RED RIVER WATERWAY PROJECT--SUMMARY OF GROUND-WATER STUDIES BY THE U.S. GEOLOGICAL SURVEY, 1962-85

By James E. Rogers

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)

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ABSTRACT

The U.S. Geological Survey (Survey), in cooperation with the U.S. Army, Corps of Engineers (Corps), investigated various aspects of the ground-water system of the Red River alluvium in relation to the Red River Waterway Project, from 1962-85. Beginning in 1962 the Survey made preliminary estimates of the effects of the construction of locks and dams on ground-water levels. The area affected by high ground-water levels was estimated to increase by more than 55 square miles for the postconstruction period. Later, these estimates were refined by use of more sophisticated techniques that required use of digital models. Results were given to the U.S. Department of Agriculture, Soil Conservation Service, for an assessment of the effects of changes in water level on agriculture. The Soil Conservation Service provided the Corps a monetary assessment of potential damages.

Subsequently, the variability of water quality with time and space in the Red River alluvial aquifer in the preconstruction period was studied. This information permits variations in water quality in the postconstruction period to be evaluated as natural or as project induced.

To complement the work on water-level predictions for rural areas, a study provided an evaluation of changes in water levels in urban areas. Damage assessments for urban areas were made for the Corps by a private contractor. Evaluation of effects of small changes in dam locations or pool stage were made periodically by the Survey. The most recent evaluation was the effect of increasing the pool stage 2 feet during the summer to permit hydroelectric power generation. The Corps made the monetary assessment of damages. Ground-water records generated during the various studies, including logs of wells, water levels, and water-quality data, were compiled and published.

INTRODUCTION

Throughout the Red River Waterway Project, 1962-85, the types of studies and means of reporting the results have varied greatly for programs conducted by the U.S. Geological Survey in cooperation with the U.S. Army, Corps of Engineers (Corps). The formats and types of publication have been so diverse that it is difficult for the Corps to identify and to reference the exact report containing the information under consideration.

Because of the frequent need by the Corps to refer to the reports documenting the hydrologic information on the Red River project, the Survey prepared a summary of all of their work conducted as part of that project. This summary contains a listing of the reports by title, background, and results; and a description of other miscellaneous work conducted by the Survey as a part of the Red River project.

The Survey documented results and preliminary interpretations of the hydrologic system as work progressed on the Red River project. The interpretive work is documented in administrative and letter reports (written communications), and Survey Open-File and Water-Resources Investigations Reports. Geologic, water-level, and water-quality data are documented in basic-data reports. Other informal exchanges of data, such as preliminary maps, preliminary data projections from ground-water modeling, or special work, are not as well documented. The Survey, also in cooperation with the Corps, maintains water-level and water-quality data networks in the Red River Valley to collect additional data for future analysis of changes in the hydrologic system.

BRIEF HISTORY OF STUDIES

The Ninetieth Congress authorized the Red River Waterway Project of the Corps, in the Rivers and Harbors Act of 1958. Since 1962, the Survey has conducted scientific investigations or contributed hydrologic information for the Red River Waterway Project (fig. 1). In that year, the Survey provided data on water levels and geology for the Red River alluvium. Shortly thereafter, the Survey, in cooperation with the Corps, made a preliminary prediction of the effect of the construction of locks and dams on the ground-water flow system in the alluvium. The Survey constructed an electrical-analog model using existing data and estimated that an additional 55 mi^2 or more of the valley might be adversely affected by higher ground-water levels caused by the structures. More detailed information was needed; therefore, the Survey studied the hydrology of the area, constructed more than 100 observation wells, and with the U.S. Department of Agriculture, Soil Conservation Service (SCS) collected more water-level data for making better projections of water-level changes.

Development of digital models permitted consideration of the effect of other variables such as rainfall, hydraulic conductivity of the beds confining the aquifer, and changes in evapotranspiration on the flow system. Ultimately, the modeling effort produced estimates of postconstruction water levels in the fine-grained deposits overlying the alluvial aquifer at 10-day intervals during the growing season. These data were furnished to SCS, who made an assessment of beneficial and adverse effects of shallow water levels on agriculture.

From March 1974 to March 1977 the Survey studied temporal and spatial variations in water quality in the Red River alluvial aquifer. The study documented preconstruction conditions, providing base-line values so quality variations in the postconstruction period could be identified as natural or project induced.

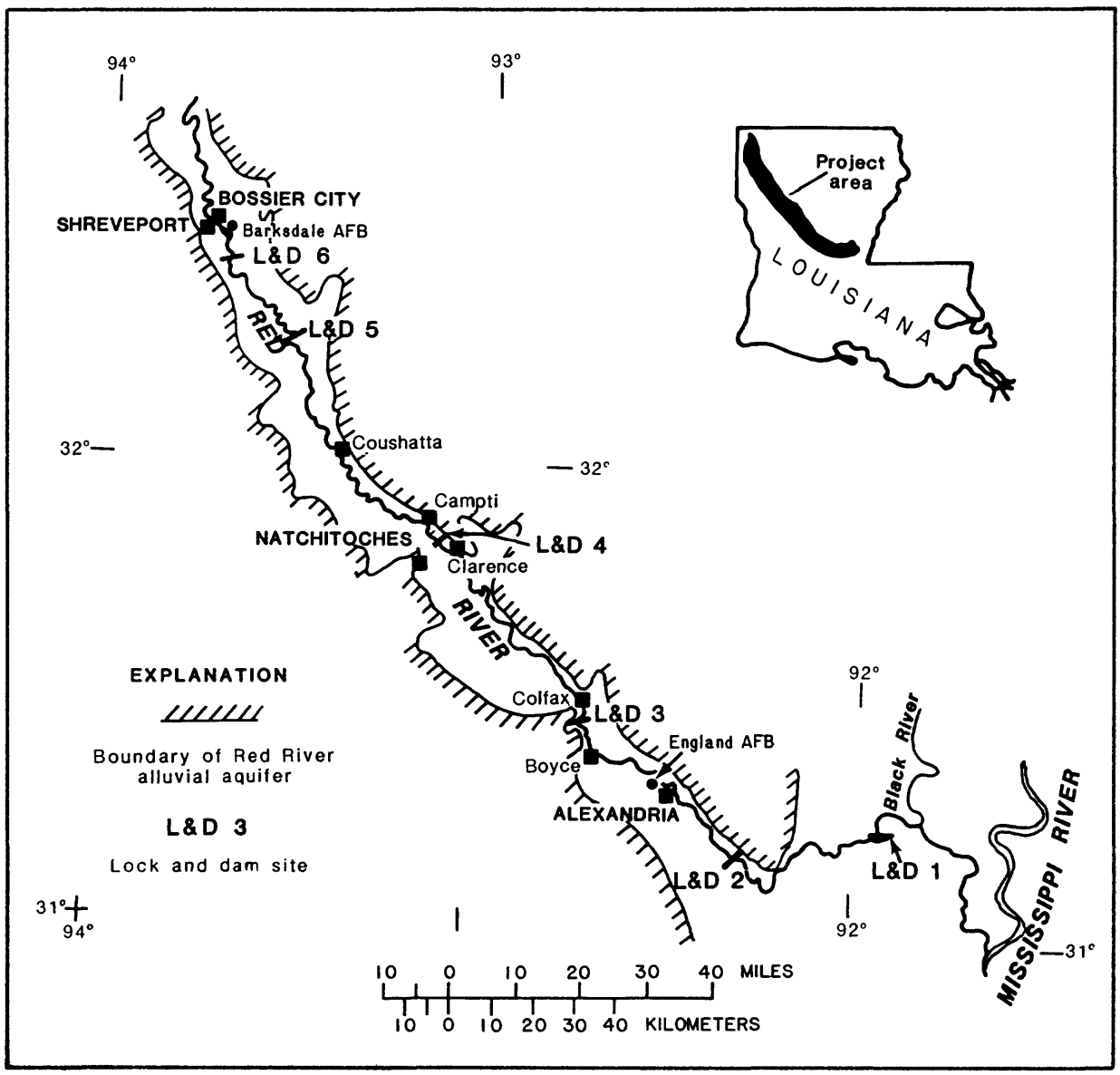

Figure 1.--Location of Red River Waterway Project in Louisiana.

In 1976, to aid the study of the effect of higher ground-water levels on urban areas in the valley, more observation wells were drilled and additional water-level measurements were made. Predictions were made of steady-state water levels in urban areas for the postconstruction period. Data from the networks were furnished to the Corps so their contractor could make an assessment of adverse effects of higher ground-water levels in urban areas.

In 1984, the Survey evaluated the potential effect of the use of dams on the Red River for hydroelectric power generation. The proposal was to raise the pool level 2 ft on each of the locks and dams, except Lock and Dam 1 which was already completed.

On occasion, the Survey has assisted the Corps in special data-collection efforts. Gas samples were collected at Lock and Dam 1 to define the source, which was found to be of natural origin ("swamp gas"). Reduction-oxidation potential, pH, and other chemical data were collected to assist in a corrosion study at Lock and Dam 1. Subsequently, the Survey analyzed aquifer-test data for Lock and Dam 2 and 3.

As the Corps proceeded with design of the lock and dam system, some additional changes were proposed for dam locations or pool stages. At the request of the Corps, the Survey estimated the changes in ground-water level that would be caused by these changes in the lock and dam system.

INTERPRETIVE GROUND-WATER STUDIES AND REPORTS

Report on Present Ground-Water Conditions and the Projected Effect of Proposed Navigation Features on Ground Water in the Lower Red River Valley, Texas and Louisiana

Background

The Corps used information on present ground-water conditions and the projected effect of proposed navigation features on groundwater in the lower Red River Valley, Texas and Louisiana, (M.S. Bedinger and R.A. Pettijohn, U.S. Geological Survey, written commun., 1965) for preliminary planning of drainage facilities or redesign of navigation structures to alleviate high ground-water levels. For the planning the Corps needed an estimate of the changes in ground-water levels that would be caused by the construction of locks and dams on the Red River. In cooperation with the Corps, the Survey developed an electrical-analog model of the ground- and surface-water flow system using existing hydrologic data. Data were available from previous geologic and hydrologic investigations by the Survey. Both published and unpublished data were used. Data synthesized for periods of missing record improved the reliability of projections. The model was used to make a preliminary estimate of ground-water levels in the alluvial aquifer during the postconstruction period.

Results

Bedinger and Pettijohn (U.S. Geological Survey, written commun., 1965) indicate that recharge to the alluvial aquifer is by rainfall and discharge is by seepage to the Red River and to major tributaries and by evapotranspira-

tion. They also report that the effect of evapotranspiration on the ground-water flow regimen is as significant as the effect of ground-water discharge to streams. Generally, however, evapotranspiration effects on piezometric contours are not as easily distinguished as is discharge to streams.

Bedinger and Pettijohn (U.S. Geological Survey, written commun., 1965) report that changes in water levels in the alluvial aquifer adjacent to the river will be as great as the change in river stage. The amount of change will decrease with distance from the river because of increased evapotranspiration and increased discharge to tributary streams. The effects caused by the change in river stage will be negligible beyond 8 or 10 mi from the river.

The following analysis was made on the assumption that ground-water levels within 5 ft of land surface may affect man's activities. Under predevelopment conditions, 114 mi^2 of the project area have average ground-water levels within 5 ft of land surface. The affected area is projected to increase to 170 mi^2 for lock and dam areas 2 through 6. Data were sparse in the Lock and Dam 1 area, so the area was not modeled; therefore, the effect in that area did not enter into the analysis.

The distribution of affected lock and dam areas (square miles) with average water levels less than 5 ft below land surface follows:

Lock and Dam No.	Area affected (square miles)	
	Preconstruction	Postconstruction
6	1	5
5	1	6
4	1	4
3	1	5
2	110	150

Digital-Computer Programs for Analysis of Ground-Water Flow

Background

Bedinger and others (1973) describe the hydrologic application for three digital-computer programs--GROUND-WATER FLOW, RIVER-INDUCED FLUCTUATIONS, and EVAPOTRANSPIRATION. These programs apply digital-computer solutions to previously described mathematical and hydrologic techniques. Knowledge of the background references given under the description of each program is needed before using the programs.

Results

The GROUND-WATER FLOW program computes the head response in an aquifer to various boundary conditions. The EVAPOTRANSPIRATION program computes the steady-state relation between evapotranspiration and depth to water as a function of thickness and layering of fine-grained material overlying the aquifer. The output from EVAPOTRANSPIRATION is applicable in some problems as boundary criteria in the GROUND-WATER FLOW program.

The RIVER-INDUCED FLUCTUATIONS program accepts as input the unit change in stream stage computed by GROUND-WATER FLOW. By using the unit response of the aquifer and a hydrograph of the stream, RIVER-INDUCED FLUCTUATIONS computes the head fluctuations in the aquifer, induced by changes in stream stage.

Simulation Procedure for Modeling Transient Water-Table and Artesian Stress and Response

Background

Reed and others (1976) describe a system of digital-computer programs written in Fortran IV. These programs are used to simulate and display transient water-table and artesian head in an aquifer in response to changes in ground-water withdrawal, stream stage, and climatic factors. The simulation procedure is contained in a program termed SUPERMOCK. DATE and HYDROG are auxiliary programs used to manipulate display data and output from SUPERMOCK.

Results

SUPERMOCK is designed to simulate transient stress and response of a ground-water flow system. The model simultaneously incorporates all components of stress on the flow field. The prototype flow system of the model is the alluvial aquifer of the Red River Valley in Louisiana. The model is designed specifically to simulate the effects on ground water of permanent changes in the stream-stage regime caused by construction of locks and dams. The model consists of three components: (1) a soil-moisture accounting, (2) a vertical-flow, and (3) a horizontal-flow. The programs are designed to model the ground-water regime in sufficient detail to determine the effects of the imposition of various types of stress on the system and to display the results in a usable manner.

Preconstruction and Postconstruction Ground-Water Levels, Lock and Dam 1, Red River Valley, Louisiana [1]

Background

Ludwig (1979a) describes the results of a study to define the present ground-water levels and to determine the effects of proposed navigation structures on ground-water levels in the Lock and Dam 1 area. Two types of analysis were made--steady state and nonsteady state. Steady-state analysis refers to the determination of change from average preconstruction to average postconstruction potentiometric surface in the aquifer. Maps illustrate the

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[1] The documentation on preconstruction and postconstruction ground-water levels for Lock and Dam 1, 2, 3, 4, and 5 and 6 originally were given to the Corps as written communications. Subsequently, these written communications were released in slightly revised form as Survey Open-File Reports. (See selected references.)

average preconstruction potentiometric surface and the projected postconstruction potentiometric surface determined from the steady-state analyses. Nonsteady state refers to the variations in the position of the potentiometric and water-table surfaces with time. In the Red River Valley, the water table generally lies in the fine-grained material above the aquifer. Nonsteady-state analyses include computations of the variation with time of the preconstruction and postconstruction water table. Nonsteady-state analyses for Lock and Dam 1 were for plan B-3, modified (proposed navigation system). Data from the analyses were given to the SCS for their analysis of the effects of water-table changes on agriculture. Selected hydrographs in the report illustrate the results of nonsteady-state analyses at specific sites.

Results

The ground-water flow system was analyzed by steady-state and nonsteady-state analyses. Water levels in the alluvial aquifer adjacent to the river will be nearly the same as the pool stage. Average water levels in the aquifer will increase as much as 9 ft near the dam and as much as 2.5 ft at the upper end of the pool. In the lower part of the lock and dam area upstream from the dam, average water levels in the aquifer will be raised a foot or more within 4 mi of the river. The potentiometric surface may be near land surface in low-lying areas and above land surface along the course of drainage features near the dam. The magnitude of water-level fluctuations in the aquifer will decrease in the postconstruction period; however, the water levels will be closer to land surface.

Preconstruction and Postconstruction Ground-Water Levels, Lock and Dam 2, Red River Valley, Louisiana [1]

Background

Ludwig (1979b) describes the results of a study to define the present ground-water levels and to determine the effects of proposed navigation structures on ground-water levels in the Lock and Dam 2 area. Two types of analysis were made--steady state and nonsteady state. Steady-state analysis refers to the determination of change from average preconstruction to average postconstruction potentiometric surface in the aquifer. Maps illustrate the average preconstruction potentiometric surface and the projected postconstruction potentiometric surface determined from the steady-state analyses. Nonsteady state refers to the variations in the position of the potentiometric and water-table surfaces with time. In the Red River Valley, the water table generally lies in the fine-grained material above the aquifer. Nonsteady-state analyses include computations of the variation with time of the preconstruction and postconstruction water table. Nonsteady-state analyses for Lock and Dam 1 were for plan B-3, modified (proposed navigation system). Data from the analyses were given to the SCS for their analysis of the effects of water-table changes on agriculture. Selected hydrographs in the report illustrate the results of nonsteady-state analyses at specific sites.

Results

The ground-water flow system was analyzed by steady-state and nonsteady-state analyses. Water levels in the alluvial aquifer adjacent to the river will be nearly the same as pool stage. Pool stage at the dam site will increase by the design amount, which may vary from plan to plan. The increase in pool stage will be less than 5 ft at the upper end of the pool. At a pool stage of 58 ft a permanent increase in river stage at the dam will be 12.5 ft. Upstream from the dam, ground-water levels will rise 1 ft or more within as much as 4 mi from the river. The average potentiometric surface may be as much as 2 ft above land surface along Chatlin Lake Canal south of Alexandria. The analysis for a 65-foot pool stage indicates a permanent increase in river stage of 19.5 ft at the dam. Ground-water levels would rise as much as 1 ft or more as far as 6 mi from the river. The potentiometric surface for the alluvial aquifer would be as much as 6 ft above land surface in part of the Chatlin Lake Canal area south of Alexandria. The potentiometric surface would be at or near land surface in much of the low-lying areas within 3 to 4 mi of the river. Effects for plans that specify intermediate pool stages (between 58 and 65 ft) would be intermediate to the extremes discussed. Because of the attenuation in river stage caused by the formation of a pool upstream from the lock and dam, the magnitude of postconstruction ground-water level fluctuations will be reduced to approximately half of existing fluctuations. The water levels, however, will be closer to land surface.

Preconstruction and Postconstruction Ground-Water Levels, Lock and Dam 3, Red River Valley, Louisiana [1]

Background

Ludwig and Terry (1979a) describe the results of a study to define the present ground-water levels and to determine the effects of proposed navigation structures on ground-water levels in the Lock and Dam 3 area. Two types of analysis were made--steady state and nonsteady state. Steady-state analysis refers to the determination of change from average preconstruction to average postconstruction potentiometric surface in the aquifer. Maps illustrate the average preconstruction potentiometric surface and the projected postconstruction potentiometric surface determined from the steady-state analyses. Nonsteady state refers to the variations in the position of the potentiometric and water-table surfaces with time. In the Red River Valley, the water table generally lies in the fine-grained material above the aquifer. Nonsteady-state analyses include computations of the variation with time of the preconstruction and postconstruction water table. Nonsteady-state analyses for Lock and Dam 1 were for plan B-3, modified (proposed navigation system). Data from the analyses were given to the SCS for their analysis of the effects of water-table changes on agriculture. Selected hydrographs in the report illustrate the results of nonsteady-state analyses at specific sites.

Results

The ground-water flow system was analyzed by steady-state and nonsteady-state analyses. Water levels in the alluvial aquifer adjacent to the river

will be nearly the same as pool stage. Pool stage at the dam site will increase by the design amount, which may vary from plan to plan. The increase in pool stage will be less than 5 ft at the upper end of the pool. Water-level changes in the alluvial aquifer for five alternate plans for construction were estimated. The five plans represent four different locations for the dam. The maximum average change in upstream stage at the proposed dam sites ranges from 20 to 25.5 ft. All analyses indicate the presence of problem areas caused by high ground-water levels. For each plan, ground-water levels occur at or above land surface in low-lying areas near the dam. For four of the plans, high ground-water levels occur between the Red River and Cane River Lake. Because of the different locations for the dams, some of the areas that would be affected by high-water levels at one proposed dam site may be downstream from another site and not be affected. Because of the attenuation in river stage caused by the formation of a pool upstream from the lock and dam, the magnitude of postconstruction ground-water level fluctuations will be reduced to approximately half of existing fluctuations. The water levels, however, will be closer to land surface.

Preconstruction and Postconstruction Ground-Water Levels, Lock and Dam 4, Red River Valley, Louisiana [1]

Background

Ludwig and Reed (1979) describe the results of a study to define the present ground-water levels and to determine the effects of proposed navigation structures on ground-water levels in the Lock and Dam 4 area. Two types of analysis were made--steady state and nonsteady state. Steady-state analysis refers to the determination of change from average preconstruction to average postconstruction potentiometric surface in the aquifer. Maps illustrate the average preconstruction potentiometric surface and the projected postconstruction potentiometric surface determined from the steady-state analyses. Nonsteady state refers to the variations in the position of the potentiometric and water-table surfaces with time. In the Red River Valley, the water table generally lies in the fine-grained material above the aquifer. Nonsteady-state analyses include computations of the variation with time of the preconstruction and postconstruction water table. Nonsteady-state analyses for Lock and Dam 1 were for plan B-3, modified (proposed navigation system). Data from the analyses were given to the SCS for their analysis of the effects of water-table changes on agriculture. Selected hydrographs in the report illustrate the results of nonsteady-state analyses at specific sites.

Results

The ground-water flow system was analyzed by steady-state and nonsteady-state analyses. Water levels in the alluvial aquifer adjacent to the river will be nearly the same as pool stage. Pool stage at the dam site will increase by the design amount, which may vary from plan to plan. The increase in pool stage will be less than 5 ft at the upper end of the pool. Five alternate sites for construction of Lock and Dam 4 were evaluated. Changes in pool stage for the plans range from 15 to 25 ft near the dam sites. Ground-

water levels would be at or near land surface in low-lying areas between the Red River and Bayou Pierre. The plans using higher pool stages would result in additional areas being affected by high ground-water levels. For plan B-3, modified, the potentiometric surface would be above land surface in areas near Campti. Because of the attenuation in river stage caused by the formation of a pool upstream from the lock and dam, the magnitude of postconstruction ground-water level fluctuations will be reduced to approximately half of existing fluctuations. The water levels, however, will be closer to land surface.

Preconstruction and Postconstruction Ground-Water Levels, Lock and Dam 5 and 6, Red River Valley, Louisiana [1]

Background

Ludwig and Terry (1979b) describe the results of a study to define the present ground-water levels and to determine the effects of proposed navigation structures on ground-water levels in the Lock and Dam 5 and 6. Two types of analysis were made--steady state and nonsteady state. Steady-state analysis refers to the determination of change from average preconstruction to average postconstruction potentiometric surface in the aquifer. Maps illustrate the average preconstruction potentiometric surface and the projected postconstruction potentiometric surface determined from the steady-state analyses. Nonsteady state refers to the variations in the position of the potentiometric and water-table surfaces with time. In the Red River Valley, the water table generally lies in the fine-grained material above the aquifer. Nonsteady-state analyses include computations of the variation with time of the preconstruction and postconstruction water table. Nonsteady-state analyses for Lock and Dam 1 were for plan B-3, modified (proposed navigation system). Data from the analyses were given to the SCS for their analysis of the effects of water-table changes on agriculture. Selected hydrographs in the report illustrate the results of nonsteady-state analyses at specific sites.

Results

The ground-water flow system was analyzed by steady-state and nonsteady-state analyses. Water levels in the alluvial aquifer adjacent to the river will be nearly the same as pool stage. Pool stage at the dam site will increase by the design amount, which may vary from plan to plan. The increase in pool stage will be less than 5 ft at the upper end of the pool. Two sites for Lock and Dam 5 and one site for Lock and Dam 6 were studied. The changes in pool stage for the various plans range from 13 to 23 ft. The potentiometric surface would be near, at, or above land surface on both sides of the river in low-lying areas for each of the plans. Water levels are near land surface in several areas under preconstruction conditions. These areas would be enlarged by the construction of the locks and dams. Because of the attenuation in river stage caused by the formation of a pool upstream from the lock and dam, the magnitude of postconstruction ground-water level fluctuations will be reduced to approximately half of existing fluctuations. The water levels, however, will be closer to land surface.

Predicted Effects of a 2-Foot Increase in Pool Stage on the Postconstruction Ground-Water Levels, Lock and Dam 5, Red River Valley, Louisiana

Background

A transmittal to the Corps on the predicted effects of a 2-foot increase in pool stage on the postconstruction ground-water levels, Lock and Dam 5, Red River Valley, Louisiana (H.L. Case, U.S. Geological Survey, written commun., 1976) presents the results of a model simulation. Model input was much the same as that used by Ludwig and Terry (1979b) except for the change in pool stage.

Results

Shortly after submittal of the modeling results for the lock and dam areas, the Corps requested an evaluation of the effects of changing the pool stage behind Lock and Dam 5, plan B-3, modified, from 145 to 147 ft. Case (U.S. Geological Survey, written commun., 1976) compares a steady-state analysis for the new pool stage to the analysis for the old stage. The area affected by shallow ground water would increase about 2 percent. The effect would be small in the Shreveport area where water-level changes would be less than 0.5 ft.

Methods and Applications of Digital-Model Simulation of the Red River Alluvial Aquifer, Shreveport to the Mouth of Black River, Louisiana

Background

Ludwig and Terry (1980) describe the methods used in the study and show their application to the Red River Waterway Project. The report discusses data collection for modeling, the conceptual model of the geohydrology, and the predictive models including calibration, output, and applications.

Results

The report systematically presents (1) development and management of the basic-data network and the types of data collected, (2) conceptualization of the geohydrology of the area, (3) description of and data requirements for the predictive models, (4) discussion of peripheral computer programs used in the project, (5) calibration of the models, (6) output from the models, and (7) applications of the models for other areas.

Chemical Character of Water in the Red River Alluvial Aquifer, Louisiana

Background

Construction of locks and dams on the Red River will alter the ground-water flow pattern, at least in part, which may cause water quality to be altered in some areas. The purpose of this report (Whitfield, 1980) is to provide the Corps with background data on the variability of ground-water

quality in the Red River alluvial aquifer, spatially and temporally in the preconstruction period. These data can be used to evaluate quality changes in the postconstruction period to determine if they are within the range of natural variability established for the preconstruction period or if quality has been affected by the navigation project. No attempt is made to predict postconstruction water quality.

Results

Results of this study show that a wide range in vertical and lateral variability of the chemical character of water from the alluvial aquifer may occur with time. Except where affected by saltwater, most water-quality changes that occurred during the project were related to seasonal differences in recharge. No evidence was found to indicate that contamination of water in the aquifer by pesticides or nitrates was a problem.

Collection of water-quality data from a network of wells at key sites should continue for a few years after construction of all locks and dams. This will help show whether water-quality variations are natural or have been project induced.

Preconstruction and Simulated Postconstruction Ground-Water Levels at Urban Centers in the Red River Navigation Project Area, Louisiana

Background

Rogers (1983) presents findings of the potential effects of plan B-3, modified on ground water in the Red River alluvium. Water levels in the alluvial aquifer at urban and suburban areas after construction of the proposed navigation system were of particular interest. The following procedures were used to determine these effects:

1. Analyze the ground-water system and determine average water levels as an indicator of preconstruction, steady-state conditions.

2. Synthesize long-term average water levels for sites having short periods of record to provide data points within urban areas compatible with those in rural areas.

3. Determine, by means of digital modeling of the aquifer-stream system, the change in ground-water levels in response to proposed changes in stage of the Red River.

4. Superpose water-level changes, determined by modeling, on preconstruction average water levels (steady-state conditions) to predict a postconstruction average potentiometric (water level) surface (steady-state conditions).

5. Determine the relation between the average potentiometric surface of the Red River alluvial aquifer and the piezometric level of the overlying confining beds.

Results

For plan B-3, modified, average water levels in the alluvial aquifer are predicted to rise as much as 8 to 12 ft near the Red River in the Shreveport area; as much as 5 to 9 ft at Coushatta; 15 to 19 ft at Campti; 4 ft at Clarence; and 8 to 10 ft at Colfax. In the Alexandria area, ground-water levels will rise 6 to 7 ft near the river and 1 ft on the side of the city away from the river.

The rise in the potentiometric surface of the aquifer will cause the top of the zone of saturation in the overlying fine-grained sediments (confining beds) to rise. Because the data base was not sufficiently long enough to calibrate a model to simulate transient flow in the aquifer, water levels were approximated by steady-state conditions. Hydrographs illustrate average monthly levels and show the relation between the top of the zone of saturation and the potentiometric surface of the aquifer. Postconstruction conditions were simulated by moving the hydrographs upward by the amount of projected change in average water level in the postconstruction period.

Other Interpretive Work

In the course of preparing more detailed plans for the locks and dams, the Corps considered several alternatives for pool stage or dam location at some sites. Late in 1977, the proposed location of Lock and Dam 4 was changed to river mile 189 (1967 mileage). A model simulation provided steady-state ground-water level data for the new location. To illustrate the similarities and differences in water levels between the two sites, water levels based on data from the new site were contoured in red on a water-level contour map based on data from the original site. The change in location caused only moderate changes in the water-level contours. A copy of this map was sent to the Corps in January 1978.

Later in 1978, the Corps requested an evaluation of the effects on ground-water levels of moving or modifying the sites for Lock and Dam 3, 4, and 5 using stage data from plan B-3, modified. Effects were minor in each instance. Data for about 2 mi^2 were adjusted to the downstream pool level at Lock and Dam 3; effects at Lock and Dam 4 were nearly the same as the values submitted in January 1978. Lowering of ground-water levels would occur in a small area below the new dam location. The location of Lock and Dam 5 was not changed but new levees were proposed. The model was not sensitive enough to show water-level changes for the small area affected. The new levees would cause some field changes. Ground-water levels between the new and old levees would be slightly lower. These results were transmitted to the Corps in January 1979.

Red River Navigation Project, Ground-Water Impact of Pool-Stage Increase of 2 Feet, June through October--Plan B-1

Background

A transmittal to the Corps on the Red River Navigation Project, ground-water impact of pool-stage increase of 2 feet, June through October--plan B-1 is an appraisal that evaluates the ground-water effect of an additional 2-foot

increase in pool stage (J.E. Rogers and G.N. Ryals, U.S. Geological Survey, written commun., 1984). Specifically, the appraisal shows the acreage of adverse effects on agriculture greater than that determined in previous studies for plan B-1. Because of time and money constraints, a full analysis of the potential change in land use, including changes from one type row crop to another, was not made. Use of detailed computer modeling techniques for transient conditions would be necessary for more precise results. Existing transient model results and steady-state models were used for the appraisal.

Results

The appraisal indicates that the increase in pool stage will affect land use only moderately. Lock and dam areas 1 and 2 would be affected the most; however, much of the effect is in backswamp areas and, thus, may not significantly affect agriculture. Most of the effect was an enlargement of previously designated affected areas. The Corps used the information to place a dollar value on the cost to agriculture. No attempt was made to evaluate the additional effect within previously designated affected areas. To fully understand and assess damages of a pool-stage increase, a transient type analysis using SUPERMOCK would be necessary.

DATA REPORTS

The ground-water studies for the Red River Waterway Project required the construction of observation wells, frequent measurement of water levels in the wells, and the collection of water samples from the wells for chemical analysis. These data provided information on geology, hydrology, and water quality necessary for the interpretive reports. Collection of water-level and water-quality data continues after publication of the interpretive reports. These subsequent data are needed to determine, more precisely, variations in the preconstruction period and to document actual variations and changes in the postconstruction period. The first two data reports, one for chemical quality of ground water and the other for lithologic logs and water levels, included data collected for the projects and pertinent historical data. Other reports document ground-water data collected subsequently. Data for surface-quality-of-water stations on the Red River are published annually.

Quality of Water in the Red River Alluvial Aquifer, Shreveport to the Mouth of Black River, Louisiana

Background

As part of the Red River Waterway Project, chemical quality was determined for water from the Red River alluvial aquifer. Water in many of the observation wells was sampled to aid in evaluating possible changes after construction of navigation structures. The purpose of this report (Ludwig, 1974) is to release historical data and data collected during the initial phase of the project on the quality of water in the alluvial aquifer.

The chemical analyses of samples collected from 296 wells through 1973 were reported by Ludwig (1974). Hardness, chloride, specific conductance, and

pH were measured at the time the wells were installed. A more comprehensive analysis was performed for inorganic constituents in samples collected from 125 selected wells in the network. Repeated sampling was done at selected wells to determine whether quality varied from time to time. Variability was great enough between samples from some wells so that a detailed study of water-quality variability subsequently was initiated.

Chemical Character of Water in the Red River Alluvial Aquifer, Louisiana

Whitfield (1980) is discussed in the section on interpretive reports. However, the report also contains extensive water-quality data. More than 500 wells were used in the study. About 2,400 analyses are in the tables, mostly collected between 1974 and 1978 but also including much of the historical data.

Records of Wells, Water-Level Measurements, and Drillers' Logs, Red River Valley, Louisiana

Background

Stephens (1976) presents a compilation of hydrogeologic data collected from July 1968 to June 1975 as part of the Red River Waterway Project.

The report includes records of 332 wells and test holes, water levels measured in 324 wells, and drillers' logs of 316 wells and test holes. Most of the data were collected between July 1968 and June 1975. Much historical data collected before July 1968 also are included.

Records of Water-Level Measurements and Lithologic Logs, Red River Valley, Louisiana, 1975-80

Background

Smoot (1983) presents a compilation of ground-water levels measured from January 1975 to December 1980 and lithologic logs of wells and test holes completed during this time. The report also includes lithologic or drillers' logs made prior to 1975 but previously not published.

Data tables are compiled by parish. Water-level records are included for 417 wells. Lithologic logs of 124 wells or test holes are tabulated.

Water-Level Measurements 1981-85 and Chemical Analyses 1978-85, Red River Alluvial Aquifer, Red River Valley, Louisiana

Background

Smoot and Guillot (1988) present a compilation of ground-water levels measured from January 1981 to December 1985 and water-quality data collected from January 1978 to December 1985. Water-level records for 404 wells and

water-quality data for 178 wells are compiled by parish. No lithologic logs are included because few, if any, new wells were drilled.

Water-Resources Data for Louisiana

A program for collecting quality-of-water data at surface-water sampling sites on the Red River started in October 1972. The Survey collected and analyzed the samples. Analyses were for common inorganic constituents, nutrients, metals, and pesticides. Samples were collected weekly, 1973-74; quarterly, 1975-77; and monthly, 1978-85. As a special project in 1979, the Survey sampled 38 additional sites along the Red River and eight sites on tributary streams in the valley. Water-quality data from the surface-water sampling program are published annually in the "Water Resources Data, Louisiana, Water Year 19__," for the water year that the data were collected.

MISCELLANEOUS WORK

Annual Progress Reports

In the early years of the Red River Waterway Project, participants (SCS, Survey, and Corps) met annually to discuss work in progress and to plan work for the coming year. Starting about 1970 the Survey prepared annual progress reports to document current and proposed work. Each report had a section on work accomplished during the current fiscal year and work proposed for the following fiscal year. Reports published, observation wells drilled, data networks, modeling, and special requested work were all topics included in the annual progress reports. Sometimes exchanges of data were documented in these reports; often, informal exchanges of data were not included. When project intensity was high in the 1970's, the reports were presented with a formal cover. As participation by the Survey became less complex in the 1980's, the information was presented in letter format. The Survey, however, has maintained the same method of presentation of the information--that is, work accomplished and work proposed.

Analysis of Samples for Methane Gas

In addition to the evaluation of the effect on ground-water levels that would be caused by lock and dam relocations or by pool-stage adjustments, several studies or data-collection efforts have been incorporated with the scope of the Red River Waterway Project. During the excavations for Lock and Dam 1, flammable gas was encountered. The gas bubbled through the soil and accumulated in some of the observation wells and dewatering wells. Although the origin of the gas was uncertain, there was some concern that the gas was leaking from an oil well or oil-test hole. The Survey sampled the gas for analysis by a commercial laboratory. The analyses indicated that the flammable component of the gas was methane. Thus, the source was considered to be of local and natural origin ("swamp gas").

Because of the gas problem at Lock and Dam 1, test wells at the proposed sites of Lock and Dam 2 and 3 were sampled for gas and for inorganic chemical analysis. No flammable gas was found.

Analysis of Samples for Corrosion

In the construction phase of Lock and Dam 1 the dewatering wells had an extensive corrosion problem. To aid the Corps in finding a solution to the problem, the Survey sampled the wells for chemical analyses and made measurements of reduction-oxidation potential (Eh) and pH of the water. The data were given to the Corps.

Analysis of Aquifer-Test Data

The Corps installed preliminary test wells at the proposed sites for Lock and Dam 2 and 3. The Corps performed aquifer tests at the two sites and the Survey assisted the Corps by analyzing the tests. Results from the tests at the proposed site of Lock and Dam 2 were inconclusive.

Reports by D'Appolonia Consulting Engineers, Inc.[2]

The Survey conducted an analysis of transient ground-water conditions in the Red River Valley for plan B-3, modified. By 1977, the question was asked if plan B-3, modified, was the best plan, hydrologically, to produce minimum damages to agriculture and structures. The Corps contracted with D'Appolonia Consulting Engineers, Inc., to evaluate other plans and assess damages for rural and urban areas. At the request of the Corps, the Survey provided D'Appolonia documentation of SUPERMOCK, all data collected for the project, and information on running the model. Reports published from 1978 to 1980 on the work done by D'Appolonia Consulting Engineers, Inc. are in Selected References.

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[2] Use of the trade name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

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