist. The slot size of the screen is usually selected that will retain ninety per cent of the particles of the envelope material.

In many wells, though not always, the screen diameter specified is nominally the same as the well casing diameter. The length of screen specified must also be determined. The cost of the screen per lineal foot is considerably more than the cost per lineal foot of well casing so economic as well as hydraulic factors must be considered in making this decision. Screens are generally subject to the most corrosive environment in the well, and are therefore usually manufactured of alloys which are more resistant to corrosion than black steel. Some of these, listed in order of their resistance to corrosion (and cost,) from greatest to least, follow:

1. Monel Metal (70% nickel, 30% copper).
2. Super - Nickel Metal (30% nickel, 70% copper).
3. Everdur Metal (96% copper, 3% silicon, 1% manganese).
4. Stainless Steel (74% low carbon steel, 18% chromium, 8% nickel).
5. Silicon Red Brass (83% copper, 1% silicon, 16% zinc).
6. Anaconda Red Brass (85% copper, 15% zinc).
7. Common Yellow Brass (65% copper, 33% zinc).
8. Armco Iron
9. Low Carbon Steel (Black Steel).

If the aquifer is not too thick it is generally a good idea to screen all of it, even though entrance velocities through the screen may be so low that it would not be necessary. Although it is assumed in well hydraulics that aquifers are homogenous and isotropic throughout their thickness, this is seldom true. Often the aquifer will provide greater permeability and flow near the bottom, but in some cases, and this is sometimes true in the Dakota sandstone formations, the sandstone aquifer may actually consist of two or more separate formations with intervening shale layers. If only the lower portion of the aquifer were screened in this situation, the upper aquifer would be virtually sealed off even though the gravel envelope extended upward through the entire thickness of the aquifer. It has been determined conclusively that the vertical flow of water down through a thin gravel envelope for a distance of twenty or thirty feet is very small compared to the horizontal flow through the same gravel envelope which may be only six inches thick or less. The location of the most permeable portions of the aquifer, actual thickness of the aquifer, and presence or absence of shale layers can only be determined by a careful examination of the driller's log, mud loss data, formation samples, and electric logging of the test holes. At this point it is advisable to assume that 50 feet of screen will be adequate and that a bid item for 50 lineal feet of screen be included in the unit price bid schedule. After the test holes have been drilled and the information evaluated, the actual length of screen to be installed can be determined and the contract price adjusted accordingly. It is further recommended that a screen of high corrosion resistance be specified. The difference in cost between a highly corrosion-resistant screen and one of lesser resistance is not too great since the labor required to construct the screen is about the same for any of the alloys. Screens of stainless steel or Everdur Metal will normally provide many more years of service than those of lower corrosion resistance. Since the screen is located at the bottom of the well it is extremely difficult and expensive (and impossible in some cases) to repair or replace one that has failed.

The artificial gravel envelope should be extended upward for several feet above the top of the screen or through the entire thickness of the aquifer if practical.

The well casing is usually of black steel, with threaded couplings or welded connections, thickness and weight in accordance with A.W.W.A. standards for drilled wells shown on Figure No. 3. Metals of special alloys for special corrosion problems are available for well casings but are costly and are not generally recommended, except in special or very corrosive environments.

The annular space between the well casing and well drill hole, from the top of the gravel packing upward to ground surface, should be sealed with cement grout to prevent contamination or pollution of the aquifer from upper water-bearing formations or ground surface seepage. The specifications should require that the cement grout be placed through tremie pipes from the bottom up, taking care to eliminate the possibility of voids.

A cross-sectional drawing through the well showing the proposed construction, similar to Figure No. 4 is normally included. A unit price type bid schedule containing the items and quantities on which bids would be received for the two hypothetical wells is shown as Figure No.5.

Construction Procedures, Quality Control, and Evaluation

The specifications require the contractor to drill two test holes, of 6 inch minimum diameter, 1,000 feet apart, in locations indicated by the engineer. Each test hole should be drilled to a depth of about 10 feet below the bottom of the Dakota sandstone in order to provide space for the probe on the electric logger to furnish accurate data on the aquifer near its bottom level. In each test hole, the contractor compiles a driller's log of materials encountered (Figure No. 6) including mud loss data, obtains formation samples at 5 feet intervals in water bearing formations (these are then analyzed for particle gradation with screen sieves, Figure No. 7), and furnishes an electric log of the test holes, Figure No. 8. After careful evaluation of the above data, the engineer and contractor jointly determine the actual depth of each well, the placement and length of the screen or screens (in this case the screen will be placed in two sections with a section of blank casing blocking off the intervening shale layer; see Figures No. 6 and No. 8), select the gradation of the gravel envelope material and slot opening for the screen (Figure No. 7), and determine the total thickness of the aquifer which will govern the respective amounts of gravel packing and cement grouting required. The contractor will also install a temporary piezometer tube in Test Hole No.2 to be used as an observation well while conducting the pumping test on Well No.1. It is essential that the contractor develop the temporary piezometer tube to obtain complete hydraulic connection with the aquifer. One set of samples should be tagged and sent to the Iowa Geological Survey.

The contractor will then proceed to drill Well No. 1 to its full diameter and depth. During the drilling operations through the overlying till and shale, he may have to vary the viscosity of the drilling fluid by use of different bentonites and add chemicals required to maintain pH, vary the weight on the drill collar to maintain progress, and use different types of drill bits depending upon materials encountered. Just before entering the water bearing aquifer, the contractor should stop his drilling operations, clean out his mud pit and refill it with clean water. In order to obtain a well of satisfactory efficiency (80% or higher) it is imperative that, during drilling through the aquifer, the contractor proceed with the greatest possible speed and deposit as little drilling mud on the face of the drill hole as possible. This requires relatively clean drilling fluid, sharp bits, well-organized drilling crews, and 24 hour a day drilling during this period. The screen, casing, and gravel packing material should also be on hand at this time so that the aquifer will not be left unsupported for any great length of time after completion of the drilling. During drilling of the well, the plumbness of the hole should be periodically checked with the driller to determine whether later problems may occur.

As soon as the drilling is completed, the hole cleaned out, and the drill rod and bit removed from the hole, the screen and casing should be assembled, centered with centering guides, and carefully placed in the hole. The gravel envelope material should then be quickly and carefully placed through tremies starting at the bottom and moving upward until the full thickness of the aquifer has been installed.

The cement grout is then normally installed and the well left for a period of about 72 hours to allow the cement to harden.

Following the cement grouting, the contractor proceeds to develop the well. Development is usually interpreted to mean that the contractor will manipulate the well with whatever methods, devices, or chemicals required to give the maximum yield of water per foot of drawdown and extract from the water bearing formation in the well the maximum practical quantities of sand as may, during the life of the well, be drawn through the well when pumped under maximum conditions of drawdown on either a continuous or permanent basis. In some cases a maximum turbidity and /or a minimum well efficiency requirement is included in the specifications. Development may be accomplished by pumping, with the use of air compressors, surge blocks, high pressure jets, explosive charges, or other methods. In some instances the contractor may have to use polyphosphates or other chemicals to help dissolve drilling muds on the face of the aquifer. If the contractor has done a careful job of drilling through the aquifer, development is usually not a difficult problem. After installation of equipment, development may require as little as six hours or more than twenty-four hours in difficult cases.

Upon completion of development, the contractor should clean out the well, install the test pumping equipment, and test pump the well for yield and drawdown. Various methods and theories for such tests have been used, but for artesian aquifers such as these, it is recommended that the non-equilibrium method, developed by Theis, Wenzel, Thiem, and others be used. It is beyond the scope of this paper to explain the theories and practices of this method but copies are available from various sources for those who are interested in studying them. In order for the test results to be valid, certain conditions must be maintained. The test will be conducted over a 24 hour period, during the first 20 hours of which drawdown readings will be made and recorded while pumping the well, and during the last 4 hours of which the pump will be shut off and recovery readings made and recorded Measurements of drawdown must be made in both the pumped well and observation well. Some wells will require a much longer pumping period than this (especially in cases where the existence of aquifer boundaries is suspected). During the period of test pumping it is essential that the pumping rate remain absolutely constant which will necessitate the installation of a calibrated orifice tube or some other measuring device and a throttling valve on the discharge side of the test pump. The water pumped from the test well during the pumping test period must be conducted a reasonable distance away from the well site so that it will not seep down into and artificially recharge the aquifer. An accurate drawdown gage must be available for each measuring point. Watches should be synchronized so that readings will be taken simultaneously at all measuring points. The schedule of observations should be made in accordance with the following table:

Pumping Well (During Pumping and Recovery Period)

Each ½ minute for first 5 minutes.
Each 5 minutes for next 55 minutes.
Each 20 minutes for next 60 minutes.
Each 30 minutes for next 2 hours (end recovery test).
Each 60 minutes for next 16 hours.

Observation Well (During Pumping and Recovery Period)

Each 60 minutes.

The exact distance from the center of the pumping well to the center of the observation well must be measured and any differences in ground elevation between the two should be noted. The drawdown measurements taken during the pumping and recovery tests may be recorded on a convenient chart similar to the one shown as Figure No. 9. The pertinent equations of Theis to be used in the computations are as follows:

$$s = \frac{114.6\ Q}{T} \cdot W(u) \qquad \text{(I)}$$

$$\text{where } W(u) = -0.577216 - \log_e u + u - \frac{u^2}{2 \cdot 2!} + \frac{u^3}{3 \cdot 3!} - \frac{u^4}{4 \cdot 4!} \ \ldots\ldots \text{(II)}$$

$$\text{and } u = \frac{1.87\ r^2\ S}{T \cdot t} \qquad \text{(III)}$$

where:

s = drawdown at any point in the aquifer, in feet.
Q = discharge of pumped well, gallons per minute.
T = coefficient of transmissibility of the aquifer.
t = time since pumping started, in days.
r = distance from the discharging well, in feet.
S = coefficient of storage of the aquifer.

In application, the solution of Equation (II) is too tedious for frequent use. Wenzel has provided a simplified solution through a table of values of W(u) for a wide range of values of u, a copy of which is included as Figure No. 10. Let it be assumed that the well is test pumped at a uniform discharge rate, Q, of 600 g.p.m. Using the "type curve" solution, it is determined that the formation coefficient of transmissibility, T, is 28,000 g.p.d./ft., and the storage coefficient, S, is 0.0001. The efficiency of the well can be computed in the following manner, assuming that the actual measured drawdown in the pumping well after 20 hours (20/24 day) of continuous pumping at 600 g.p.m. is 54 feet. The actual specific capacity, $Q/_s$, at that time is 11.1 g.p.m./ft. It has been determined previously that the aquifer is split into two sections, the bottom portion being 26 feet thick with a 10 foot layer of shale separating it from the upper portion which is 56 feet thick. Twenty-five feet of screen have been installed in each portion of the aquifer. The following computations are then made:

WELL EFFICIENCY CALCULATIONS

$T_1 = 56/82\ (28{,}000) = 19{,}100$ g.p.d./ft. (Upper Formation)
$T_2 = 26/82\ (28{,}000) = 8{,}900$ g.p.d./ft. (Bottom Formation)

Upper Portion of Aquifer

$$u_1 = \frac{1.87\ r^2\ S}{T_1\ t} = \frac{1.87\ (1.0)^2\ (1.0 \times 10^{-4})}{1.91 \times 10^4\ (20/24)} = 1.18 \times 10^{-8}$$

From Standard Table
$W(u_1) = 17.7$

$$Q/s_1 = \frac{T_1}{114.6\ W(u_1)} = \frac{19{,}100}{114.6\ (17.7)} = 9.42 \text{ g.p.m./ft. drawdown}$$

Lower Portion of Aquifer

$$u_2 = \frac{1.87\ r^2\ S}{T_2\ t} = \frac{1.87\ (1.0)^2\ (1.0 \times 10^{-4})}{0.89 \times 10^4\ (20/24)} = 2.52 \times 10^{-8}$$

From Standard Table

$W(u_2) = 16.9$

$$Q/s_2 = \frac{T_2}{114.6\ W(u_2)} = \frac{8{,}900}{114.6\ (16.9)} = 4.61 \text{ gpm./ft. drawdown}$$

Total Maximum $Q/s = Q/s_1 + Q/s_2 = 9.42 + 4.61 = 14.03$ gpm/ ft. drawdown

Correction for Incomplete Aquifer Penetration by Screens
Upper Formation Penetration = 25/56 = 45% Penetration
Lower Formation Penetration = 25/26 = 96% Penetration

From Kozeny Formula Curves, Figure No. 11.
$m_1/r = 56/1.0 = 56$; % Q/s_1 obtainable = 78% (9.42) = 7.35 gpm/ft.

$m_2/r = 26/1.0 = 26$; % Q/s_2 obtainable = 100% (4.61) = 4.61 gpm/ft.

Total Q/s obtainable = 11.96 gpm/ft.

. Efficiency of Wells = 11.1/11.96 = 92.5% Efficient

From this result it can be seen that the well drilling contractor has done a careful job of construction and has been successful in removing most of the drilling mud from the face of the bore hole during development.

Using the "type-curve" data and additional computations with Equations (I) and (III), a reasonably accurate estimate of future pumping levels in each well can now be made which will determine the pump suction level setting of the permanent pumping equipment. The results are tabulated on Fig. No. 12.

From these data, the engineer should probably decide to set the actual pump suction intake level at 160 ft. below the surface with a blank suction tail pipe of 10 ft. This should assure the pumping equipment not breaking suction from draw down during the period of expected life of the equipment. The actual pump suction level selected, based upon aquifer computations, is 15 ft. deeper than was initially assumed. As a result of this it will be necesary to check the system head characteristics again and in all probability modify the specifications for the pumping equipment which can readily be done by a simple contract change order.

In summary, it should be noted that even though the well drilling contractor did an excellent job of constructing the well (92.5% efficiency), one of the reasons the actual required pump setting is lower than anticipated is because the coefficient of transmissibility of the formation at the new site is only about 60% (T=28,000 g.p.d./ft. as great as that at the existing City well sites (T=45,000 g.p.d./ft.). Although the well fields are only about 2½ miles apart, a variation in formation characteristics of this magnitude is not unusual in the Dakota sandstones. If the entire aquifer (26 ft. + 56 ft.) had been screened, instead of screening just 50 ft. of it, the cost of each well would probably have been increased by about $1,000.00, but the pumping heads decreased by about 10 ft. An economic evaluation in which the differences in costs, including power costs, are amortized over a period of 20 years would probably indicate that it would have been more economical to have screened the entire aquifer in this area.

In the event that the engineer suspects the presence of aquifer boundaries, a pumping test of more than 24 hours should be conducted. The presence of aquifer boundaries, unless they are very close to the well site, will normally not show up in such a short period of time. If the time-drawdown data are plotted on a semi-log graph such as Figure 13, the slope of the plot, after the initial pump-off has been achieved, will be a straight line, and the slope of this line, ΔS, will be the same for each log cycle of time, unless a boundary condition exists. If a boundary condition exists, the slope of the time drawdown curve will abruptly change downward and will be twice the slope of the first limb. If an additional boundary is present, another abrupt change downward will occur in the time-drawdown curve and the slope of the third limb will be three times the slope of the first, etc. The effect of the boundaries occur at the same elapsed time period regardless of pumping rate. It is possible, therefore, to establish the slope of the time-drawdown curve for any desired discharge rate. Where boundary conditions exist, the slope of the first limb is used to determine the formation transmissibility. Using adaptions of the following modified non-equilibrium equations (IV), (V), and (VI), given below, the locations in feet of the boundaries from the observation well (generally two or more are required) can be determined.

$$T = \frac{264\ Q}{\Delta s} \qquad (IV)$$

$$S = \frac{0.3\ T\ t_o}{r^2} \qquad (V)$$

$$\frac{r_o^2}{t_o} = \frac{r_1^2}{t_1} = \frac{r_2^2}{t_2} = K \qquad VI$$

where:

- T = Coefficient of transmissibility, g.p.d./ft.
- Q = Pumping rate in gpm.
- Δs = The change in drawdown in feet per log cycle in the straight-line portion of the drawdown curve.
- S = Coefficient of storage.
- r = Distance in feet from the discharging well.
- t_o = Time value in days of the intercept of the straight line portion of the drawdown curve (and the zero drawdown line).
- K - A constant.

Another type of aquifer boundary condition which sometimes exists in water table formations is a surface recharge boundary. This exists when an aquifer has a hydraulic connection with a lake or stream. The effect of this is the opposite of the impermeable aquifer boundary previously discussed and the time-drawdown curve, instead of bending downward, will bend upward and become horizontal after the cone of depression intersects the recharge boundary, eventually establishing conditions of equilibrium. The same principles used for the location of impermeable boundaries can be applied to locate the recharge boundaries.

After completion and evaluation of the pumping test, the test pumping equipment is removed and any sands deposited in the bottom of the screen during test pump are removed. The well is then checked for plumbness and alignment by lowering a straight section of pipe or a rigid dummy which is usually about 40 ft. in length down to the top of the screen. The outer diameter of the pipe or dummy to be lowered should not be more than 1/2 inch to 1 inch smaller in diameter than the diameter of that part of the casing being checked. The dummy is made from a rigid spindle with three circular rings, each 12 inches long, with one ring at each end of the dummy and one located in the center.

The interior of the well is then swabbed, using washing solutions if necessary to remove oil, grease, etc., and following this the well is disinfected with a solution of chlorine. A chlorine concentration of 50 p.p.m. is desirable and should be left in the well for 24 hours before removal by pumping.

Pumps and Auxiliary Pumping Equipment

The subject of pump characteristics and factors which affect the selection and specification of pumps is too broad to attempt to cover in this paper. Let it be assumed for this particular application that a vertical centrifugal (turbine-type) pump has been selected and specified. Some of the factors that affect pump selection are mineral quality of the water, total dynamic head, volume of water to be pumped, impeller shape, characteristics, size, materials, and trim, pump bowl requirements, pump shaft and line shaft size and materials, column discharge pipe, size and material, types of and locations of bearings, stuffing boxes and packing glands, pump bowls, pump discharge head, rotational speed, motor type, thrust capabilities, wire to water efficiency, horsepower requirements, and many others. Determination of these factors can be made by referring to manufacturers pump catalogs and their representatives.

The subject of auxiliary pumping equipment is one that is often overlooked by engineers but is of importance to good operation and the convenience of the water plant operator. Some suggestions for items of auxiliary pumping equipment are anchor bolts to anchor the pump to the pump pedestal, airline and gage or similar equipment to determine pumping levels, casing vent with insect screen, discharge pressure gage, expansion joint on discharge line, air and vacuum release value, check valve and gate valve, flow meter, sampling cock, and an auxiliary orifice tube. The auxiliary orifice tube has not been included on many wells in the past but is a convenience for the operator which will permit him to check the calibration of the meter or conduct a time-drawdown pumping test of the well at any time that he suspects screen incrustation or formation problems.

The pump and equipment should be disinfected before installation in the well. Prior to use in the system samples of the water should be sent to the State Hygienic Laboratory to determine its potability.

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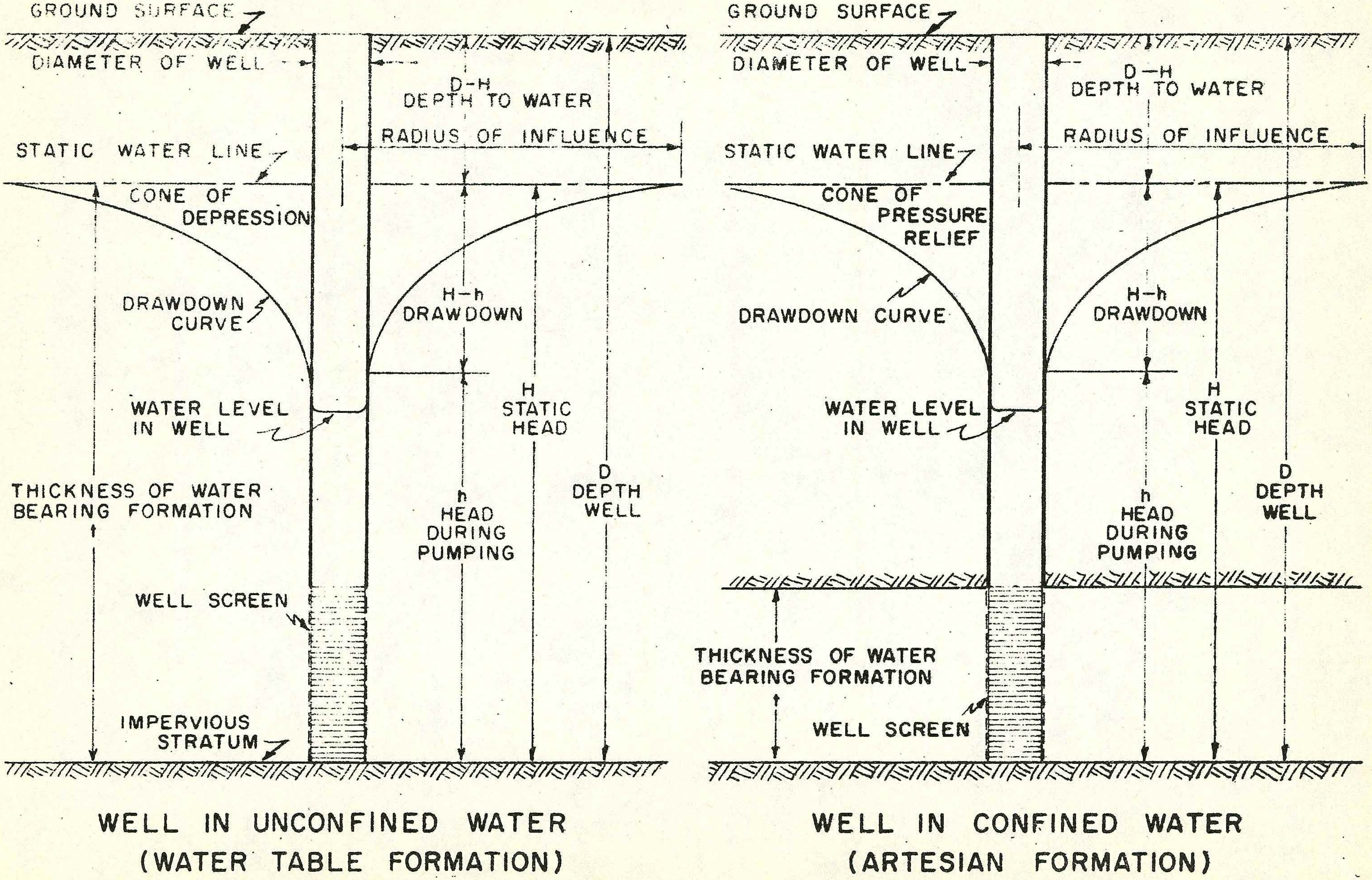

GROUND SURFACE
DIAMETER OF WELL
D-H
DEPTH TO WATER
RADIUS OF INFLUENCE
STATIC WATER LINE
CONE OF DEPRESSION
DRAWDOWN CURVE
H-h
DRAWDOWN
H
STATIC HEAD
WATER LEVEL IN WELL
THICKNESS OF WATER BEARING FORMATION
h
HEAD DURING PUMPING
D
DEPTH WELL
WELL SCREEN
IMPERVIOUS STRATUM
WELL IN UNCONFINED WATER
(WATER TABLE FORMATION)
GROUND SURFACE
DIAMETER OF WELL
D-H
DEPTH TO WATER
RADIUS OF INFLUENCE
STATIC WATER LINE
CONE OF PRESSURE RELIEF
DRAWDOWN CURVE
H-h
DRAWDOWN
H
STATIC HEAD
WATER LEVEL IN WELL
D
DEPTH WELL
h
HEAD DURING PUMPING
THICKNESS OF WATER BEARING FORMATION
WELL SCREEN
WELL IN CONFINED WATER
(ARTESIAN FORMATION)

FIG. I-A

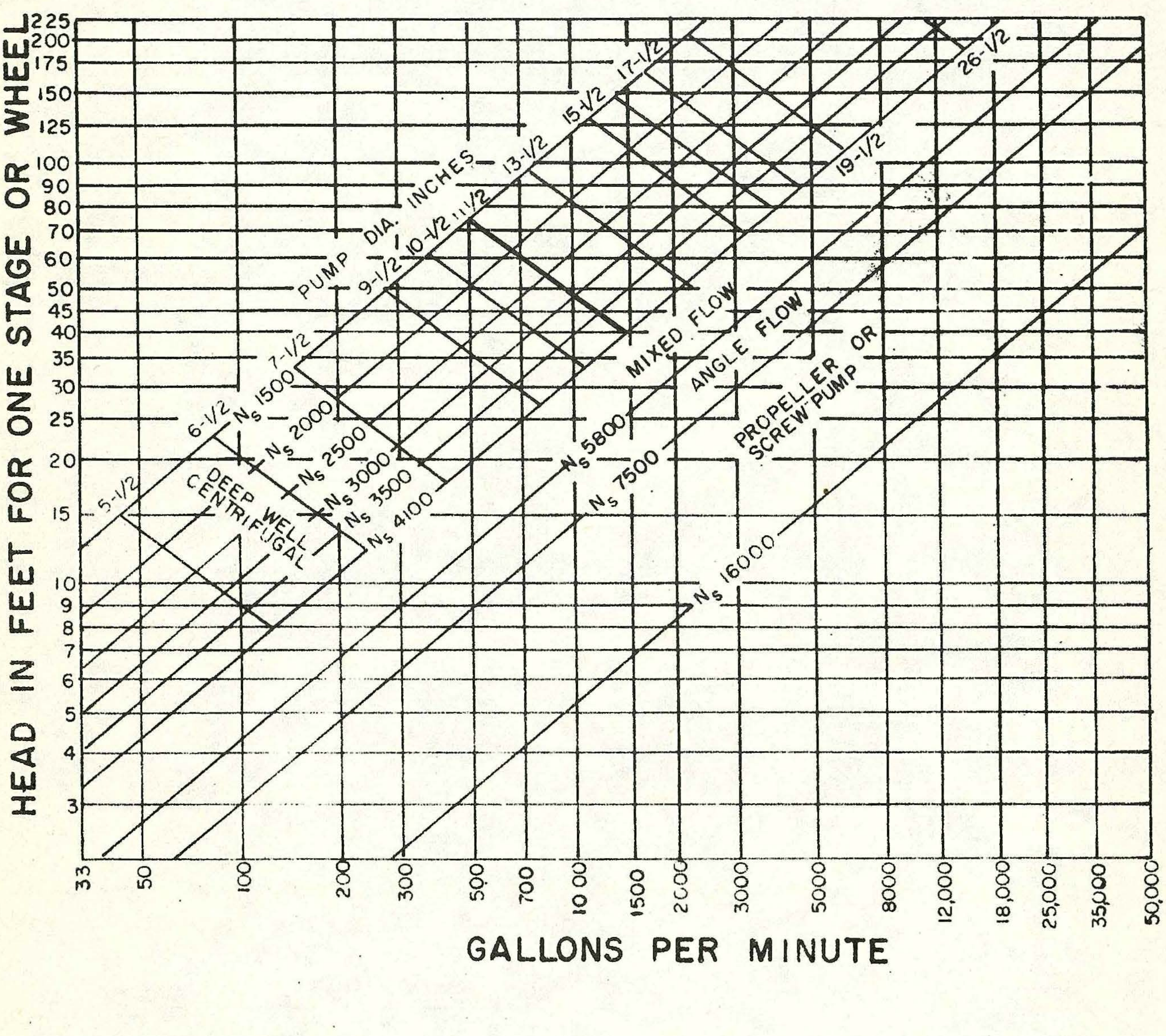


FIG. IB. CHART FOR DETERMINING SIZE AND TYPE OF VERTICAL SHAFT PUMP OPERATING AT 1750 R.P.M.

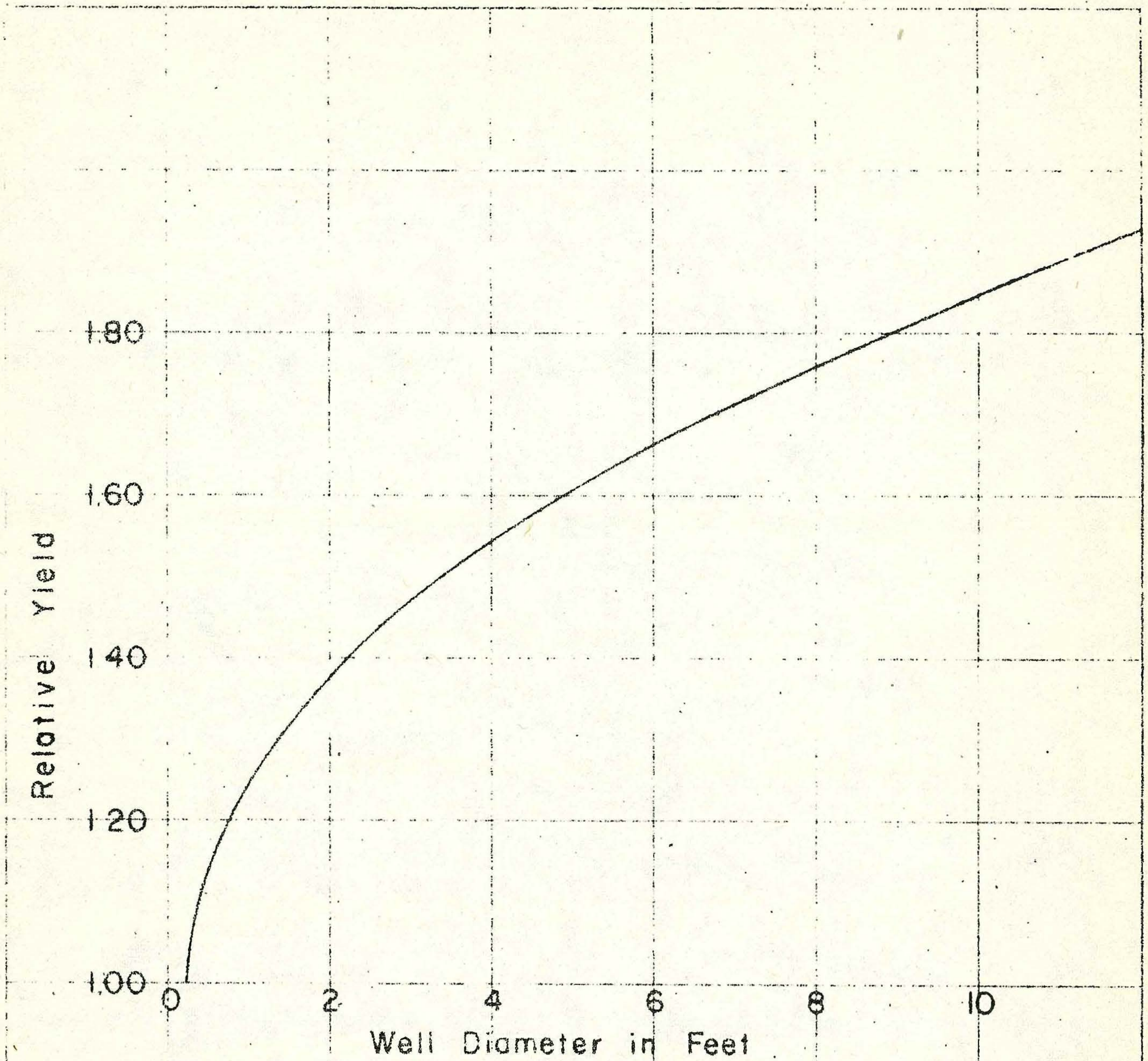


Fig. 2
Curve showing relation between diameter and yield in wells of same depth, same screens and same formation

FIGURE NO. 3

Steel Pipe, Black or Galvanized

Size-in.	Diameter--in.		Thickness in.	Weight per Foot-lb.	
	External	Internal		Plain Ends (Calculated)	With Threads and Couplings (Nominal)
6	6.625	6.065	0.280	18.97	19.18
8	8.625	8.249	0.188	16.90	17.80
8	8.625	8.071	0.277	24.70	25.55
8	8.625	7.981	0.322	28.55	29.35
10	10.750	10.192	0.279	31.20	32.75
10	10.750	10.136	0.307	34.24	35.75
10	10.750	10.020	0.365#	40.48	41.85
12	12.750	12.090	0.330	43.77	45.45
12	12.750	12.000	0.375#	49.56	51.15
14	14.000	13.500	0.250	36.71	
14	14.000	13.250	0.375#	54.57	57.00
16	16.000	15.376	0.312	52.36	
16	16.000	15.250	0.375#	62.58	65.30
18	18.000	17.376	0.312	59.03	
18	18.000	17.250	0.375#	70.59	73.00
20	20.000	19.376	0.312	65.71	
20	20.000	19.250	0.375#	78.60	81.00
22	22.000	21.376	0.312	72.38	
22	22.000	21.250	0.375	86.61	
22	22.000	21.000	0.500#	114.81	
24	24.000	23.376	0.312	79.06	
24	24.000	23.250	0.375	94.62	
24	24.000	23.000	0.500#	125.49	
26	26.000	25.376	0.312	85.73	
26	26.000	25.000	0.500#	136.17	
28	28.000	27.376	0.312	92.41	
28	28.000	27.000	0.500#	146.85	
30	30,000	29.376	0.312	99.08	
30	30.000	29.000	0.500#	157.53	
32	32.000	31.276	0.312	105.76	
32	32.000	31.000	0.500#	168.21	
34	34.000	33.376	0.312	112.43	
34	34.000	33.000	0.500#	178.89	
36	36.000	35.376	0.312	119.11	
36	36.000	35.000	0.500#	189.57	

- Indicates recommended practice.

Taken from Table I, AWWA Standard, A100-58,

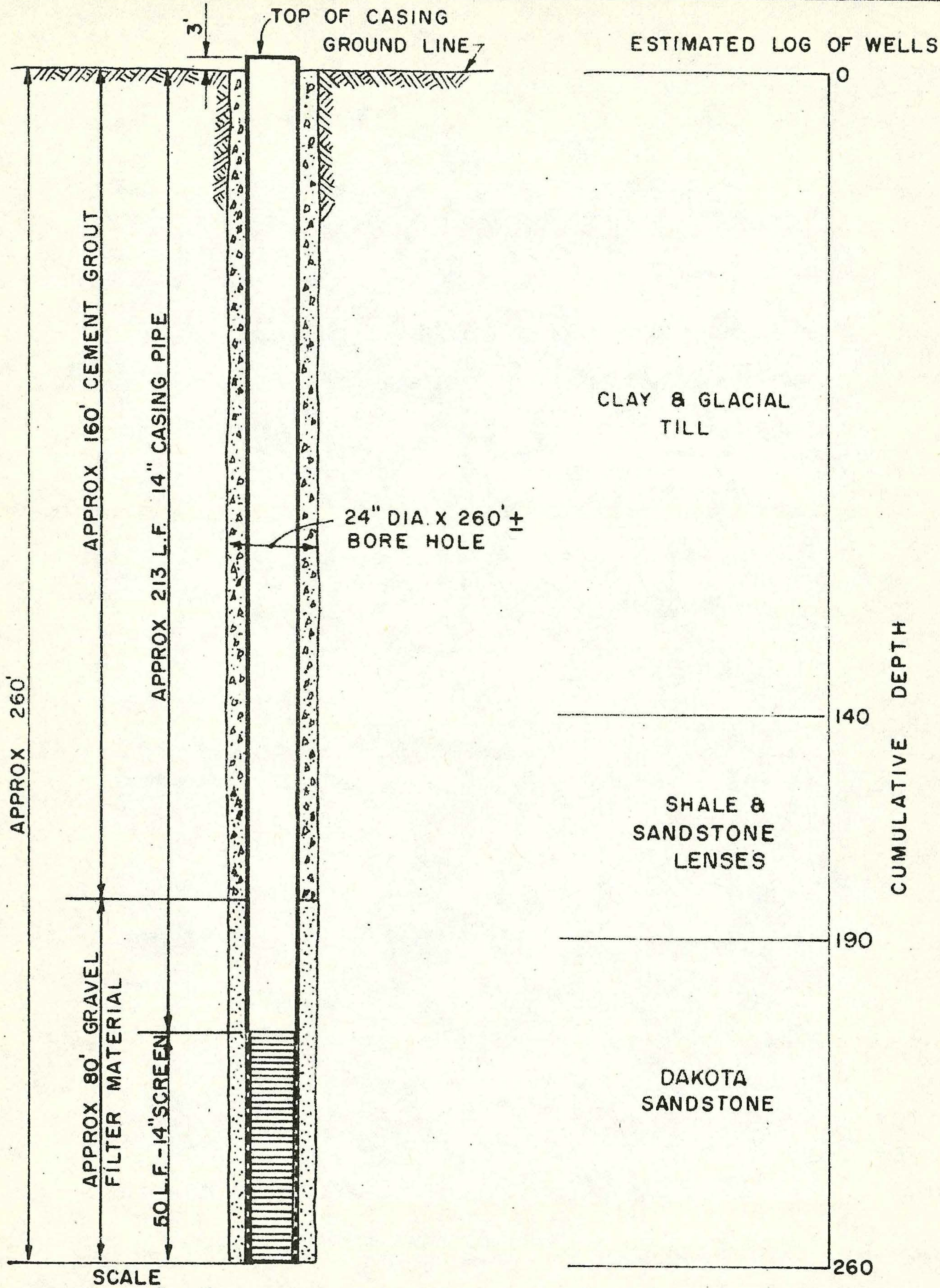


FIGURE NO. 4
CROSS SECTION THROUGH PROPOSED WELLS

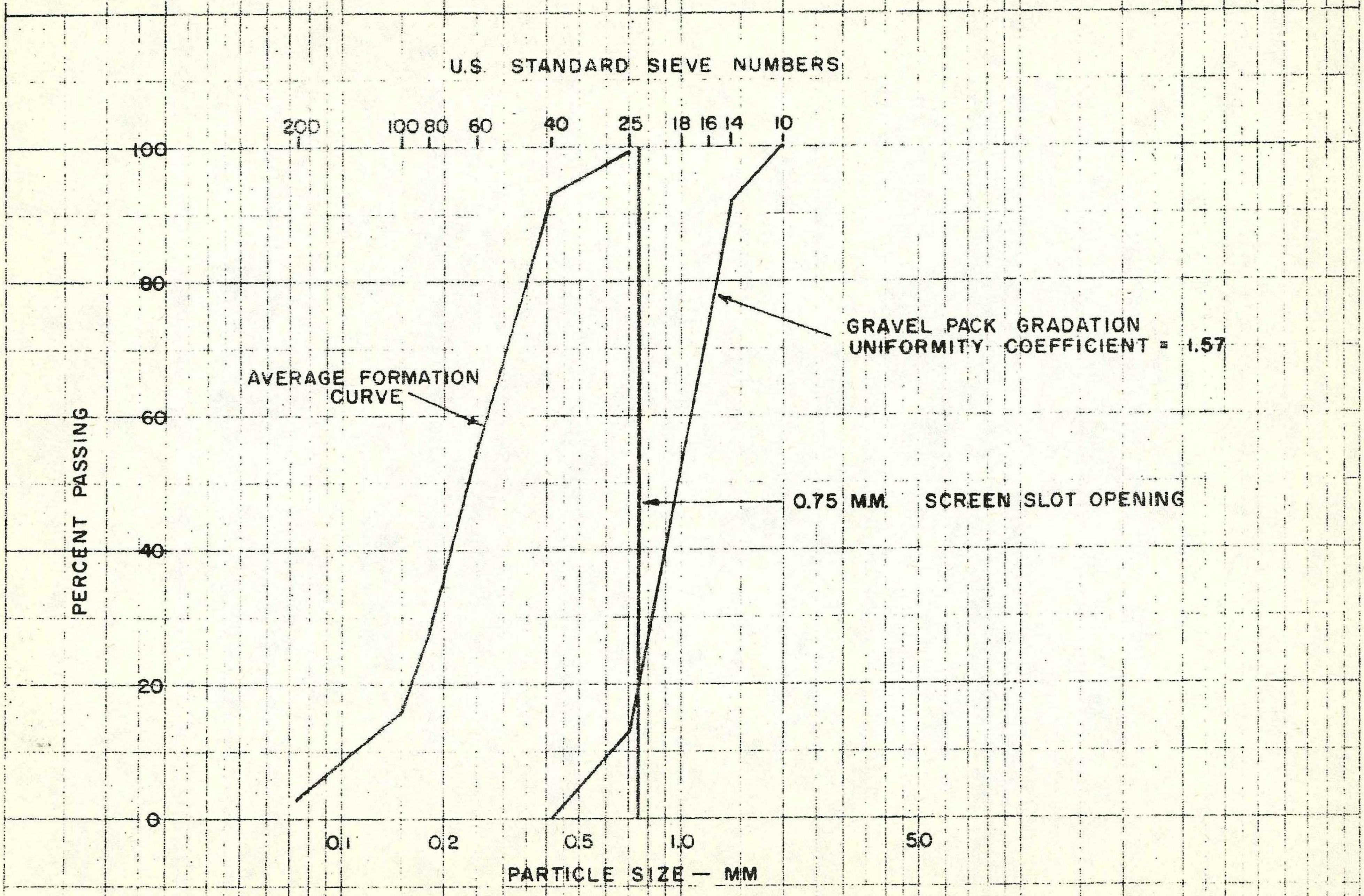
FIGURE NO. 5

UNIT PRICE BID SCHEDULE
(For Complete Construction of Two Wells)

Item No.	No. of Units	Item Description	Unit Price	Total Cost
1.	Job	Mobilization Charge	$ Lump Sum	$ ________
2.A.	540 L.F.	Test Hole, 6 in. min. dia., per L.F.	________	________
B.	520 L.F.	Drill Hole, 24 in. dia., per L.F.	________	________
C.	426 L.F.	Black Steel Casing, 14 in. dia., per L.F.	________	________
3.	100 L.F.	Stainless Steel Screen, 24 in. dia., per L.F.	________	________
4.	30 Tons	Gravel Packing, per Ton	________	________
5.	360 L.F.	Grouting Annular Space, per L.F.	________	________
6.	48 Hours	Developing Well, per Hour	________	________
7.A.	Job	Furnish, install, remove test pump, both wells	Lump Sum	________
B.	40 Hours	Test Pumping, per Hour	________	________
8.	Job	Swabbing & Disinfecting	Lump Sum	________
9.	Job	Samples & Records	Lump Sum	________
		TOTAL COST -		$ ________

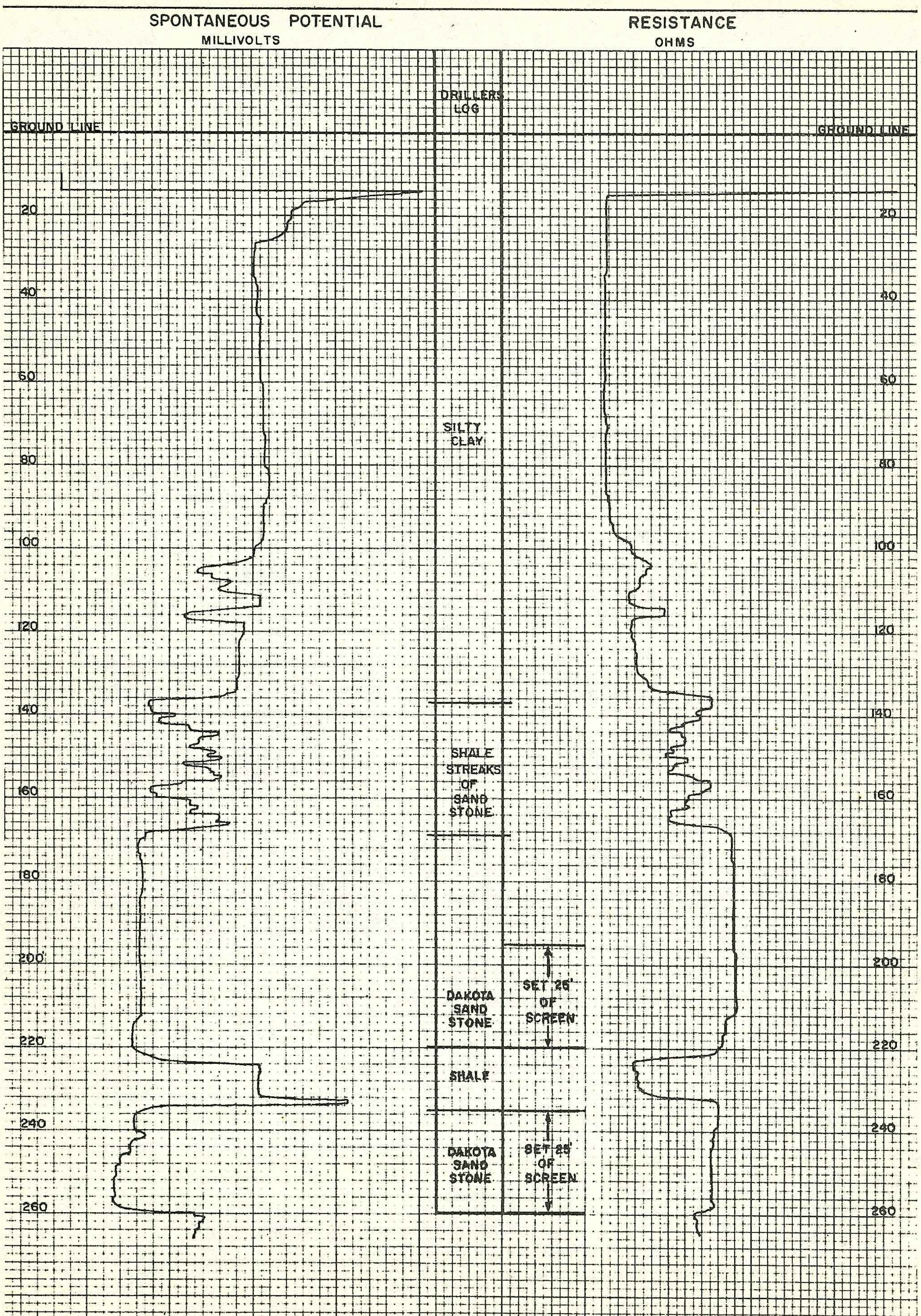
FIGURE NO. 6 - TEST LOG

FROM	TO	Marsh Funnel Viscosity Seconds	Mud Pit Loss Inches	Static Water Level ____ Measured ____ Hours After Completion Information
0'	8"			Brown Clay.
8"	12'			Fine to medium sand and gravel with boulders 8' to 12'.
12'	35'			Light gray silty clay.
35'	67'			Darker gray silty clay.
67'	70'			Green silty clay.
70'	105'			Gray silty clay-small boulder at 92'
105'	112'			Gray silty clay with sand streaks.
112'	115'			Green silty clay.
115'	124.5'			Mottled gray and brown and white silty clay. (hard streak @ 124.5')
124.5'	137			White to light gray clay.(Hard streak at 134')
137'	141'			Sandstone with shale streak.
141'	153'			Shale with sand streaks, few small boulders.
153'	157'			Sandstone-"chattered"-clay streaks.
157'	169'			Shale with sand streak-pull down.
169'	180'	37	1"	Sandstone - "chattered'.
180'	190'	35	1"	Sandstone - "chattered".
190'	200'	34	1"	Sandstone - "chattered'.
200'	210'	34	1.5"	Sandstone - chattered".
210'	220'	32	1.5"	Sandstone - chattered".
220'	225.5'			Sandstone - "chattered".
225.5'	250	32	1"	Sandstone.
250'	259'	32	1"	Sandstone.
259'	270'			White shale. (boulders 259' to 261')



SIEVE ANALYSIS

FIGURE NO. 7



ELECTRIC LOG FIGURE NO. 8

FIGURE NO. 9

WELL PUMPING TEST DATA SHEET

Project ______________________________.
Producing Well & Location _______
______________________________.
Depth ______________________________.
Aquifer ______________________________.
Construction Details _______________
______________________________.
Pump Equipment _______________
______________________________.
Length of Airline _______________.

Date Tested ______________________.
Observations By ______________________.
Drawdown Readings Made With Following Equipment ______________________
______________________.
Flow Measurement Equipment ____________
______________________.
This Test Sheet Shows Drawdown Measurements of (Producing Well) (Observation Well No. ________).
Location & Description of Observation Well ______________________
______________________.

Time	Elapsed Time Min.	Piez. Reading (Inches)	Flow G.P.M.	Alt.Gage Ft.	Feet to Water	Draw-down	Remarks

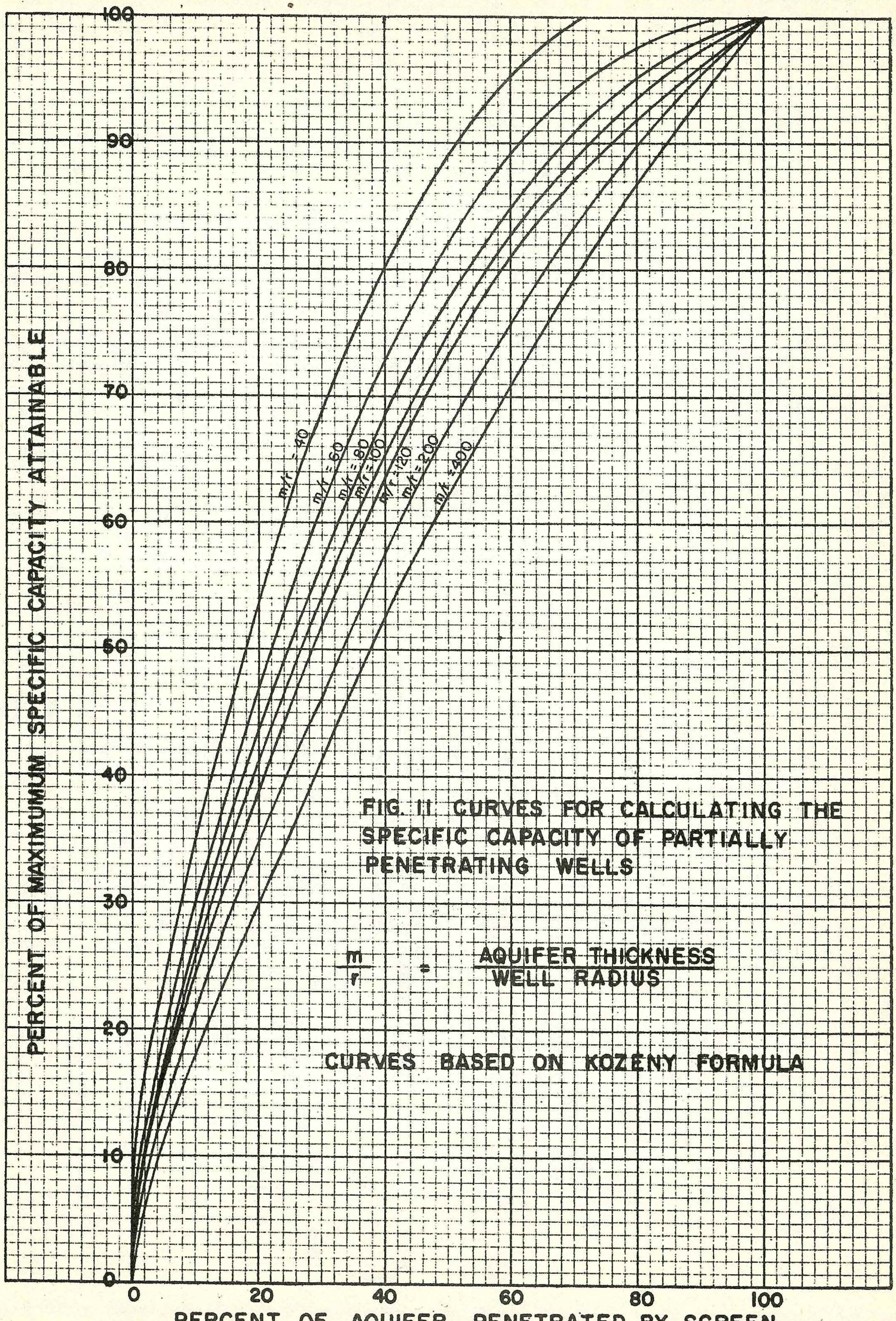


FIG. 11 CURVES FOR CALCULATING THE SPECIFIC CAPACITY OF PARTIALLY PENETRATING WELLS

FIGURE NO. 12

ESTIMATED FUTURE PUMPING LEVELS

	After 5 years	After 10 years	After 20 years
Self-caused drawdown in new well #1, @ 600 g.p.m.	73'	75'	77'
Drawdown in well #1, caused by pumping New Well #2, 1000' away, @ 600 g.p.m. (Interference)	14'	16'	17'
Drawdown in Well #1, caused by pumping existing City wells, 8000' away, @ 1,000 g.p.m. (Interference)	6'	8'	9'
Areal aquifer recession caused by long term withdrawal of water from formation	4'	6'	7'
Static Water Level, at present time	53'	53'	53'
Estimated Future Pumping Levels	150'	158'	163'

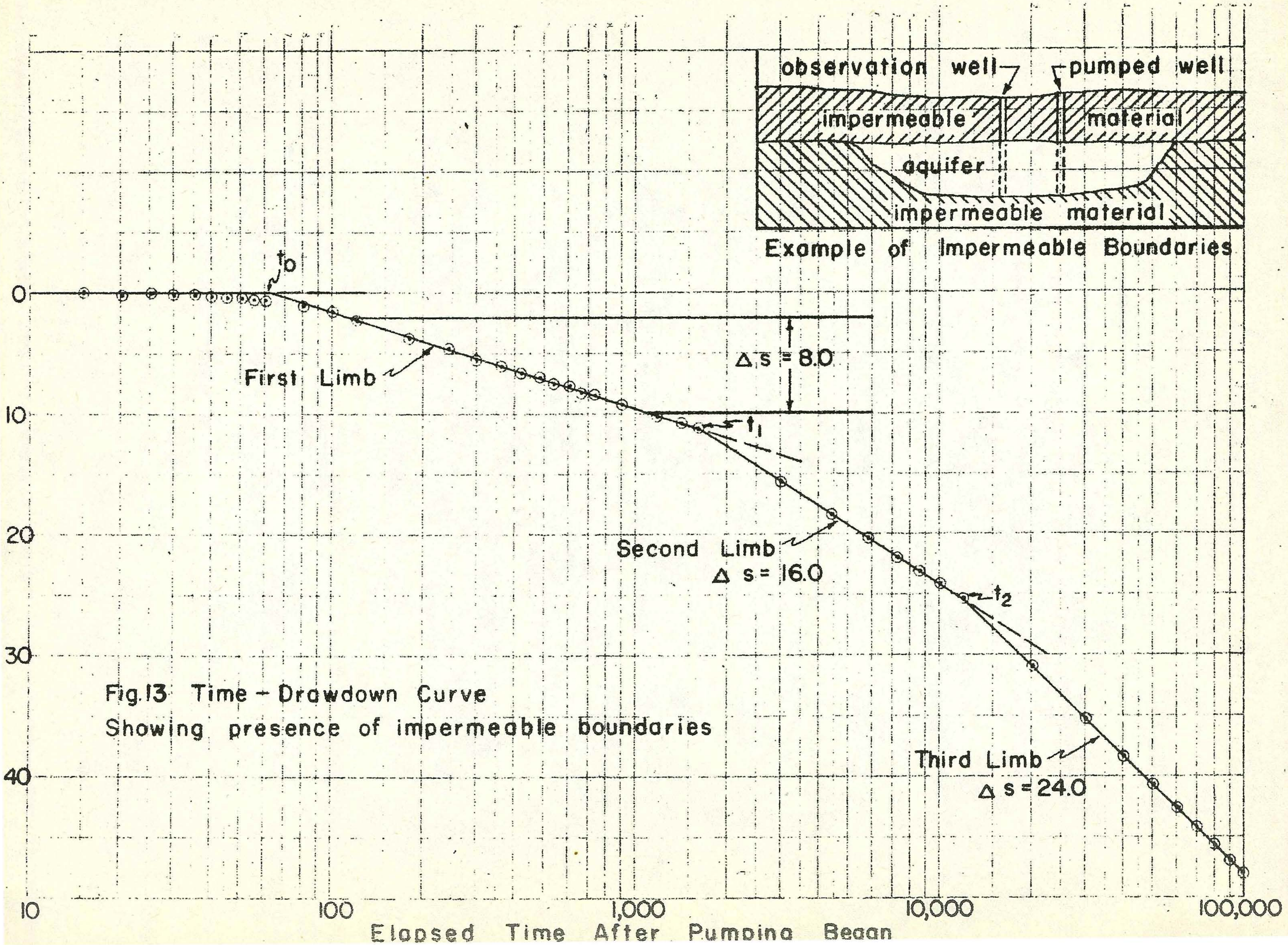


Fig. 13 Time – Drawdown Curve
Showing presence of impermeable boundaries

ESTIMATING CONSTRUCTION COSTS--

Techniques, Records, Applications

Paul R. Lilly
Lilly Engineering
Boone, Iowa

There are three parts to any complete estimate.

I. Quantity takeoff for physical inventory
II. Pricing
III. Market pulse or profit factor

I. Quantity takeoff
Quantity takeoff is nothing more than a system of accounting. The one used here takes each classification of work and the totals from a classification are summarized. Classification summaries after they have been extended and totaled are then entered on to a master summary.

The master summary is a check list, index, and balance sheet.

The printed sheet passed among you shows three different wall conditions and the relative cost of each. This is a category summary and points out the following:

a. The number of items considered in a typical category.
b. Variation that might be found in a classification
c. Example of what a typical classification summary looks like

Oppose pricing of an entire category on a lumped basis rather than the detailed breakdown of component elements. Most classifications of work are not singularly definable things that can be answered as to the price of a bushel of corn. Where a job is bid on a unit basis, be certain that the limits of the unit have been adequately defined.

II. Pricing
Pricing should be a product of the field report. Actually the field report, its requirements and the final analysis of the information is a very very difficult thing to do.

Following are problems as they might relate to the matter of cost analysis.

a. The office did not clearly define what they wanted
b. Requirements of the office were made without fully understanding the problems of the man in the field.
c. The man in the field is:
   1. tired
   2. afraid of comparison
   3. does not do it DAILY
   4. is a poor record keeper
   5. has not been properly trained

Basically pricing comes from specific isolated cost figures that have been validated. The perceptive contractor will see a chance on a job to define one item and will concentrate on this one thing.

Many contractors will state that they know some of the unit prices they use in a particular category are excessive. They are reluctant, however, to cut them because the amount they are long is being used up by some other item in the estimate where they are short. They cannot pin point this shortage so are reluctant to cut a known overage.

III. The job has been completely taken off and sensibly priced and we come to the matter of profit and general overhead. The question now is: What can I get for the job? I would like to see a summary made in which a list of profit factors must be answered. The questions asked would be as follows:

a. What was last years volume in this area?
b. What was last years weather?
c. What time of year will this project encompass?
d. What is this years volume in the area?
e. What supply of workman is available?
f. What is the relation of labor on the project to the total cost?
g. What percent of my general overhead for the coming year is already paid by profit from other jobs?

The general overhead of most contracting operations will run between 6% and 7½% depending on their accounting procedures. It is a rarity to find a contractor adding 10% gross profit to his total cost. It is generally less than that. This means that the overhead once deducted from his gross profit figure is very probably in the range of 2% to 2½%.

As an Engineer that designs projects, you can help keep your projects within your budget by constantly reviewing the following:

a. How do they fabricate specific parts of the job
b. Keep dimensions in mind
c. Relate the complexity
d. Space lettings if at all possible, not just for bidding purposes but also building purposes
e. Relate the time of year with the demand of the job
f. Relate short quantity so that premiums are eliminated.

With the shortages of labor and the constant rise in both material and labor rates nothing is going to get cheaper. Some things reduce productivity and many contractors faced with labor shortages have accepted lower yearly volume. Every one of these above factors add to the cost. <u>GET YOUR BUDGETS UP</u>.

Assessments and Land Reclassification in Drainage Districts in Iowa

by

W. C. Otto
Consulting Engineer
Sac City, Iowa

presented at

4th Water Resources Design Conference
Iowa State University
Ames, Iowa

January 19 and 20, 1966

Reclassification of a drainage district is a most difficult, exasperating, frustrating, confusing, controversial and sometimes almost impossible task. There is no way of determining the exactness or rightness of the results. Certainly it is not as simple as cutting a 12" board into 2-6" pieces and comparing the pieces. The best that can be expected is reasonable equity.

I would not recommend it as a way of making friends. It occurs to me that in its confusing aspect it can be a little like the lady in the bar who rather loudly and vehemently said to her escort, "I feel more like I do now than I did when I came in."

Iowa is blessed with a large share of all of the Grade A agricultural land in the nation. This was brought about to a considerable extent by the several ice sheets. These great lobes of ice covered a considerable part of the north half of the state and progressed as far south as Des Moines. The shearing and washing action had a leveling effect upon the area and when it receded left the over run land poorly drained. In fact a very early map of north central Iowa was simply marked, a thousand lakes. The ice sheets destroyed the prior existing drainage system and left the land covered with pot holes and swamps. These were connected by flat prairie creeks. During the period between the ice sheet and the coming of the white settlers the land was covered with lush prairie grass and the marsh grasses and plants and the yearly reoccurring growth helped produce our rich top soil.

As Iowa became settled the first land claimed and occupied bordered upon the major waterways. These areas afforded some protection from the elements, and provided material for shelter, game for food and means of transportation. In fact, my wife's ancestors settled in a steep valley in Eastern Iowa. Years later when asked why they chose such a site, they simply stated that they thought the flat grass was sour and that the beautiful timber growth indicated fertile soil.

Gradually the new comers were forced to occupy the flat wet prairie lands. They broke the sod on the dry areas and planted their first crops. The prairie chicken provided an important item of food and the pelts of the abundant muskrats in the many marshes taken during the winter of those first trying years provided a small cash income.

Soon all the land was taken and the most important problem of the new settlers was the wetness of the land. Some of the new comers were from Illinois and had some knowledge of land drainage. Necessity brought into use the bull ditches, capstan ditches, ground mole, etc.

Since most drainage ventures were cooperative (that is one land owner was limited in what he can do on his own) it became necessary to appeal to the Legislature to provide drainage laws. The Legislature provided Iowa with drainage laws.

These new laws permitted the rapid construction of many thousands of drainage districts most of them being constructed between 1900 and 1925.

Basically these districts were organized by petitions filed with the Board of Supervisors in the county in which the improvement is located. If the petition was sufficient in form and acceptable surety was posted, the Boards employed a qualified Engineer to prepare a preliminary report and cost estimate. After the Engineer had filed his report and the same was accepted by the Board, notice was given all affected parties of a hearing on the proposed improvement.

If, after the hearing, the Board determined that the plan was in the public interest and not excessive in cost, they appointed a qualified Engineer to prepare the Plans, Specifications, Bid, and prepare a letting as by law provided. The Engineer generally supervised the construction and carried it through to its successful conclusion. These improvements, were diverse, that is open ditch, or open ditch and tile drain combinations or a closed system alone. The areas of the district varied greatly from 80 acres to in excess of one hundred thousand acres.

After the construction was initiated (and often in the case of small districts, not until the work was completed and accepted) it was necessary to raise the funds to pay for the improvement.

To carry out this function the Board appointed a qualified Engineer, together with two free holders of the county. These men viewed the lands in the district and did determine the benefit to each 40 acre tract or fraction thereof, together with the benefits as might accrue to public roads or railroads within the district. The construction cost was apportioned in proportion to the benefits as determined by the Commissioners.

The assessments thus determined were published and the affected parties were given an opportunity to be heard. If the assessments were affirmed by the Board and no appeal was taken, the assessments also became the basis for all future maintenance of the district.

If the assessments, as just described, applied to a district composed of only one entity, namely an open ditch or a closed tile drain, the assessment is for a single simple benefit. However, if the original district was large and consisted of a main open ditch, several open ditch laterals, and a number of closed tile systems the matter becomes complex. Then there are some tracts of land in the district receiving not less then three benefits, namely a benefit from the outlet ditch, a benefit from an open ditch lateral, and a benefit from a closed tile system directly serving the land and outletting into the lateral ditch.

In a situation as I have just described it should have been the duty of the original Commissioners to consider the several benefits that accrued to some tracts of land within the district in arriving at a total assessment. However, this they did not always do.

I can recall only one instance when an original assessment schedule I examined showed separately the open ditch benefit and the tile benefit and the total thereof.

Let us assume that a large district composed of main open ditch, lateral ditches, and various closed tile systems, must have the main open ditch repaired and improved. If the board orders the work done and a twenty per cent (20%) assessment is made a man whose original assessment is composed of 20% main open ditch, 30% open ditch lateral and 50% closed tile system, pays 80% for benefits not provided him by the main drain. This fact makes reclassification of drainage districts a necessity.

The Board of Supervisors, if they have proof that there is an inequity in the assessments of any drainage district under their jurisdiction, may by resolution institute proceedings to reclassify such drainage district. Further if improvements are contemplated to an existing district and the cost thereof exceeds 25% of the original cost plus subsequent improvements then notice shall be given all affected parties and the question of reclassification publicly considered at such hearing. If, however, such a district is composed of open ditch and closed tile laterals and the benefits therefore have not been classified separately, then such reclassification shall be manditory. When a reclassification is finally established it shall then become the basis for all future assessments.

The proceedings for reclassifications shall in all particulars be governed by the same rules as for original classifications. The need for a reclassification indicates that the original assessments are not equitable and do not represent the real benefit to the land. The benefit to be determined under a reclassification is not a new benefit but the actual benefit provided by the original construstion. To me this indicates that the reclassification Commissioners should reapportion the original cost plus the cost of any subsequent improvements.

Therefore, it is necessary to search the original records and determine from them the total costs of all the separate parts of the original district, the cost of the main open ditch, the cost of each open ditch lateral, and the cost of each tile system. The sum total of these original costs should equal the total assessment of the original districts. If subsequent improvements have been made to any part of the district the cost of such improvements should be added to that particular segment of the original districts.

Now that the original costs have been determined, the Commissioners appointed to reclassify, must locate a map of the original construction, which shows the watershed, the several parcels of land, the public highways and the railroads. If such a map shows all the ponds, swamps, and wet land, together with the elevations the Commissioners are in luck. The Commissioners must also have marked upon the map all the interior divides. If the map does not show such divides they must be determined in the field. The interior divides are necessary because they determine the boundary of tile benefits. The same is true in the apportionment of the cost of the lateral ditches. The cost of such lateral ditches shall be equitably apportioned to the land tributary thereto, and the cost of the main open ditch must be fairly apportioned to all the land in the district.

In one instance when checking the original assessment against a 40 acre tract in an old district, I found that such original assessment was less than the benefit provided by the tile system alone. Thus other lands in the district was paying for its lateral and open ditch benefit.

It becomes evident at this point that when the Commissioners have completed their task and the same has been approved by the Board after a proper hearing, the district in fact is broken up into separate financial entities. If repairs are made to the main open drain, the schedule of the main open ditch is used as a basis of payment therefor. If repairs are made to a tile system the cost of the repair of such tile system is based upon the schedule of that system.

It should be apparent that reclassification of a drainage district is not an easy matter. I must emphasize thatthe Commissioners must use all of the information available to them to assist them in their judgment. Since the original condition of the land is no longer apparent a reclassification usually increases the assessment against less benefited land and reduces the assessment against the land most dependent upon the improvement.

I recall, during a district court action involving reclassification of a drainage district, the presiding Judge asked me, "Do you not believe since all the land in the district is now tillable to approximately the same degree that you should take the total cost and divide it by the total acres." This reasoning is false.

A drainage district comes into being because certain lands are too wet for cultivation. It is the purpose and intent of the improvement to make the wettest land productive. This land receives the greatest benefit. Other land in the watershed receive a lesser benefit. The benefit does not change, because if you would destroy the improvement the land would again revert to its original state.

I have refrained from going into the actual mathematics of arriving at the dollar assessments. Since there are several different approaches and after all the arithmetical results are merely the reflection of the judgment of the Commissioners.

The last Legislature, made certain changes in the drainage laws, one being that, the Board of Supervisors as trustees of a drainage district are not required to reclassify an entire drainage district, but only the land tributary to the facility being repaired.

This provision of the law is completely unworkable. A district must be completely reclassified in all its aspects to be equitable.

I have thoroughly enjoyed speaking to this distinguished group. I only hope I have not left you thoroughly confused..

W. C. Otto, P. E.
Sac City, Iowa

Financing County Recreation Projects with Bond Issues

by

Mr. Wendell Cornwall, Member
Mr. Jack Fisher, Secretary
Boone County Conservation Board
Ogden, Iowa

Summary: Messrs. Cornwall and Fisher discussed various aspects of planning, publicity, and coordination in this first use by a county of the new bond program enacted by the last General Assembly. The Boone County Conservation Board utilized the new program to borrow funds for completing the development of the Don Williams Lake and Recreation area on Bluff Creek near Ogden.

To gain full support of the public and obtain approval of a bond issue the Boone County Conservation Board carefully planned and carried out a publicity and information program. The objectives of the park development were outlined, and the need and desire for rapid completion explained. Boone County taxpayers subsequently approved the bond issue.

The material contained in the following pages is part of the illustrative folder prepared for the publicity program.

TO THE VOTERS OF BOONE COUNTY

We, your Conservation Board, have worked six years in preparing this program for all our citizens. We feel the diversification of facilities such as golf, boating, swimming, hiking, picnicking, camping, fishing, and hunting provides a complete family park. By selecting this area on Bluff Creek, we believe we have a centrally located site, well served by paved county roads. The 600 acres contains an excellent growth of timber which enhances the beauty of area and provides an ideal setting for camping, picnicking, and other recreational facilities. The 160 acre lake to be formed from the clear, clean water of Bluff Creek will provide the chief attraction of the area.

We believe those of you who have visited this area will agree that we have a terrific opportunity to add to the natural beauty of our county an outdoor area which can provide all our citizens a complete vacation recreation and conservation center. We solicit your questions and your support at the coming election.

Respectfully,

County Conservation Board

VOTE YES ☒ AUGUST 10, 1965

WHAT WILL THIS PROGRAM COST?

To finance our needed improvements to the Don Williams Lake, a bond issue of $300,000 will be needed. To retire this issue .451 mills of the one mill County Conservation Board's annual levy will be pledged. There will be no increase in the Board's total operating levy to pay for these bonds.

The individual shares of the cost of this program now represented by a one mill levy and which will continue to be so represented what with .451 mills to go to retire the bonds of this program over a period of 15 years is as follows:

Average Per Acre Cost -- Improved Farm Land	$ .036
Average Annual Cost -- Improved 160 Acre Land	$ 5.83
Average Annual Cost -- Home Owners	$ .87
Average Annual Cost -- Commercial Property	$ 2.45
Average Annual Cost -- Industrial Property	$12.95

WHAT WILL WE RECEIVE FROM THIS PROGRAM?

The bulk of the proceeds of the issue will go to build an earthen dam, adjacent to the spillway now under construction. This dam will be approximately 600 feet long, 55 feet high, and three hundred feet thick at its base. This dam will form the lake which will be the basis of the recreational area. It is estimated that this dam will cost $250,000. The balance of the funds ($50,000) will be used to complete roadways, build boat ramps, and provide equipment for picnic and camping areas.

WHY THIS PROGRAM NOW?

Recent changes in the Iowa Law, effective July 4, 1965, have authorized Iowa Counties to accelerate their Conservation and Recreational Programs.

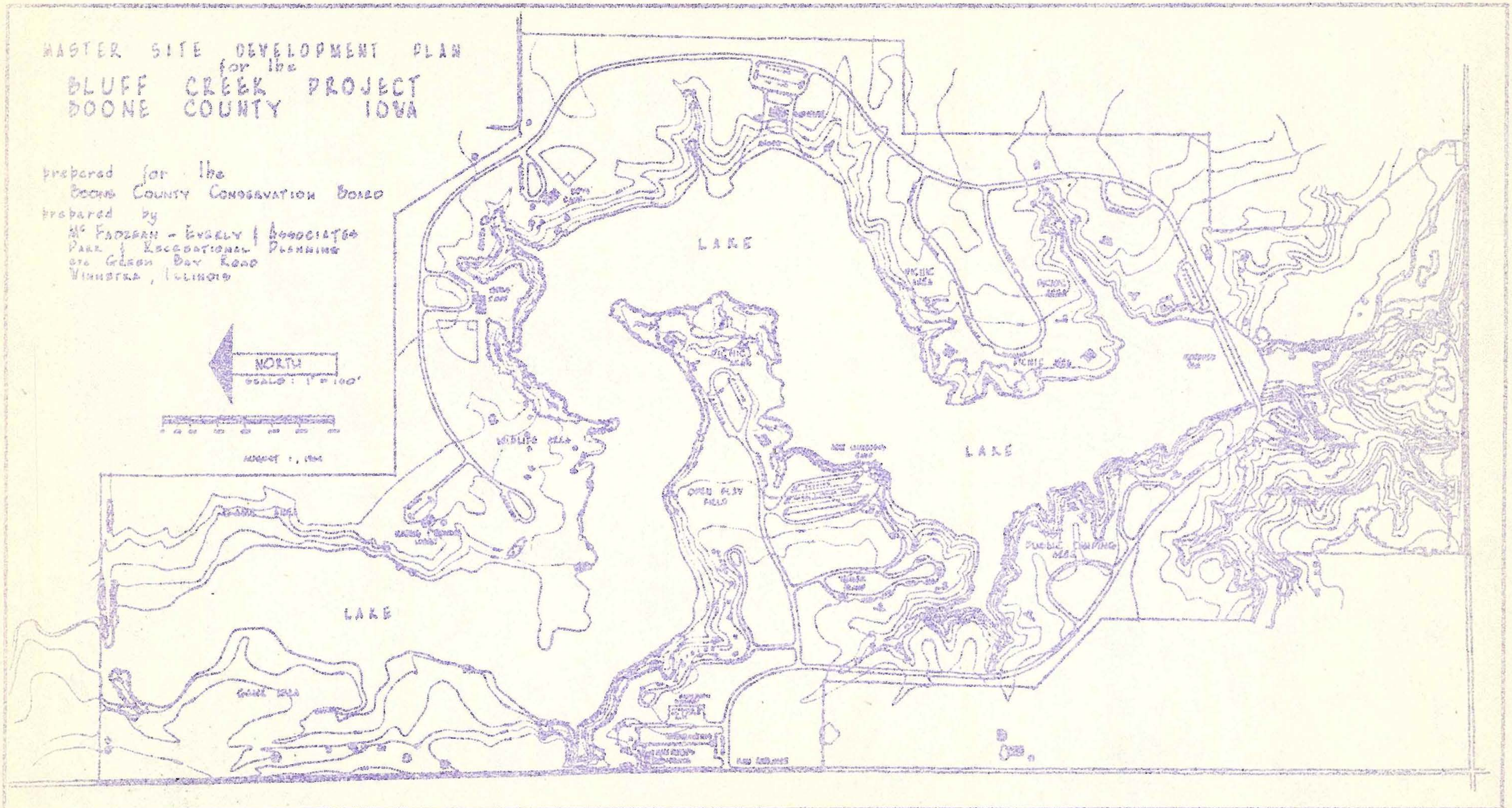
Boone County's Board has been working over six years in developing the Don Williams Lake Area as a completed Conservation and Recreational Program for the county.

By using the Bond Procedures authorized by the last Iowa General Assembly, the development of this area can be completed now, six years ahead of schedule.

WHAT HAS BEEN ACCOMPLISHED UP TO NOW?

The County Board has purchased approximately 600 acres as shown on the map included and has developed a master plan. The golf facilities have been in use less than a month. The camping and picnic facilities have been used by many in the county for the past year. Many service roads have been completed and the spillway for the dam is now under construction. But this has taken six years and the completed program is needed now.

THE BOONE COUNTY CONSERVATION BOARD
PRESENTS PLANS FOR INCREASING THE
CONSERVATION & RECREATIONAL FACILITIES OF OUR COUNTY



VOTE YES ☒ FOR THE ACCELERATION OF THE DEVELOPMENT OF
THE DON WILLIAMS LAKE & RECREATIONAL AREA