SUMMARY REPORT

Iowa State University
Water Resources Research Institute

University of Iowa
Institute of Urban and Regional Research

AMES RESERVOIR ENVIRONMENTAL STUDY

ISWRRI 60-SR
IURR-FRS-9-SR
1973

SUMMARY REPORT

AMES RESERVOIR ENVIRONMENTAL STUDY

By

Iowa State Water Resources Research Institute,
Iowa State University, Ames, Iowa
in cooperation with the
Institute of Urban and Regional Research,
University of Iowa, Iowa City

For

U.S. Army
Corps of Engineers
Rock Island District
Contract DACW25-72-C-0033

Iowa State University:
ISWRRI Completion Report
No. 60-SR
University of Iowa:
IURR Final Report
Series No. 9-SR

An environmental resources review study of the proposed Ames Reservoir, Skunk River, Iowa — including the valley's natural resources, agricultural and urban growth, people and their attitudes, recreation needs, water use and pollution control, flood problems, economic values, and impact of alternative development patterns.

1973

Frontispiece. The Skunk River valley at the Ames Reservoir site: A winter view of its physical attributes.

AMES RESERVOIR ENVIRONMENTAL STUDY

(ARES)

The ARES Summary Report is dedicated to those individuals and Congressmen who framed the National Environmental Policy Act of 1969 and to the resource, development, and construction agencies at local, state, and federal governmental levels who earnestly adopt and energetically apply its principles.

Co-principal Investigators and Editors,
ARES Summary Report:
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Director, Iowa State Water Resources Research Institute
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Declaration of a New National Policy:
—To encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation—

National Environmental Policy Act of 1969

Publication of the Summary Report and general office administration were financed in part by funds provided from the Department of Interior, Office of Water Resources Research under Public Law 88-379 and made available to the Iowa State Water Resources Research Institute, and in part by funds provided through the Office of the Vice President for Research and the Engineering Research Institute, Iowa State University.

Ames Reservoir Environmental Study

Summary Report

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9. G. Bultena, D. Rogers, and V. Webb, Public Response to Planned Environmental Change: A Study of Citizen Views and Actions on the Proposed Ames Reservoir, available from the Department of Sociology and Anthropology, ISU, as Sociology Report 106, January 1973.

USEFUL DEFINITIONS AND PROJECT DESCRIPTION FOR THE ARES REPORT

Project Terminology

Ames Reservoir, Ames Lake, Ames Dam: Construction of a large dam in a natural river valley creates a reservoir in which water can be stored. The Ames Dam consists of the earth embankment, an outlet works for normal release of water to downstream users and controlled release of floodwaters, and a combination of spillways for discharging floods of large magnitude. The reservoir's water surface area is called the Ames Lake. Both terms, Ames Reservoir and Ames Lake, frequently are used interchangeably in referring to the overall reservoir project.

Multiple-purpose project = Multi-purpose project, and related beneficial uses: A water resources project which provides water and/or water storage for more than one beneficial use group in our society. Flood control, outdoor recreation, water quality, water supply, and fish and wildlife propagation are specific beneficial use categories associated with the Ames Reservoir project.

Conservation pool = normal pool = permanent pool: This is the reservoir storage volume (acre-feet) and its related water surface elevation (feet above the mean sea level datum) and area (acres) in which water is held for long periods for selected beneficial uses, such as water-oriented recreation, fish and wildlife propagation, water quality, and water supply. Withdrawal or release of water during drought periods will reduce its elevation, volume, and area.

Flood pool = Flood control storage allocation: This is the pool formed by a reservoir when it temporarily stores flood water. This storage allocation is placed above the conservation pool. Snowmelt or rainfall floods are temporarily stored and released slowly to reduce flood damages downstream. The duration of temporary storage can extend for several months for great floods before the water level returns to its normal operating level.

Surcharge pool = an additional vertical increment of depth (and related water surface area) above the flood pool: This accommodates additional flood storage, provides adequate spillway discharge capability for floods whose volume might exceed the flood control storage allocation, and provides for safety against the dam ever being overtopped.

Drawdown: A term which refers to gradually reducing the elevation of the reservoir flood control or conservation pool as water is released from temporary or conservation storage.

Inundation = flooding by natural or reservoir conditions: A term used to express water covering a land surface to a stated depth by natural or stored floodwaters.

Other Physical Terms

cfs = a rate of water flow, cubic feet per second.

mgd = MGD = a rate of water use, or quantity per day, million gallons per day; 1 cfs is equivalent to 0.646 mgd.

ac-ft = acre-foot or acre-feet = a volume of water accumulated or stored, equivalent to covering one acre to a depth of one foot. In one day, a rate of 1 cfs would accumulate to a volume of 1.98 or about 2 acre-feet; a rate of 1 mgd for one day would accumulate to a volume of 3.07 acre-feet.

M.S.L. = MSL = vertical elevation as referenced to mean sea level; the average level of the ocean, in feet.

mg/l = milligrams per liter, equivalent to ppm, parts per million; a means of expressing concentrations of substances found in water. One pound of a substance dissolved, or mixed and suspended, in one million pounds of water is equivalent to 1 ppm.

Other Economic Terms

Discount rate: The discount rate represents the cost of capital or of borrowed money. Discount rates are usually based on the interest rate for alternative investments. Discount rates used in public project analysis should assure that public facilities return benefits equivalent to alternative investments.

Present worth of costs and/or benefits: This is a dollar value representing today's worth of all disbursements to be made during the life of a project and of today's value of the annual stream of benefits expected or received as a result of the project. Present worth combines all investment costs and all annual expenses into a single sum that would be necessary at the present time to finance the entire project. It accomplishes a similar objective for benefits, however they might be evaluated and to whomever they might accrue. It is sensitive to the discount rate applied to investments.

Take line: A line demarking the extent of property acquisition for a project. Roughly, the take line for the Ames Reservoir Project is elev. 983. The actual take line will be established through negotiations with property owners.

Principal Features of the Proposed Ames Reservoir

Drainage area at dam site: 314 sq mi;

Sediment storage pool: surface area of 800 acres; elevation of 933 ft, mean sea level datum (MSL); storage volume allocation of 8,400 acre-ft;

Conservation pool: surface area of 2,100 acres; elevation of 950 ft, MSL; storage volume allocation of 26,100 acre-ft;

Flood control pool: surface area of 5,000 acres; elevation of 976 ft, MSL; storage volume allocation of 89,500 acre-ft; total volume of storage is 124,000 acre-ft for the three pools, at elevation of 976 ft;

Subimpoundments for additional recreation use purposes:

Dam site: 30-acre lake at east abutment of dam, elevation of 1,000 ft MSL, using access road as a secondary dam across a narrow valley; active consideration in detailed planning phase;

Bear Creek: 160-acre lake at elevation of 970 ft, MSL; dam and spillway at I-35 embankment; removed from active consideration in the design phase;

Shallow subimpoundment, in upper conservation pool: improved aquatic habitat area; shallow dam-road overflow section at "40 and 8" county road; active consideration in detailed planning phase;

Construction features:

Earth dam: height of 85 ft above streambed; crest length of 1,450 ft; county road to be placed across top of dam;

Outlet works: tunnel outlet conduit, 500 ft long, concrete lined; gate tower at upstream end;

Principal spillway: concrete ogee crest at elevation of 951 ft, MSL, with one tainter gate, 26 ft high and 48 ft wide; concrete walls at abutment and bridge across spillway;

Emergency spillway section: earth cut, vegetative cover; 800 ft long crest at elevation of 982 ft, MSL; crest formed by using proposed county road;

Principal relocations:

State highways: 0.5 mi;

Interstate 35 (already relocated during initial construction); riprap protection;

County roads: abandon certain roads; construct new crossings; total of 6.7 mi affected;

Telephone lines: 10 mi;

Electric power lines: 13.5 mi;

Urban remedial works and flood protection; Story City: levee and street raises, alterations at water pollution control plant.

AMES RESERVOIR ENVIRONMENTAL STUDY

Abstract

An environmental resources review study was conducted of the federally authorized Ames Reservoir (Ames Lake), located on the Skunk River northeast of Ames, Iowa. The multi-purpose water-resources project, planned by the U.S. Army Corps of Engineers, would serve several beneficial uses: water supply and water quality control for the City of Ames, outdoor water-oriented recreation for a nine-county central Iowa region, flood control for the agricultural flood plain landowners downstream of Ames, and incidental fish and wildlife (waterfowl) propagation. The reservoir site is located in the most scenic reach of the Skunk River valley in the headwater region. The reservoir as authorized would control runoff from a 314-sq-mi watershed, about 8 percent of the basin's total drainage area of 4300 sq mi. The 12-mile long reservoir reach is in the only unstraightened segment lying between the upland drainage-ditch headwater areas and the downstream straightened main-channel reach extending over 100 miles from Ames to the Mahaska-Keokuk County line.

The study was conducted by an interdisciplinary research team from Iowa State University and the University of Iowa, involving the Iowa State Water Resources Research Institute and the Institute of Urban and Regional Research, respectively. Sponsored by the Rock Island District Corps of Engineers, the study will serve as a resource inventory and project evaluation basis for federal preparation of the environmental impact statement required by the National Environmental Policy Act of 1969. Identification of the resource uniqueness of the

reservoir site and an evaluation of the environmental responses anticipated under alternative development patterns were major objectives of the study. Five major categories were used in conducting the study: (1) Natural and archaeological resources of the valley, reservoir site, and stream system; (2) social and economic impact; (3) outdoor recreation and open-space uses; (4) agricultural influences and effects; and (5) urban influences and effects. The study offered a unique opportunity for faculty and graduate and undergraduate students in some 17 disciplines to combine and direct their research efforts in evaluating the environmental impact of the proposed project. Results of previous research and several new field investigations conducted during the study provided information for evaluating the project and formulating conclusions. The research group introduced nine alternative development plans: four reservoir alternatives and five open-space, green-belt, outdoor-recreation alternatives. These were evaluated in a combined physical, social, economic, and institutional framework, considering both spatial and temporal aspects. The reservoir alternatives included the proposed Corps project both with optimum and with minimum recreational facilities, and a reduced-scope multi-purpose project. The open-space and recreation alternatives included a large recreation lake, a river green belt with tributary recreation lakes, a minimum river green belt, a maximum valley green belt, and a "do-nothing" alternative which would permit the existing use patterns in the natural valley to continue.

The Category I team inventoried the soil, geological, vegetative, forest, wildlife, and stream aquatic life resources. A comprehensive digital computer landscape overview model was developed and used for displaying the resource data. A comparative resource-suitability model was incorporated into the study for weighing and evaluating the resource data in various proposed-use contexts. The forest inventory showed that 25 percent (2000 acres) of the valley woodland in Story County is contained in the 34-section study area, with a total of 15 percent (1700 acres) being contained in the proposed 5000-acre reservoir area. Three upland forest communities were inventoried: Oak-hickory, elm-ash, and maple-basswood. One bottomland-mixed-flood plain-forest category was studied. Mineral resources were identified and inventoried in the reservoir area. Sand, gravel, and limestone rock are extracted at several locations for construction materials. Many soils in the valley and the upland are not conducive to septic tank effluent tile systems, and others are sensitive to intensive use stress by recreational users. Wildlife census data revealed a quantity and quality level of fair to good for species counts and adequacy of habitat. The existence of the interstate highway route and the continued stress of rural-residential housing growth have an adverse effect on larger animals. The study showed that any reservoir alternative would have a greater impact on the natural resources than the open-space, green-belt, or recreation alternatives. The magnitude of the impact was determined for each alternative. The "do-nothing" alternative also poses a threat to the valley as it exists today.

Archaeological sites were inventoried in a reconnaissance study. Fifty-one sites of occupancy identified were among the following cultural traditions: the historic Euro-American, native American "Indians," Post Woodland and Woodland Tradition, and possible Archaic Tradition. All sites could be endangered by development patterns, whether for reservoir, mineral extraction, roads, or rural-residential housing use.

The stream system is affected both by hydrologic variables (floods and droughts) and by man's influence (agricultural and urban). The reservoir reach, being a natural, unstraightened segment, contains a good fisheries habitat. It has the only small-mouth bass fisheries in the upper basin (800 sq mi) above Colfax, Iowa. The reservoir fisheries potential was evaluated, and the sport-fish and rough-fish species composition was forecast.

The general social and economic impact of resource use and development, as studied by Category 2, was determined by interviewing residents of the area, by evaluating project benefits and costs, and by analyzing regional economic trends. A study of social impacts and public attitudes in the upper basin indicated an absence of majority opinions, in that 30% opposed construction of a reservoir, 25% were in favor, 16% were undecided, and 4% had no opinion. The remaining 25% were unaware of the project despite hearings, meetings, news articles, and other publicity. Results were also obtained for upstream vs downstream residents and for other water and recreation-oriented aspects, with a definite pattern existing towards a considerable majority being uninformed about the project, its benefits, and its associated losses. Dividing the respondents into above- and below-the-dam categories resulted in a clear opposition to the project from the upstream group, with continued divided opinion downstream.

A second social study was made of the displacement of residents in the reservoir area. These included those who would be displaced by the project (up to 170+ individuals in 55 households), those immediately outside the acquisition boundaries (113+ individuals in 28 households), and other local residents experiencing external effects only (75 individuals in 20 households). Federal relocation requirements would apply to the first group, and assistance funds would be needed.

A regional economic study showed that direct and indirect benefits would occur to the region. Secondary benefits in the indirect economic sector would be low to modest in magnitude. The associated economic impact on the local economy was evaluated and the gains and losses listed.

Outdoor recreation and open-space needs were evaluated by Category 3 in a regional context. The five existing recreational areas within the reservoir were inventoried and attendance levels ascertained. These areas include the 94-acre McFarland county park area, three small river access areas, and a municipal park and golf course at Story City. The role of all nine alternative development opportunities was evaluated for (a) attendance, using a regional model, (b) facilities cost, and (c) benefits, using visitor-day values adopted nationally. Greenbelt alternatives provide in general a higher benefit-to-cost ratio over reservoir or lake alternatives in the single-purpose recreational analysis. However, the latter alternatives would serve a greater number of people.

Evaluated within the context of the existing multi-purpose reservoir development at Red Rock and Saylorville, and currently planned state park and open-space acquisitions, the immediate need for additional water-area in the Ames area is not urgent. Current regional plans would provide an increase from less than five acres of lake water area per 1000 capita to more than 20. Population growth in the region would indicate that adding the Ames Reservoir (five acres per 1000 capita level) in the 1995-2020 period would permit regaining the 20 acres per 1000 capita level at that point in time. Comparative recreational studies conducted at the Coralville Reservoir-Lake MacBride complex at Iowa City has shown the mix in recreational facilities which needs to be provided at multi-purpose reservoirs. Results are summarized in the review study.

The agricultural role in the basin as determined by Category 4 has a substantial influence on water quality in the stream system and on regional development. Over 75% of the land is tilled, with most in corn or soybeans. Drainage of the flat agricultural fields using drain tile and open ditches is a predominant practice. Fertilizer application is heavy, and from 5-25 lb of N-nitrogen and up to 2 lb of P-phosphorus may be delivered to the reservoir site from each acre of the watershed per year, depending on rainfall and runoff.

The livestock production in the region is nonintensive. A large-scale turkey-growing region exists in the basin upstream of the reservoir, but on fairly flat terrain. There are few large-scale open feedlots, with two observed as having runoff control facilities. There are, in total, large quantities of manure produced in the upper basin. Water quality in the streams is affected mostly during snowmelt runoff and during summer thunderstorm periods of high-intensity rainfall. Both oxygen-demanding carbonaceous organic residues and ammonia-nitrogen are pollution constituents and could pose a problem in reservoir or stream management for water quality control and enhancement. In addition, the total nutrient input to the proposed reservoir (or alternatives) from combined crop and livestock production and from urban sources would result in algal growth and "bloom" problems and would require related water quality management programs.

The pollution potential of pesticides was studied; 60% of the farmers surveyed used insecticides and 80% used herbicides, mostly on corn and soybeans. Atrazine, aldrin, treflan, and amiben are commonly used herbicides; insecticides include the chlorinated hydrocarbons and the phosphates. Negligible or low concentrations of these were measured during the study. Although not posing a threat to domestic water users, the influence on the aquatic habitat could be more serious.

The sediment yield of the basin was evaluated, with results showing nominal amounts of sediment production. About 300 tons per square mile is delivered to the stream system annually (0.5 ton per acre per year). This represents less than a 0.07% loss of reservoir capacity per year for any of the multi-purpose reservoir alternatives. Over 75% of this sediment yield originates from the sloping lands adjacent to the main valley and channel network. The influence of the reservoir on the drainage tile and ditch systems in the reservoir area was also determined, and critical areas inventoried.

Flood damages to agricultural lands downstream of the reservoir were reviewed, and the impact on lands within the reservoir also determined. Changes in crop yields and prices since the original Corps studies would indicate that damage levels could be increased by a factor of 1.7 or more (70% increase). Introduction of a different flood-frequency method in a sensitivity analysis reduced the given flood damage figures by a factor of 0.50, to a 50% level or less. The average result was a factor of approximately 0.9 (90%), if one combines the 0.50 and 1.70 factors as a product. Little if any urban flood damage has been reported in the basin.

Urban water resource problems and needs were evaluated by Category 5. The population growth at Ames, in Story County (within which the reservoir is located), and in the remainder of the nine-county region of influence were forecast for the 1970-2020 period. Of the 62,200 residents of Story County (1970 census), 53,000 live in incorporated towns or cities, 4600 are farmers, and 4600 are rural-residential dwellers.

The population of the nine-county central Iowa area in 1970 was over 560,000. This can increase from 50% to 100% by the year 2020, with a 75% increase forecast as the most probable growth trend. Changes in birth rates and other stabilizing factors yielded different results than were obtained by other state and federal agencies in regional water resource studies. Water supply and water pollution control needs were evaluated for Ames. The current water supply source — a surficial groundwater supply — is adequate until the period 1995-2000, with a long-term permissive sustained yield of 13 mgd, and a maximum short-term yield of 17 mgd capability. Other sources must be obtained after that date, such as additional exploitation of the alluvial aquifers, use of bedrock aquifers, or reservoir sources. Water quality control is a major problem; without low-flow augmentation from reservoir storage, the natural drought low flows are near the zero level at Ames, as the city well field induces all the low flow of the stream into the groundwater seepage pattern. Advanced waste treatment is needed for ammonia reduction or nitrification, regardless of reservoir water availability; phosphate removal is an alternative which could be avoided through reservoir storage and supplemental low-flow releases. Treatment costs for the City of Ames for the 50-yr period (1970-2020) could increase to a total average level of $800,000 per year, compared to one-third of this today, if all facilities for advanced treatment are required. Water quality problems at Story City in the reservoir headwaters and pollution problems associated with the reservoir area from housing developments also were evaluated and reported.

The detailed project evaluation was conducted by Category 2 researchers using a sensitivity analysis and new water resources criteria adopted nationally in 1972 and early 1973, or proposed for adoption. Discount rates for economic analysis of 3-1/4, 5-1/2, and 7% were used, and variations in flood frequency methods, population growth rates, and variable needs for recreation, water supply, and water pollution control were introduced to provide an array of results. The results show that at the currently-used project discount rate of 3-1/4%, and using the maximum-use criteria permitted by the Corps, the reservoir project continues to have a favorable benefit-to-cost ratio, 1.4 to 1.0. However, if the new national criteria are used, as now adopted or proposed, the benefit-to-cost ratio drops to less than 0.5 to 1.0 (returning only 50¢ per dollar expended), and all reservoir alternatives, including a reduced-scope project, fail to survive the economic test.

The environmental impact of all alternatives is presented in the summary report in an expanded array presentation. The research teams conclude that the reservoir alternatives have a substantial and detrimental impact on the existing valley; a "do-nothing" alternative which includes continued mineral extraction, rural-residential housing development, and urban recreational stress would be equally detrimental or unacceptable. The maximum green-belt alternative, with or without small recreation lake developments, represents the favored solution. This would have increased merit to the City of Ames and other beneficiaries if it included a reservoir site preservation concept, in a temporal sense. The reservoir alternatives, for the benefit of the large urban area at Ames, show a much greater potential need fulfillment and water role after the year 2000. With the green-belt alternatives, other water problems — including flood damage reduction and water quality control — would have to be solved using other physical and economic alternatives. Additional basin-wide studies are needed to formulate these solutions. The study team expresses great concern that adoption and implementation of one of the green-belt alternatives will fail because of lack of public concern and funding, or of inadequate local and state initiative. If one of the green-belt, open-space alternatives cannot be achieved, the reduced-scope reservoir alternative offers the public more open-space and recreation potential than that foreseen by the "do-nothing" alternative. A problem of considerable magnitude remains in the area of decision-making by local, state, and federal officials and agencies who must determine the most appropriate course of action. The results of the environmental review study will serve as a basis for this decision-making.

PART I

THE VALLEY, ITS PEOPLE, AND DEVELOPMENT OPPORTUNITIES

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part I. The Valley, Its People, and Development Opportunities

Chapter 1.

OBJECTIVES AND SCOPE

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ARES SUMMARY REPORT

Chapter 1

OBJECTIVES AND SCOPE

Introduction

In early 1972, the U.S. Army Corps of Engineers contracted with the Water Resources Research Institute at Iowa State University to conduct an environmental resources review study of the federally authorized Ames Reservoir. The environmental study was carried out in cooperation with the Institute of Urban and Regional Research at the University of Iowa. An interdisciplinary research team representing several water-related disciplines or areas of emphasis in the humanities, sciences, and engineering at the two schools was formed to make the study. This report summarizes the findings of the environmental study team. Because construction of the reservoir and lake project, located on the Skunk River near Ames, Iowa, is imminent, the environmental review study serves a timely purpose. The Skunk River basin and the general location of the reservoir are shown in Fig. 1-1.

The study was performed during a period of re-examination and re-evaluation at the national level of several water resources development objectives. One development objective involves the recent National Water Commission and its studies which outline and designate several nonstructural land-use control alternatives to structural flood control measures of an engineering nature. A recommendation requiring financial reimbursement by those benefiting from federal construction of engineering works for flood control is being advocated.

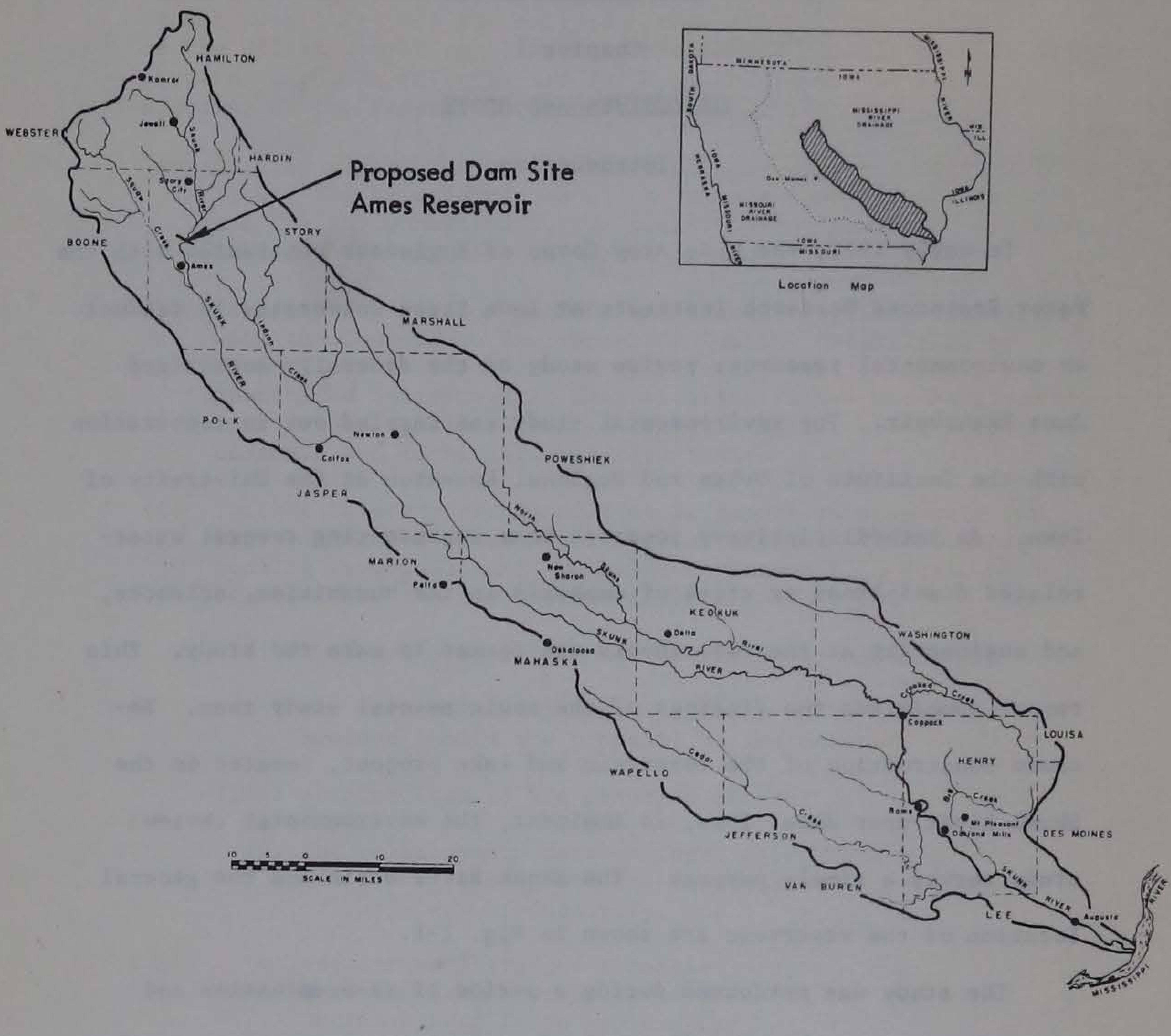

Fig. 1-1. The Skunk River Basin.

A second national objective involves new considerations in the field of water quality, as expressed in the Water Quality Act of 1972. For the enhancement of water quality in the nation's streams, additional advanced treatment of wastes may be required at the source, assuming the necessary technology is available. Low flow augmentation from reservoir storage can be considered an enhancement measure, if it is needed in addition to advanced treatment.

The third objective affecting the study concerns the federal Water Resources Council and its recommendations on interest or discount rates. Movement towards a higher rate was recommended in the evaluation of direct monetary-related benefits and costs associated with water resources projects. When combined with an emerging concept which stresses decentralized public decision-making, enhanced through passage of the National Environmental Policy Act of 1969, this national re-evaluation leads to new perspectives on multiple-purpose reservoirs.

Water resources development is an important aspect of the general economic development of a region. As with all economic development, an increased rate in the use of natural resources may be expected. Today, as a part of adopted public policy within the environmental context, detailed analysis of technical, economic, and institutional factors are required. National and regional objectives, alternative plans for development, competitive-use patterns, priorities of resource use, values associated with resource development, and other factors must be identified and included in comprehensive studies leading to economic development programs. Public decision-making has become a complex subject, and public involvement has been enhanced through passage of the National Environmental Policy Act of 1969 (NEPA).

The Charge of Responsibility Contained in NEPA

Evaluation of the environmental response to water resource development projects became a major thrust in the initial application of this environmental act. The research and analytical depth to which environmental studies are to be carried is outlined in Sec. 102 of the Act:

"Sec. 102. The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall . . .

(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment;

(B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by Title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical considerations;

(C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on . . .

(i) The environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved.

Copies of such statement and the comments and view of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by Section 552 of Title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(E) recognize the worldwide and long-range character of environmental problems, and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(F) make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(G) initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(H) assist the Council on Environmental Quality established by Title II of this Act."

The sections of this Act which apply most specifically to the review study of the Ames Reservoir are Sections 102(A), (B), parts i-v of (C), (D), and (G). The combined research team of the two universities performed an interdisciplinary analysis and evaluation of environmental effects of the proposed Ames Reservoir, within these stated objectives.

The Role and Position of Reservoir Storage Projects

Reservoir storage projects are a major component of river basin programs directed to the full economic development of the water resource. Reservoir sites must have favorable physical characteristics; as a result, the number of sites available in a given river basin is limited, and these sites can be identified through comprehensive river basin studies.

Reservoir sites are a unique, scarce resource in their own right. However, their preservation and eventual use must be analyzed in context with other demands for resource use. Both spatial (space location) and temporal (time-changing) uses of the natural resources of a reservoir require study and evaluation. The competitive role of reservoir site use is quite clear. Once committed to reservoir use and filled to capacity, submerged areas of these sites are thereafter unavailable for other uses, whether for land, timber or crop production, mineral or other resource needs, recreation and open space aesthetics, and general social well-being garnered through scenic views.

The temporal aspects of reservoir implementation plans are very critical, and a sequential planning and use concept needs to be included in regional economic development programs. The point in time when reservoir construction is implemented (assuming it is economically and environmentally justified) should be carefully planned and programmed. An optimum land and water use policy might provide for the sequential development and exploitation of the natural resources of a reservoir site prior to construction and inundation, accompanied by extensive mitigation measures required to assure compliance with environmental enhancement criteria. Economic and institutional factors weigh as heavily as the technical factors and in the past have tended to favor short-term solutions.

Technology in dam and reservoir construction has followed the path of many other technical developments, including the generation and use of electric energy, the development and acceptance of the automobile as a convenient and mobile means of transportation, and the introduction of the airplane into the transportation picture. As with these three examples, almost all development and use of reservoir sites in the United States has taken place since 1900, a brief 70-year period. The rate at which natural resources are used for such pursuits is under severe scrutiny, and long-term objectives and goals are being studied in additional detail.

The rate at which reservoir sites are used deserves the same careful analysis within the same long-term pattern. The trends and emphasis on dam construction to date indicate the complex and combined role of (a) technology, in making dam construction easy although expensive, (b) identification of water shortages, excesses, or needs, and (c) a favorable water resources development policy existing at both national and state levels of government. Within the guidelines of the Environmental Policy Act of 1969, a longer planning period or horizon is foreseen. Perhaps this will permit introduction of a more desirable long-term approach to natural resource development and use of technology, identification of water shortages and needs, and implementation of a more comprehensive and equitable water resources policy framework at national and state levels.

The Proposed Ames Reservoir

The proposed Ames Reservoir, located on the Skunk River upstream of Ames, Iowa, was authorized by Congress in 1964. The upper Skunk River basin, which is located upstream of Colfax, Iowa, is shown in Fig. 1-2, which identifies the reservoir site in the context of the surrounding region and its immediate area of influence for beneficial

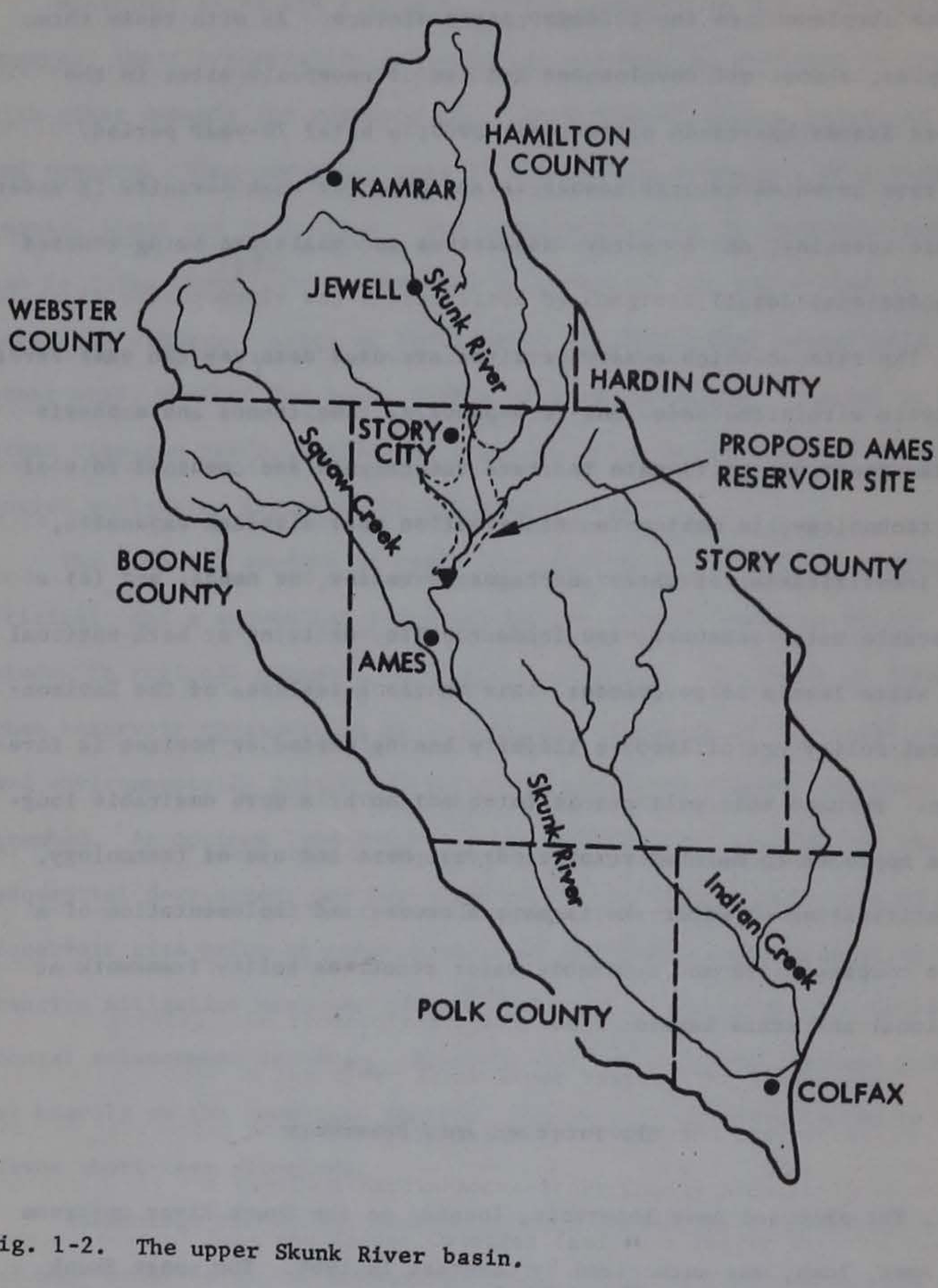

Fig. 1-2. The upper Skunk River basin.

use of the water resource. The reservoir is shown in more detail in Fig. 1-3, especially as it influences the local Ames-Story City area.

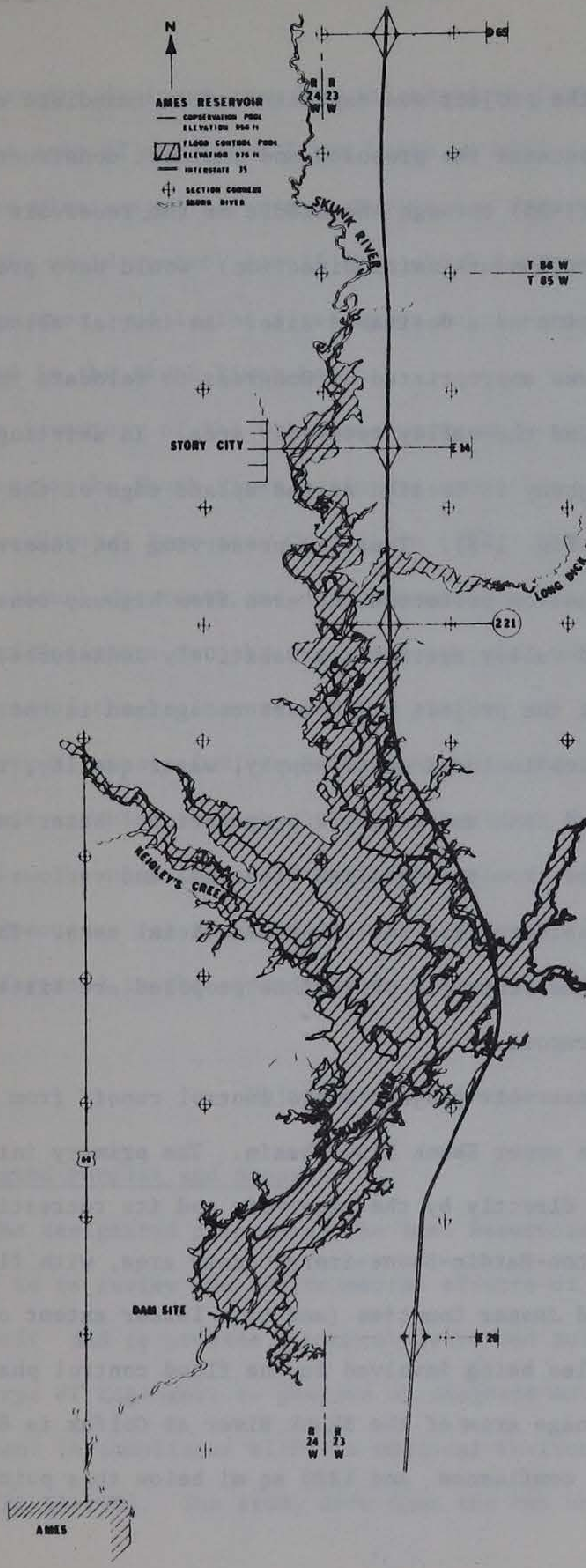

Fig. 1-3. Detailed features of the Ames Reservoir.

Authorization of the project was expedited as an immediate reservoir preservation measure, because the proposed and imminent construction of an interstate highway (I-35) through the middle of the reservoir site (in the longitudinal north-south axial direction) would have precluded its economic consideration as a desirable site. An initial allocation of funds subsequently was appropriated by Congress to relocate the interstate highway around the valley reservoir area. In skirting the reservoir area, the highway is located at the upland edge of the timbered valley bluff area (see Fig. 1-3). Thus, in preserving the reservoir site, the legislative action protected the area from highway construction and left the stream and valley system in a relatively undisturbed state.

Beneficial uses of the project which were recognized in the initial reservoir project studies included water supply, water quality, recreation, flood control, and fish and wildlife propagation. Water supply subsequently was dropped from the detailed planning, and various levels of development were considered for the other beneficial uses. The principal features of the reservoir project as proposed are listed in the beginning of this report.

In general, the reservoir project would control runoff from 314 sq mi of drainage area in the upper Skunk River basin. The primary intrastate region influenced most directly by the reservoir and its recreation potential is the Hamilton-Hardin-Boone-Story County area, with flood plain areas of Polk and Jasper Counties (and to a lesser extent other downstream counties) also being involved in the flood control phase of the project. The drainage area of the Skunk River at Colfax is 807 sq mi above the Indian Creek confluence and 1220 sq mi below this point. At

Oskaloosa the drainage area has increased to 1635 sq mi. The total drainage area of the Skunk River basin is 4355 sq mi at its confluence with the Mississippi River near Burlington (see Fig. 1-1). The reservoir would control runoff from about 8 percent of the total basin drainage area and is the first major multi-purpose reservoir project proposed in the Skunk River basin.

An inventory of the water resources and identification of water problems in the Skunk River basin was summarized in a state report by the Iowa Natural Resources Council in 1957. Several interim reports, congressional documents, and design memoranda have been prepared by the Corps of Engineers for the reservoir project. Most recently, the water resources of the basin were further studied and reported as a part of the Upper Mississippi River Basin Comprehensive Study program by federal and state agencies through the auspices of the federal Water Resources Council. The need for additional development and control of the basin's water resources was stressed in this latter report. These documents are referenced in the appendices to this report.

Objectives and Scope

Designated Purpose and Scope

The designated purpose of the Ames Reservoir Environmental Study (ARES) is to review the environmental effects of the authorized Ames Reservoir and to provide a comprehensive and authoritative basis for the Corps of Engineers to prepare an adequate environmental impact statement in compliance with the National Environmental Policy Act of 1969 (PL 91-190). The study drew upon the two universities' educational programs, as well as contributing to them. It involved the faculty and staff of areas concerned with water resource problems and related environmental problems and the solution of such problems.

The study encompassed a comprehensive inventory of natural resources in the upper Skunk River basin (upstream of Colfax), including the reservoir area; analysis of the rural and urban population characteristics and future trends; identification of water-use groups and their present and future demands; and an evaluation of the actual, probable, or potential environmental effects of the proposed federal water resources development project.

The study was conducted by an interdisciplinary research team composed of faculty and staff at Iowa State University and the University of Iowa. Disciplines involved included agronomy, agricultural engineering, botany, biology, forestry, fish and wildlife, outdoor recreation, landscape architecture, economics, geology, geography, sociology, civil and sanitary engineering, urban and regional planning, water resources, and zoology. The study included a review of the project documents, many technical reports and research bulletins associated with the Skunk River basin and its water problems (some of which had been published as a result of field and laboratory research efforts at the two universities), and a comparative study of the known or probable environmental responses to the proposed project based on all available knowledge. Additional field and applied research was undertaken to obtain information necessary to complete the environmental evaluation of the project.

The review study included identification of the resource uniqueness of the region. An evaluation of the environmental responses anticipated with the project was undertaken, and nine alternative development patterns were included for complete evaluation. As much as possible, the authorized project was evaluated in the context of future time spans.

Functional Categories for the Review Study

The proposed Ames Reservoir is located in an agricultural region noted for high crop productivity and livestock and poultry operations. Numerous small towns are located in the basin, and one large urban community, Ames, had a population of 39,505 in 1970. The rural population (outside corporate limits of the cities and towns) is growing in the reservoir area because of suburban or rural residential occupancy of wooded areas. Decreases in population are common in strictly agricultural townships. As a result, resource development must be reviewed in the context of a combined rural-urban atmosphere and related economic activities.

Therefore, a functional outline was proposed for dividing the interdisciplinary approach into meaningful study areas. The functional groups established for study purposes are listed in Table 1-1. This functional grouping permitted some division of responsibility between the two universities. Many elements of the study required close contact and coordination. Appropriate coordinating meetings, which included the category study teams and representatives of the Corps of Engineers, were held to accomplish the purpose of the review study. Additional coordination was achieved by establishing a coordinating technical committee of local, county, and state agencies concerned or interested in the reservoir project. Public meetings were also held at the initiation of, during, and at the conclusion of the study.

Table 1-1. Description of functional areas of research.

Major responsibility	Description of study categories
ISU	1. The reservoir site and the stream system as resource entities — inventory of the natural and archaeological resources of the valley — the competitive role and impact of the reservoir with other existing or potential uses of the land and river system
UI	2. Social and economic impact of the reservoir — relationship of the reservoir to people in the region of influence — relationship of the reservoir to the regional and national economies — direct and indirect production: related effects; and direct and indirect consumption: related impacts — detailed project evaluation
ISU and UI	3. Recreation and related open space uses — existing types and amounts of use — complementary and competitive nature of proposed water recreation activities — area of influence, participation, and economic influence of recreation
ISU	4. Physical relationship with the agricultural sector of the environment — relationship between agriculture, the stream system, and the reservoir • land use, erosion, sedimentation, and watershed management • agricultural water quality: pesticides, fertilizers, animal and poultry wastes • drainage • flooding: agricultural flood damages and flood control downstream of the reservoir
ISU	5. Physical relationship with the urban sector of the environment — relationship between urban uses, urban growth, and the reservoir • population growth trends and projections • water supply • water quality • urban flood plain management and flood control • miscellaneous and related uses

Reporting the Results in an Appendix Series

The results obtained, formulated, and presented by each study category were both comprehensive and voluminous. It was decided early in the study to present results initially as an appendix series. From the material contained in the six appendices, this summary report was prepared. The following appendices were prepared and are available as separate but supporting documents:

- Appendix 1. Natural and Archaeological Resources of the Reservoir Site and Stream System (published in two volumes).
- Appendix 2. Economic and Social Impact.
- Appendix 3. Outdoor Recreation and Open Space Use.
- Appendix 4. Physical Relationship with the Agricultural Sector.
- Appendix 5. Physical Relationship with the Urban Sector.
- Appendix 6. Detailed Economic Review and Project Evaluation.

The listing and availability of these documents published as a part of the ARES project review are included in the foreword section of this report.

Final Rationale of the Study

The proposed Ames Reservoir project is the first multi-purpose reservoir project in the Skunk River basin authorized by Congress under the federal Civil Works Program. Others are being identified in comprehensive river basin planning studies. Under the provision of the 1969 Act, an environmental impact statement must be prepared for this project before additional consideration can be given to its detailed planning and construction. Therefore, the project presented an opportunity for analysis by an interdisciplinary research team, with the results having additional applicability in future planning studies.

During the course of the study, the river and valley system served as a field research area for various scientific and engineering disciplines within the research group. Additional studies were made of the Coralville Reservoir project, a similar multi-purpose project, by both the University of Iowa and Iowa State research groups. Constructed in the 1950's on the Iowa River near Iowa City, the project has had a considerable impact on the environment and a related water use and control role worthy of more intensive studies. Preliminary results of environmental studies and other resource and water use data were also available for two additional multi-purpose reservoirs in Iowa having large flood control storage allocations. These are the Red Rock Reservoir on the Des Moines River and the Rathbun Reservoir on the Chariton River. In addition, Saylorville Reservoir is under construction on the Des Moines River immediately upstream of Des Moines, and preimpoundment studies relating to water resources, water quality, and reservoir development are available for this project, also. Their locations are shown in Fig. 1-4.

A wealth of data has been collected, studied, and made available, all of which relates to some aspect of the environment. The interdisciplinary research team has conducted and completed a comprehensive environmental resources review study of the Ames Reservoir project, which is summarized in this report. This information can serve as a basis for decision-making by affected or interested agencies — local, state, or federal — and by individuals, organizations, and Congress, who authorized the project in the first instance. Of the nine alternative development plans studied, including the "do-nothing" alternative, the one which would be of the greatest net benefit to all of the residents of the region would be preferred in a social sense. Because of the

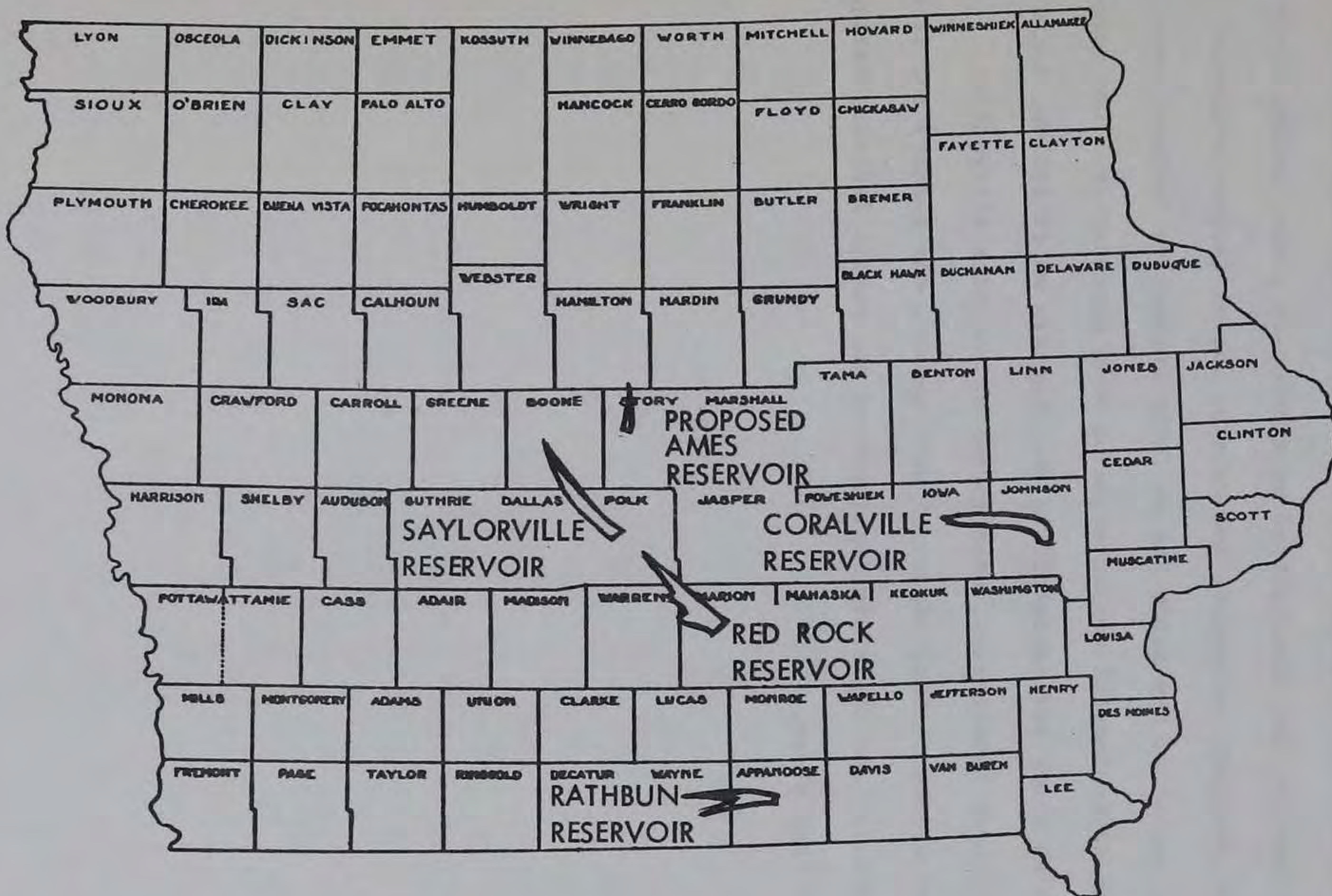

Fig. 1-4. Location of completed and partially constructed multi-purpose reservoirs of the Corps of Engineers in Iowa.

difficulty or impossibility of measuring all benefits quantitatively, or of canvassing each resident, the research team has used additional methods to express the alternatives on a priority scale, basing their decision on physical, economic, and related social factors evaluated during the course of the study and on their collective judgment concerning the environmental consequences of each alternative. The results of the review study are contained in the chapters which follow, including natural resource inventories, description of the nine alternative development opportunities, impact of development, the summary and final recommendations, and the study implications and public decision-making which must take place.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part I. The Valley, Its People, and Development Opportunities

Chapter 2

THE VALLEY AND ITS NATURAL RESOURCES

CONTENTS

FIGURES

TABLES

ARES SUMMARY REPORT

Chapter 2

THE VALLEY AND ITS NATURAL RESOURCES

Existing Valley Features and the Study Area

The Terrain in the Upper Basin

The Skunk River valley (see frontispiece) offers a welcome change from the level landscape of the upper Skunk River basin. The flat upland prairie, characteristic of the most-recent glacial drift sheet in Iowa (the Wisconsin), is almost entirely placed in agricultural crop production. The scattered farms and local communities present the major vertical relief in an unbroken prairie landscape. Only occasional recessional moraine features of the most-recent glaciation add to the scarce vertical relief in the upper basin north of Ames. Poor drainage patterns, saucer-like depressions, and "swell and swale" features characterize this youthful, immature topographic surface. Tiling and surface drainage ditches paved the way for intensive cropping practices in this agricultural region.

The streams form a dendritic pattern as they descend into youthful but incised and narrow valleys, with Squaw Creek and the Skunk River joining at Ames where the alluvial valley is wide and, geologically, much older. However, the difference in topographic relief remains only a little greater than 100 ft from level floodplain to the flat upland features.

The flatness of the prairie upland lends importance to the stream valleys in the upper basin. The rolling topography of the valley slopes, amply sprinkled with native timber, complements the meandering stream system and occasional small tributary creeks. Several dense woodlands are seen here and there, and they add measurably to the low degree of landscape variability experienced in the upper Skunk River basin. These valley features present a scenic view greatly appreciated by the people living in the region and by those traveling southward through the flatness of central Iowa.

Downstream from Ames, the straightened channel, wide alluvial valley, and intensive cropping of the broad fertile floodplain present a much different landscape which has less aesthetic appeal and recreation potential. The Skunk River valley upstream from Ames is narrow and compact with many identifiable and unique natural features. The environmental resources inventory, made by the research teams of Categories 1 and 3, has shown which archaeological, geological, vegetative, aquatic, and other ecological forms and features are truly distinctive; the uses existing in the valley; and the changes which might be expected in the future. These features and variations set the upstream valley apart from other landscape areas in the 800 sq mi of upper-basin drainage area upstream of Colfax.

The Reservoir Study Area and Landscape Overview

The 12-mile reach of valley extending from Ames to north of Story City (Story-Hamilton County line) is the most scenic reach in the upper basin, of which 10 miles are in the proposed Ames Reservoir (see Fig. 1-3). This 12-mile area was designated the study reach for environmental resource evaluation. An area of 34 sq mi (34 sections of land, about 22,000 acres) was designated as the inventory area, encompassing the main valley, the tributary valleys of Long Dick Creek, Bear Creek, Keigley Creek and its upland drainage ditch tributary, and several smaller creeks and ravines. This inventory area included some upland agricultural cropland but provided a simplified rectangular study area for field investigation and resource inventories. The reservoir study area is outlined in Fig. 2-1.

After the site study area was delineated, resource information was collected and a computer data bank and printout system developed as a land-use computer model. A visual analysis also was carried out, supported primarily by a photographic interpretation scheme. The aerial photos served as a base for preparing artists' sketches of the visual impact of various alternative reservoir development plans. The resource information and the land use computer model were used to study resource suitability and analyze land-use for alternative development patterns. A special study of the timber resource was made, which included quantifying the changes which might be expected under various development alternatives. These phases were studied in detail by the Category 1 research team and are reported in Appendix 1. The results are summarized in this chapter and others of the summary report.

Geological Resources

Soils in the Region

Under newer soil classifications, the soils within the upper Skunk River basin are assigned to the Clarion-Nicollet-Webster Soil Association. The parent materials are glacial drift of relatively recent origin — the Wisconsin drift. About 75% of the area has level to gently sloping topography. The level fertile land is heavily used for

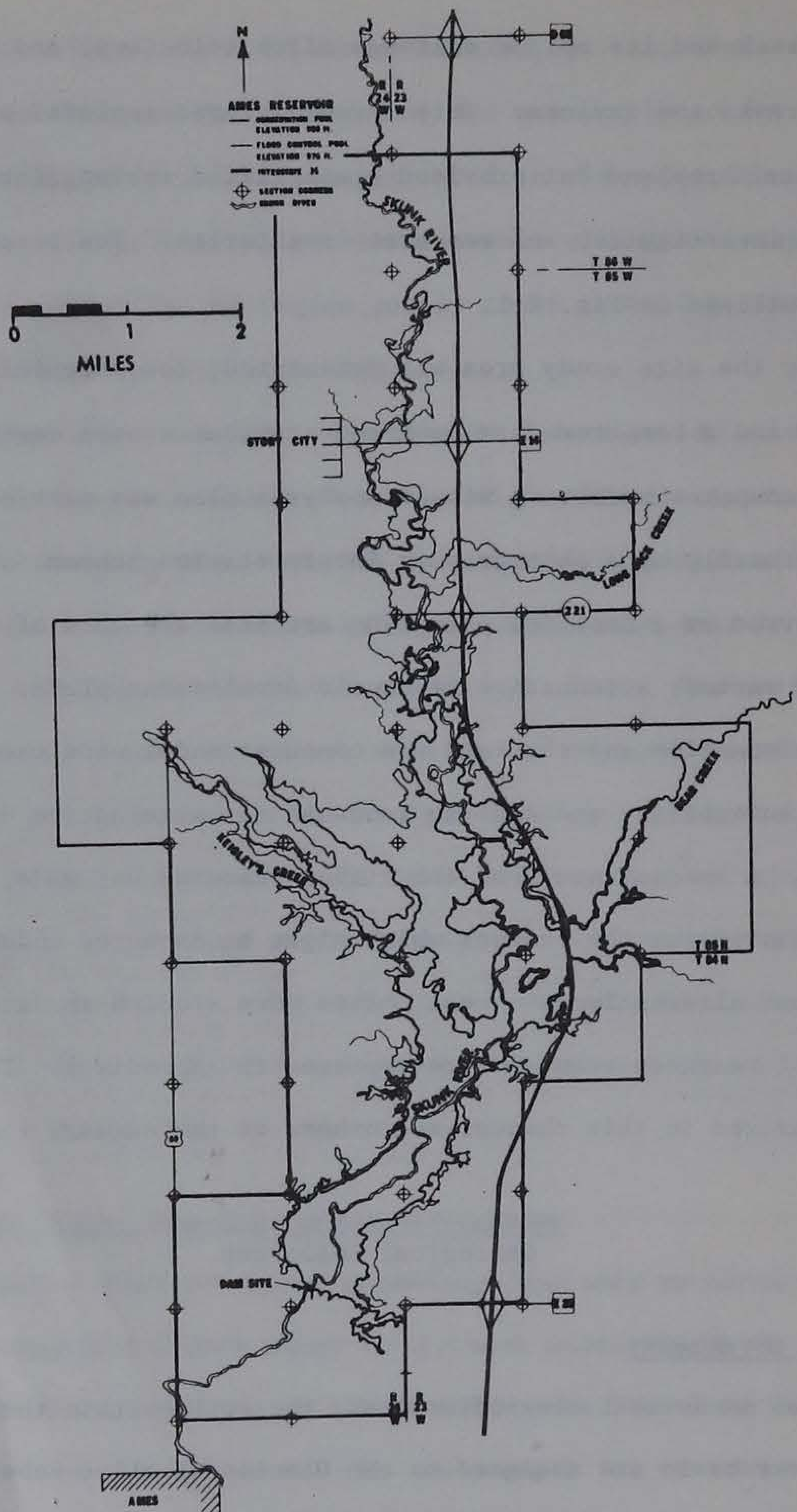

Fig. 2-1. The 34-section study area selected for natural resource inventory and impact analysis.

cash grain farming. The characteristics of these major soil types are presented in Table 2-1.

Table 2-1. Characteristics of major soil types in Clarion-Nicollet-Webster Soil Association Area.

Soil type	Typical slope percent	Natural internal drainage	Percent organic matter At 4"	12"	24"	Particle size, mm Clay < 0.002	Silt 0.002-0.05
Clarion loam	2-5	Good	2-3	–	–	20-25[a]	35-50
Nicollet loam	1-3	Somewhat poor	3-4	–	–	20-25	35-50
Webster silty clay loam	0-2	Poor	5	3.7	0.5	28-35	30-40
Glencoe silty clay loam (Okoboji)	0	Very poor	5	2.3	1.0	30-40	30-45

[a]Percent in each category.

A high percentage of the soils have poor natural drainage. Thirty-eight percent of the soils in Story County have poor natural drainage; 51% and 31% of Hamilton and Hardin County soils, respectively, have poor natural drainage. Three to 5% of the acreage is in soils associated with potholes which contain ponded water after heavy rains. With the exception of the Clarion loam soils, all are high in total nitrogen.

The use of the Skunk River valley (sideslopes and upland fringe timber areas) for rural residential housing developments depends in part on the type of wastewater treatment which is permitted. The high clay content, low permeability soils are not conducive to filtration for septic tank use. The acceptance and implementation of a estimated, probably only five million have the desired grain size, and of these, only a few locations would prove economical.

At the present time, the Hallett gravel pit (downstream of the dam site and outside of the immediate reservoir area) produces about 200,000 tons per year. It has an estimated 10-yr reserve on the present property with a potential 15- to 20-yr reserve on adjacent properties not presently under Hallett's control. The Peterson gravel pit upstream of the dam site is producing 100,000 tons/yr and has estimated reserves of approximately two million tons. Any reservoir alternative would eliminate this site. These are the two primary production areas in the reservoir study area.

Bedrock and the Limestone Resource. Limestones, shales, and sandstones of the Pennsylvania Series outcrop along Bear Creek. Exposures of rocks of the older Mississippian Series — limestones, dolomites, and shales — are prominent along the Skunk River valley from Soper's Mill to the dam site. These formations are quarried commercially today but also were a source of materials for implements for the earliest residents of the region, the native American Indian.

The present limestone operations within the proposed reservoir area are located southeast of the dam site on the eastern side of the Skunk River. The rock quarried at this location is part of the St. Louis Formation, Mississippian Series, and consists of approximately 18 ft of limestone bedrock. The rock is used as county road stone and asphalt aggregate.

The bedrock outcrops along the river but is overlain by approximately 60 ft of glacial drift overburden a short distance from the river. This overburden is removed as part of the quarry operation. Two companies, the Ray Cook Construction Company and Martin-Marietta Corporation, presently have active quarries in Sec. 13 and 24, T84-R24. The limestone is close enough to the surface from the present quarry locations on the east side of the river north to the junction with Bear Creek (Sec. 13 and 24, T84N-R24W; Sec. 5, 6, 7, and 18, T84N-R23W).

At the present rate of use (approximately 200,000 tons/yr), five to six acres per year are required for quarry operations. At the present time, approximately 120 acres are under lease by Cook's Quarry, or approximately 20 to 24 yr of leased reserves. Other areas identified in the vicinity from which rock can be obtained represent 3.25 sections of land usable for agriculture and residential housing, as well as for mineral extraction. These reserves represent approximately 2000 acres or over a 400-yr supply at the present rate of use.

This quarry area borders the reservoir at the dam site and probably will not be flooded out by any reservoir alternative. There is the possibility that these potential quarry sites will be lost by urbanization induced by the reservoir. The nearest quarry operations or potential locations which could serve as substitutes are located in Hamilton, Hardin, Marshall, Jasper, Marion or Madison Counties, from 15 to 60 mi in distance.

The best quarry location for Story County, because of its proximity to Ames and Nevada, is the present site. If this site were lost, the county-line quarry just north of Roland would be the next best selection.

Vegetation and Timber Resources

Vegetative Communities

The Skunk River valley supports a wide variety of both native and cultivated vegetative communities. It is a diverse area with plant communities ranging from mixed flood plain forests to dry, upland prairie and from oak-hickory woods to fertile, rolling farmland. Hundreds of plant and animal species are found in the valley, some unusual ones found seldom in central Iowa and others found commonly associated with agricultural operations. Different plant species are found at various elevations. Cottonwood, elm, silver maple, and hackberry are found on the lowland flood plains. Oaks and hickories dominate the upland forests. The terraces along the river support hard maples, hop hornbeam, walnut, and various other tree species. The understory vegetation is just as diverse.

An inventory of existing vegetation, its distribution in the reservoir area, and analysis of the forest species and production potential was made as part of the environmental study. Of the 51 categories included in the list of vegetative categories and surface land features applicable to central Iowa, all but seven were found within the study area. These are listed in Table 2-2. Some of the natural plant communities are small, some have been poorly managed in the past, and access to others is difficult. Although they may not be major components of the Iowa landscape, they represent a natural richness measured in the past only by subjective assessment and a richness which, once lost, cannot be restored in our generation.

Table 2-2. Vegetative categories and acreage in each, for the 34-section study area.

Computer identification	Category	Total acres	Computer identification	Category	Total acres
1.0	STRUCTURES	132	7.0	WOODED PASTURE	
1.1	Farm Buildings	376	7.1	Juniper	161
1.2	Urban Dwellings	431	7.2	Juniper-Honey Locust	35
1.5	Industry	5	7.3	Honey Locust	38
			7.4	Shrubs	71
2.0	URBAN		7.5	Scattered Large Trees	460
2.1	Golf Courses	42		(little understory)	
2.2	Wooded Parks	70	7.6	Scattered Large Trees	123
2.4	Cemetery	22		(woody understory)	
3.0	CULTIVATED	14,433	8.0	TREE PLANTINGS	50
			8.2	Christmas Trees	3
4.0	NONFORESTED		8.3	Orchard	3
4.1	Pasture	1,275	8.4	Hardwood Plantings	
4.2	Dry Prairie Relict	25	8.5	Mixed Farmlot Plantings	20
4.3	Mesic Prairie Relict	45			
4.4	Marsh	7	9.0	FORESTED	
4.5	Prairie Potholes	27	9.1	Oak-Hickory Forest	789
			9.2	Elm-Ash Forest	151
5.0	UNIQUE		9.3	Maple-Basswood Forest	148
5.1	Quarry	150	9.4	Mixed Floodplain Forest	91
5.4	Ponds and Reservoirs	45		(little understory)	
5.8	Quarry Spoils	96	9.5	Mixed Floodplain Forest	838
				(woody understory)	
6.0	EDGE				
6.1	Wooded-Cultivated	26			
6.2	Wooded-Pasture	12			
6.3	Stringers	400			
6.4	Fence Rows	103			
6.5	Roadsides	1,070			
6.6	Windbreaks	14			

Shrubs and other understory vegetation of which the herbaceous species are composed include many varieties. Juniper and honeylocust are found in many wooded pastures. The mixed woody shrubs, in addition to the above two, include sumac, hawthorn, prairies crab apple, prickly ash, gooseberry, raspberry, multiflora rose, and chokecherry. Scattered groves of large trees in the study area vary in composition by location. Upland wooded pastures possess species such as bur oak, white oak, shagbark hickory, black maple, and black walnut. Most commonly found is the bur oak.

The lowland wooded pastures are composed of American elm (80 to 90% of which have succumbed to the Dutch elm disease), ash, sycamore, cottonwood, silver maple, yellow-bud hickory, etc. Bluegrass and other grass species dominate as ground cover.

The Forest Types and Their Importance

Several types of forests are identified in the vegetative inventory. Three types of upland forest have been categorized and one bottomland forest. The three upland forest communities are the oak-hickory, elm-ash dominance, and maple-basswood. Acreages are listed in Table 2-2 for each category. There are 2017 acres of forest in the 34-sq mi study area, or about 10% of the total study area.

The oak-hickory forests are located on well-drained uplands, on south and west facing slopes, and in characteristic forest prairie intergrade soils. These dry, gently-rolling upland forests were once bordered by the prairie, but now stand adjacent to cultivated fields. Species in this category include bur oak, white oak, shagbark hickory, basswood, black cherry, yellow-bud hickory, butternut, and red oak.

The elm-ash category is represented on the more mesic upland sites and on terrace situations within the study area. Its dominance is common along natural upland drainage ways and in the more slowly drained soils of the upland woods. American elm, white ash, green ash, slippery elm, and hackberry predominate. Changes are being experienced with the loss of the elm. Junipers seem to possess the greatest advantage in the openings in canopy caused by the loss of elms.

The maple-basswood community is scattered throughout the reservoir area. Commonly found on the north facing slopes and sloping terraces in the valley, it represents the older, less disturbed woods of central Iowa. It can be found also in lowland areas associated with small elevation changes in the flood plain. The most important trees include the sugar maple, basswood, yellow-bud hickory, elm, and white oak. The understory shrubs include ironwood, chokecherry, gooseberry, and some bladder nut. Many wild flowers and other ground layer species also thrive in this community. This community would be quite susceptible to moisture changes such as would be caused by the proposed reservoir.

The bottomland mixed-flood-plain forests are found on the alluvial soils along the Skunk River and the major streams of the area. Often the soils are submerged by floodwaters. Closest to the river on the sandbars and mudbanks are the willows, cottonwood, river birch, and sycamore. Back from the river, the flood plain forest contains silver maple, elm, basswood, ash, and blackberry. Nut trees such as the black walnut, butternut, and yellow-bud hickory are also mixed throughout the bottomland. Many species of shrubs, some weedy, some wildflowers, exist on the flood plain. More open areas contain the grasses and sedges.

There are at least three locations where the plant resources deserve special emphasis in regard to their historical and educational value. These are Soper's Mill, the prairie potholes, and the I-35 scenic overlook, which are evaluated in detail in Appendix 1. A transect sketch of the vegetation at the Soper's Mill area is shown in Fig. 2-2.

The Wildlife Resource

Data on wildlife were collected by senior Fisheries and Wildlife Biology students under the supervision of members of the research team. Interviews with landowners included such topics as attitudes toward the reservoir wildlife in general and economic values. A general cover map delineating topographical and other variations was prepared for each habitat. Habitat analysis was accomplished by use of randomly selected quadrants of specific sizes for qualifying and quantifying various heights and classes of vegetation. Evaluations of habitats and wildlife population densities were made through consideration of cover density, shelter sites, human influences, food availability, and wildlife census figures.

A wildlife census was conducted by use of time-area counts, trapping, observation of arrival signs, and strip and whistling counts. Through the use of aerial photos and a grid matrix used in conjunction with ground reconnaissance, population extrapolations were made.

Approximately 71 landowners in the reservoir area were interviewed in the wildlife study. Most were not in favor of the reservoir construction. Monetary reasons and close emotional attachment to their land were the primary causes for opposition. Those in favor of the

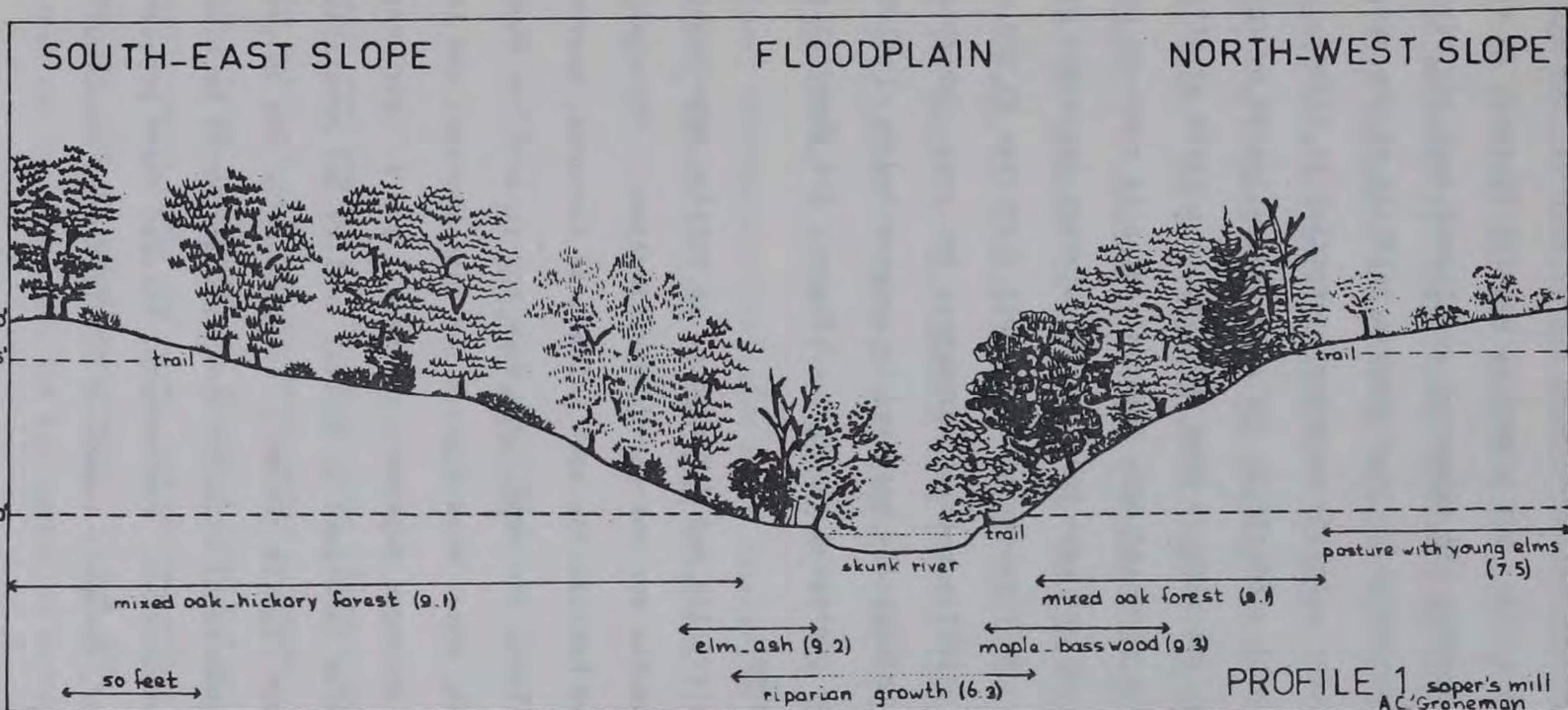

Fig. 2-2. Profile sketch of upland forest on a southeast and a northwest slope near Soper's Mill access.

reservoir were generally motivated toward economic "benefits." There appeared to be a wide but sometimes passive interest in wildlife. Some enjoyed hunting and trapping or allowed such activities on their land; others preferred to just observe wildlife of the area. There was little active wildlife management practice in effect. A present monetary value of wildlife in the area was estimated by interview value preference, and the results were averaged to a value of $174,000.

The entire proposed Ames Reservoir area is composed only of fair wildlife habitat and less than fair population densities of most wildlife species. Both values were probably distorted by the uneven distribution of most wildlife species throughout the area, the short census period which undoubtedly resulted in underestimates of wildlife populations, and the averaging together of figures for abundant and less abundant species.

Human activities and differences in habitat requirements are mostly responsible for the uneven distributions. Obviously the area contained good habitat for such animals as raccoons, sparrows, and rabbits. On the other hand, the conditions were not so good for river otters, dabbling ducks, etc. When figures for both abundant and less abundant species were averaged together, the result was a "fair" rating for all wildlife species in regard to habitat quality and population densities. In short, these figures probably underemphasize the amount of good habitat and numbers of wildlife species which would be eliminated should the dam be constructed. Furthermore, because these populations were underestimated, economic losses of wildlife were conservatively estimated as well.

The average habitat quality and population density classification for each wildlife category for all available habitats in the 34 sections are reported in Appendix 1. Figures for each species were determined by comparison with optimum conditions as reported in the literature. All habitat areas were assigned a value (1 = optimum, 2 = good, 3 = fair, 4 = poor, 5 = nonexistent), and the average for all wildlife categories was 3.02. The population density classification values were likewise assigned (1 = optimum, 2 = fair, 3 = low, 4 = nonexistent). A value of 2.69 was obtained in the study. As indicated above, this "fair" value probably is underestimated. Additional studies over a longer period are needed to substantiate this initial inventory or to determine if it is better. The area does contain good habitat, although the urban stress is gradually intensifying in the reservoir area. Other development alternatives will also place increasing stress on the wildlife resource, unless habitat is replaced elsewhere in the area in an optimum location.

The Aquatic Resources

Introduction

The aquatic environment of the Skunk River plays a large role in evaluating the worth of alternative development patterns. In a region which has such a large percentage of tillable farmland and a low percentage of public-owned lands and parks, the wooded slopes and natural valleys themselves take on added importance. If one adds to this dearth of forest and pasture lands the low number of natural lakes, then the existing stream system becomes a relatively valuable resource.

It not only serves as a source of water, but provides an aquatic habitat and wildlife sanctuary and, in addition, offers a recreation opportunity which is enjoyed by many of the residents of the basin. There is only one natural lake left undrained or unditched in the upper Skunk River basin. This is Little Wall Lake, a shallow 270-acre lake located south of Jewell. Other than a small public pond at McFarland Park in the reservoir area and several miscellaneous private ponds located in the rolling topography adjacent to the river valley, no other bodies of water of any appreciable size exist in the upper basin upstream of Colfax. Hickory Grove Park, located near Colo in the adjacent Indian Creek basin or watershed, has a 100-acre constructed lake. The park is operated by the Story County Conservation Board.

Additional water areas are becoming available in the region through the construction of the Saylorville Reservoir project on the Des Moines River southwest of Ames. These will include the Big Creek Lake and Saylorville Reservoir impoundments with water areas of 885 and 5400 acres, respectively.

It can be seen that the stream system in the Skunk River valley is an important resource. The hydrologic variability of the Skunk River is an important factor in evaluating its worth. Other factors include water quality characteristics and agricultural and urban effects. The limnological attributes of the stream in sustaining a viable aquatic habitat and good fisheries resource in the reservoir area are also important to the ARES evaluation.

Hydrologic Variability

An important environmental variable in the reservoir review study is the high degree of variability in the magnitude of stream flow of the Skunk River. This variability affects every one of the beneficial use groups identified with the reservoir project — fish and wildlife, recreation, flood control, water quality control, and water supply. The discharge of the Skunk River near Ames at the gaging station downstream of the dam site (drainage area of 315 sq mi) has varied from zero low flow during drought periods to a peak flood discharge of 8630 cfs.

The flow characteristics of the Skunk River are summarized in Table 2-3. This shows both the spatial and temporal variations of flow. The average discharge of the river increases proportionately with the drainage area. The unit area contribution, obtained by dividing the average discharge by the drainage area, increases from 0.4 csm (cubic feet per second per square mile) to 0.5 csm at Augusta. This is caused by an increase in average annual precipitation (from 30 to 35 in.) across the basin — from Blairsburg to Augusta — as well as increased ground water contributions. The amount of water available for use is definitely greater in the downstream reaches. In terms of total magnitude, the average discharge increases over 16-fold (134 cfs to 2233 cfs) with the distance involved being about 206 mi. This represents roughly an increase of 100 cfs every 10 mi of main river valley in the magnitude of average discharge. Analysis of the discharge data of the Skunk River shows that the average discharge is exceeded less than 30% of the time; conversely, the flow of the river is less than the average discharge more than 70% of the time.

Table 2-3. Stream discharge characteristics of the Skunk River.

Stream and location	Drainage area, sq mi	Average discharge cfs	Record 7-day low flow cfs	Discharge, cfs, exceeded the indicated percent of time				
				20%	50%	80%	90%	95%
Skunk River near Ames	315	134	0	165	43	5.3	1.6	0.56
Skunk River below Squaw Creek	556	242	0	285	71	3.6	0.65	[a]
North Skunk River near Sigourney	730	406	0.1	480	118	25	9.9	4.5
Skunk River near Oskaloosa	1635	795	2.0	1110	313	74	36	20
Skunk River at Augusta	4303	2233	7.4	3080	880	244	122	66

Source: U.S. Geological Survey and Iowa Natural Resources Council bulletins.

[a] No value, municipal well field pumping rates at Ames induce almost total stream flow into the sands and gravels of the alluvial aquifer system.

Variability also decreases as the drainage area increases. This is particularly true of the record low flows and of all duration data. The low-flow discharge at the 90% duration level (the magnitude of discharge exceeded 90% of the time) is computed to be only 1% of the average discharge at Ames, but increases to almost 5% at Augusta, the most downstream station. Therefore, the upper Skunk River basin experiences a high degree of flow variability which can adversely affect the aquatic and fisheries habitat.

Limnological Characteristics of the River

Because the fish populations of a river or a reservoir depend in part upon the physical, chemical, and biological characteristics of the environment, the limnological features of the Skunk River and the fish populations must be analyzed. There are distinct differences in the physical characteristics of the river north and south of a point beginning about 1 mi north of Ames. This is illustrated in Fig. 2-3. Near Hallett's gravel pit, there is a marked geologic change. In the northern portion or reach which includes all of the reservoir area, the river consists of a series of pools and riffles in a rather narrow, meandering channel. Bottom substrates ranged from small boulders, large rocks, gravel, and sand to silt. In the southern portion, downstream of Hallett's pit, the valley widens and the bottom substrates consist of shifting sands with occasional silted pools. In addition, the stream channel from Ames to the Mahaska-Keokuk County line was artificially straightened by dredging during the years 1893-1923. The straightened reach has a shifting sand bottom, but the river is undergoing the process of re-establishing a meandering course. From an

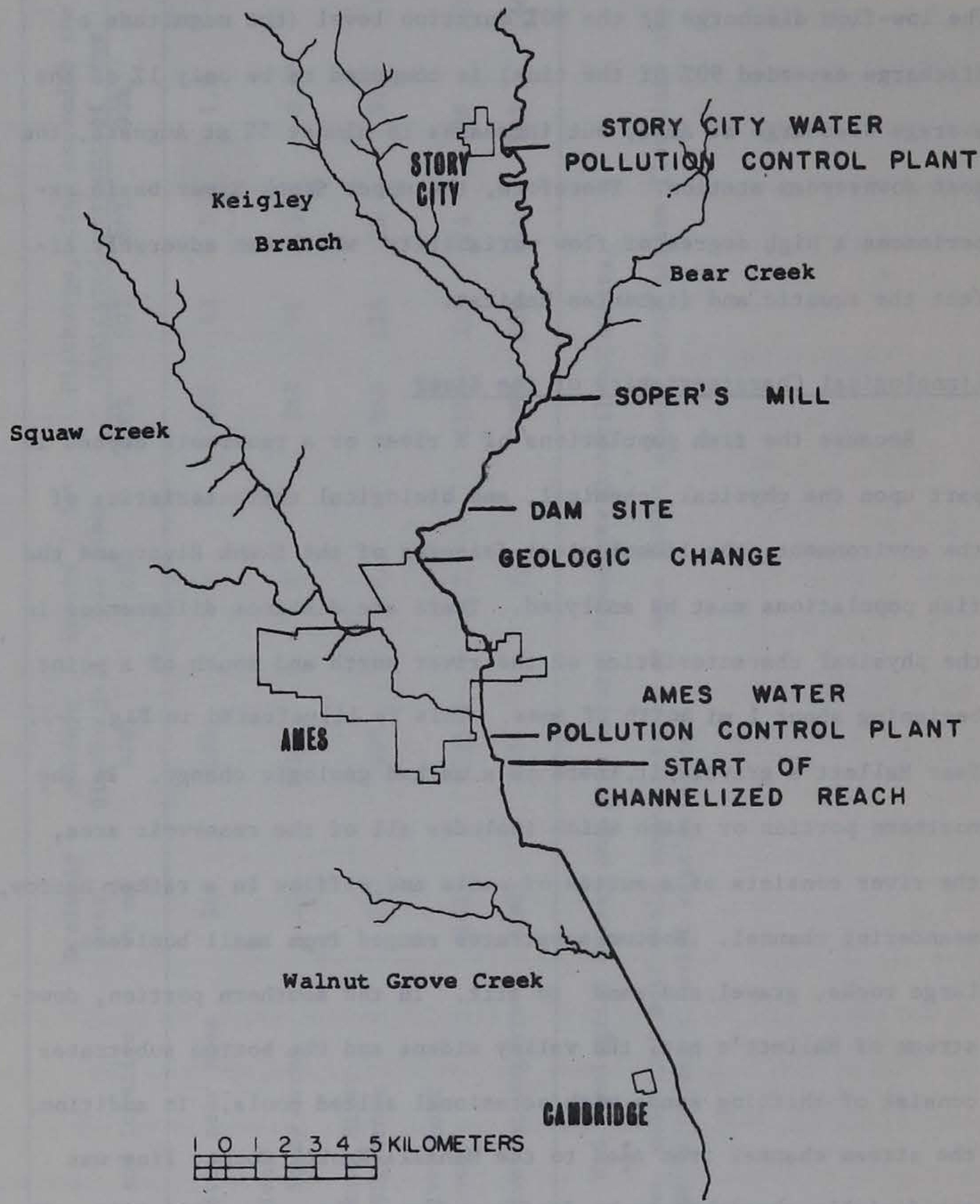

Fig. 2-3. Limnological features of the Skunk River in the reservoir area.

ecological standpoint, the portions north and south of the point of geological change provide distinctly different types of aquatic habitats with differing patterns in the distribution and abundance of the aquatic flora and fauna.

Another important environmental factor is the high degree of variability found in the volume of flow in the river at different times; the measured flows can vary by several orders of magnitude. Also, in spite of recorded flows near zero at Ames, the fisheries studies indicate that the Skunk River in the upper reaches has maintained permanent fish populations.

River temperatures tend to follow air temperatures throughout the year. Water temperature variations range from 32-33 °F to more than 92 °F. Diurnal changes in water temperatures follow the daily changes in air temperatures. Diurnal variations in water temperatures ranged from zero in the winter to as much as 20 °F in the summer. Maximum water temperatures range from 89 to 92 °F during periods when air temperatures reached 92 to 96 °F. During the winter months, the river has an ice cover with open areas existing immediately below the effluent discharge points of the Story City and Ames water pollution control plants.

Water Quality Characteristics

Water quality parameters at several stations between Story City and Cambridge, Iowa, were measured throughout 1970 in a limnology and fisheries study. Values obtained for the sampling station at Soper's Mill are summarized in Table 2-4. This station is located in the pool area of the proposed reservoir and should be representative of the

Table 2-4. Average values for some water quality parameters in the Skunk River as measured at the Soper's Mill bridge in 1970.

Parameter	Number of samples	Average value	Range of values
Ammonia nitrogen mg/l as N	40	0.77	0.27-2.81
Nitrate nitrogen mg/l as N	38	3.12	0.0-9.0
Orthophosphate phosphorus mg/l as P	41	0.20	0.07-0.45
Chlorides mg/l	35	26.6	17.1-52.5
Dissolved oxygen % saturation	41	75.6	40-101
Specific conductance micromhos/cm at 25 °C	30	694	518-868
Chemical oxygen demand mg/l	33	26.2	7.7-76
pH	7	8.0	7.6-8.3
Turbidity JTU	27	34	10-124
Chlorophyll *a* mg/m^3	34	47.6	1-177

water quality in the inflowing waters. The levels of plant nutrients that were found in the Skunk River are somewhat higher than those found in a survey of several central Iowa streams during 1969 and 1970. The central Iowa rivers had average values of 0.15 mg/l PO_4-P, 0.54 mg/l NH_3-N and 1.74 mg/l NO_3-N. The Skunk River levels of nitrates, chemical oxygen demand, and turbidity increased with increases in stream flow while the values for chlorides, specific conductance, and chlorophyll *a* decreased with increasing flow. The concentrations of ammonia nitrogen and orthophosphate phosphorus were not correlated with the volume flow of the river.

Additional water quality data were obtained during the 1972 field observation period by both categories 4 and 5, the agricultural and urban sectors. The 1972 data indicate unusually large loads of nutrients, partly because of the higher than average flows. The results are summarized in Table 2-5. It appears from field examinations and review of the results that the relatively high nitrate, NO_3-N, concentrations are associated with tile- and bank-drainage water derived from the excessive amounts of precipitation and frequent high water tables.

Table 2-5. Results of the 1972 sampling network for water quality parameters, March-August[a].

Parameter	Average value	Range of values
Ammonia nitrogen, NH_4-N, mg/l	0.4	0-4.0
Nitrate nitrogen, NO_3-N, mg/l	9	0.4-25
Phosphate, PO_4-P, mg/l	0.3	0.12-0.83
Dissolved oxygen, mg/l	9$\pm$	6.5-15.4
pH	8	7.3-8.7
Biochemical oxygen demand, BOD_5, mg/l	5$\pm$	2.2-7.1
Chlorides, mg/l	35$\pm$	18-67

[a]Data from Appendix 4 and 5, agricultural and urban study groups, representing upstream contribution at Story City.

Additional evaluation of urban vs agricultural contributions is included in the Appendix 5 results. These nutrient levels, combined with urban effluent additions, are more than sufficient to pose a eutrophication problem for any impoundment. The levels of carbon, nitrogen and phosphorus, in the absence of silt-laden turbid water, will provide during low flows a high nutrient input for the aquatic habitat. Therefore, algal blooms in the natural stream during any low-flow period also remain a distinct possibility. Agricultural waste and nutrient contributions, and Story City and Ames urban effluent discharges, constitute the major water-quality problems for the aquatic habitats in the Skunk River.

Fish Populations in the Skunk River

The Skunk River, as noted above, experiences a sharp geological change near Ames, Iowa. The subsequent change in the stream's substrate, from that of rocks and gravel above Ames to one of shifting sand below Ames, has had the most effect on present-day fish populations in the Skunk River in the Ames vicinity.

Before agricultural practices had changed the Skunk River of the 1800's, an early fisheries survey was conducted on the Skunk River at Ames, Iowa. This study showed 48 species of fish with largemouth bass, channel catfish, northern pike, suckers, buffalo, and bullheads found to be abundant. Included in this collection was a specimen of a large muskellunge. Recent surveys in the same area have found only 25 species of fish. Evidently, the channelization of the stream bed below Ames and the increased water fluctuations in the stream caused by extensive tile draining in the Skunk River watershed have brought about the elimination of many species.

Largemouth bass and northern pike were entirely absent from later surveys, with catfish and buffalo found to be rare. Carp represents 79% of the total number of fish collected in recent surveys below the geological change. Of the 48 species of fish first observed, 26 species have disappeared from that area of the river while an additional nine species have appeared. Regarding endangered fish species, none are presently found in the Skunk River.

Physically, the Skunk River between Story City and the geological change at Ames has changed very little compared to the 1890's. Extensive tiling of headwater lowlands and channelization of headwater tributaries have no doubt caused more erratic water level fluctuations to take place, but the stream still winds through its narrow, wooded valley with sandstone, shale, and limestone exposed to view in several areas.

Unfortunately, there are no early records of fish populations in this section of the river. Recent studies have shown that a more diverse fish population now exists above the geological change than below it. Thirty-six species of fish have been reported in this area with a good population of smallmouth bass and channel catfish in the proposed reservoir area. The stream's fish population has suffered far less in the reservoir area than below it due to intensive agricultural practices. These two parts of the same river should in fact be considered as two different systems because of the extreme differences in habitat between them.

Studies have shown that the section of river above the change in substrate is the only section of river within a 15-mi radius of Ames that contains adequate numbers of game species to provide sport fishing. Because the stream is not a large one, it is not able to withstand unlimited fishing pressure; however, it is not uncommon to find fishermen at each access point to the river during a summer evening. This section of the river above the geological change at Hallett's gravel pit is quite unique for the local area in that it represents the only small stream, smallmouth bass fishery within a radius of 45 mi from Ames.

There is little or no sport fishing on the Skunk River below the geological change for a distance of 10-15 mi because of the total lack of suitable habitat for sport fish in this section of the river. During normal flows, the average depth of the river in this section is less than one foot. Holes in the river of sufficient depth to hold larger fish are few and far between and are found scoured out around bridge abutments and fallen trees. As the stream increases in size below Ames, catfish populations do improve so that by the time the river reaches 10-15 mi downstream from Ames, some sport fishing for channel catfish is found. Therefore, the reach between Cambridge and Colfax is more of a popular catfish haven for fishermen than the reach extending from north of Ames to Cambridge. Also, during low-flow periods, the effluent from Ames water pollution control plant causes problems in addition to those of a straightened stream having a rather sterile sand bottom.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part I. The Valley, Its People, and Development Opportunities

Chapter 3

MAN'S INFLUENCE AND FUTURE POPULATION TRENDS

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ARES SUMMARY REPORT

Chapter 3

MAN'S INFLUENCE AND FUTURE POPULATION TRENDS

Introduction

The environmental review study of the proposed reservoir project renewed an interest in the history of the Skunk River valley among the members of the research group and residents of the area. The history and evidence of early man, in an archaeological sense, and of the more recent native Americans were of primary interest. Accounts of pioneer settlement by the Euro-Americans are well documented; these settlements were the beginning of the agricultural development of the region. Continued growth of the population has depended also on urban expansion of commerce, industry, transportation, education, and other activities. Regional development and economic growth will largely determine the population levels in the future and are related to the use of the natural resources of the region and of the Skunk River valley in the reservoir area. Because people and their needs, including water, are the determining factors in resource development and use, historical growth patterns and future population forecasts are a valuable adjunct to the ARES review. This summary chapter will include the results of the archaeological studies, review the historical development of the region, and furnish future population trends.

The results of the archaeological study, supported both by the ARES contract and the National Park Service, have been published as a report — Stalking the Skunk, by Gradwohl and Osborn, Papers in Anthropology, No. 1, Iowa State University (1972) — and are summarized in the

Appendix 1 material. References and other details will be found in the report. Additional historical data obtained as part of the agricultural and urban review studies (Categories 4 and 5) are also included in this summary chapter.

Pertinent information concerning the geomorphology, ecology, history, and previous archaeological investigations of the valley was assimilated and reviewed. The present archaeological survey identified 51 sites at which artifactual materials were recovered. A summary was prepared of the cultural-historical sequence in the reservoir area of the valley, including an appraisal of impact, recommendations for salvage, and site preservation and interpretation in the event of any intensive development of the valley for water resources or other urban encroachment.

Population projections for the period 1970-2020 were made for a nine-county region representing the largest area of influence of the proposed Ames Reservoir. Both primary and secondary areas of influence were outlined in the study. The counties forming the primary area include a four-county area in the immediate vicinity of the reservoir — Boone, Story, Hamilton, and Hardin Counties. A five-county secondary area composed of Dallas, Jasper, Marshall, Polk, and Webster Counties was also identified. The locations of these nine counties and the principal cities and towns of the area in relation to the Ames Reservoir are shown in Fig. 3-1. A more intensive population component analysis was conducted for the immediate Story County and Ames area, including Iowa State University student enrollment, remainder of Ames without students, and rural (farm and rural residential) and urban

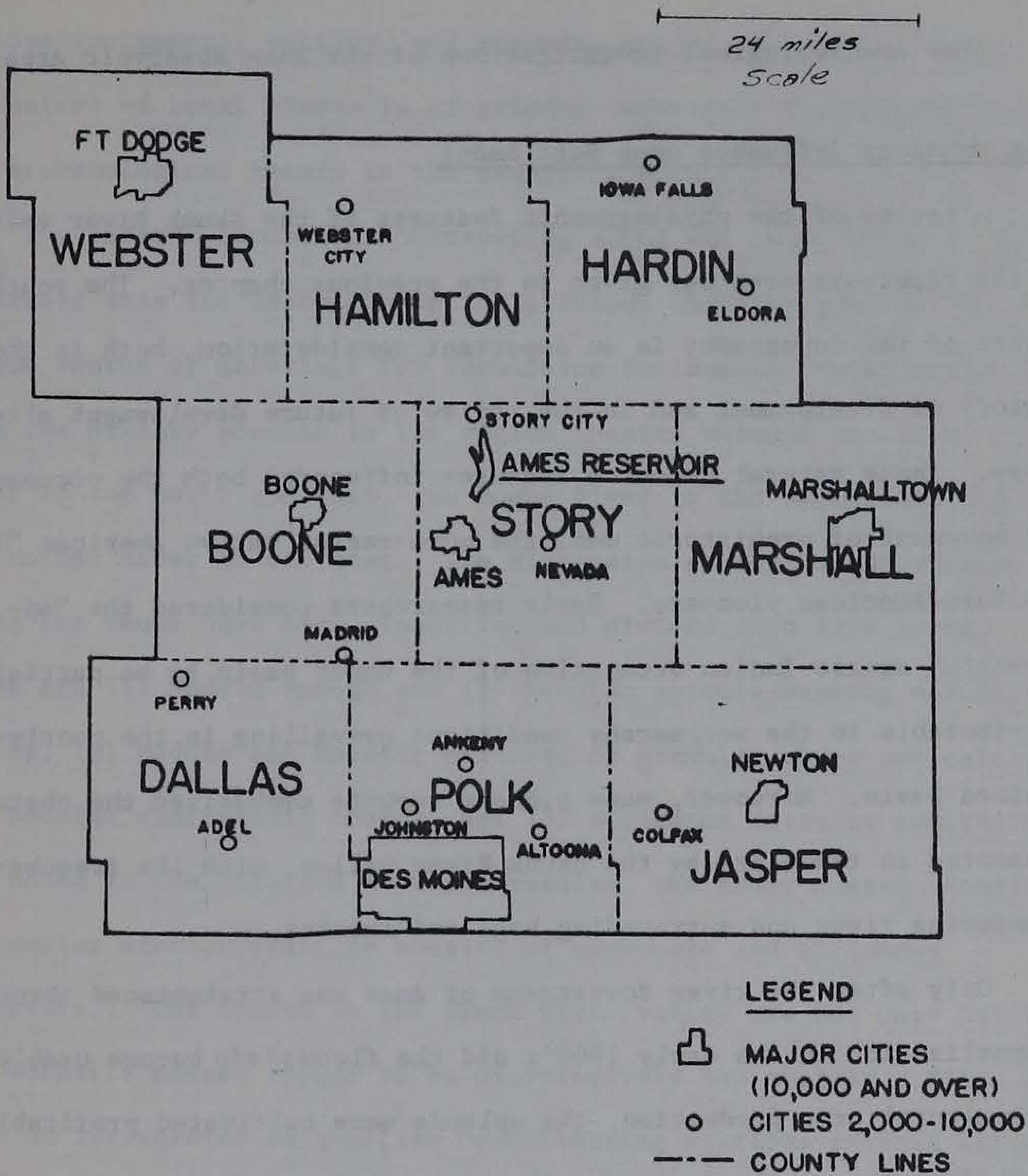

Fig. 3-1. Nine-county total area of influence of the Ames Reservoir.

(community) growth in the remainder of the county. Population forecasts were made for three growth levels: low, medium, and high. The detailed methodology and development of mathematical population models for projecting growth trends are contained in Appendix 5. The population data were used in subsequent studies of water supply, water pollution control, recreation demand, land use and related agricultural and urban activities.

The Archaeological Investigations of the Ames Reservoir Area

Geomorphology Influence upon Settlement

A review of the physiographic features of the Skunk River valley in the reservoir area was given in the previous chapter. The youthful nature of the topography is an important consideration, both in the history of development and in the review of future development alternatives. These natural resource features influenced both the occupancy and movement of prehistoric man, the more-recent native American "Indians," and Euro-American pioneers. Early researchers considered the "apparently" sparse Indian occupation of the upper basin to be partially attributable to the wet, marshy conditions prevailing in the poorly-drained basin. Moreover, many pioneer reports emphasized the obstacle presented to travelers by the Skunk River valley with its treacherous, meandering river and surrounding bogs and marshes.

Only after the river downstream of Ames was straightened through channelization in the early 1900's did the flood plain become usable for agricultural crop production; the uplands were cultivated profitably only after the poorly-drained soils were tiled and drainage ditches were constructed. Following the completion of these man-made improvements, the agricultural economy of the region dominated over other nonagricultural enterprises.

Bedrock Exposures and Chert Availability

Aboriginally, as archaeological investigations have shown, the chert-bearing strata in exposed bedrock formations were exploited as a source of siliceous materials. The cherts were used in the manufacture of various implements, cutting, and scraping tools. An understanding of the nature of local cherts is of primary importance in interpreting the archaeological record in the reservoir area.

The bedrock formations outcropping along the Skunk River in the reservoir area (as described in the previous chapter) provided a unique source of materials for fashioning implements; these probably were the primary sources in the region located between the Iowa River to the north and east, the Boone River to the northwest, and the Des Moines River to the west. The Mississippian cherts outcropping along the Skunk have been classified and divided into five types. These are (1) bedded sponge and (2) nodular spicule-bearing dolomite cherts, (3) bedded and nocular mixtures of granular chert and calcite, (4) nodular chalcedonic cherts, and (5) siliceous dolomite concretions. (As noted in the detailed research results, the chert masses consist of complex microcrystalline mosaics of carbonate and siliceous materials.) The cherts in the Skunk River valley are not only heterogeneous, but workable masses appear to be of relatively low quality. Sites identified or interpreted as quarries or collecting stations exhibit litter of many discarded fragments and rejected chunks of chert-nodule interiors. Finished artifacts normally imply a preference for the relatively homogeneous chert and chalcedon masses.

Archaeological Investigations and Identified Sites

Systematic surveys for prehistoric and historic archaeological sites have never been conducted previously in Story County. Only since 1971 have archaeological sites been officially recorded; however, some preliminary investigations and reconnaissance surveys were conducted during the period 1966-71. The current study is the most comprehensive survey to date in the county. Four methods were used in locating archaeological sites: (1) perusing documentary sources; (2) seeking information from local residents, etc.; (3) studying aerial photographs; and (4) conducting surface reconnaissances and site surveys. For the latter, the area was subdivided into seven reconnaissance units and 32 reservoir site survey units. Some 51 separate archaeological sites were identified and numbered in the Smithsonian Trinomial System.

The 51 archaeological sites identified in the study are shown in Fig. 3-2. Each specific site is described in detail in the separate report and its resource inventory explained and illustrated. Documentary sources assisted in locating several pioneer cemeteries and the Soper's Mill site in the reservoir area. There was no evidence in previous reports of any permanent encampments of Indians and only sketchy references to contact between the early Euro-American settlers and resident Indian groups. The most successful results were obtained from the surface reconnaissance techniques. Chipped stone artifacts, source and waste material, heat treatment effects, and ground or pecked stone artifacts were recovered and inventoried. Historic or pioneer materials included glass, china, stoneware, and porcelain fragments, metal and bricks. Faunal remains, such as bones and teeth and shell fragments, were also inventoried.

Cultural-Historical Interpretations

The results of the archaeological investigations in the reservoir reach of the Skunk River valley indicate that the area was occupied prior to the Euro-American settlement. Evidence was obtained of the

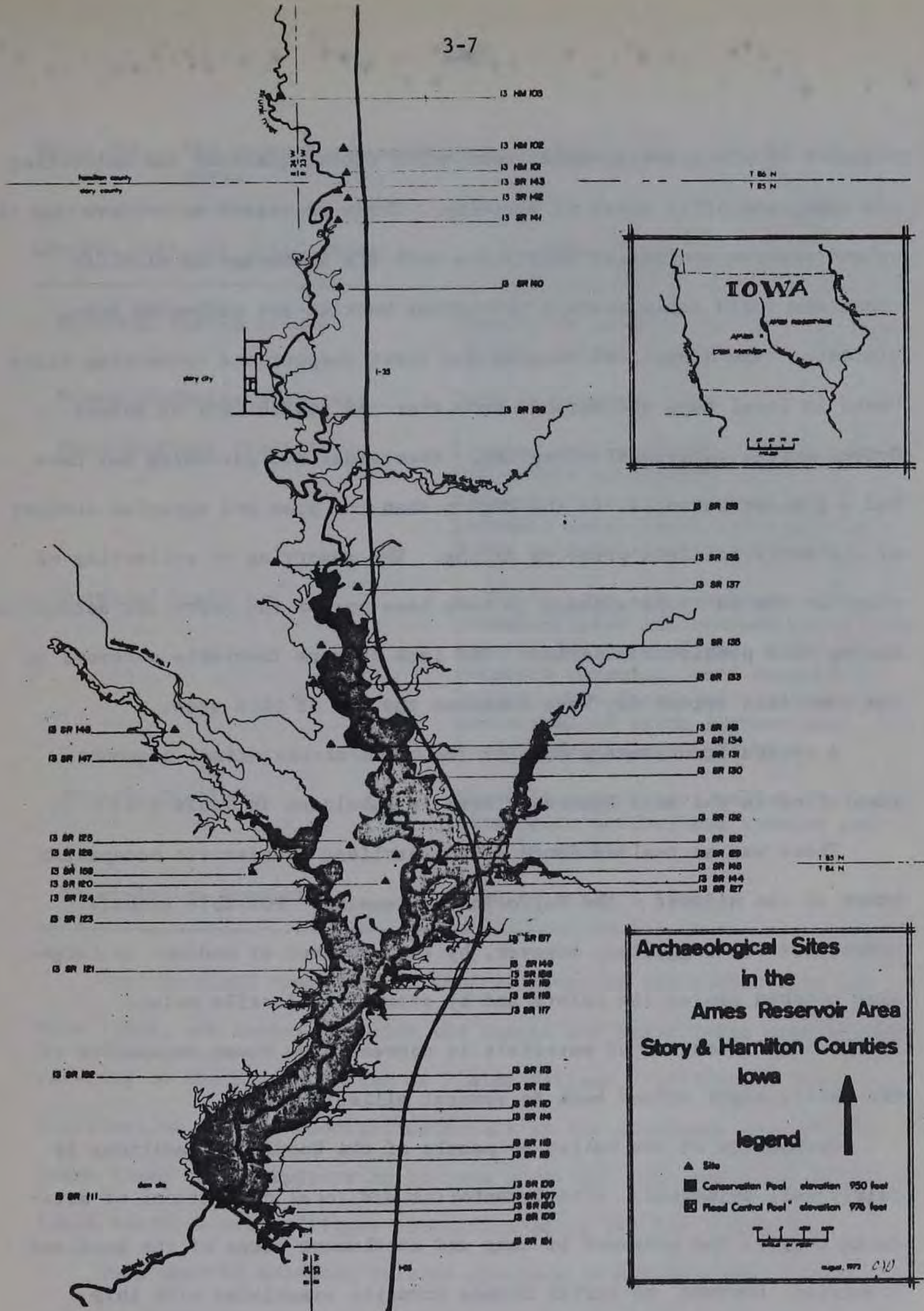

Fig. 3-2. Archaeological sites identified in the ARES investigations.

presence of prehistoric camps, settlement sites, quarries and collecting stations, and other areas of activity. There is reason to believe that the upland prairie and valley vegetation with its accompanying wildlife resources could amply sustain aboriginal hunting and gathering subsistence. The historical records and field inspections concerning bison bones in local bogs and marshes show that the possibility of animal drives merits additional attention. Aboriginal hoe gardening may have had a greater potential in the region than the plow and agrarian economy of the early settlers prior to tiling. The quarrying or collecting of chert at the outcrops appears to have been one of the important activities during this prehistoric period. The lack of more favorable outcrops in the immediate region may have enhanced the use of this area.

A generalized summary made of the cultural-historical sequence identified in the Ames Reservoir area is tabulated in Table 3-1.

There was no real evidence of the earliest prehistoric occupation known in the midwest — the Paleo-Indian remains. Possible archaic composites are suggested, however, by the presence of medium- to large-size notched projectile points and by stemmed projectile points. If the identification of materials is correct, the human occupation of the valley might extend back to several millenia B.C.

Occupation of the valley by people of the Woodland Traditions is fairly well evidenced. Site inventories and local collections of artifacts suggest the presence of camp and settlement sites of the Woodland Tradition; however, no burial mounds normally associated with this group were found. The Woodland sites investigated in the reservoir area would be expected to range within the period 1-1000 A.D.

Table 3-1. The general cultural-historical sequence in the Ames Reservoir area.

General cultural affiliation	Archaeological evidence
Historic Euro-American	Remains of pioneer homesteads, cemeteries, mills, towns, etc.
Historic Native American	None at present time
Post-Woodland Traditions	Limited sample of small, triangular projectile points and small, side-notched projectile points; one probable Great Oasis rim sherd, possibly post-Woodland body cherds.
Woodland Tradition	Probable camp and settlement sites; corner-notched and stemmed projectile points; 3/4-grooved axe; grit/sand tempered ceramics, cord roughened bodies, rims decorated with bosses, cords wrapped stick impressions; linear dentate stamped sherd
Archaic Tradition	Possible composites; medium- to large-sized side-notched and stemmed projectile points
Paleo-Indian Tradition	None at present time

Post-Woodland complexes in central Iowa, as identified also in this study, are associated with the Oneota and Great Oasis occupations relating to the Mississippian or Plains Village Traditions. The distribution of Post-Woodland materials in the reservoir area of the Skunk River valley appears to be less plentiful than the relatively large horticultural villages identified along the Des Moines River.

Only sketchy evidence relates pioneers to any knowledge of the historic native Americans at the time of early explorations and settlements. The public land survey parties and earliest settlers (squatters) had the greatest contact with the native Americans, but any archaeological evidence of this in Story County is entirely lacking. It appears that one cannot verify at this location the commonly accepted ethno-history of Iowa in which the Ioway Indians were displaced by the Fox and Sauk. Probably the settlers' accounts in the mid- and late-1800's refer to the Mesquakies who returned to Iowa (Tama County) and foraged up the valleys on hunting expeditions. Pottawattamies also were reported on occasion.

Pioneer History of the Area

The Euro-American pioneer settlement was found to be amply documented and is described in detail in the archaeological publication. Public records and private accounts, partially preserved cemeteries, and several extant buildings and building sites confirm this developing period. The ethnic composition of the pioneer population is explained quite well by gravestones having inscriptions in Norwegian and German, as well as in English. Pioneer homesteads, trails, mills, and towns also contribute to the archaeological history of the region, and remnants were found in the field investigation.

Iowa had attained statehood before the first Euro-Americans settled in Story County. Settlement tended to be in the groves of trees along the streams since the rest of the upland was open prairie, frequently beset with prairie fires. In the northern part of the county, the timber was more sparse. The first settler in the reservoir area was John H. Keigley. He located in the northeastern part of Franklin Township sometime in 1851 and so named the tributary stream near his settlement. Others soon arrived, for the earliest infant graves are dated December 1851. Story County was formally organized in

January 1853. Although some of the early settlers moved into the area from nearby counties or states, others were immigrants. Norwegians established two main areas of settlement within Story County, one near Cambridge and the other near Roland. A few Danes located in the northwest part of Story County. Germans were also present, as evidenced by gravestone inscriptions.

The only towns in Story County before 1855 were Cambridge and Nevada. Soon, however, land speculation and the influx of settlers caused many small towns to be platted throughout the northern part of Story County. Fairview, established in 1855, was renamed Story City in 1881. Bloomington, near the reservoir dam site, was platted in 1857, but later abandoned when the railroads neglected it. Smithfield was platted near a mill site on Long Dick Creek in 1854, but today no remains of either can be found. Other towns near the reservoir area in northwest Story County which disappeared in time included New Philadelphia, Prairie City, Sheffield,and Summit.

Numerous roads, including the old stage coach trail from Ames to Story City, also traversed the Skunk River valley. Undoubtedly, the early travelers found the wet, marshy prairie upland unfavorable for easy travel and the rolling topography and valley terraces were preferred. Early township maps show several valley roads between Story City and Ames which no longer exist. One such road passed on the east side of the M'Michael cemetery, southwest of the present McFarland Park, thence northward to Story City.

Population and Development Patterns, 1850-1970

Development of the region into a viable agricultural economic unit proceeded rapidly once the original prairie sod was plowed under and drainage enterprises constructed. A study of the population growth of the region indicates the farm population reached its peak by 1900-1910. It has declined since that period, but not as much in Story County as in the more rural counties of Iowa. Urban growth in Story County has continued at a steady pace, and rural residential growth has been fostered by the continued growth of Ames and Iowa State University. The variations in population growth in the nine-county region are discussed in this section.

Initial Settlement of Ames and the Beginning of Iowa State University

Iowa was formally opened to settlement in 1832 and attained statehood in 1846, prior to real settlement of the Ames area. Ontario, a village west of Iowa State University and now a part of Ames, was as important as its future master in these early days. In 1852, the population in the Ames area was 214, in this town located at the junction of Squaw Creek and the Skunk River. The town was officially platted in 1864, being named for Congressman Oakes Ames of Massachusetts. By then, Ames had grown to a population of 300, according to local historians. The population growth trend at Ames is listed in Table 3-2.

Iowa was the first state to accept the terms of the Morrill Land-Grant Act. In March 1863, the General Assembly awarded Iowa's grant to the recently chartered institution at Ames. The school opened its doors in the fall of 1868, and a class of 26 was graduated at the first

Table 3-2. Population of Ames, 1832-1930[a].

Year	Population	Year	Population
1832	40?	1895	1,910
1852	214	1913	5,000
1864	300	1916	5,091
1870	656	1920	6,270
1875	820	1926	9,332
1880	1,153	1930	10,281

[a]Meads (1955), At the Squaw and the Skunk.

commencement in 1872. Iowa State University (ISU) has grown considerably since 1868 when, as the Iowa State Agricultural College and Model Farm, it consisted of four faculty members and 68 students who lived and worked in one building, surrounded by 658 acres of wild prairie. In 1970, the faculty numbered over 1700 and the student enrollment exceeded 19,000. Today this requires 439 buildings situated on some 700 acres of land.

Figure 3-3 shows the total fall enrollment at ISU from its beginning in 1868 to the present. This graphical history of the University reflects the growth and history of the United States, its involvement in war, and its economic periods of growth and recession. The constantly increasing rate of growth of Iowa State University since 1868 presents some interesting implications, but continued projection of this trend can hardly be advocated. The immediate cessation of this increasing rate occurred in 1970, illustrating that some method other than graphical extension of previous trends is required for projecting future enrollments and student numbers. The needs of these 19,000 students for water supply, water pollution control, outdoor recreation, and other

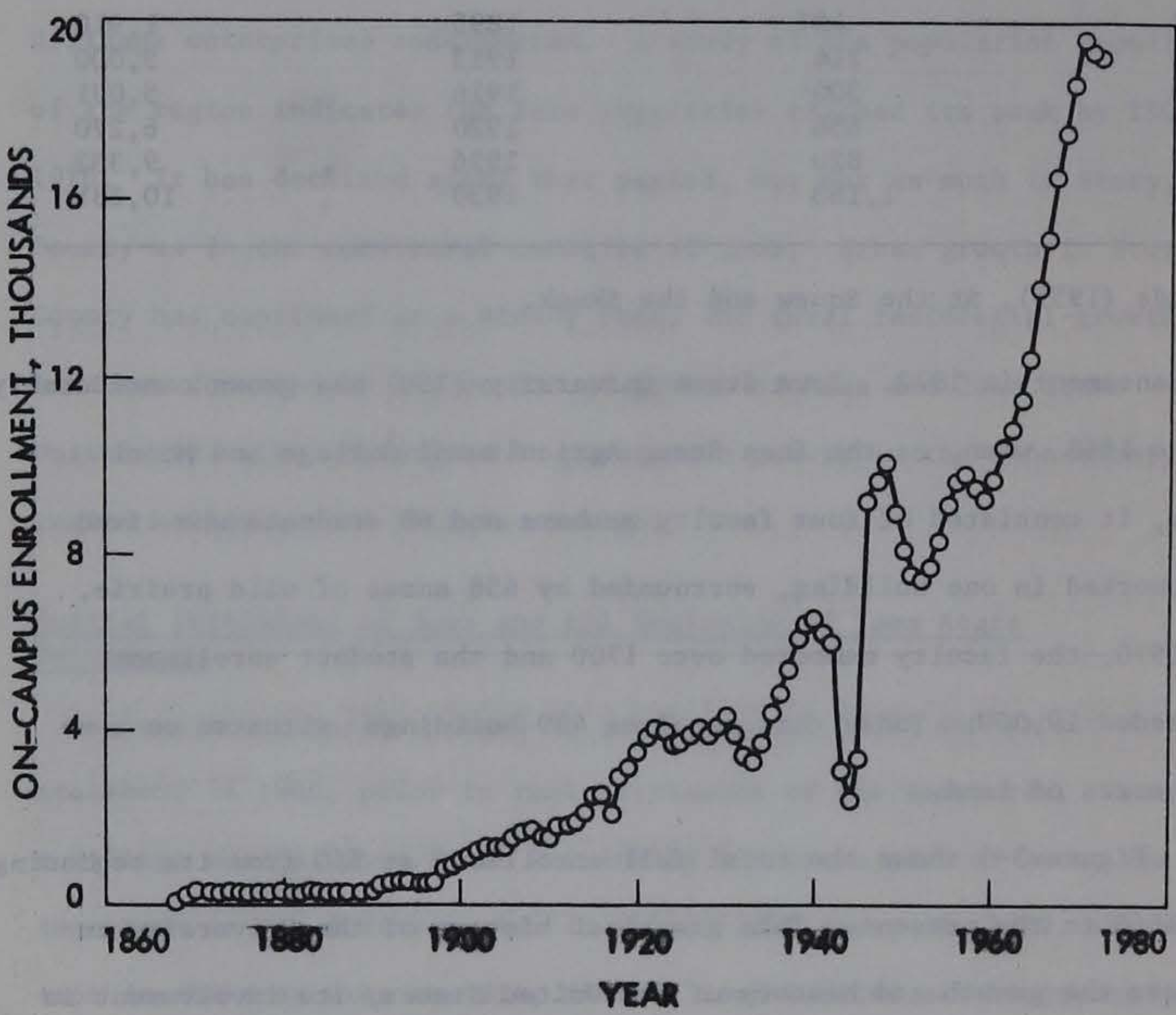

Fig. 3-3. Enrollment at Iowa State University, 1868-1972.

water-related uses is important in the Ames Reservoir environmental resources review study.

Population Growth of Ames and Story County

The City of Ames has experienced a steady population growth since the turn of the century, reaching a total city-residents and college-student population of 39,505 in 1970. The growth of Story County has paralleled this urban growth, although rural townships have experienced a decline in the farm population with changing agricultural practices. Over 62,000 persons resided in Story County in 1970. The population growth trends for these two groups are listed in Table 3-3 and illustrated in Fig. 3-4. The students enrolled at Iowa State University have been included in the data base.

Of the 1970 Story County population of 62,783 persons, 53,520 persons lived in incorporated cities and towns, and 9263 lived in rural areas. Approximately one-half of these were on farms, placing at least 4600 persons in the "rural residential" category. This breakdown illustrates first and foremost the urban character of Story County and implies a substantial use of rural areas for scenic driving, aesthetic views, and open-space and outdoor recreation utilization by urban dwellers. Second, the large size of the rural-residential category implies a real interest in developing wooded areas along the valley slopes into rural subdivisions for home construction. The third item of importance in an environmental sense is the smallness of the farm population; yet the ownership of most of the county remains in this agricultural category. Very little land is in parks, for instance. This means that the visual aesthetics of the Skunk River valley and its tributaries are

Table 3-3. Population growth of Ames and Story County, 1900-1970, including students enrolled at Iowa State University[a].

	Ames			Story County		
Year	Nonstudent residents	ISU students	Total	Incorporated towns	Rural, nontown	Total
1900	2,422	1,062[b]	3,484	11,200	13,021	24,221
1910	4,223	1,547[b]	5,770	14,489	11,141	25,630
1920	6,270	3,584[b]	9,854	19,760	10,009	29,769
1930	10,261	4,318[b]	14,579	24,502	10,957	35,459
1940	12,555	5,811[c]	18,366	28,620	10,625	39,245
1950	15,083	7,815[c]	22,898	33,686	10,608	44,294
1960	18,934	8,069[c]	27,003	38,781	10,548	49,327
1970	22,227	17,278[c]	39,505	53,520	9,263	62,783

[a]Adjusted figures with census data modified to account for students not being included prior to 1950, and using fall or spring enrollment figures (see Appendix 5).

[b]Fall enrollment at Iowa State University.

[c]Spring enrollment at Iowa State University.

maintained largely by the agricultural landowner or his successor in developed areas — the rural nonfarm residential homeowner.

Development in the Area of Influence of the Reservoir

The population of the four-county area influenced by the Ames Reservoir (Story, Boone, Hamilton, and Hardin Counties) has generally followed the same pattern as the non-Ames portion of Story County. These trends are listed in Table 3-4 and illustrate a decreasing farm population with a steady but low rate of increase in the urban category (see Appendix 5 also). As a result, all three of the other counties

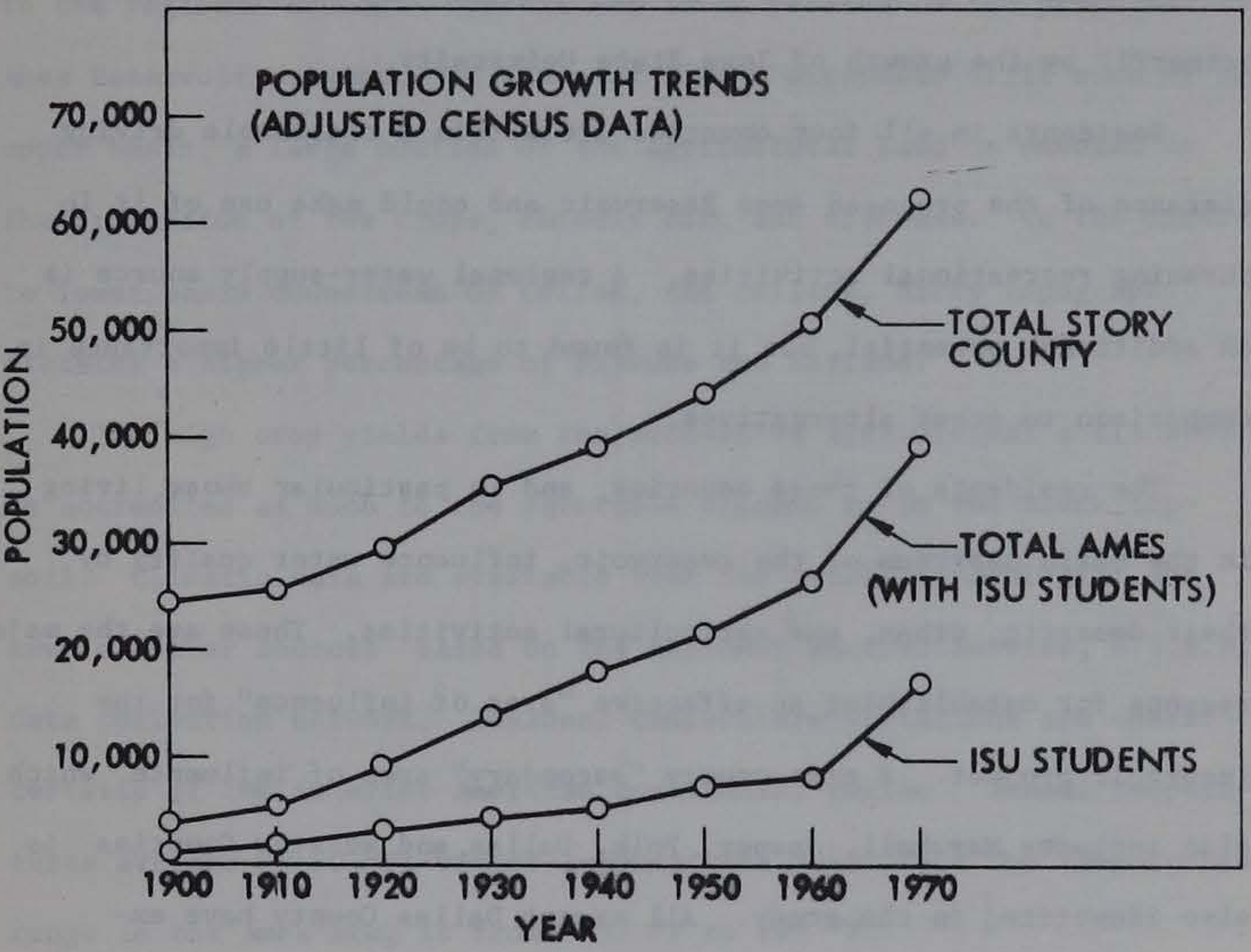

Fig. 3-4. Population growth trends for Ames and Story County, 1900-1970.

Table 3-4. Four-county primary area population, 1900-1970, as listed in census reports.

Year	Boone	Hamilton	Hardin	Story
1900	28,200	19,514	22,794	23,159
1910	27,626	19,242	20,921	24,083
1920	29,892	19,531	23,337	26,185
1930	29,271	20,978	22,947	31,141
1940	29,782	19,922	22,530	33,434
1950	28,139	19,660	22,218	44,294
1960	28,037	20,032	22,533	49,327
1970	26,470	18,383	22,248	62,783

showed a slight decline in population between 1960 and 1970. Only at Ames has a rapid growth been experienced since the 1940's, evidenced primarily by the growth of Iowa State University.

Residents in all four counties are within a reasonable driving distance of the proposed Ames Reservoir and could make use of it in pursuing recreational activities. A regional water-supply source is an additional potential, but it is found to be of little importance in comparison to other alternatives.

The residents of these counties, and in particular those living in the basin upstream of the reservoir, influence water quality by their domestic, urban, and agricultural activities. These are the major reasons for establishing an effective "area of influence" for the reservoir project. A nine-county "secondary" area of influence which also includes Marshall, Jasper, Polk, Dallas, and Webster Counties is also identified in the study. All except Dallas County have experienced steady urban growth in population. Residents of these counties are within relatively close driving distance of the Ames Reservoir. One-fifth of the population of Iowa resides in this nine-county area; however, the area also includes the Red Rock and Saylorville Reservoirs located on the Des Moines River (affecting also Marion County), and persons in Jasper and Polk Counties are within the area of influence of the Rathbun Reservoir.

Agricultural Trends

Agriculture has developed as the basic enterprise in the upper Skunk River basin as well as in the four-county area of influence. The water requirements (and associated water-quality problems) of crops, livestocks, farmsteads, and local communities are of major importance in the regional economic context and as it relates to the proposed Ames Reservoir project. In the most recent Wisconsin drift area of the upper basin, a large portion of the agricultural land is devoted to the production of row crops, chiefly corn and soybeans. In the middle to lower basin downstream of Colfax, the rolling, hilly topography dictates a higher percentage of pasture and hayland.

The high crop yields from the productive agricultural soils should be accredited as much to the favorable climate as to the black topsoil. Climatic data are available from the state climatologist and several other sources based on the National Weather Service, E.S.S.A., data collection network. Seasonal temperature variations are characteristic of the interior American continental region. Summer temperatures average 70-80 °F; winter temperatures 20-30 °F. The temperature range in the Ames area is from - 37 °F to 109 °F.

The average frost-free season is 163 days, from April 30 to October 10. Annual precipitation averages 30-32 in. in the upper basin, over 70% of which occurs as rain during the growing season. Snowfall averages about 30 in. annually. The average annual stream runoff is about 5-6 in. Wind velocities average 8-14 mi per hour; however, summer thunderstorms and tornadoes are not unusual, with at least two tornadoes reported in Ames itself in the last 10 yr. Lake evaporation in the Ames area is about 36 in. annually, indicating that it exceeds slightly the average annual precipitation.

The climate was also favorable to the growth of prairie vegetation prior to pioneer settlement. The prairie upland was characterized by tall grasses and broad-leaf flowering plants. The early settlers favored the wooded areas for settlement and concentrated along the woodlands bordering the water courses and in scattered groves.

In Story County, as reported in 1955, the land use was allocated as follows:

Land use	Percent of the total
Corn	38.5
Oats	19.5
Soybeans	9.1
Hay	10.9
Pasture	14.2
Miscellaneous	6.1
Other cropland	1.7

The percentage of land cultivated in row crops has increased steadily since that time. The results of Category 4 studies show that the land in the watershed of the proposed reservoir is heavily cropped. Seventy to 75% of the land is tilled. Today, 90-95% of the tilled land is in corn or soybeans. The average rate of application of fertilizer is 10-20% above the state average. Pesticides and other chemicals are also used effectively.

An intensive turkey-growing region is located in the area around Ellsworth, including a major processing plant. Other livestock production in the upper basin is of average numbers. As a result, the agricultural region presents a water quality impact of some potential which must be considered in determining the usefulness of any proposed reservoir alternative in regional development plans.

Population Projections for the Future

Method of Analysis

The population study was introduced by reviewing state population growth patterns. The second step was a detailed analysis of student enrollment at Iowa State University (ISU) and the related growth of Ames. The remainder of Story County and the other eight counties of the nine-county area were analyzed in the third step. Results are presented in this section. Low, medium, and high projections were prepared to reflect the variability which may occur in the economic growth of the region. In the absence of economic data and models for conducting detailed input-output studies, more traditional methods of projecting population growth were used. The modest population increases experienced in the past support the methods used, except perhaps for the trends at Ames for which additional studies were conducted.

Iowa and the Nation

The population study was introduced by reviewing state population growth trends. Table 3-5 depicts the relative trends of Iowa and the United States during the period 1900-1970. The birth, death, and net out-migration rates for Iowa have resulted in one sobering fact. The growth of the state's population in the 50-year period 1920-1970 was only 420,000 — from 2.40 million to 2.82 million; this occurred during a period when the nation's population doubled. This modest increase for Iowa represents a net growth rate of only 8,400 persons per year or less than 100,000 per decade. At this same rate of increase, it would take over 100 years to reach a state population of 3.8 million.

Table 3-5. United States and Iowa population trends, 1900-1970.

Census year	Population totals		Percentage change per decade		Iowa's rank among states
	United States	Iowa	United States	Iowa	
1900	75,994,575	2,231,853	—	—	10
1910	91,972,266	2,224,771	+ 21.0	- 0.3	15
1920	105,710,620	2,404,021	+ 14.9	+ 8.1	16
1930	122,775,046	2,470,939	+ 16.1	+ 2.8	19
1940	131,669,275	2,538,268	+ 7.2	+ 2.7	20
1950	150,697,361	2,621,073	+ 14.5	+ 3.3	22
1960	179,323,175	2,757,537	+ 19.0	+ 5.2	24
1970	203,184,772	2,825,041	+ 13.3	+ 2.4	25

Several studies of future population levels in Iowa have been made by community planning and federal water resource agencies. Growth indices developed through these studies exhibit a wide variation. Studies at Iowa State University show a 0-10% growth range may be realistic for the year 1990, whereas federal studies based on higher fertility rates and net in-migration show as much as a 50% increase by 1990 and a doubling in 50 years by 2020. The drop in both the annual birth rate (from 25 to less than 15 per 1000) and in numbers of live births (66,000 to 45,000 or less per year) during the period 1951-1971 indicates very well that a net in-migration must occur if more growth is to occur in the future than has been experienced with the modest trend of the past. Therefore, the 50-year (1970-2020) trend for Iowa could easily be a modest 10-20% increase rather than a 50 to 100% increase as forecast by some agencies. As tremendous a variation is noted in the Appendix 5 studies of the future projected population as among these several studies. The high rates of growth, in view of past trends and present economic factors, can be seriously questioned.

Population Projections for Ames and Story County

The component method of population analysis was used at Ames and for Story County because of the large influence of Iowa State University on both the city and county population growth (for April 1970: 17,250 students; 39,505 total city; 62,783 total county). Population projections were made for several components: students, Ames without students, other incorporated communities (modified urban category) in Story County, and a modified rural group (farm and rural residential category).

Future enrollment trends at Iowa State University were studied in view of decreased birth rates, future state population trends, and influence of educational trends and needs. Variable percentages of the simulated college-age population group were assumed to be attracted to Iowa State University. Three levels were forecast — low, medium, and high. All three projections show some decline from the forecasted 1975-1980 highs (reflecting high birth rates and live births in the 1950's) of 19,000-20,000+ students to future levels (1995-2020 period) of 14,000-15,000 (low), 16,000-23,000 (medium), and 16,000-25,000 (high). Present trends in birth rates, economics, and in education mix (introduction to area community colleges and vocational schools, etc.) indicate that the low and medium estimates may be the most relevant for planning purposes. The results are illustrated in Fig. 3-5.

The population growth of the remainder of Ames (without students) depends largely on industrial and commercial growth since expansion at ISU and at the Iowa State Highway Commission has stabilized. The historic trend since 1930 is about a 20% increase per decade, with an estimated 22,200 nonstudent population in 1970 (April). Review of

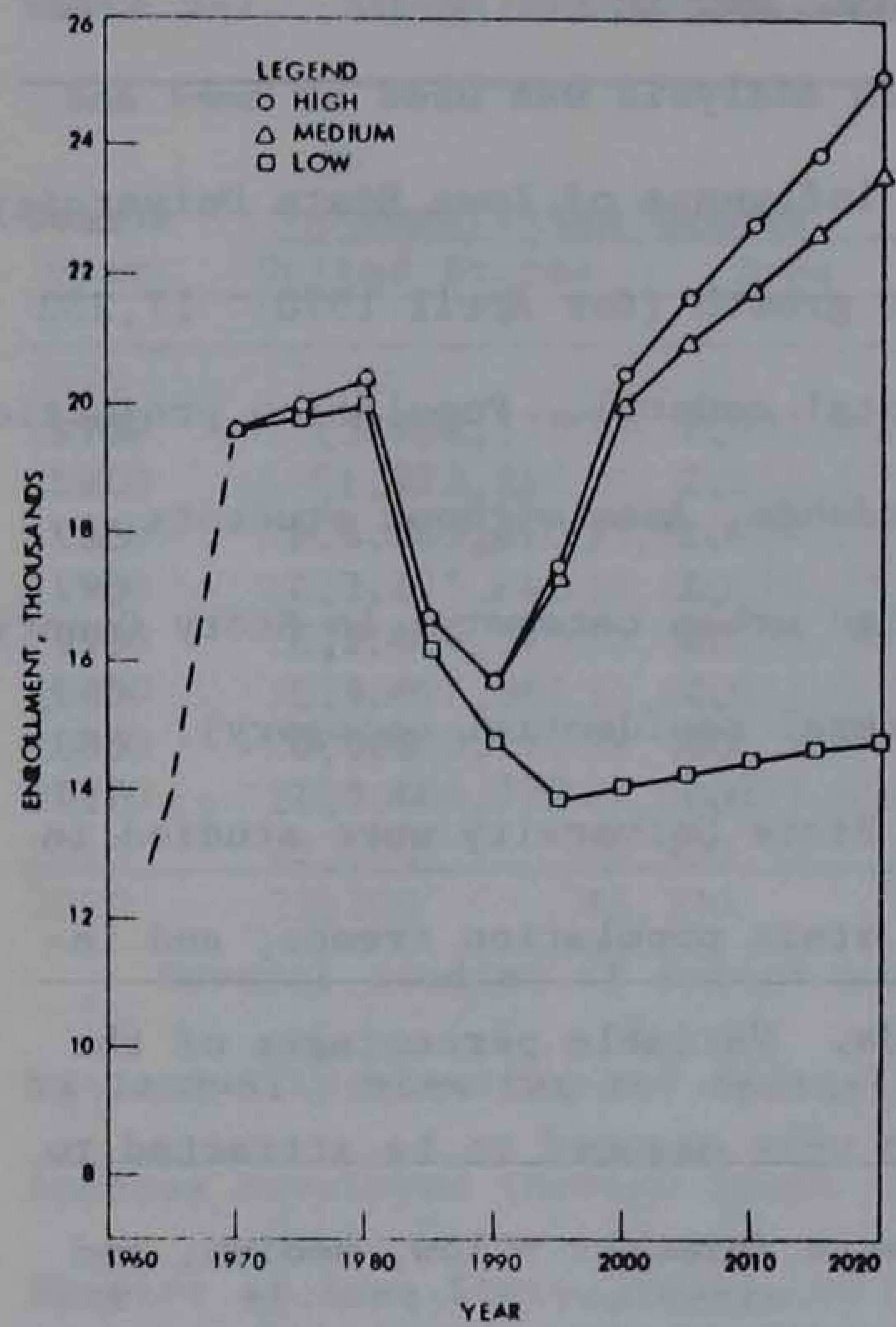

Fig. 3-5. Projected fall ISU student enrollment.

building permit and utility hook-up data showed a continued growth pattern at Ames, so five geometric growth rates were introduced (1.0 to 3.4% annual increases). Population projections for the nonstudent category ranged from 28,500 to 51,200 in 1995 and 37,000 to 118,000 in 2020. The medium estimate was 38,200 (1995) and 65,900 (2020). Including students, the total Ames population would be 54,200 (1995) and 87,700 (2020) for the medium estimate. The five population projections are shown in Fig. 3-6.

The population projections for the remainder of Story County were made by using and comparing two methods, (1) graphical extrapolation of rural and urban categories using low, medium, and high ranges and (2) birth, death, and migration rates for the entire county. Lower projections forecast a decline in the rural component, a stabilized trend for the medium, and an increasing growth for the higher estimates. Urban growth as experienced in almost all towns and cities in Story County would continue. Medium estimates for the entire county including Ames are 79,400 in 1995 and 114,900 in 2020. The projected levels for the total Ames population, other urban and rural areas of

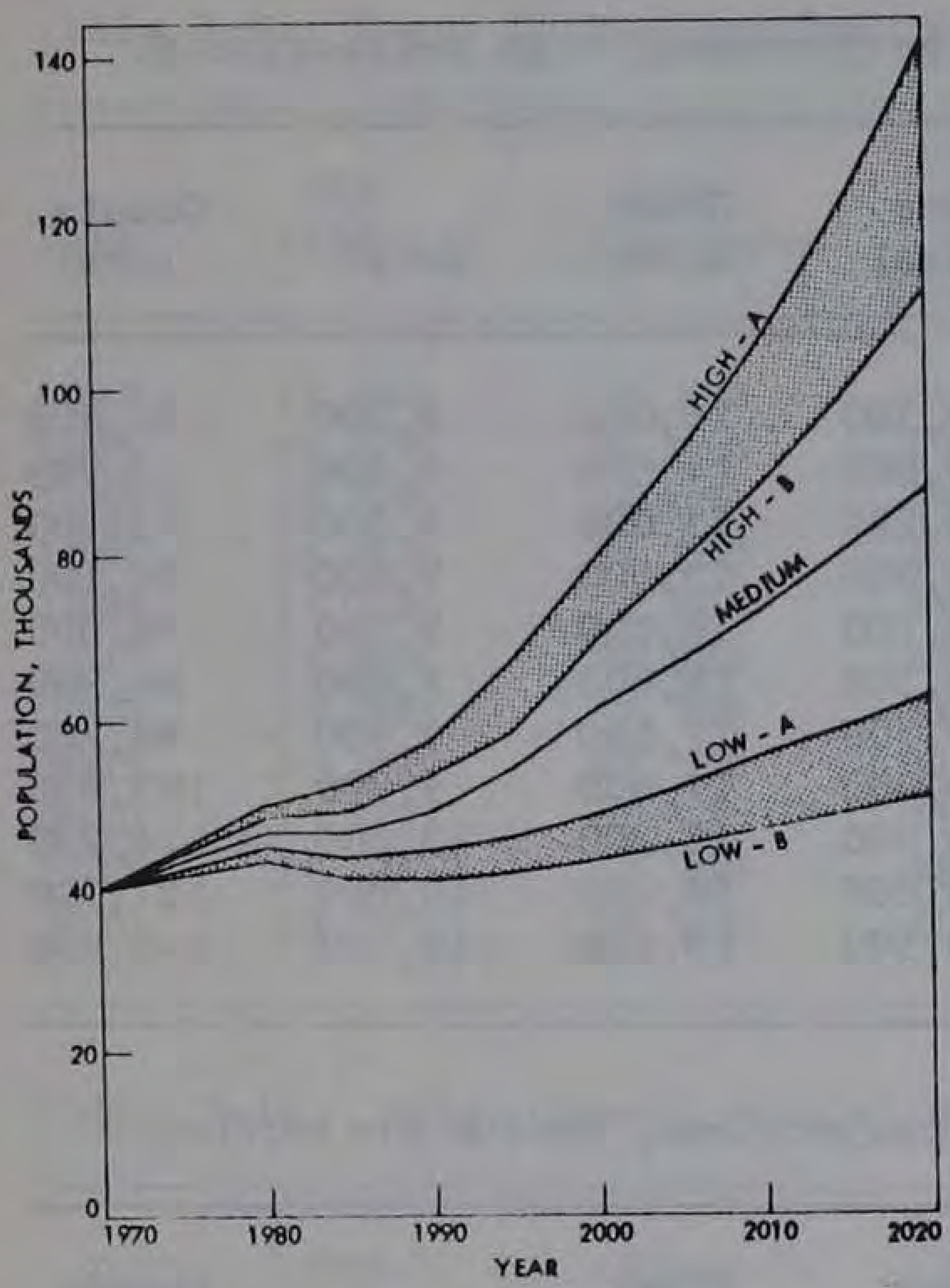

Fig. 3-6. Total Ames population as projected for the period 1970 to 2020.

Story County, and the total Story County population are shown in 5-year increments in Tables 3-6 through 3-10. The comparative trends of growth with these five rates are illustrated in Fig. 3-7.

Population Projections for the Other Counties

The population projections for the remaining eight counties were made using a mathematical population-growth model incorporating birth and death rates and three magnitudes of

Table 3-6. Story County population projection, high projection-A.

Year	ISU students	City residents	Ames total	Other urban	Rural	County total
1970	17,300	22,200	39,500	14,000	9,300	62,800
1975	18,500	26,200	44,700	14,500	9,400	68,600
1980	18,800	31,000	49,800	15,000	9,500	74,300
1985	15,400	36,700	52,100	15,500	9,600	77,200
1990	14,500	43,300	57,800	16,100	9,700	83,600
1995	16,200	51,200	67,400	16,600	9,800	93,800
2000	18,900	60,500	79,400	17,100	9,900	106,400
2005	20,000	71,500	91,500	17,600	9,900	119,000
2010	21,000	84,600	105,600	18,200	10,000	133,800
2015	22,100	99,900	122,000	18,700	10,000	150,700
2020	23,200	118,100	141,300	19,200	10,100	170,600

Table 3-7. Story County population projections, high projection-B.

Year	ISU students	City residents	Ames total	Other urban	Rural	County total
1970	17,300	22,200	39,500	14,000	9,300	62,800
1975	18,500	25,500	44,000	14,500	9,400	67,900
1980	18,800	29,300	48,100	15,000	9,500	72,600
1985	15,400	33,600	49,000	15,500	9,600	74,100
1990	14,500	38,600	53,100	16,100	9,700	78,900
1995	16,200	42,300	58,500	16,600	9,800	84,900
2000	18,900	50,800	69,700	17,100	9,900	96,700
2005	20,000	58,400	78,400	17,600	9,900	105,900
2010	21,000	67,000	88,000	18,200	10,000	116,200
2015	22,100	76,900	99,000	18,700	10,000	127,700
2020	23,200	88,300	111,500	19,200	10,100	140,800

Table 3-8. Story County population projections, medium projection.

Year	ISU students	City residents	Ames total	Other urban	Rural	County total
1970	17,300	22,200	39,500	14,000	9,300	62,800
1975	18,500	24,800	43,300	14,400	9,300	67,000
1980	18,800	27,600	46,400	14,800	9,300	70,500
1985	15,400	30,800	46,200	15,200	9,300	70,700
1990	14,500	34,300	48,800	15,600	9,300	73,700
1995	16,000	38,200	54,200	15,900	9,300	79,400
2000	18,500	42,600	61,100	16,300	9,300	86,700
2005	19,400	47,500	66,900	16,700	9,300	92,900
2010	20,100	53,000	73,100	17,100	9,300	99,500
2015	21,000	59,100	80,100	17,500	9,300	106,900
2020	21,800	65,900	87,700	17,900	9,300	114,900

migration rates. Only Polk, Story, and Dallas Counties have experienced net in-migration during the 1940-1970 period. The nine-county area presently has about 20% of the state's population or 567,000 people. The population projections for the medium projections for the year 1995 are 139,900 for the four-county area and 729,800 for the total nine-county area; and for the year 2020, 169,400 and 981,100 respectively.

Table 3-9. Story County population projections, low projection-A.

Year	ISU students	City residents	Ames total	Other urban	Rural	County total
1970	17,300	22,200	39,500	14,000	9,300	62,800
1975	18,300	24,000	42,300	14,300	9,200	65,800
1980	18,500	26,000	44,500	14,500	9,100	68,100
1985	15,000	28,200	43,200	14,800	9,000	67,700
1990	13,700	30,500	44,200	15,000	9,000	68,200
1995	12,800	33,000	45,800	15,300	8,900	70,000
2000	13,000	35,700	48,700	15,600	8,800	73,100
2005	13,200	38,700	51,900	15,800	8,800	76,500
2010	13,400	41,900	55,300	16,100	8,700	80,100
2015	13,600	45,300	58,900	16,300	8,700	83,900
2020	13,700	49,100	62,800	16,600	8,600	88,000

Table 3-10. Story County population projections, low projection-B.

Year	ISU students	City residents	Ames total	Other urban	Rural	County total
1970	17,300	22,200	39,500	14,000	9,300	62,800
1975	18,300	23,300	41,600	14,300	9,200	65,100
1980	18,500	24,500	43,000	14,500	9,100	66,600
1985	15,000	25,800	40,800	14,800	9,000	64,600
1990	13,700	27,100	40,800	15,000	9,000	64,800
1995	12,800	28,500	41,300	15,300	8,900	65,500
2000	13,000	29,900	42,900	15,600	8,800	67,300
2005	13,200	31,400	44,600	15,800	8,800	69,200
2010	13,400	33,100	46,500	16,100	8,700	71,300
2015	13,600	34,700	48,300	16,300	8,700	73,300
2020	13,700	36,500	50,200	16,600	8,600	75,400

The three projected population levels for the four- and nine-county areas are shown in 5-year increments in Tables 3-11 through 3-16 and are plotted in Figs. 3-8 and 3-9.

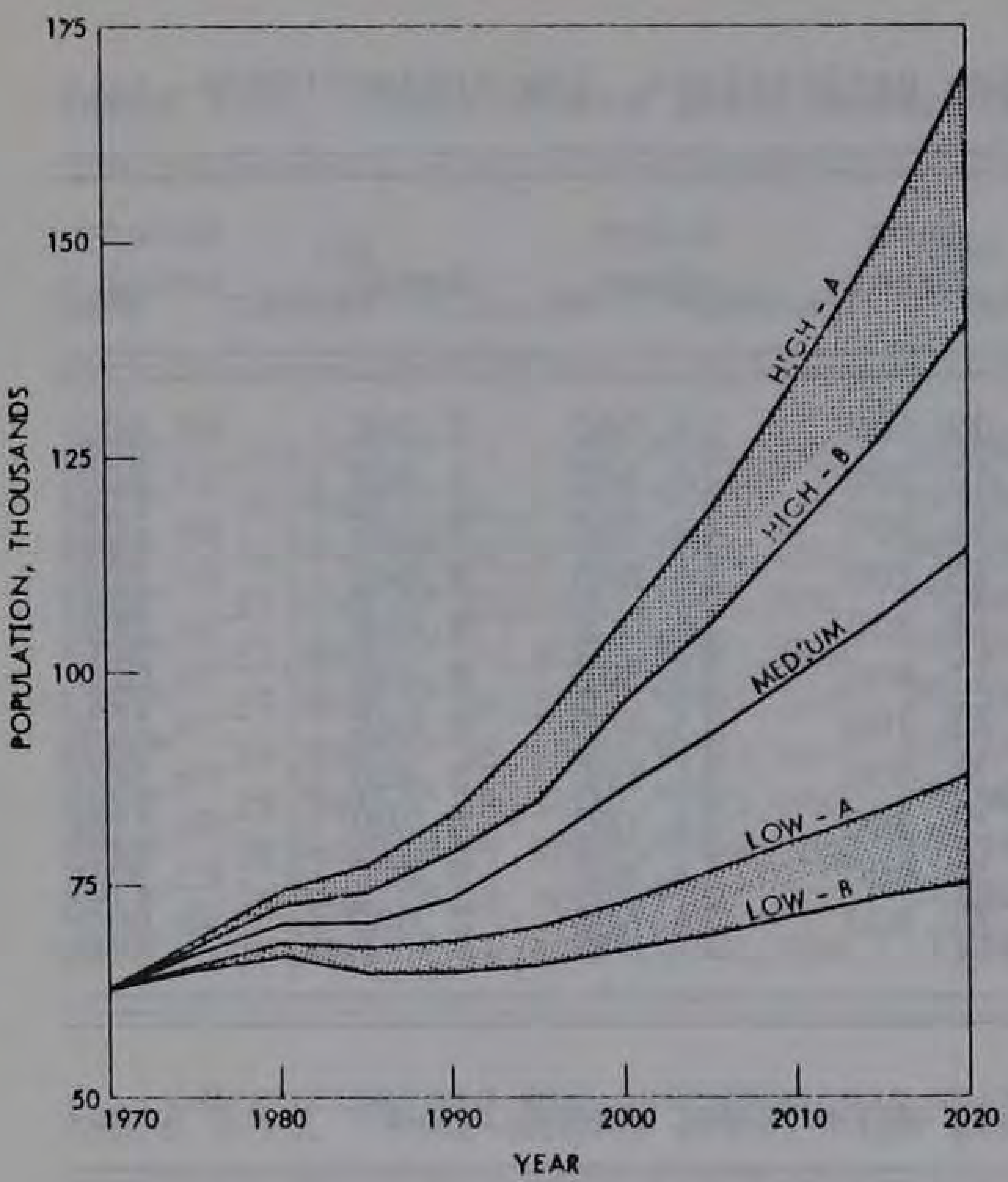

Fig. 3-7. Total Story County projected population.

Discussion and Summary

All of the above projections have been based upon several assumptions. The projected birth rates represent a continuation of the current lower birth rates. The projected death rates reflect the increasing percentage of persons age 65 and over living in Iowa. The historic net out-migration rates will be reduced in the future. Each of these rates should be construed as crude birth, death, and net-migration rates which are average rates for the 50-year projection period and not as specific rates for sex and age cohorts. The accuracy of these

Table 3-11. Four-county area, low projection.

Date	Boone	Hamilton	Hardin	Story	4-county total
1970	26,500	18,400	22,200	62,800	129,900
1975	24,700	18,000	21,400	75,800	130,900
1980	24,800	17,700	20,700	68,100	131,300
1985	24,000	17,300	20,000	67,700	129,000
1990	23,300	17,000	19,300	68,200	127,800
1995	22,500	16,600	18,600	70,000	127,700
2000	21,800	16,300	18,000	73,100	129,200
2005	21,100	16,000	17,400	76,500	131,000
2010	20,400	14,700	16,800	80,100	133,000
2015	19,800	15,400	16,200	83,900	135,300
2020	19,100	15,100	15,600	88,000	137,800

Table 3-12. Nine-county area, low projection.

Date	Dallas	Jasper	Marshall	Polk	Webster	5-county subtotal	9-county total
1970	26,100	35,400	41,100	286,100	48,400	437,100	567,000
1975	25,800	35,600	41,300	306,700	48,800	458,200	589,100
1980	25,500	35,800	41,500	328,800	49,100	480,700	612,000
1985	25,100	35,900	41,700	352,400	49,500	504,600	633,600
1990	24,800	36,100	41,900	377,800	49,900	530,500	658,300
1995	24,500	36,300	42,100	405,000	50,200	558,100	685,800
2000	24,200	36,500	42,400	434,200	50,600	587,900	717,100
2005	23,900	36,700	52,600	465,400	51,000	619,600	750,600
2010	23,600	36,800	42,800	498,900	51,400	653,500	786,500
2015	23,300	37,000	43,000	534,800	51,800	689,900	825,200
2020	23,000	37,200	43,200	573,300	52,200	728,900	866,700

Table 3-13. Four-county area, medium projection.

Date	Boone	Hamilton	Hardin	Story	4-county total
1970	26,500	18,400	22,200	62,800	129,900
1975	25,800	18,200	21,700	67,000	132,700
1980	25,200	18,000	21,100	70,500	134,800
1985	24,600	17,900	20,600	70,700	133,800
1990	24,000	17,700	20,100	73,700	135,500
1995	23,400	17,500	19,600	79,400	139,900
2000	22,800	17,300	19,100	86,700	145,900
2005	22,200	17,200	18,600	92,900	150,900
2010	21,700	17,000	18,200	99,500	156,400
2015	21,100	16,800	17,700	106,900	162,500
2020	20,600	16,600	17,300	114,900	169,400

projections will depend upon how well these estimated future rates reflect which actually occur in the future.

It also must be emphasized that the selection among the low, medium, and high projections for any purpose should be made in cognizance of probability concepts. There is a high degree of probability that the low estimates will be achieved in the future, a reasonable probability of

Table 3-14. Nine-county area, medium projection.

Date	Dallas	Jasper	Marshall	Polk	Webster	5-county subtotal	9-county total
1970	26,100	35,400	41,100	286,100	48,400	437,100	567,000
1975	26,400	35,900	41,700	309,700	49,500	463,200	595,900
1980	26,800	36,500	42,400	335,300	50,600	491,600	626,400
1985	27,100	37,000	43,000	363,000	51,800	521,900	655,700
1990	27,400	37,600	43,600	393,000	52,900	554,500	690,000
1995	27,800	38,200	44,300	425,500	54,100	589,900	729,800
2000	28,100	38,700	45,000	460,600	55,400	627,800	773,700
2005	28,500	39,300	45,600	498,700	56,600	668,700	819,600
2010	28,800	39,900	46,300	539,800	57,900	712,700	869,100
2015	29,200	40,500	47,000	584,400	59,200	760,300	922,800
2020	29,600	41,100	47,700	632,700	60,600	811,700	981,100

Table 3-15. Four-county area, high projection.

Date	Boone	Hamilton	Hardin	Story	4-county total
1970	26,500	18,400	22,200	62,800	129,900
1975	26,000	18,400	21,900	67,900	134,200
1980	25,600	18,400	21,500	72,600	138,100
1985	25,100	18,400	21,200	74,100	138,800
1990	24,700	18,400	20,900	78,900	142,900
1995	24,300	18,400	20,600	84,900	148,200
2000	23,900	18,400	20,300	96,700	159,300
2005	23,400	18,400	20,000	105,900	167,700
2010	23,000	18,400	19,700	116,200	177,300
2015	22,600	18,400	19,400	127,700	188,100
2020	22,200	18,400	19,100	140,800	200,500

the medium estimate, but much less or very low probability of reaching the high estimates. Plans for resource development in urban areas should normally aim for a medium level, especially in the field of water supply and water pollution control. This avoids overstressing sources of supply, inadequate treatment plant capacities, dangers of water shortages, and inadequate pollution control since rapid expansion of

Table 3-16. Nine-county area, high projection.

Date	Dallas	Jasper	Marshall	Polk	Webster	5-county subtotal	9-county total
1970	26,100	35,400	41,100	286,100	48,400	437,100	567,000
1975	27,100	36,300	42,100	312,800	50,200	468,500	692,700
1980	28,100	37,200	43,200	342,000	52,200	502,700	640,800
1985	29,200	38,200	44,300	373,900	54,100	539,700	678,500
1990	30,300	39,100	45,400	408,800	56,200	579,800	722,700
1995	31,500	40,100	46,600	446,900	58,300	623,400	771,600
2000	32,700	41,100	47,700	488,600	60,600	670,700	830,000
2005	33,900	42,200	48,900	534,200	62,900	722,100	889,800
2010	35,200	43,200	50,200	584,000	64,300	777,900	955,200
2015	36,500	44,300	51,400	638,500	67,700	838,400	1,026,500
2020	37,900	45,400	52,700	698,100	70,300	904,000	1,104,900

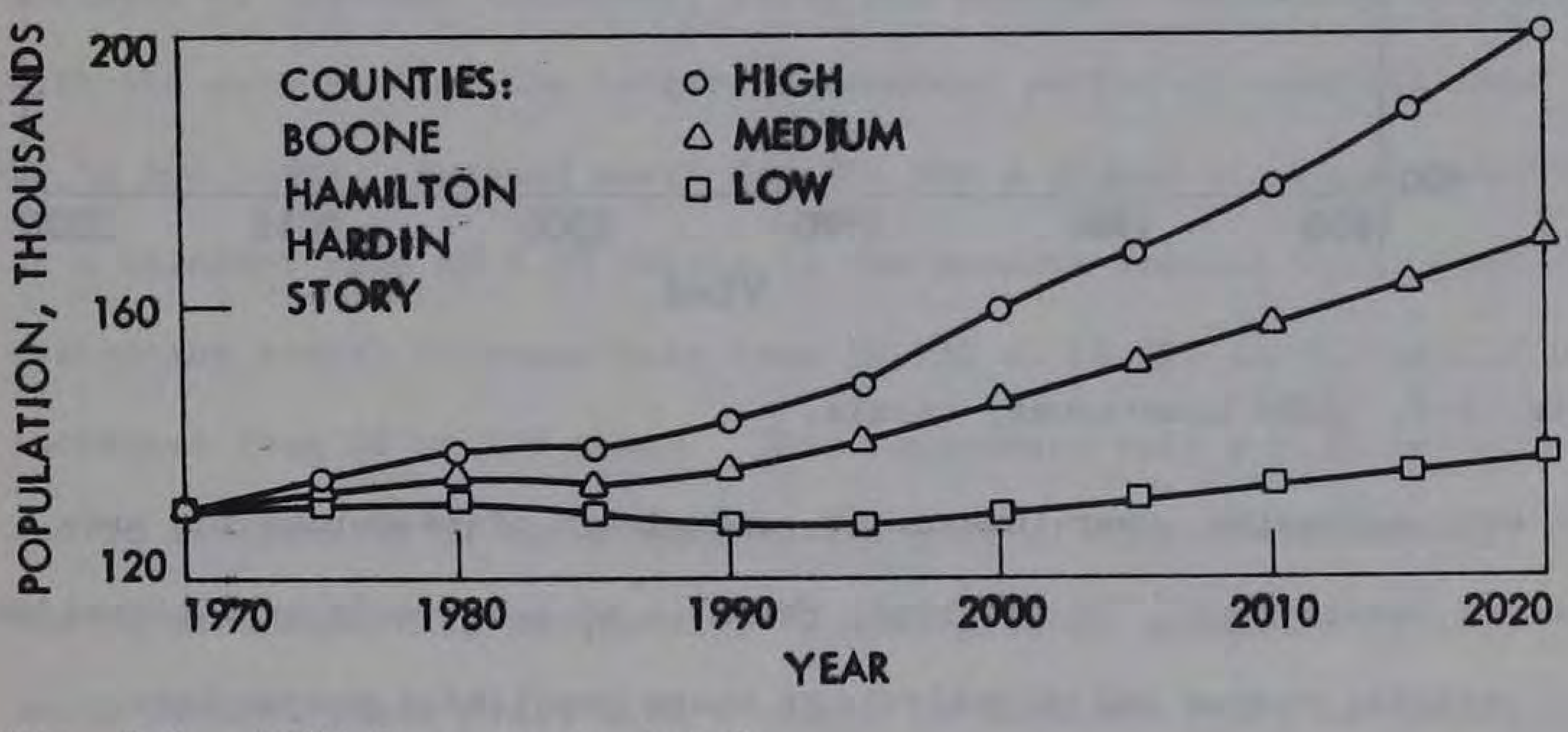

Fig. 3-8. ARES four-county totals.

treatment facilities can seldom be economically planned and constructed. Flood plain management and land-use planning also have some margin of safety in the medium estimate. Recreation may not have as much need for above-minimum estimates; however, the stress currently noted in certain state parks such as the Ledges illustrates the need for continued planning and investment in lands for open space and outdoor recreation. Conversely, use of inordinately high estimates may result

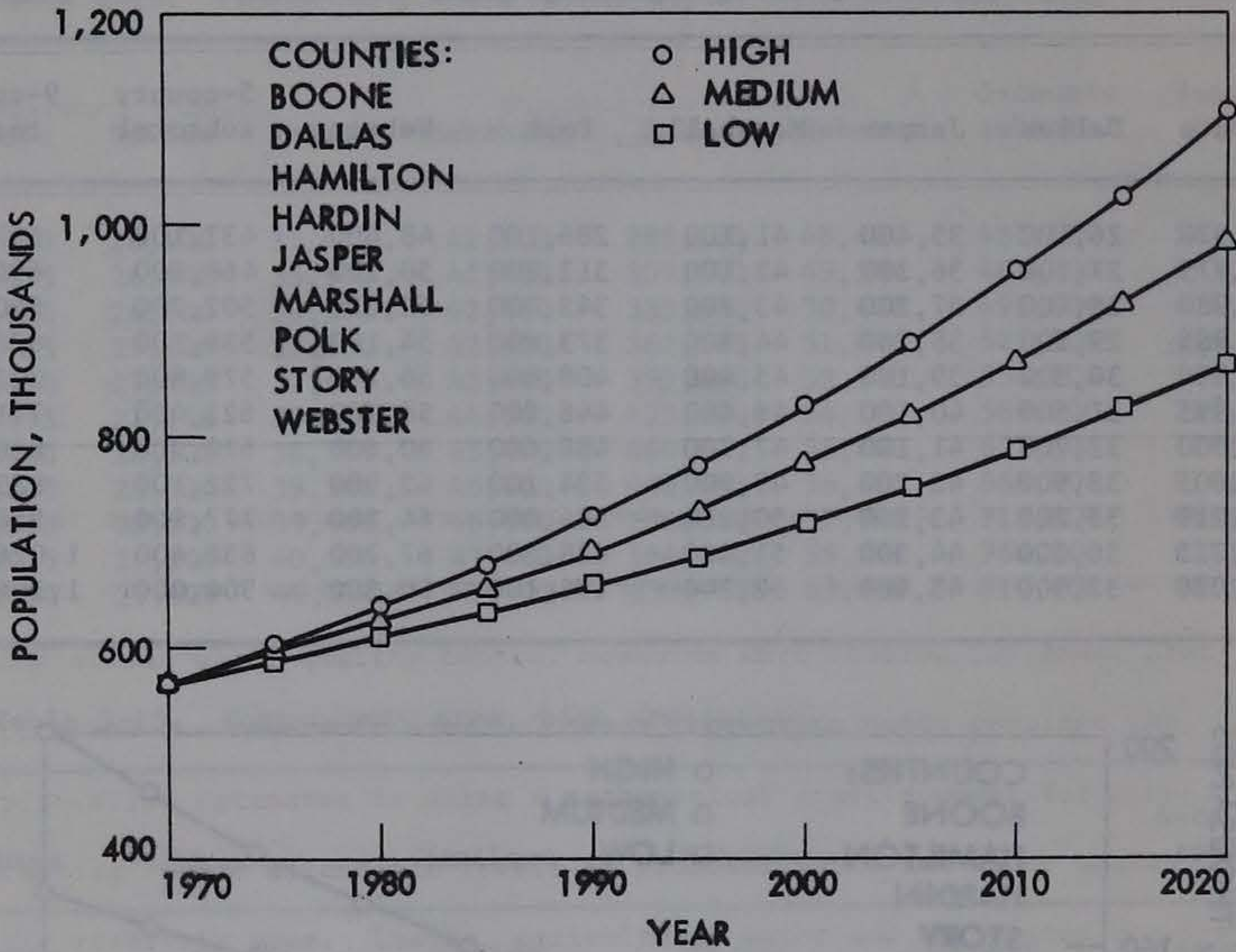

Fig. 3-9. ARES nine-county totals.

in over-expansion, over-investment, and misuse of resources for premature development. In addition, there is no substitute or alternative to periodic review and re-analysis of these population projections. Review every decade would aid in guiding future development and reduce the margin of error for any specific future year.

The use of the Ames Reservoir by people in the four-county primary area of influence may be relatively great, since it offers considerable open space and water area. Its use by residents of the five-county area of secondary influence is less and must be measured within the competitive influence of the Saylorville-Big Creek Reservoir project, the Red Rock Reservoir, and, to a lesser extent, Rathbun Reservoir. The latter two can easily attract people from Dallas, Polk, and Jasper Counties who will have interstate highway access also to the Ames Reservoir area.

A brief review of the period 2020-2070 was made to reflect on the permitted 100-year period for water resources economic evaluation. Realistic population projections are not considered feasible for such a long period. Low, medium, and high projection levels would, in general, tend to indicate additional growth increases beyond 2020 of 50, 75, and 100%, respectively. The study also showed the greater importance of discount (interest) rates for economic evaluation compared with the extension of the length of economic period of analysis from 50 to 100 years. Present worth factors for a stream of annual benefits at a discount rate of 5.5% (close to the present federal water resource evaluation rates) increase only from 16.932 to 18.096 as the period is increased from 50 to 100 years. This represents only a 6.9% increase, and it is doubtful if water demands and initial construction costs can be estimated this accurately. A much greater change in present worth factors takes place with a change in interest rates as indicated in Table 3-17. Use of recommended higher discount or interest rates reduces appreciably the present worth of future streams of annual benefits. However, long-range planning for physical conservation of resources and identification of development patterns may need to reflect the longer period, 100 years or more.

The population projections provided the base from which detailed study of the several alternative development opportunities proceeded.

Table 3-17. Change in present worth factor with discount rate.

Discount rate, %	Present worth factor, 50-year analysis	Percent change
4.0	21.482	
		- 21.2
5.5	16.932	
		- 18.5
7.0	13.801	

Water supply and water treatment needs at Ames and in the region (in terms of rural water systems) were evaluated. Water pollution control and stream water-quality control measures were studied for Ames, Story City, and the reservoir area. Outdoor recreation needs required the population estimates in using a mathematical gravity model for forecasting future attendance levels in proposed parks and water bodies in the reservoir area. Lastly, agricultural water and wastewater requirements can be evaluated within the variations which can be expected in the future. These are reported in Appendices 3, 4, and 5 and are summarized in several of the chapters in Part II of this summary report.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part I. The Valley, Its People, and Development Opportunities

Chapter 4

ALTERNATIVE DEVELOPMENT OPPORTUNITIES

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ARES SUMMARY REPORT

Chapter 4

ALTERNATIVE DEVELOPMENT OPPORTUNITIES

Introduction

The National Environmental Policy Act of 1969 (NEPA) specifically requires that attention be directed not only to the proposed action (which, under Congressional authorization and initial appropriations for I-35 relocations and land acquisition, is to construct the Ames Reservoir) but also to alternatives to the proposed action. As a result, the ARES research team outlined during the review study several alternative plans for development which could be pursued in greater extent and depth in detailed studies by each category. The nine alternatives (including the "do-nothing" alternative) which resulted from the initial and subsequent review of the region and its growth potential are listed and discussed in this chapter.

Growth Patterns in the Ames Area

The environmental review study showed that the varied landscape patterns along the wooded slopes of the valley walls have not gone unnoticed by the urban dweller. Specific attention has been afforded to the problem of urban land-use requirements at Ames and related rural-residential growth in unincorporated areas of Story County. Technological advances permit the rural-residential homeowner today to have dependable sources of construction materials, water supply, electric power, telephone, surfaced road systems, lawn maintenance equipment, but probably less-than-satisfactory wastewater disposal if septic tanks and tile fields are used for effluent seepage control.

Observations made in field studies illustrate the gradual encroachment of scenic areas of the Skunk River valley with rural-residential developments. Intensive development has taken place since World War II in the tributary valleys which are immediately adjacent to Ames. These include Worle, College, Clear, and Onion Creeks in south, southwest, west, and northwest Ames, respectively, and in several smaller unnamed creeks along the valley bluffline. Some of these areas have been or are being gradually incorporated into the City of Ames. More remote development occurred along the Squaw Creek and Skunk River valleys north of Ames and along the Skunk River valley north and south of Story City in the 1950's and 1960's, but several large-scale subdivisions in both valleys have been platted in more recent years. As a result of this popular trend towards increased rural-residential development, the research team determined early in the study that development of the valley for more intensive uses was a real and practical possibility. There is little chance that a "status quo" category would have any meaning.

<u>Other Competitive Development Patterns</u>

This growth and development stress is supported by several other events occurring in recent years. These have altered the agricultural-use pattern which has existed since the pioneers settled the valley in the 1800's. The initial proposal in the early 1960's to locate Interstate I-35 in the Skunk River valley between Ames and Story City (which progressed to the point of land acquisition for road right-of-way) represented a highway encroachment. The existence of limestone bedrock at or near the surface (Cook's quarry) and extensive sand and gravel deposits (Hallett's and Peterson's gravel pits) has led to timber clearing, stripping of overburden into spoil piles, and excavation of rock or of sand and gravel has left denuded waste areas and materials stock piles remaining as remnants of this new occupation. The reservoir now poses an additional problem which can lead to further environmental degradation, especially in regard to its fluctuating flood control pool. Therefore, including the rural-residential occupancy of this scenic valley area, there exist four major development patterns which pose an environmental degradation problem in the Skunk River valley. These illustrate very well the need for comprehensive land-use planning and development and implementation of sound land-use policies in Story County.

It was determined in the beginning of the review study that further development will take place unless and until more strict land-use controls are applied. As a result of these field observations and analysis of basic data, nine alternative development plans were introduced into the study. These permitted the research team to comply substantially with the NEPA provisions. The nine major alternatives are described in the next section.

Nine Potential Development Alternatives

Formulation of Alternatives

Within the context of the experienced pattern of urban growth, suburban sprawl, and increased rural-residential development, several future development alternatives were identified and formulated. The initial selection was modified and extended during the course of the environmental study. Six alternative development plans were outlined in the initial phases of the study. These were modified slightly in the outdoor-recreation study phase by the Category 3 research group. An additional, more comprehensive green-belt and open-space program was introduced in the final phases of the study. The physical, social, economic, and institutional impact of these alternatives was explored by the research team. Some alternatives have been studied in more detail than others because of data availability or from judgment of the relative importance of some over the others. Nine alternatives (Alternatives 1, 1A, 2, 3, 4, 4A, 5, 6, and 7) were included in the final physical, social, economic, and institutional analyses. These are listed in Table 4-1 and illustrated in Fig. 4-1 and Fig. 4-2.

The Nine Development Alternatives

Alternative 1 is the Ames Reservoir project as proposed by the Corps of Engineers in Design Memorandum No. 1 (prepared in 1968). It expands the project scope included in the original authorization studies. Two subimpoundments are added to the main reservoir project, both directed to enhancing water-oriented outdoor recreation by having constant-level water surfaces (the Bear Creek and dam-site subimpoundments).

Alternative 1A maintains the same maximum conservation and flood pool elevations as Alternative 1, but eliminates the Bear Creek subimpoundment. Because the dam-site lake is small and is considered as an integral part of any dam construction at the major reservoir site, its inclusion is implied in any multi-purpose reservoir alternative.

Table 4-1. Alternative development opportunities for the Ames Reservoir area.

Alternative	Description	Pool designation for new water areas	Elevation, ft MSL	Total surface area, acres	Total storage volume, acre ft
1	Ames Reservoir with 2 subimpoundments, as planned in Design Memo No. 1 of the Corps of Engineers	Conservation Pool Flood Pool Bear Creek Lake Dam-site Lake	950 976 970 1,000	2,100 5,000 155 30	34,500 124,000 2,650 300±
1A	Ames Reservoir as modified by Design Memo No. 3A, with one subimpoundment	Conservation Pool Flood Pool Dam-site Lake	950 976 1,000	2,200± 5,000+ 30	35,000± 124,000± 300±
2	Ames Reservoir, smaller conservation pool for recreation only, no flood pool	Conservation Pool	940	1,410	16,800
3	Tributary recreation lake development only — Bear Creek and dam site	Bear Creek Lake Dam-site Lake	970 1,000	155 30	2,650 —
4	Green-belt, open-space plan with minimum acquisition, continuation of private ownership	None			
4A	Comprehensive green-belt, open-space plan with public control or acquisition of land	Hallett's gravel pit area	893	About 40	Unknown
5	Ames Reservoir as modified by Design Memo No. 3A, with minimum recreation development	Conservation Pool Flood Pool Dam-site Lake	950 976 1,000	2,100+ 5,000+ 30	34,500 124,000 300±

Table 4-1. Continued.

Alternative	Description	Pool designation for new water areas	Elevation, ft MSL	Total surface area, acres	Total storage volume, acre ft
6	Reduced-scope, multi-purpose project for Ames Reservoir	Conservation Pool	940	1,410	16,800
		Flood Pool	965	3,620	77,200
		Bear Creek Lake	970	155	2,650
		Dam-site Lake	1,000	30	300±
7	Do-nothing, or status quo, for recreation developments; no capital improvements, use existing McFarland Park and other river access areas; continued uncontrolled rural-residential development	None			

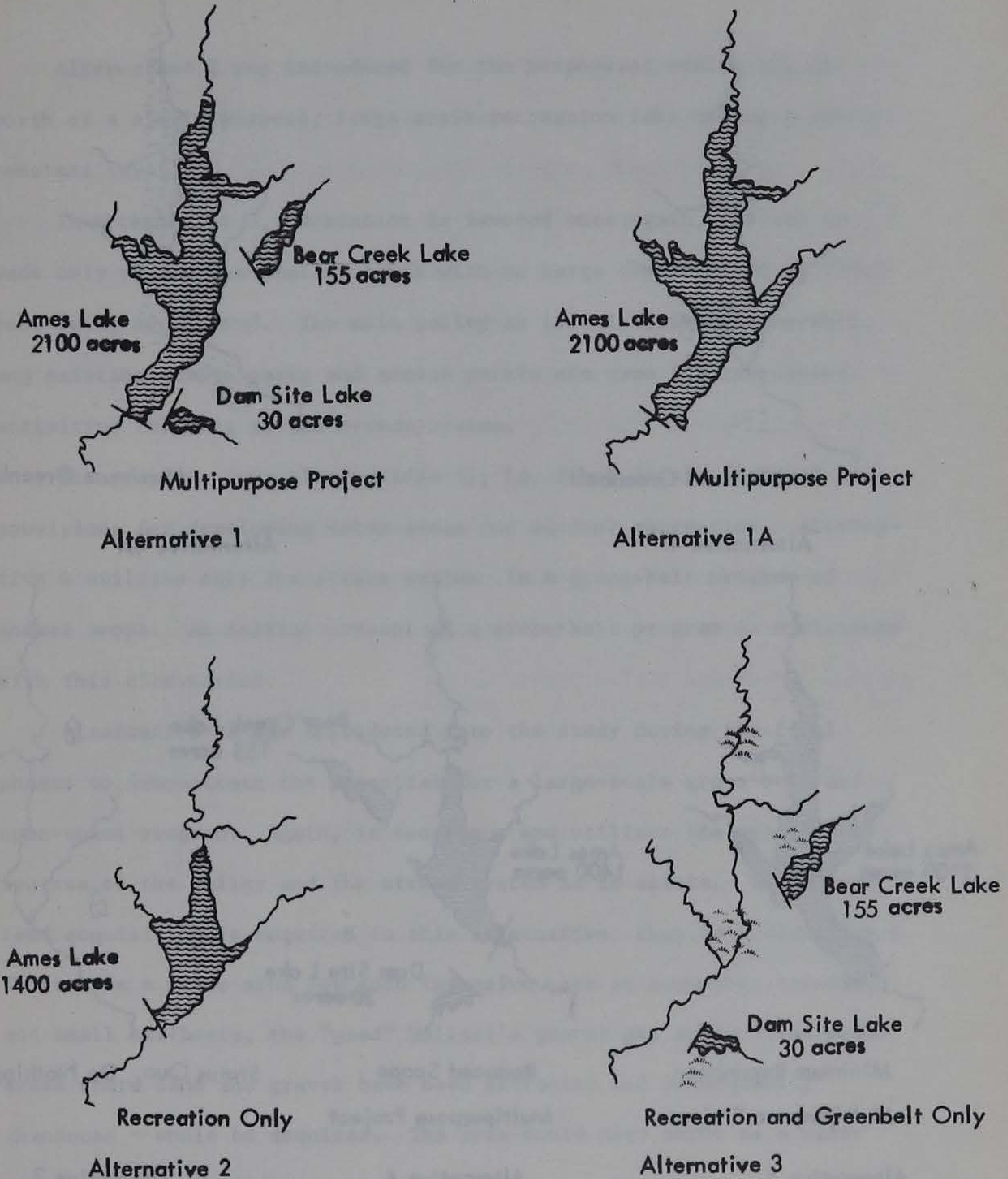

Fig. 4-1. Schematic illustration of Alternatives 1, 1A, 2, and 3 of the nine alternative valley development opportunities.

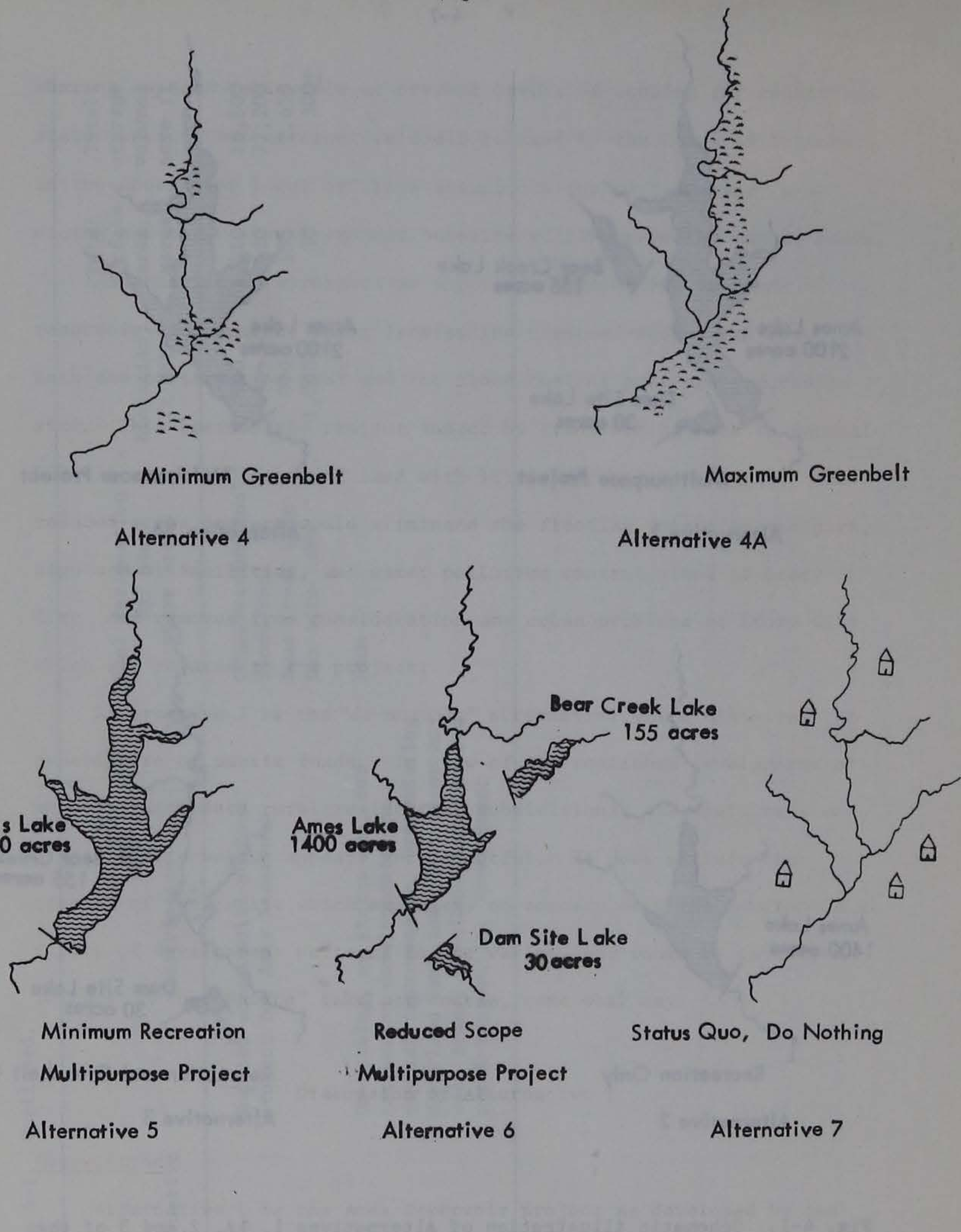

Fig. 4-2. Schematic illustration of Alternatives 4, 4A, 5, 6, and 7 of the nine alternative valley development opportunities.

Alternative 2 was introduced for the purpose of evaluating the worth of a single-purpose, large-scale recreation lake having a fairly constant level.

In Alternative 3, recreation is favored once again, but use is made only of the two smaller lakes with no large conservation or flood pool being considered. The main valley is left in private ownership, and existing public parks and access points are used for recreation activities relating to the stream system.

The previous four alternatives (1, 1A, 2, and 3) all included provisions for developing water areas for outdoor recreation. Alternative 4 utilizes only the stream system in a green-belt program of modest scope. An initial concept of a green-belt program is envisioned with this alternative.

Alternative 4A was introduced into the study during the final phases to demonstrate the potential for a large-scale green-belt and open-space program. Again, it conserves and utilizes the natural resources of the valley and the stream system as it exists. Much more land acquisition is required in this alternative than in Alternative 4. To provide a water area for such intensive uses as swimming, canoeing, and small sailboats, the "used" Hallett's gravel pit areas — the water areas where sand and gravel have been extracted and subsequently abandoned — would be acquired. The area could also serve as a water supply storage facility.

Alternative 5 also was introduced late in the study. It is similar in reservoir scope to Alternative 1A, but drops out the optimum recreation development plan. It is included because local cost sharing appears impossible at present levels of funding for county and state parks. This alternative could be used by the Corps of Engineers in the absence of local or state assurances for cost sharing, providing the total annual project benefits still exceed the annual costs.

Alternative 6 represents an important alternative in terms of reservoir development, being labeled the "reduced-scope" project. Both the conservation pool and the flood control pool are reduced in size. This lessens the project impact by transferring back to natural habitat some 1100 acres of land with little or no flood damage. The reduced-scope project would eliminate the flooding impact on the park, high school facilities, and water pollution control plant at Story City and removes from consideration any urban problems at Story City which are related to the project.

Alternative 7 is the "do-nothing" alternative which minimizes the expenditure of public funds. In view of the continued development of wooded tracts into rural-residential subdivisions, its usefulness as a viable alternative appears very doubtful. It does satisfy that segment of the public which expresses no concern over the environmental impact of development patterns in the valley and would be satisfied to have "Mother Nature" take her course, come what may.

Discussion of Alternative 1

Description

Alternative 1 is the Ames Reservoir project as developed by the Corps of Engineers following authorization of the project by Congress. It was presented in Design Memorandum No. 1 in 1968. It includes storage for flood control, water-quality control, outdoor recreation, fish and wildlife propagation, and sedimentation allocation. The main reservoir contains a large-scale conservation pool of 2100 acres at elevation 950 ft and a fluctuating flood control pool having a maximum elevation of 976 ft for which the temporary flood storage would cover a total of 5000 acres (an additional 2900 acres). Two sub-impoundments were included for purposes of enhancing water-oriented outdoor recreation, the Bear Creek and Dam-site Lakes. The flood control pool was increased in storage volume from the initial allocation of 60,000 ac ft (equivalent to 3.6 in. of flood runoff from the 314 sq mi basin) to 89,500 ac ft (5.3 in. of runoff from the basin).

The principal reservoir features of Alternative 1 are:

Pool designation	Surface elevation of top-of-pool, ft MSL	Surface area of top-of-pool, acres	Incremental storage allocation, ac ft
Sediment allocation	933	800	(8,400)
Conservation pool	950	2,100	(26,100)
Flood control pool	976	5,000	(89,500)
Total storage			124,000 ac ft at elev. 976
Bear Creek Lake	970	155	2,650
Dam-site Lake	1,000	30	300±

Scope of Alternative 1

The conservation pool would support the large-scale water area requirements of powerboats, houseboats, water skiing, etc. More intensive recreation uses (such as beaches, swimming, canoeing, sailboating, etc.) would be assigned to areas around the stable-level subimpoundments. The site of the Bear Creek Lake is located east of Interstate I-35, and its features and usefulness would be similar to the existing Hickory Grove Lake and Park (100+ acres of water) of the Story County Conservation Board, located near Colo in the eastern part of the county. The two lakes at the reservoir site would be stable-level impoundments, a prerequisite for ideal recreation lakes. They add both to the benefits and the costs of the project and, under current federal legislation, would require considerable cost sharing at the local or state level of government. Presumably the most satisfactory or ideal mix would be local participation in the Dam-site Lake (City of Ames) and state (or combined county and state) participation in the Bear Creek Lake and main impoundment.

The value of recreation subimpoundments has been shown in the Coralville Reservoir-Lake MacBride combination at Iowa City and, to a certain degree, in the Red Rock Reservoir-Roberts Lake combination at Pella. However, additional control measures are implied in the development of water-based recreation in the reservoir area, because Roland has a waste stabilization pond just upstream of the proposed Bear Creek impoundment and because Story City discharges its effluent from a trickling filter plant into the main impoundment.

The conservation storage would be used to augment low flows in the downstream channel during drought periods. Discharges of a 40-50 cfs range could be sustained by the reservoir, which would deplete the pool severely at least once every 10 years — mostly in the fall and winter seasons. This low-flow augmentation would recharge the alluvial and buried-channel groundwater system (aquifers) in the Ames area, to the benefit of water supply, and would provide dilution water for water pollution control at Ames.

The release of water, up to 40-50 cfs for low-flow augmentation, compares to a zero low flow experienced in drought periods in the past. This reservoir release rate is also 2 to 3 times the projected wastewater flows projected for Ames and provides a very reasonable streamflow condition for the assimilation of the effluent discharged from the Ames water pollution control plant. As indicated in Appendix 5, when the dilution ratio has been above 3, fewer water pollution problems (ammonia toxicity being the major problem) have been encountered. However, the reservoir does not eliminate the need for some level of advanced waste treatment at Ames.

The flood control storage allocation with this alternative is sufficient to permit controlling incoming flood volumes (record peak of 8630 cfs) with a maximum release rate of 1000 cfs downstream. This is the maximum reduction of all the alternatives. The inclusion of 5.2 in. of runoff storage (from the 314 sq mi basin) in the flood pool places it midway between Coralville Reservoir (about 3 in. of runoff storage) and Rathbun Reservoir (over 12 in. of runoff storage). Therefore, a more effective flood control project is achieved from the standpoint of protecting downstream landowners on the flood plain who benefit from such storage and operation. Adequate storage is necessary to be able to effectively reduce the discharges and stages during periods of prolonged outflow, which can otherwise adversely affect groundwater levels in downstream flood plain reaches. This alternative requires a minimum of supplemental agricultural levee construction in the reach between Ames and Colfax; however, a comprehensive flood plain management program is needed with all alternatives, especially to permit continued control of urban encroachment.

Land-Use Requirements and Visual Perception

Approximately 7750 acres of land would be required for water storage and associated recreation and open-space needs. This is based on providing an optimum recreational program for the population residing within the area of influence. This alternative represents the largest scale of development of the nine studied.

The relationship of the water area requirements of Alternative 1 to the 34-section study area was studied by Category 1. The flood pool is large with water being ponded in the main valley, in each tributary stream, and across the flat plateau located between Keigley Creek and the Skunk River. The visual perception of this alternative is shown in Figs. 4-3 and 4-4 for the conservation pool and flood pool, respectively. The islands at Soper's Mill and at the mouth of Bear Creek, with the residual timber cover at the crest of each, are well illustrated. The conservation pool at elevation 950 creates some shallow areas along the periphery of the "Story City flats" (the plateau area lying between Keigley Creek and the Skunk River valley). There are 760 acres of timber in the conservation pool area. The Bear Creek subimpoundment offers a recreation lake area having much less fluctuation in its water level.

The flood pool at elevation 976 covers much of the valley, an extensive area of the plateau, and extends upstream through the Story City area of the valley. Approximately 1600 acres of timber lie below the 976 elevation. Only the fringe timber on the higher slopes remains

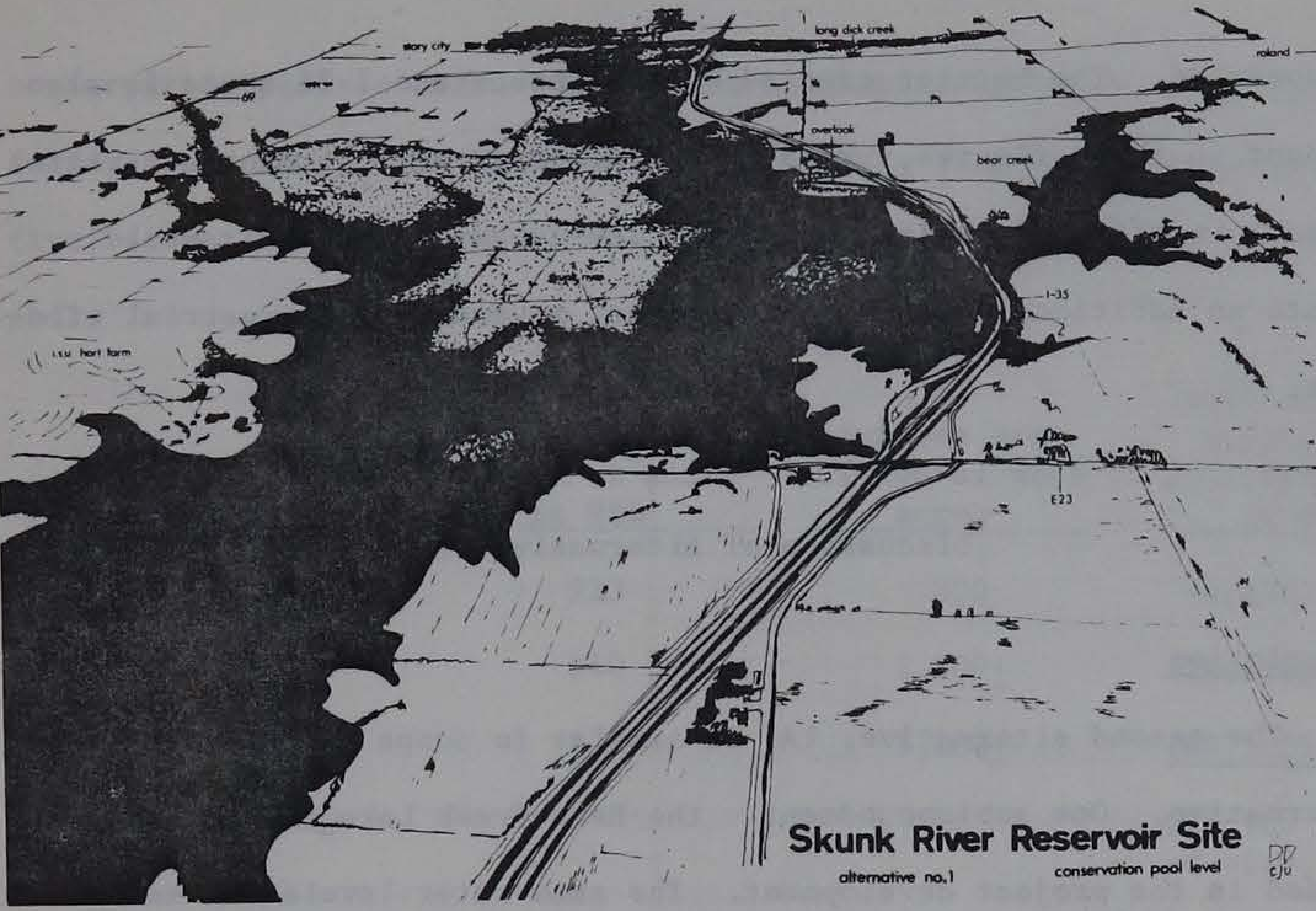

Fig. 4-3. Visual perception of the conservation pool of the Ames Reservoir, for Alternative 1.

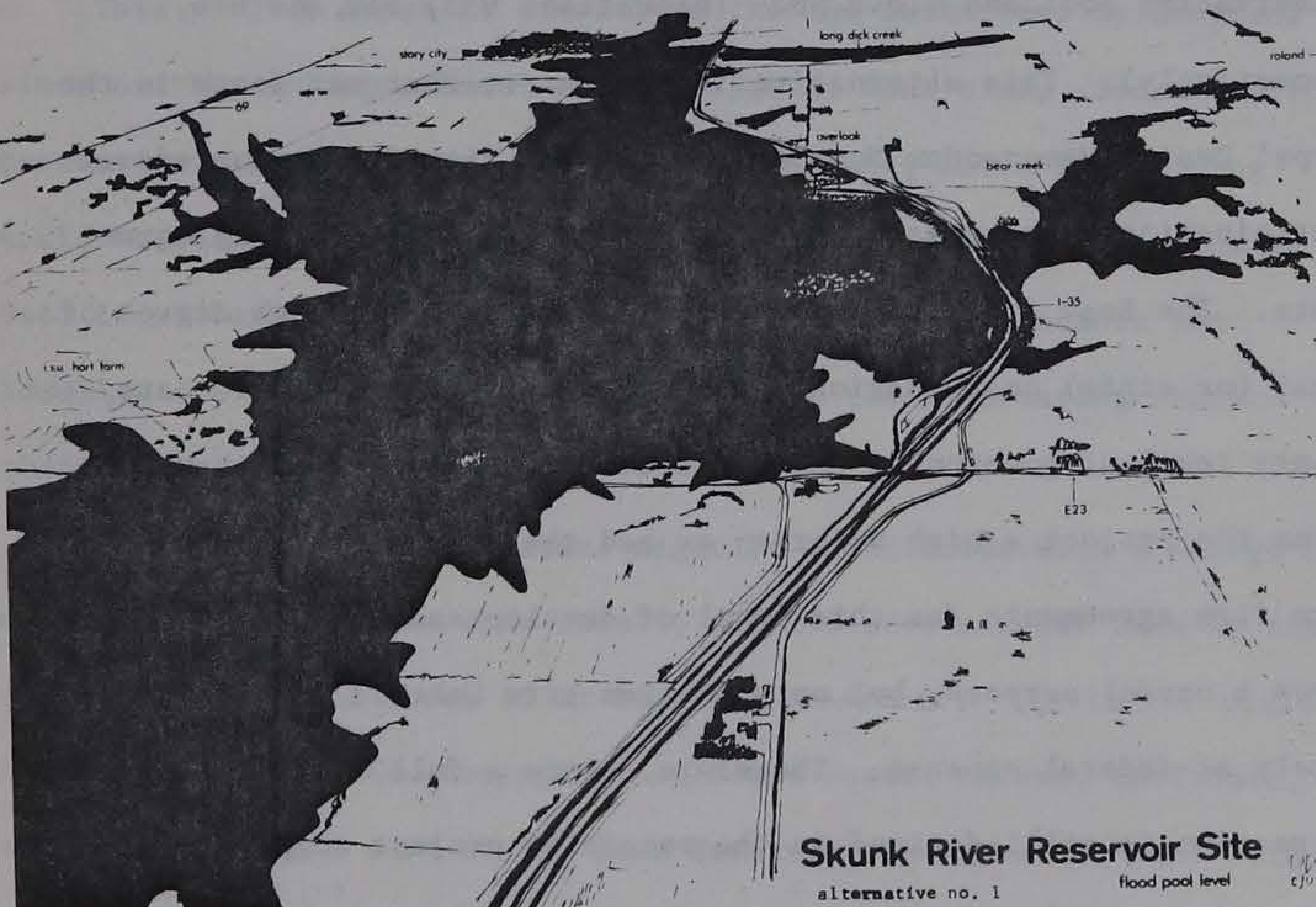

Fig. 4-4. Visual perception of the flood control pool of the Ames Reservoir, for Alternative 1.

unsubmerged. The barrier created by the interstate I-35 route is also evident in these figures. Wildlife movement, as well as many activities of man, is affected by this barrier. The proposed reservoir would create an additional barrier to east-west movement of terrestrial wildlife.

Discussion of Alternative 1A

Description

The second alternative, 1A, is similar in scope to the first alternative. One subimpoundment — the Bear Creek Lake — is not included in the project development. The same water levels and associated storage volumes are maintained in the sediment allocation pool, conservation pool, and flood pool (elevations 933, 950, and 976, respectively). This alternative is similar to that set forth in the Corps' Design Memorandum No. 3A and assumes significant nonfederal participation in recreation development through cost-sharing agreements. The Bear Creek subimpoundment would require a high degree of local (or state) cost sharing for recreation facilities. To date, the county level of government and the state recreation agency have not given the project a high priority or had the financial resources to sign firm agreements for this level of development. The subimpoundments serve a useful purpose, but only the Dam-site Lake is included entirely at federal expense. Therefore, since a full measure of outdoor recreation is still desired in the remaining project scope, all water-oriented recreation facilities must be located in and around the fluctuating flood pool. These facilities suffer further when the conservation pool is drawn down for water quality control. The principal features of Alternative 1A are changed slightly from the first alternative, since the Bear Creek arm of the reservoir is no longer a separate pool:

Pool designation	Surface elevation of top-of-pool, ft MSL	Surface area of top-of-pool, acres	Incremental storage allocation, ac ft
Sediment allocation	933	800	(8,400)
Conservation pool	950	2,200±	(26,600)
Flood control pool	976	5,100±	(89,500)
Total storage			124,500 ac ft at elev. 976

Scope of Alternative 1A

This project scope is similar to the one authorized by Congress since neither subimpoundment was included at that time. Because all recreation uses must share the main impoundment, water-area zoning would be desirable. Operation and maintenance of beach and swimming facilities becomes most difficult, and recreation attendance and benefits are reduced accordingly to reflect the fluctuating characteristics of the flood pool.

Zoning of recreation waters might be coordinated with a change of use at Little Wall Lake near Jewell, the 270-acre natural lake in the upper basin located about 15 mi from the reservoir. The latter could be zoned for small low-horsepower outboard boats, canoes, sailboats, etc. with the main part of the Ames Reservoir conservation pool being allocated for large powerboats, water skiing, etc. Fish and wildlife uses would be decreased somewhat, especially with the loss of the lake fisheries of the constant-level Bear Creek Lake.

The project scope for the other beneficial use categories remains essentially the same. A slight additional amount of conservation and flood control storage is regained by eliminating the Bear Creek sub-impoundment. Because the flood control pool in Alternative 1 could back into the Bear Creek Lake, above elevation 970, the flood control storage for Alternative 1A remains almost unchanged. Therefore, water supply, water-quality control and flood control aspects of the project remain the same as for Alternative 1.

Land-Use Requirements and Visual Perception

The lands required for Alternative 1A remain about the same. Less land acquisition is implied along the Bear Creek valley, but because the recreation mix is still considered to be at a high level of development, additional land is needed along the reservoir perimeter to develop the full recreation potential. The surficial water area for the Bear Creek arm of the reservoir is reduced at the conservation pool level of the project, but remains the same for the flood control pool as with Alternative 1. The visual perception also remains about the same as shown in Figs. 4-3 and 4-4, except for the reduced conservation pool elevation of the Bear Creek arm of the reservoir. Areas of vegetation affected remain about the same as with Alternative 1. Therefore, no additional figures are needed for visual perspective (see Figs. 4-3 and 4-4).

Discussion of Alternative 2

Description

Occasionally, it is suggested that recreation interests are a water-associated use category that supports multi-purpose reservoir development to obtain a water area at little or no cost to itself. For the purpose of evaluating the worth of a large-scale recreation lake having a fairly constant level, Alternative 2 was introduced. No flood control storage is provided, but the conservation pool could assist in water-quality control, fish and wildlife propagation, and to a measure in recharging the local surficial aquifers for water supply. The features of this alternative are as follows:

Pool designation	Surface elevation of top-of-pool, ft MSL	Surface area of top-of-pool, acres	Incremental storage volume, ac ft
Sediment allocation	927	520±	(4,200)
Conservation pool	940	1,400	(12,300)
Total storage			16,500 ac ft at elev. 940

Scope of Alternative 2

The construction of this alternative would require a large-size spillway to keep rises in the water level to a minimum during periods of flood runoff. The sediment allocation has been reduced to one-half of the amount previously used. This implies the planning and implementation of an adequate soil conservation and watershed management program in all sloping lands around the valley and in the watershed. Studies by the Category 4 research team showed that this reduction would be physically feasible if a program could be implemented that was socially acceptable and institutionally sound and permissible. The conservation storage volume could be used to augment low-flow discharges, both for water-supply aquifer recharge and for water pollution control. A discharge of 15-25 cfs could be maintained on a once-in-10-years risk probability of having inadequate storage to maintain this flow (10% chance of having inadequate storage in any one year). For more severe droughts, the pool would be evacuated before the end of the drought period, and no additional release of water could be made until additional runoff was received. This reduction in low-flow augmentation implies a greater degree of advanced waste treatment at Ames.

The recreation potential of a constant-level, large-size lake is greater than the other alternatives, but conflicts of use can arise when all recreation-use groups must share the same water area. Realization of the benefits of this alternative depends on zoning the water area effectively to separate intensive uses from passive water uses, e.g., separate water skiers from the lake fisherman and sailboaters. As stated in the Alternative 1A discussion, the potential of including Little Wall Lake in a zonal classification system has some merit. Fish and wildlife propagation should be enhanced with a more-constant-level pool. Additional physical facilities might be required for this resource category.

Because this alternative is one of several which eliminates flood control storage at the reservoir site, other means of reducing flood damages are implied. A flood plain management program would be a definite requirement. This would control urban encroachment and also building of agricultural structures. To reduce agricultural flood damages, other structural measures for engineering works are implied. A real possibility is a comprehensive system of agricultural levees. This would fall within the newer concepts and objectives being advocated by the National Water Commission for it could place more, if not all, of the costs on the agricultural landowner who is directly benefited. Observations during 1972 and early 1973 have shown that many farmers have low levees that have operated very successfully in providing protection from average-size floods. The Polk County reach is in an organized levee district having levees which were breached in only 2 or 3 years (1944, 1947, and 1954). Therefore, this alternative and all others not having flood control storage imply that such flood damage reduction and flood plain management programs can be effectively developed and implemented at the local, county, or state level.

Land-Use Requirements and Visual Perceptions

This alternative requires a minimum of 1,400 acres that would be completely submerged by the lake waters. Temporary flooding easements and park acquisitions would require additional lands, possibly as much as 500 acres or more, or a minimum total requirement of about 2,000± acres. When compared to Figs. 4-3 and 4-4, it is observed that much less land area is required for this alternative. A total of 400 acres of timber lie below elevation 940 or 1200 acres less than Alternative 1 or 1A.

The visual perception of this alternative is shown in Fig. 4-5. The water area is reduced sufficiently to leave a greater fringe of trees around the perimeter. The wooded hill or "knob" at Soper's Mill access is left relatively undisturbed and accessible by land. However,

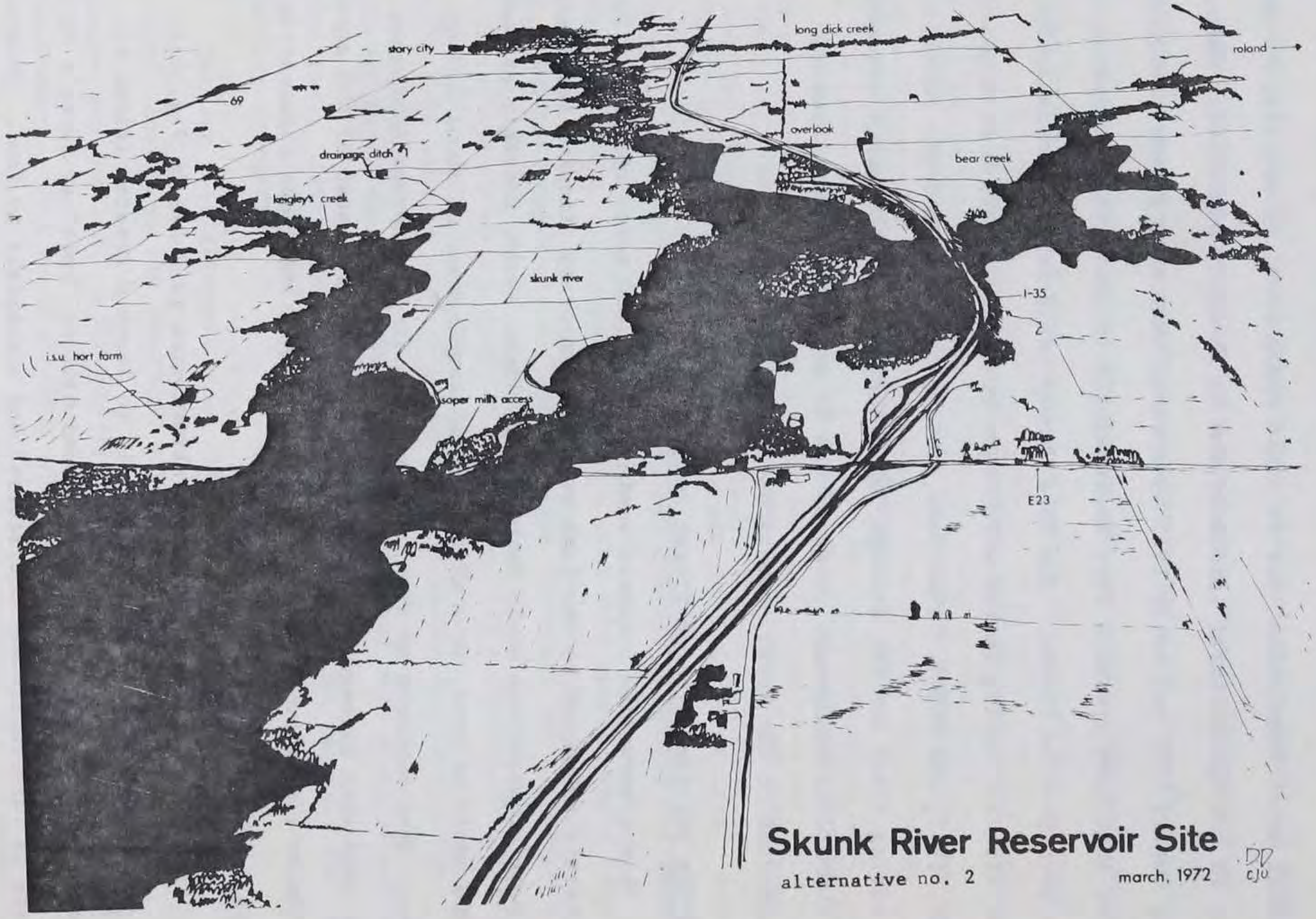

Fig. 4-5. Visual perception of the recreation lake of Alternative 2.

all existing low facilities at Soper's Mill would be eliminated. The hill at the mouth of Bear Creek remains an island, but its woodland slopes would be less affected than in Alternatives 1 and 1A. The construction of this development alternative implies great stress by the rural-residential occupancy interest group, more so than any other alternative. Funding programs for this alternative would also pose a problem under present policies, programs, and budget constraints of local, county, state, and federal governments concerning major recreation projects.

Discussion of Alternative 3

Description

This alternative begins a move away from large-scale reservoirs and lakes as multi-purpose units, but favors water-oriented recreation activities. It includes the two smaller lakes, the Bear Creek and dam-site impoundments. The investment in water-area development is much less than for Alternative 2. It also introduces a measure of a green-belt and open-space program, because the main river valley would not be used for a major reservoir site. It would remain in its present status, a combination of wooded slopes and flood plain, some rural-residential housing, and rock quarry and gravel pit activities for extraction of mineral resources. The present river access points would be maintained; possibly some additional expansion of these would be made. The principal features are:

Pool designation	Surface elevation of top-of-pool, ft MSL	Surface area of top-of-pool, acres	Storage allocation, ac ft
Bear Creek Lake	970	155	2,650
Dam-site Lake	1,000	30	300±
Main valley	(12 mi of natural valley left as it is, with acquisition of selected public areas and land-use controls)		

Scope of Alternative 3

This alternative is oriented towards many outdoor recreation activities, but does not provide for the large-scale water activities such as large powerboats, water skiing, houseboats, etc. The two smaller lakes would be treated much as the county and state artificial lakes — a 6-horsepower limit for the Bear Creek Lake and only electric motors for trolling on the Dam-site Lake. Canoes, sailboats, paddle-boats, and smaller-type craft would be permitted, and beach and swimming facilities would be provided for intensive use. This would add a recreation lake to the county which would be similar to the Hickory Grove Lake of the Story County Conservation Board, located in the Colo area. It would balance the water area needs for the county residents, providing a good-size new water area near the major population center of Ames. It should be noted, as discussed in Appendix 3, that much use is made of Hickory Grove Lake by Marshall County residents. Therefore, this alternative would have additional importance if it is determined that the use of Hickory Grove Park and Lake is reaching an over-stressed condition.

This alternative also eliminates the flood control storage allocation, as did Alternative 2. As a result, the same implications are introduced for the reduction of flood damages. A positive flood plain management program with possible development of agricultural levees (where physically and economically feasible) is the downstream alternative to a flood-control reservoir project.

There is no provision for low-flow augmentation, since the Bear Creek Lake has inadequate storage to accomplish any real low-flow capability during drought periods. Therefore, this alternative requires complete advanced treatment of wastewater at Ames, including ammonia nitrification and nutrient removal (phosphate primarily, with related reductions in carbon and other constituents). Likewise, there is no storage provision and related potential for water supply assistance through the recharge concept or through more direct stream withdrawal and treatment.

Land-Use Requirements and Visual Perception

The occupancy of the valley for rural-residential homes would continue unless and until a positive land-use policy is developed for the county. The scenic attributes of the valley would be left in the care of private landowners, except for public access areas such as Soper's Mill and McFarland Lake. This alternative would be most viable if the City of Ames expanded its park system in the Skunk River valley and occupied the Dam-site Lake area. The Bear Creek Lake probably would be more than the existing county finances could support, and state and federal assistance would be necessary if it were to become a reality.

The visual perception of this alternative is shown in Fig. 4-6. The Dam-site Lake is not shown, but would be to the lower left about 1 mi

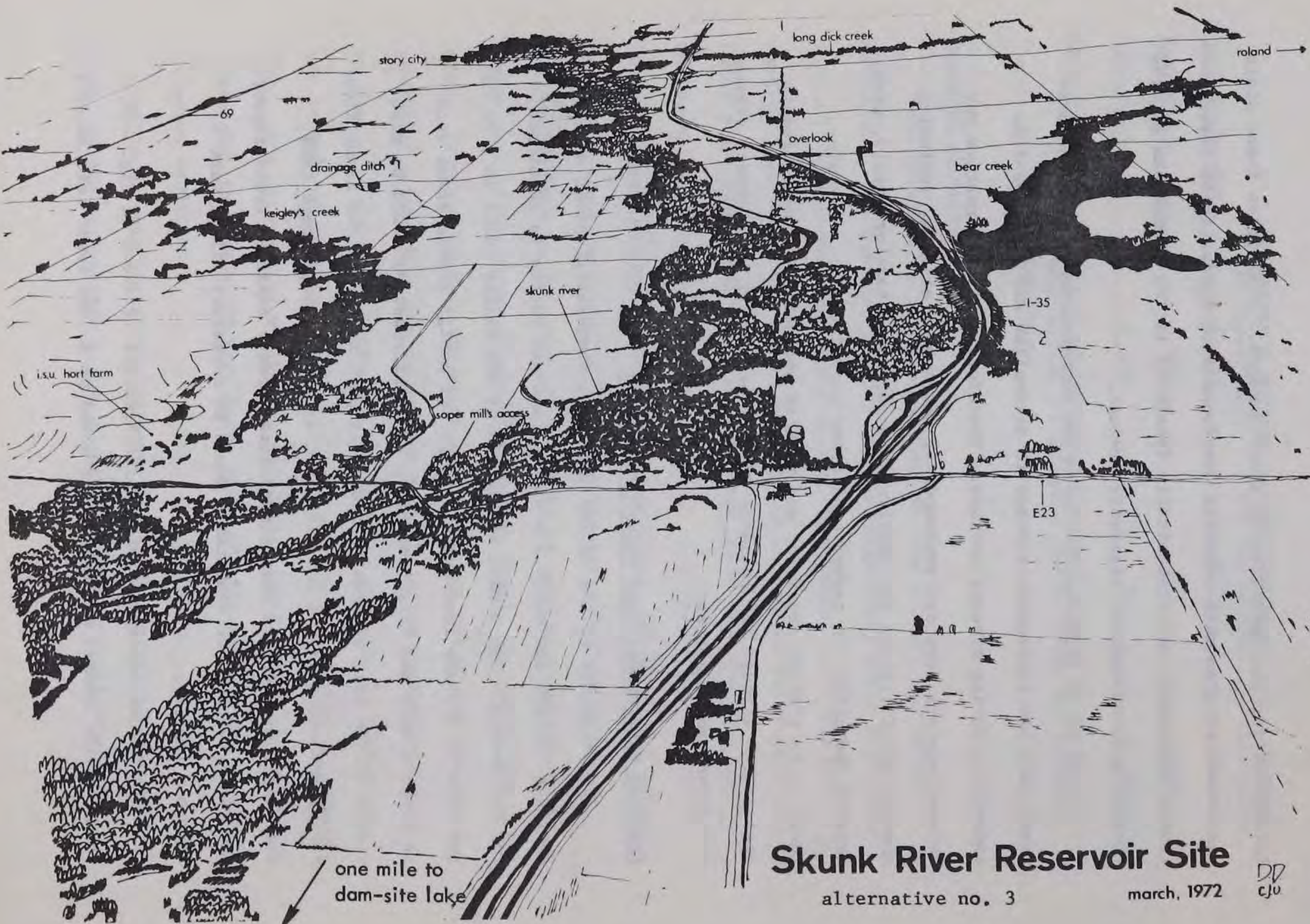

Fig. 4-6. Visual perception of the two smaller lake developments of

in distance. This figure illustrates the noninterruption of the existing stream system in the main Skunk River valley. The Bear Creek and Damsite Lakes occupy very little of the study area, about 185 acres of water in 22,000 acres of valley and adjacent upland farm cropland. Less than one-half the area is in timber. About 250 acres of land is the minimum needed for the total recreation system. The development of Bear Creek Lake would require positive soil conservation and erosion control practices in the sloping lands adjacent to the lake area. Agricultural lands in the Bear Creek watershed, upstream of Roland, are quite flat and are low sediment production areas. Therefore, sedimentation should not pose a serious problem if the adjacent lands are fully controlled. As noted previously, additional control measures may be required at the Roland waste stabilization pond.

This alternative illustrates that the valley can be left in an open-space category, a water area provided for many recreation uses, and the main valley remain fairly undisturbed. Whether other uncontrolled uses (including mineral extraction, agriculture crop production, and rural-residential housing) would deteriorate this existing pattern cannot be forecast. Unless a more positive land-use and zoning plan is implemented, problems are foreseen.

Discussion of Alternatives 4 and 4A

Description

These two alternatives will be discussed together since both consist of green-belt, open-space programs. Alternative 4 is of modest scope, utilizing the existing stream system and public access points (including the Soper's Mill and McFarland Park areas, with the existing small lake at McFarland Park) and adding a small amount of land to the public-use category. Several small areas would be acquired and developed for campers and for fishing and canoe access to the river. Because of the rapid occupancy of other valley areas in the Skunk River-Squaw Creek region with large-scale subdivisions, including one area in the reservoir area, Alternative 4A was introduced to indicate the effectiveness and related costs of a comprehensive green-belt program. The principal features of each are:

	Alternative 4	Alternative 4A
1. Additional water area provisions	No	Yes
2. Water area location	None	Hallett's gravel pit (used areas)
3. Amount of additional water area made available	None	30-40 acres now — 60-80 acres future
4. Land area to be acquired, acres		
Purchased	72	1,420
Easement or rental	0	2,350
5. Assumes county can achieve firm public control of land use and development	No	Yes

Scope of Alternatives 4 and 4A

Alternative 4 is a step forward from Alternative 7, the "do-nothing" alternative. It designates additional areas for outdoor recreation use, with purchase of 72 acres for camping sites and fishing access points. Additional roads, picnic areas, and water and sanitary facilities would be provided. It assumes that the private ownership ethic of maintaining the wooded slopes would prevail, although present development trends indicate more stress, less open space, and less provision for or acceptance of public use or trespass than has been tolerated in the past.

Alternative 4A is a comprehensive, large-scale green-belt program. It requires substantial investment of land-use control through purchase, easements, or rentals, and in providing recreation facilities. As indicated in the description, some 1420 acres of land would be purchased. This would include the river channel and a strip of land on each side, all key dense timber stands in the valley, and much of the upland agricultural land on the east side of the valley adjacent to I-35. Wooded slopes would be rented or scenic easements obtained, as an additional 2350 acres would be controlled through rental or easement agreements. This includes obtaining control, through rental or purchase, of the "used" areas of Hallett's gravel pit located north of Ames at the downstream end of the 12-mi scenic river valley reach. The used areas of the gravel pit would be converted to a water-oriented recreation area similar to the Gray's Lake area in Des Moines. Swimming beaches, canoeing, paddleboats, small sailboats, etc., could be included in the water program. This offers a substantial water-oriented recreation component into the analysis and becomes as realistic in a local open-space program as does the major reservoir project for multipurpose development. It provides also for propagation of fish and wildlife in the 12-mi reach of valley between Ames and Story City.

Both alternatives leave unanswered the water problems associated with floods and water quality. The Hallett's gravel pit area, as incorporated into a recreation system, has water supply features also. It can serve as a direct source of water, or wells can be placed around its perimeter, etc. Selection of these alternatives implies that flood damage reduction can be achieved through the flood plain management program and possible use of agricultural levees, etc., as were listed before. Some application of the PL 566 watershed program of the Soil Conservation Service, U.S. Dept. of Agr., in the watersheds downstream of Ames also could be studied. Little application is foreseen upstream of Ames because of the flat terrain, potholes, etc., where smaller impoundment sites cannot be found, and agricultural drainage practices and crop-production patterns of use preclude broad surface storage of excess runoff. Advanced treatment of wastewater at Story City and Ames is foreseen with Alternative 4A, including nutrient removal and ammonia nitrification.

Land-Use Patterns and Visual Perceptions

The visual perception achieved through Alternative 4A (and to Alternative 4 to a lesser extent) is shown in Fig. 4-7. The surficial stream pattern is left unaltered. Alternative 4 implies continued and perhaps rapid rural-residential home development and occupancy of the valley. Alternative 4A would place 3800 acres in firm public control and includes the concept also of open-space uses in the flood plain and east valley slopes and a minimum of residential occupancy on the west side of the valley.

This alternative is the optimum green-belt and open-space conservation program. However, the control of 3800 acres (through purchase of 1400± acres, rental or easements of 2400± acres) and the provision of

Fig. 4-7. Visual perception of the green-belt development of Alternatives 4 and 4A.

recreation facilities requires a substantial public investment. The source of funds for this alternative has not been outlined and might prove difficult to achieve. This alternative could, through careful planning and development, serve also as a reservoir site preservation plan which might be of interest to the federal water resources agencies. The extent to which different types of federal funding could be made available for achieving this alternative deserves more attention, in selecting among the nine alternatives.

Discussion of Alternative 5

This alternative was included primarily because of the economic analyses being conducted as part of the ARES project review. The Corps of Engineers may not have sufficient commitments from local and state recreation agencies to pursue Alternatives 1 and 1A. Therefore, a supplement to Design Memorandum No. 1 was prepared by the Corps of Engineers (D.M. No. 3A, 1972) which deleted the optimum recreation planning of either Alternatives 1 or 1A. A minimum recreation facilities program would be introduced. The same reservoir scope as Alternative 1A would be used: a 2100-acre conservation pool at elevation 950 and a 5000-acre maximum flood pool area at elevation 976. Although the additional 440 acres of recreation land would be included, the intensive use facilities would be excluded and dropped from consideration. Primitive area facilities would be provided as a minimum concept. This alternative, however, does not speak well for a water area development located a few miles from a major urban area. A considerable amount of "unhappiness" could be forecast if this alternative were implemented.

The project scope would include the other beneficial uses listed in Alternative 1A. These are flood control storage for flood damage reduction, low-flow augmentation for water-quality enhancement and water pollution control (maximum dilution water capability), water supply potential, on a recharge basis, and fish and wildlife propagation.

The land-use impact and visual perceptions would be similar to those pictured in Figs. 4-3 and 4-4.

Discussion of Alternative 6

Description

Alternative 6 is labeled the "reduced-scope" project in comparison to Alternative 1A. The conservation and flood control pools are reduced in size to decrease the impact on the environment caused by the full-scale project. The two subimpoundments are included to provide an optimum recreation mix. The project features are as follows:

Pool designation	Surface elevation of top-of-pool, ft MSL	Surface area of top-of-pool, acres	Storage allocation, ac ft
Sediment allocation (1/2 of full scale, No. 1A)	927	520±	(4,200)
Conservation pool	940	1,400	(12,300)
Flood control pool	965	3,620	(60,700)
Total storage			(77,200 ac ft at elev. 965)
Bear Creek Lake	970	155	2,650
Dam-site Lake	1,000	30	300±

Scope of Project

The reduced-scope project was introduced for two purposes, first to provide an economic comparison for "scale" of development, and second to reduce all reservoir flood impact at Story City.

It decreases the environmental impact on vegetation by reducing the water area by 1100 acres. Some of this is oak-hickory and maple-basswood upper-slope timber, most valuable of the timber species. Flood plain impact is reduced at Story City, and all remedial works are eliminated. The conservation pool would be smaller in size. The reduction is desirable in that it removes shallow areas in the plateau area between Keigley Creek and the Skunk River. The reduction in size and depth would be unfavorable in the vicinity of the I-35 overlook at the mouth of Bear Creek. Shallow depths here would probably develop into a marshy area having substantial growth of water weeds, etc.

Reduction of the flood pool would permit saving several hundred acres of agricultural farmland located on the plateau area. This would permit several landowners to remain in the area and not be relocated or removed from the agricultural sector of the economy, as discussed in Appendix 4.

The reduced-scope project would provide less flood control storage, although it maintains the 3.6 in. of runoff from the basin which was proposed in the initial authorization phase. Some decrease in flood control benefits is foreseen, but if low agricultural levees similar to those already constructed by many farmers were included, a viable flood damage reduction program might be achieved.

The reduced-scope project also provides for a lower level of low-flow augmentation. It would be similar to Alternative 2 in this regard. Additional advanced treatment for nutrient removal would be required primarily for those of the phosphate category. About the same benefits for recreation and fish and wildlife propagation should be achieved as with Alternative 1 or 1A.

Land-Use Requirements and Visual Perception

This project should reduce by 1200 acres or more the lands needed for use and control, or will require about 6500 acres instead of the 7750 forecast for Alternative 1 or 1A. The visual perception of the reduced-scope alternative is illustrated in Fig. 4-8. There would be 1200 acres of timber affected, 300 acres less than with the full-scale flood control pool. Additional land areas in the Keigley Creek-Skunk River plateau are left above the flood pool.

Additional use of levees or "polders" has been suggested in Appendix 1 to prevent frequent flooding and loss of use of the flat agricultural lands on the plateau area.

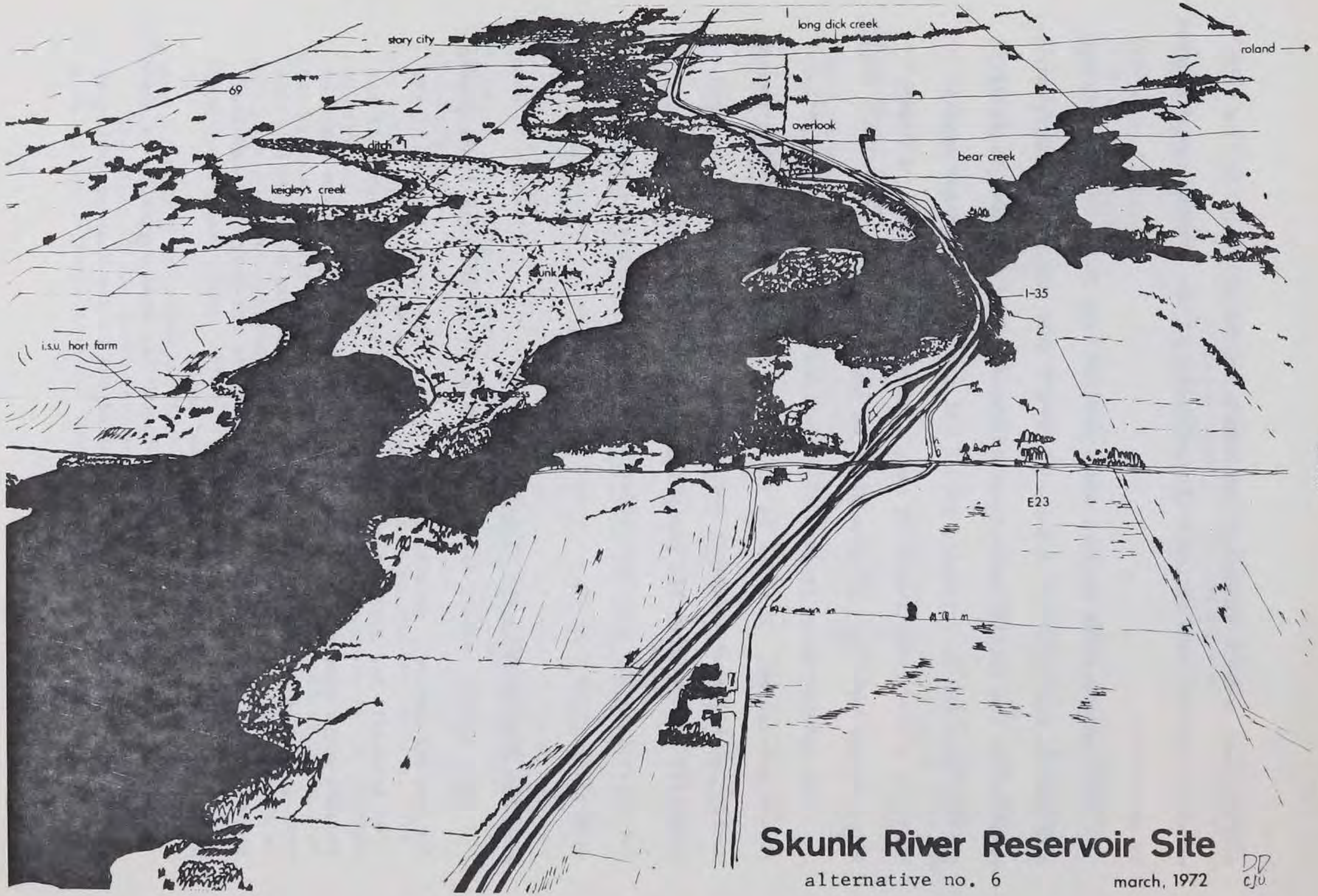

Fig. 4-8. Visual perception of the conservation and flood control pools of the Ames Reservoir, Alternative 6.

Discussion of Alternative 7

This is the "do-nothing" alternative. It minimizes the investment of public funds in the valley and leaves the responsibility for maintaining a quality environment to private landowners. The Soper's Mill access and McFarland Park areas would remain as the primary public-use areas. No further enhancement or control is foreseen. The rapid occupancy of the most scenic areas with rural-residential housing is forecast if this alternative is selected or is obtained by default as other alternatives are rejected. Extraction of mineral resources could continue and would interfere at certain locations with the scenic views desired by those constructing rural residences. Conversely, septic tank effluent problems could be obnoxious and become a nuisance to the materials processing group. The quality of the stream water would depend on the establishment and enforcement of water quality stream standards from Story City to Ames and below. Flood problems would remain the responsibility of local landowners and of city, county, and state levels of government.

Summary

These nine alternatives illustrate quite well the future potential development patterns in the Skunk River valley, any of which have a fair probability of occurrence. Evaluation of these will provide decision-makers with a rather complete picture of the consequences of selecting any particular alternative. The economic impact has been of major concern in water resources development, but environmental impact plays an equally important role today under the NEPA provisions and requirements.

The environmental study incorporated a well-balanced analysis of alternatives. In addition to an up-dated economic analysis of the reservoir project as originally advocated, the study provided an in-depth analysis of the valley's resources, its people and their needs and desires, and an analysis of environmental impacts for the alternative development patterns. Three distinct elements are:

1. identification of relevant impacts,
2. measurement of the likely interaction of these impacts for each alternative, and
3. valuation of those impacts in a qualitative sense, if not capable of being measured quantitatively, and in a monetary sense.

This approach, applied to the nine alternative development patterns, lays the foundation for decision-making and for plying trade-offs in resource allocation. The results of the study of the three elements listed above are summarized in the remainder of this report.

PART II. IMPACT EVALUATION OF ALTERNATIVES

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part II. Impact Evaluation of Alternatives

Chapter 5

STUDY FRAMEWORK FOR TOTAL IMPACT ANALYSIS

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ARES SUMMARY REPORT

Chapter 5

STUDY FRAMEWORK FOR TOTAL IMPACT ANALYSIS

Introduction

Comprehensive planning of public works projects is a criterion today under the provisions of NEPA and other federal and state legislations. This requires that a meaningful range of project alternatives be given balanced consideration and that all relevant impacts of those projects be analyzed and openly discussed. Any position to the contrary, except as an agency may have insufficient funds for planning budgets and other jurisdictions, may result in having an informed public, to which the agency must answer, as ultimate client.

In fullest interpretation, however, the necessity of integrating all relevant impacts into project evaluation methodology implies a bewildering complexity. Although procedures of benefit-cost analysis appear to be so neat, precise, and deterministic, the full consideration of distributional, environmental, social, cultural, and institutional impacts of a project remains so complex and interwoven as to precipitate relative chaos in technical analysis and in any subsequent forum of public participation and evaluation. Typically, agency technical expertise lacks the interdisciplinary qualifications to meet this charge. Yet the usual public hearing finds conflicting interest-groups confusing claims of impact intensities with what actually are value judgments or "weights." The orderly assembly of impact information is essential for objective assessment of trade-offs to be realized. For this paramount reason, a carefully structured taxonomy, or classification scheme, for impact analysis is required for comprehensive public works planning.

Taxonomy for impact analysis may be constructed either in reference to impact mechanisms or in terms of impact incidence. A mechanism-based classification, which would be most useful to efforts in technical analysis, distinguishes between different impacts in terms of how those impacts occur in a cause and effect context. An incidence-based classification, which would be most useful to the ultimate (public-participatory) evaluation process, differentiates impacts in terms of where and upon whom they occur, i.e., among various "interest groups." For evaluation problems as complicated as that of the Ames Reservoir situation, the preferable approach utilizes both taxonomical elements: a mechanism-based classification for technical analysis, with eventual transformation into an incidence-based classification for purposes of participatory decision-making. As developed in Appendices 2 and 6, these evaluation methods are summarized in this chapter.

Conventional Impact Classification in Water Resources Development

Water resources development has been an important element of public-works evaluation methodology ever since the Flood Control Act of 1936. In particular, the water resources discipline has fostered the practical interpretation and application of welfare economics, resulting in a rich body of technical insights regarding the economic analysis of proposed public works projects. However, in the context of contemporary planning problems it appears that the discipline's contributions to depth have seriously compromised breadth. Much of the taxonomy which is evident in the water resources literature is built upon the fundamental preoccupation with economic perspectives and, in particular, on the benefit-cost structure.

The literature on water resources planning offers considerable elaboration on "tangible" benefits. These are divided further by a distinction between "primary" and "secondary" benefits. Primary benefits usually are defined to include three categories of economic impacts": (a) direct benefits to user of project outputs (e.g., reduction of crop and property damages through flood control); (b) indirect benefits whereby private parties realize economic gains through technological "spillovers" (e.g., reduction in temporary losses of productive capacity or reduction in interruptions to transportation service); and (c) land-enhancement benefits (e.g., improvements in the productivity of floodplain land and property through conversion to higher use). Secondary benefits typically are classified into "stemming from" (i.e., effects realized through forward production linkages) and "induced-by" (i.e., effects realized through backward production linkages) categories, as transmitted through market relationships.

This taxonomical structure provides a relatively simple classification of economic effects, so long as the distinction between "indirect primary benefits" and "secondary benefits" is understood. Both types of impacts refer to indirect events in the sense that they are realized only through the influence of immediate effects via some organic or structural medium. Although the distinction between direct and indirect effects cuts across the primary-secondary differentiation, the latter is based on explicit considerations of phenomenological impact mechanisms. It also reflects an underlying concern with differentiating between those effects which enter into benefit-cost calculations and those which do not (to include secondary benefits would constitute double-counting under most circumstances). In some cases, nevertheless, the measurement of secondary benefits may be of interest for distributional concerns, particularly in view of emerging public sensitivity thereto.

For impacts relating to objectives other than that of national income, other taxonomical schemes must be defined. If possible, it would be desirable in a more comprehensive impact analysis to reconstruct a general taxonomical paradigm, or model, which embraces both economic and noneconomic impacts without unduly compromising insights into the former. In this vein, the discussion now turns to other taxonomical constructs for project impact analysis.

Taxonomical Structures for Environmental Impact Analysis

Primarily in response to NEPA requirements for environmental impact statements, several efforts have recently emerged with proposed taxonomical schemes for evaluating environmental effects. Although these developments have focused largely upon noneconomic effects and offer quite detailed stratifications, their general structures are of interest to this study.

A review of this new literature reveals consistent use of a basic cross-classification between sources of potentially degrading influences (i.e., various structural and nonstructural courses of action) and of objects or incident parties which must bear the environmental impacts. To a lesser extent, attention is given to the nature of the linkage or medium and to differentiation among incident parties or organisms in terms of relative vulnerability or immunity to a specified environmental impact. Also, ongoing efforts within the disciplines of ecosystems and zoology deal in substantial detail with the complexity of interdependencies between various ecological "sectors."

A recent USGS document by Leopold, et al., 1971, is apparently the most exhaustive attempt at environmental impact classification to date. It proposes a set of procedures for identifying, analyzing, and evaluating environmental impacts, where those procedures focus on an "environmental impact assessment matrix." The proposed matrix defines in great detail a cross-classification between causative actions and existing environmental conditions that might be affected. The procedures alertly distinguish between impact magnitudes or intensities and the importance or "weight" associated with each. Although the document seems to entrust excessively the determination of relative importance to technical analysis, its classification of "existing characteristics and conditions of the environment" is fairly astute and exhaustive. This classification identifies four major categories (plus a provision for "others") of environmental elements including physical and chemical characteristics, biological conditions, cultural factors, and ecological relationships. Physical and chemical characteristics embrace various attributes of earth, water and atmospheric resources, and associated "processes." Biological conditions refer to various species of flora and fauna and associated "barriers or corridors." Cultural factors encompass a host of activities or opportunities for activity involving interactions between map and nature, including the spectrum of economic and other land uses, recreation, aesthetics, and human interest (including unique scenic and archaeological attributes); this category also covers socioeconomic measures of cultural status and activities involving man-made facilities and services. The final category ("ecological relationships") essentially covers all system interactions involving elements of the natural environment noted above.

The other document of interest to this discussion is a Regulation issued in December 1972 by the Office of the Chief of Engineers, Dept. of the Army, entitled "Guidelines for Assessment of Economic, Social, and Environmental Effects of Civil Works Projects."

Like the USGS circular (but with more substantive discussion of methodological issues), these guidelines set forth a body of procedures for identifying, analyzing, and evaluating project alternatives. The perspective of the Army document, however, represents a deliberate effort to consider economic and noneconomic impacts integrally and offers some taxonomical structure to that end.

As in the USGS matrix, the two major dimensions of this structure are "causative factors" and "project effects." While causative actions are of lesser interest here as discussed earlier, one appealing feature of the Army taxonomy is that it explicitly distinguishes between project inputs (factor inputs, structural and nonstructural "systemic" inputs, and operations and maintenance inputs) and project outputs (various beneficial uses), recognizing that indirect impacts associated with project production and project consumption may be inherently very different.

The Systems Analysis Paradigm

As mentioned earlier and in Appendix 2, other planning disciplines generally have adapted concepts of economic analysis from the leading developments of water resources economists. However, a few of those disciplines have had to deal most seriously with noneconomic impacts, either because their objectives are inherently noneconomic or because public controversy over their noneconomic side effects has forced the issue. The latter is strongly parallel to the pressures currently facing water resource planners, wherein there is an urgent need for impact classification which embraces economic and noneconomic impacts integrally.

The most outstanding work in this direction has evolved in the context of urban transportation planning which has spent the last decade immersed in public resistance to dislocation and environmental impacts. Owing largely to its everyday visibility to much of the public, urban transportation has been a focal point for the resolution of interest group conflicts through some form of trade-off analysis. The most substantive and comprehensive technical response to those circumstances to date was developed through research at the university level, at Northwestern University by Thomas and Schofer in 1970 and by Wachs at the University of California at Los Angeles in 1972. (See Appendix 2 for references.)

The efforts at Northwestern redefined a broad cost-effectiveness paradigm for project evaluation in situations involving a variety of incommensurate impacts. That paradigm, which supercedes yet retains more traditional concepts of benefit-cost analysis, places much greater emphasis on identifying and measuring such impacts than on "weighting" them on the premise that such value judgments can only be determined within the political forum. Accordingly, great attention is given to problems of organizing impact analyses and their resulting information. Impact taxonomy takes on a crucial role for purposes of that organization, and both research efforts adapt general concepts of systems analysis in this vein. The resulting construct offers straightforward transferability to other disciplines of planning which involve economic objectives and typically capital-intensive projects; hence it merits review here.

The taxonomy of Wachs defines a cross-classification of project impacts as depicted in Table 5-1. For each of the aforementioned phenomena (inputs, performance outputs, and concomitant outputs), three levels of impacts are identified. First-order impacts embrace the most direct effects of system modification. These effects, usually

Table 5-1. The relationship between successive orders of infrastructural system impacts and the inputs and outputs of infrastructural systems (Wachs, 1972).

	System inputs	Performance outputs	Concomitant outputs
FIRST-ORDER impacts	Measured as direct changes in inputs or outputs within the system.		
SECOND-ORDER impacts	Social, economic, and environmental consequences, measured in terms of interrelationships between system and environment.		
THIRD-ORDER impacts	Structural and institutional changes occurring principally in the environment of the system; a few steps removed from the inputs and outputs themselves.		

the most measurable and predictable, refer to the immediate consequences associated with change in inputs (e.g., additional factor acquisition and related resource costs), performance outputs (e.g., increases in system usage and savings in user costs), and concomitant outputs (e.g., dislocation effects of project construction or emission of pollutants by virtue of system operation).

Linkages between these first-order impacts and the system's environmental framework give rise to second-order impacts. In response to immediate resource commitments as system inputs, for example, the local economy (an element of the system's environment) may occasion a transient and/or permanent multiplier effect. In response to first-order performance effects (such as the construction of a large lake and state park area for public use), it is often observed that broader patterns of economic and social activity (elements of the system's environment) may undergo adjustments (such as the development of residential activity in the vicinity of the recreation site); these second-order impacts generally are proportional to the level of first-order performance impacts. Similarly, second-order concomitant effects embrace responses of the system's environment to their first-order counterparts (e.g., relocation of wildlife displaced by the housing areas, or the effects of water pollutants from the housing area upon the aquatic life in the lake).

Third-order impacts refer to long-run structural and institutional changes which, if not entirely attributable to a proposed project, at least may be reinforced by that project and/or the process by which it is implemented:

> The second-order impacts of changes in systems may give rise to further repercussions entirely within the physical and institutional environments of those systems, which result from but do not directly involve the performance or concomitant outputs of the system or its inputs. Thus, a third-order impact might be a change in the levels of citizen organization within a community through the creation of ... action groups or through letter-writing campaigns. Such a third-order impact might be a change of response resulting from a second-order impact which occurred as an intended or concomitant result of first-order impacts.

This taxonomical construct is appealing in its exhaustiveness and mutual exclusivity as well as its flexibility to incorporate distributional considerations. However, its somewhat oversimplified character leaves that classification in want of some elaboration (e.g., to distinguish more clearly between externalities which are proportional to performance levels and those which are independent of same). Moreover, although the need to distinguish between relatively immediate and relatively remote impacts is acknowledged, the two dimensions of "impact source" and "impact order" are somewhat redundant (especially the notions of concomitant outputs and second-order impacts). To its credit, on the other hand, the method gives no particular preoccupation to monetary impacts, though neither does it disavow the usefulness of benefit-cost analysis if applied in proper perspective.

The foremost intention underlying this paradigm is to present impact information for a variety of alternatives to a "participatory evaluation forum," for discussion and action by all individuals, organizations, and agencies concerned through means of a matrix display which facilitates explicit assessments of trade-offs. Particular attention has been granted to various methods of implementing and displaying these intentions, and work in this context forms the basis for the broader evaluation methodology discussed in Appendix 6.

A Mechanism-Based Taxonomical Paradigm for Technical Analysis

In contrast to the economic preoccupation of conventional taxonomy in water resources planning, this study of the Ames Reservoir requires a model for impact classification which fosters as broad a perspective as the one just discussed. Although a detailed template for analyzing a project's economic impacts may be desirable under more traditional circumstances, the need here for genuine and parallel consideration of impacts upon the physical and social environment calls for an impact taxonomy which transcends strictly economic concerns. Moreover, given the complex interactions between the varied impacts of water resources projects, a mechanism-based taxonomy is prerequisite to coherent technical analysis. Transformation of such a taxonomy into more incidence-oriented terms, though essential to a participatory evaluation process encompassing all interested parties, is a comparatively straightforward matter, as described in the next section.

The Paradigm

The mechanism-based impact taxonomy adopted for this study, as shown in Table 5-2, synthesizes various features highlighted in the previous sections. Its scope clearly seeks the balanced perspective advocated by the Office of the Chief of Engineers (OCE) in the sense that the taxonomy should span both economic and environmental impacts without preoccupation toward either. Its basic structure is a cross-classification in broad terms of impact "source" and impact "order." Impact source is defined variously as either production-related or

Table 5-2. Mechanism-based impact taxonomy for the Ames Reservoir Environmental Review Study.

	FIRST-ORDER	SECOND-ORDER Indirect Project Impacts					THIRD-ORDER
	Direct Project Impacts	ECONOMIC		PHYSICAL	SOCIAL	POLITICAL	Institutional Impacts
		Technological	Pecuniary				
		Agriculture Farm machinery ... Services	Agriculture Farm machinery ... Services	Landscape Vegetation Animal/wildlife Aquatic Geological Archaeological	Rural farm Rural nonfarm ... Urban	State County Township Municipality	
PRODUCTION-RELATED							
CONSUMPTION-RELATED							

consumption-related, mainly to distinguish between input-oriented and output-oriented externalities as suggested by the OCE Regulation and the systems analysis paradigm. Impact order, as reviewed in Appendices 2 and 6, involves a threefold distinction between immediate or "direct" project effects, all project externalities or "indirect" effects, and long-run institutional impacts of a project and/or the project-selection process.

First-order or direct effects are defined according to traditional notions of project evaluation in water resources development, embracing all project inputs and purposeful outputs which are conventionally included in economic benefit-cost analysis. Again in reflection of the OCE Regulation and the systems analysis paradigm, second-order or indirect project impacts are categorized into generic groupings which correspond to the various activity systems within the "environment" of the river basin system. Moreover, subclassifications within each of these categories may be defined to provide some account of impact incidence.

An Incidence-Based Taxonomical Paradigm for Participatory Project Evaluation

The previous section emphasized reference to impact mechanisms as a taxonomical aid to organized technical analysis. However, for evaluation purposes this technical classification must be transformed into terms which are more easily understood by various interest groups. Whereas the Corps has been concerned in the past primarily with traditional benefit-cost calculations for ultimate accountability to Congress, the pressures for more participatory process now call for explicit accountability to the general public. Accordingly, information on project impacts must be transformed into a classification or paradigm which highlights the incidence of those impacts upon various potential interest groups.

Given adequate technical analysis, the transformation of impact information into an incidence-based classification for effective participatory evaluation by all interested parties is largely a matter of information display. Particular interest groups may be identified from past records of controversy over the Ames Reservoir and similar projects and from intuition gained by the technical analysis. At this level of public participation, moreover, a preoccupation with assigning every impact measure to one or another project objective(s) is not especially important:

> The traditional view that benefits and costs have meaning only in relation to a specified objective is perhaps best replaced by the notion that benefits and costs have meaning only in relation to specified individuals who perceive such impacts. Obviously it is impossible to be concerned with "benefits and costs" to each individual so the problem can be altered slightly to discuss individuals in their multiple roles as taxpayers, recreationists, labor suppliers, entrepreneurs, consumers, etc. When considering location-specific impacts — say within a project region — it is useful to articulate project impacts by specific groups upon which these effects impinge. Hence, the information-generating system of accounts discussed above merely provides the mechanism or framework wherein specific project impacts to specific groups of individuals in specific locations may be systematically ascertained. (From Bromley, et al., 1971; see Appendix 2.)

Based on available documentation of past public hearings, the experience of several case studies conducted by the University of Wisconsin, and staff discussions during the current study, the incidence-based tableau depicted in Table 5-3 was adopted for this study. This matrix

Table 5-3. Incidence-based impact taxonomy for the Ames Reservoir Environmental Review Study.

PROJECT ALTERNATIVES	AGRICULTURE INTERESTS	RECREATION INTERESTS		ENVIRONMENTAL INTERESTS	MINING INTERESTS	REAL ESTATE INTERESTS	GOVERNMENTAL INTERESTS		RESIDENTS INTERESTS
		water	land				state	local	

identifies, without any notions whatsoever of relative importance, six particular interest groups: agricultural interests, recreational interests, environmentalists, quarry operators, land developers, and governmental units. Information on all relevant impacts, within the constraints of the study's resources, should be entered within the respective incidence grouping for each of the alternatives considered. Such impact information may range in precision from quantitative monetary estimates to qualitative verbal statements. Also, for impacts such as landscape effects,it would be advisable to supplement this tabular presentation with illustrative sketches. Also, specification of likely temporal and spatial incidence might be included where enlightening.

In general, not all interests may be anticipated; however, so long as the technical impact analysis itself is sufficiently thorough the emergence of unanticipated interest groups within a participatory evaluation forum can be accommodated by preparing additional columns in such a matrix.

Summary

This chapter has addressed the overall problem of organizing the analysis of project impacts in a manner which transcends traditional economic perspectives and eventually facilitates a participatory evaluation process. The basic premise throughout is that the Corps of Engineers, in the Ames Reservoir project, is accountable not only to established channels of project justification, but also to the concerned public with its particular composition of interest groups.

Given the complexity introduced by the multi-objective context of the Ames Reservoir situation, a deliberate organization of potential impacts is essential to methodical technical analysis. This organization is provided by a flexible taxonomy or classification system based primarily on impact mechanisms or linkages. This chapter has reviewed the respective taxonomical structures found within traditional literature on economic analysis of water resources projects, within recent literature on environmental impact assessment, and within relevant literature in companion planning disciplines (notably, urban transportation). Various elements of these structures then were synthesized into a mechanism-based impact taxonomy for this study. The core of that taxonomy is a master cross-classification involving the dimensions of impact "source" and "order" which is amplified in terms of economic, social, and environmental categories, and subclassifications thereof.

The latter concern of the chapter provides for transformation of impact information from the mechanism-based taxonomy to an incidence-based classification for display within a participatory evaluation forum encompassing all effected or interested parties. Emphasis is shifted away from preoccupations with technical project objectives and toward the accommodation of potential interest groups. Given an adequate impact analysis in terms of the mechanism-based paradigm or model, information on incidence patterns may be generated as a direct response to the emergence of any unanticipated interest groups.

The overriding message throughout this discussion is that strictly economic calculations are no longer sufficient for comprehensive project evaluation. The conventional notion of "prices" must be extended to the generalized concept of "trade-offs" which holds for all types of incommensurate impacts. However, this position hardly denies the value of conducting benefit-cost calculations within this broader context since, if performed diligently, one can at least collapse the totality of economic impacts into figures-of-merit which may enhance the manageability of the entire project evaluation process and be more easily understood by the decision makers.

Application of the taxonomy developed herein to the Ames Reservoir project is presented later in Chapter 11. Intensity values for the proposed project are collected from analysis presented in the appendices and are presented for comparative and evaluative purposes with intensity values for the various alternatives that have been considered.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part II. Impact Evaluation of Alternatives

Chapter 6

IMPACT ON NATURAL RESOURCES: CATEGORY 1 STUDIES

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ARES SUMMARY REPORT

Chapter 6

IMPACT ON NATURAL RESOURCES: CATEGORY 1 STUDIES

Introduction

The nine alternative development opportunities will have varying impacts on the environment of the Skunk River valley — its people and its natural resources. The natural resources of the valley are of major concern to environmental interest groups. Implementation and maintenance of a useful and viable program for the conservation and wise use of natural resources is a primary objective of these groups. The effect of these alternatives on vegetation, forest, limnology, stream and lake fisheries, mineral resources, archaeological resources, and ecological implications are summarized in this chapter from the work of Category 1, as reported in Appendix 1.

In general, the impact of reservoir developments will be severe, both for the area in which temporary impoundment of floodwaters occurs as well as for the area permanently inundated. Smaller scope reservoirs, including the use only of smaller recreation lakes, lessens this impact. Continued use of the area for extraction of mineral resources and for rural-residential housing represents a localized impact which, although it can be severe in a small area, does not represent such a large-scale impact. A positive land-use plan and comprehensive green-belt and open-space development offers an opportunity for conserving the natural resources of the Skunk River valley. Details are found in the summary sections which follow.

General Visual Impact and Land Use Changes

The summary comments of this section are based on an inventory and analysis of the physical resources in the reservoir study area, the visual qualities of the site, and the potential changes accompanying the nine alternatives. The computer-based land-use model analysis has shown that three percent of Story County is covered by natural woodland and that most of this woodland is associated with the stream valleys. The 34-section study area contains approximately 25% of the county's natural woodland.

The Skunk River is channelized south of Ames and, if impounded north of Ames, only 15% of the river's distance through the county would be left in a natural meandering state. This natural portion of the river passes through the Ames community. Therefore, if a reservoir is constructed, the river essentially would be a managed unit, impounded, urbanized, and channelized. Few natural river scenes would remain along the Skunk River valley; this would place even greater importance on the Indian Creek and Squaw Creek valleys.

The creation of a large stable-level recreation lake (Alternative 2) has less visual impact than a fluctuating reservoir because of its smaller size, less woodland removal, and no "bathtub ring" (flood-pool edge area created by the fluctuating water level). The recreation opportunities offered by a large lake are a tradeoff from the present activities of the site. The lake-based activities are less diverse and more concentrated than river activities (because of a less diverse site) and must be carefully planned to avoid deterioration of the site and the surrounding area.

Significant recreation landscapes are those that offer a wide range of potential experiences. The study area of the reservoir offers a diversity of experiences due to topographic variation, stream meandering, vegetation, and its associated wildlife which is in contrast to the surrounding landscape. Both the proposed landscape (reservoir alternatives) and the existing one are in contrast to the normal Iowa farmscape. Any proposed reservoir, when filled with water, will accentuate the flatness of the landscape while the existing valley and its timber resource creates vertical relief and seasonal contrast, especially during the winter.

The proposed landscape(s) will afford a greater opportunity for recreation through more physical activities than is afforded now — for example, swimming and water skiing as forms of personal competition. The existing landscape affords greater recreation with nature that involves "finding" — for example squirrel hunting, bird watching, mushroom hunting, hiking, etc. It is likely that the proposed landscape(s), while serving more people, will provide a less diverse range of experiences.

The existing valley reach of the reservoir site is visually changing. Gravel and limestone extractions continue to spread while some areas of timber are being cleared and others are dying from Dutch elm disease. Residential development is impinging on the site at the southwest portion of the study area along Arrasmith Road and along Dayton Road northeast of the proposed dam site. Presently residents of the county live on the land in the following ways:

a. large community (Ames)

b. small towns

c. rural setting (farmstead or rural-residential housing along timber and valleys).

The reservoir alternatives offer one additional choice — homes in close proximity to a water body.

Conservation pools (Alternatives 1, 1A, 2, 5, or 6) would become a public landscape due to the existing scenic overlook, rest-stop areas on Interstate 35, and the large proposed take-line near E-29 (potential camping area). This cluster of identification points along I-35 will give the lake high visibility and, with that, high public use.

With inundation by any major reservoir alternative, views from the west to east across the lake will be focused on Interstate 35 (due to tree removal and elevation); associated with this will be increased noise which is presently partially absorbed by the timber. Heavy evergreen planting parallel to the interstate on the knolls (east side) can absorb some of this auto noise and screen some of the views of the interstate from the west shoreline and the lake water area. This proposed planting would be aesthetically pleasing from the lake, highlight views from the interstate, absorb noise, and form a backdrop for the lake when viewed from the west.

On the basis of the report and the above comments, Alternatives 2 or 3 (having a stable recreation lake) or Alternatives 4 or 4A (open space and green belt) would be most acceptable from a visual and aesthetic standpoint. But more important, whether the decision is for open-space development or lake development, careful planning and management of the valley must be provided. A well-integrated and executed plan for the valley area is highly desirable because of the future recreation and development pressures on open space in Iowa. Opportunities for visual and aesthetic control of the site exist in Alternative 4A, including fee title purchase and surface easement. These should be investigated for use in the area for all open-space uses (Alternatives 3, 4, and 7). Surface easements provide rights to the user while individual stewardship of the land is maintained.

Archaeological Sites in the Valley

Expected Impact of Reservoir Alternatives

The construction of any of the proposed reservoir alternatives will strongly affect most, if not all, of the sites reported in this survey. The impact of a reservoir, under Alternatives 1, 1A, 5, and 6, is summarized in Table 6-1. This shows the immediate and total destruction of 23 sites due to earth-moving and other constructional activities connected with the building of dam and spillway structures, permanent inundation of the conservation pool, and pool wave action. Thirteen additional sites will suffer partial to total destruction by the intermittent inundation and wave action of the flood control pool. At least seven sites, while not within the reservoir *per se*, would be part of peripheral land acquisition for recreation purposes. Furthermore, activities in the easement area and that immediately outside the reservoir limits would potentially endanger at least eight sites at some distance from the actual lake edge. The location of borrow pits, construction access roads, and areas of heavy tree and understory removal has not yet been specified, and these activities may endanger the aforementioned or additional sites.

Table 6-1. Expected impact of multi-purpose reservoir alternatives on archaeological sites.

Item	Type of impact	Number of sites affected
1	Total destruction by construction of the main dam and associated structures	4
2	Total destruction by construction of Bear Creek Sub-Impoundment Dam	2
3	Total destruction by permanent inundation and wave action of the conservation pool	17
	Subtotal, complete destruction	23
4	Partial to total destruction by intermittent inundation and wave action of the flood control pool	13
5	Above flood control pool, but possible endangerment within acquisition area	7
6	Within easement area or outside reservoir limits, but possible endangerment by peripheral construction or development activities	8
	Subtotal, partial effect	28
	Grand total	51

At the same time, it should be noted that for all the development alternatives archaeological resources will be subject to destruction by erosion, cultivation, road construction, quarrying, housing developments, etc., both within and outside of the reservoir. At least one site within the scheduled conservation pool may already have been effectively destroyed by clearing for gravel operations not directly connected with reservoir construction.

The total impact of these nine development alternatives might, of course, extend well beyond the area specifically surveyed during the 1971-72 reconnaissance. Housing developments and farming practices such as contour plowing and terracing, the building of erosion-control and sedimentation ponds surrounding the reservoir, and other development measures would imperil archaeological resources. Present settlement and land-use patterns would presumably be changed outside the area actually acquired in any specified development alternative. The creation of a lake near the expanding City of Ames would boost the construction of housing and other developments in the area on land previously given totally to agriculture and scattered farmsteads. An archaeological salvage program is needed for the valley, regardless of which alternative development program is pursued.

Salvage Recommendations

In the previous discussion based on the information presently at hand, salvage recommendations have been made for each individual site. If a decision is made to construct any lake or reservoir or to develop any specific area for any purpose, a comprehensive archaeological salvage program should be authorized and undertaken as soon as possible. Since the present study constitutes a preliminary survey, additional factors should be considered as the specific construction plans are finalized. The archaeological program should include further reconnaissance, re-checking of sites located in the present survey, testing of certain sites, and larger-scale excavation at still other selected sites. Recommendations for salvage archaeology and site preservation in the Ames Reservoir are included in Appendix 1.

Vegetation

General Effects of Reservoir Alternatives

Construction of a multi-purpose reservoir having a flood control pool or the large recreation lake will have a drastic, irreversible effect on many existing plant and wildlife communities. Partial or complete destruction or substantial altering of these areas is forecast in practically every category surveyed in the study. Also, completion of the reservoir would eliminate farming of approximately 2210 acres for cultivation and 558 acres for pasture, for Alternatives 1, 1A, and 5, and somewhat less for Alternatives 2 and 6. Some of this intensively managed land would be permanently inundated by the conservation pools and lost forever from its present use. However, due to the narrow, steep-sloped topography of the river valley, most of the flat to gently rolling farm land does not lie within the proposed conservation pools of these alternatives. Upon release from cultivation or grazing these agricultural areas will, through secondary succession, slowly proceed toward more stable and diverse seral stages. Areas such as these, which are located upon the higher valley slopes and in the upper reaches of each multi-purpose reservoir and flooded less frequently than once in 10 years, may progress to communities of shrubs and pioneer woody species offering increased wildlife habitat. Where no inundation occurs, they may progress and eventually mature into upland timber. Increased frequency of inundation in the flood control pools will halt the successional trends, killing the existing vegetation and initiating once again the early stages of succession.

Land released from intensive farm practices in all the alternatives can result in increasing wildlife habitat, the formation of more open-space recreational area, and the re-establishment of natural plant communities. However, management goals must be determined and carried out or these same areas become potentially weedy areas lacking aesthetic values and requiring control treatments. The existing flood plain and spoil areas at gravel pits and rock quarries exhibit these weed-growth tendencies.

The construction of a multi-purpose reservoir in Alternatives 1, 1A, 5, and 6 or the large recreation lake of Alternative 2 would substantially decrease the amount of forested land. As proposed, 65% of the total forested land within the 34-section study area would be inundated (some permanently, some periodically) if any of the three large-scale alternatives are selected — 1, 1A, or 5. Most, if not all, of this existing forest would either be cleared during construction or lost through periodic submergence in the flood pools. A slightly lower amount is affected with Alternative 6, the reduced-scope project. This percentage does not include the forested area affected by increased recreational development or by expected increases in the ground water levels around the periphery of the reservoir. An additional 240 acres of riparian vegetation or "stringers" might be lost to such intensive use stress in each of these alternatives.

Reservoirs in Iowa primarily designed for flood control are characterized by frequent fluctuations in water levels when compared with most natural and artificial recreation lakes. When floods fill the reservoirs, water rapidly submerges the vegetation. Replacement of the herbaceous vegetation is being observed on both Red Rock and Coralville

Reservoirs in Iowa. Species composition in the areas exposed after drawdown seems to partially depend on the time of year in which drawdown occurs. A great majority of the species re-establishing in these disturbed areas are annuals, many of which are agricultural weeds.

Flood records indicate that in central Iowa the major floods generally occur in May and June with some localized floods in July, August, and September as the result of local heavy rainfall. Floods of less to equal magnitude sometimes occur during the spring breakup as the result of snow- and ice-melt in conjunction with moderate rainfall. This means that the highest water levels in the reservoirs are often reached early or in the middle of the growing season when the vegetation is most vulnerable to water damage of the root system.

Plant succession on the relatively flat areas (such as the plateau area lying between Keigley Creek and the Skunk River or more upstream flood plain areas) that are occasionally flooded is regularly interrupted. Even the lowland marsh species cannot thrive because of the fluctuations of the water level. Upland species may disappear because frequently they cannot survive even a short period of inundation. The weedy species get established first, until the next flood kills them, too. In some areas, dense stands of willow or cottonwood grow up until the next flood submerges them, often killing the new growth, also. We call these low flood plain lands or flat terrace areas where fluctuations frequently occur "mudflats" to emphasize the lack of any permanent type of vegetation.

For Alternatives 1, 1A, and 5, it seems reasonable to designate as the potential "mudflats" in the Ames Reservoir all flat areas (5%

slope or less) lying between the elevation lines 965 (wet once in 10 years) and 940 (dry once in 10 years), even though the effects of inundation would extend to elevation 976 ft or to the highest point that flood waters reach in alternative reservoir designs. This amounts to approximately 1490 acres in the potential "mudflat" category, between elevations 964.5 and 939.5. For the reduced-scope alternative, No. 6, this would extend from about elevation 960 down to elevation 935, and slightly less area would be in the "mudflat" category.

Summary

Completion of the Ames Reservoir under either Alternatives 1, 1A, or 5 will unquestionably result in the loss of 2100 acres of existing vegetation due to construction of the conservation pool. Another 2900 acres falling within the perimeter area of the operating flood control pool will be subject to a visible vegetational change of varying degree, depending on frequency and depth of flooding as well as seasonal manipulations of the water level. About 1500 acres of potential "mudflat" exposure exist in the most frequently fluctuating portions of the conservation and flood pools.

For Alternative 2, a large recreation lake, the total vegetative loss is reduced to 1400 acres. For the reduced-scope project of Alternative 6, an additional 2000 acres of vegetation and timber in the fluctuating flood pool would be affected. There is no real loss of the valley vegetation with the green-belt, open-space and river recreation alternatives, if housing developments are controlled. Construction of Bear Creek Lake would eliminate some 160 acres of existing vegetation.

Woodlands and Wildlife

The Timber and Forest Resource

Three percent of Story County is covered by natural woodland, and most of this woodland is associated with the stream valleys. The 34-section study area contains approximately 25% of the natural woodland (rural, unincorporated areas) in Story County. The reservoirs of Alternatives 1, 1A, and 5 (at a maximum pool flood control pool elevation of 976, covering over 5000 acres) would inundate as much as 15% of the natural woodland of the county and about 1.2% of the county's land area. Therefore, the visual impact and timber loss is much greater than might otherwise expected because of the concentration of the county's natural woodland in the Skunk River valley.

Almost one-seventh of the woodland area and volume (13.6% and 14.8% respectively) to be found in Story County will be removed or seriously altered by the presence of the impoundment described in Alternatives 1, 1A and 5. In the 34-section study area along the Skunk River, almost two-thirds of the area and volume of woodland would be removed or altered by the impoundment as proposed in these three alternatives (61.0% and 62.1% respectively). According to the study of the forested areas, approximately 25,600 tons of stem-wood would be flooded or altered by seasonal flooding. Of the 2905 acres of woodland along the Skunk River within the project area and of the 1,858,400 cu ft, each of the proposed alternatives would flood out land and volume in the amounts listed hereafter: Alternative 1: 1771 acres and 1,153,200 cu ft; Alternative 1A and 5: 1737 acres and 1,126,400 cu ft; Alternative 2: 641 acres and 429,800 cu ft; Alternative 3: 140 acres and 92,299 cu ft;

and Alternative 6: 1403 acres and 1,021,100 cu ft. The graphical relationship of reservoir water surface elevations to acres of land inundated and to acres of timber inundated are shown in Fig. 6-1. Data are summarized in Table 6-2. The relationship of timber impact for the valley and Story County is shown in Fig. 6-2.

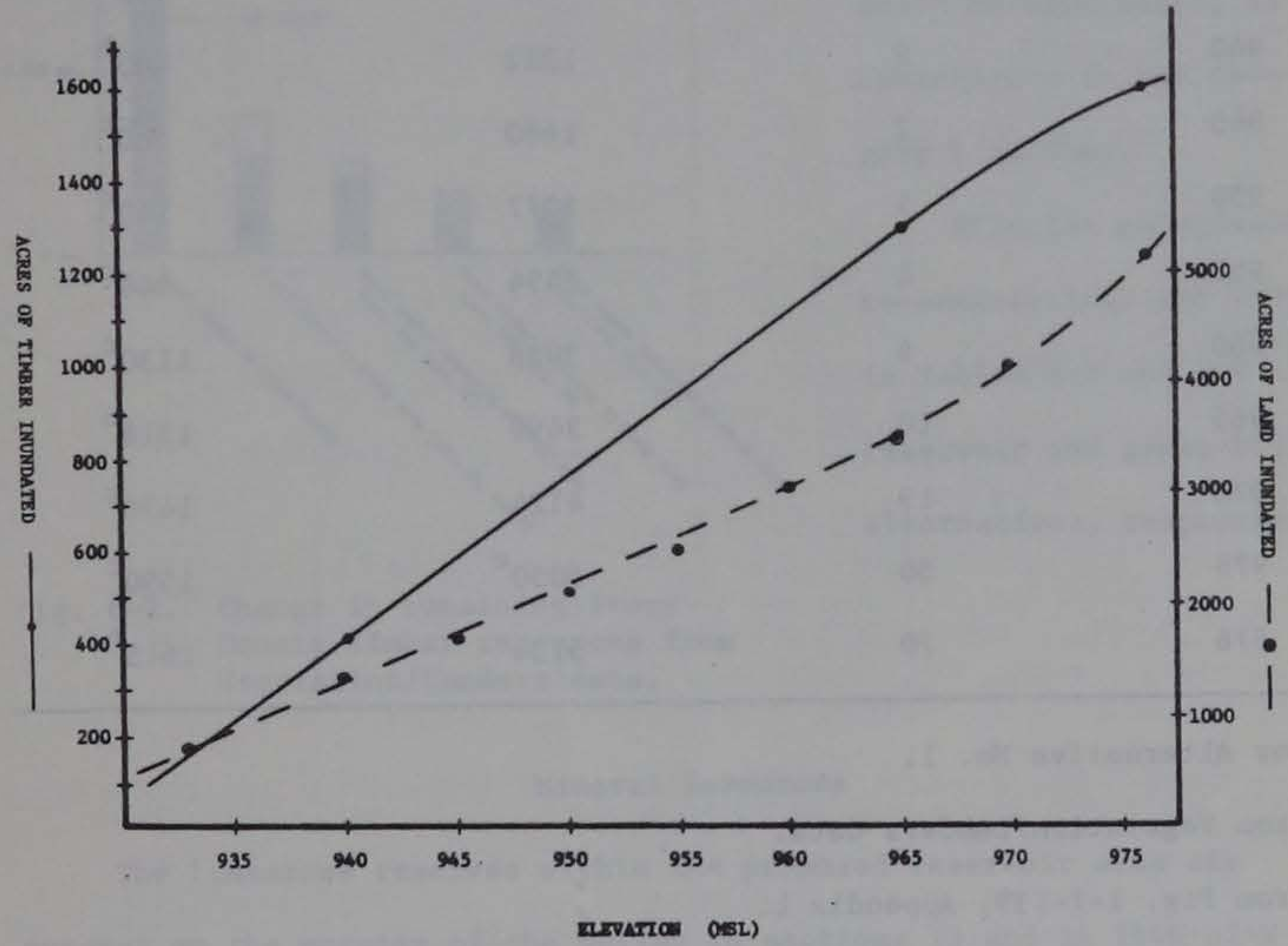

Fig. 6-1. Acres of timber and land inundated.

Wildlife

The results of the wildlife studies show that the valley's wildlife fauna and flora do have a definite economic value to many residents within the proposed Ames Reservoir area. Each landowner placed relative monetary values on the wildlife, and a rather high figure has resulted. There exists a deep emotional attachment that local landowners have for their property and for the valley in general. Although there

Table 6-2. Inundation of rural timber in study area.

Elevation of pool	Inundation frequency = X (once in X years)[a]	Acres of land inundated	Acres of timber inundated
933	45	769	155[c]
940	9	1312	403[b]
945	2	1660	580[c]
950	1	2077	760[c]
955	4	2494	940[c]
960	6	3028	1130[c]
965	10	3499	1318[b]
970	19	4124	1470[c]
975	50	5050[c]	1590[c]
976	70	5134	1615[b]

[a]For Alternative No. 1.

[b]From Vegetation/Landers data.

[c]From Fig. 1-1-139, Appendix 1.

were certain cases of only "passive" interest in wildlife, it appears that if wildlife were eliminated from this area, the people would then realize wild animals contribute a subtle but important role toward this strong attachment. On a purely economic basis, probably more wildlife benefit would be derived if the reservoir were constructed ($1,390,100 total annual worth of benefits vs $174,000 worth of wildlife lost). But if examined more closely, reasons for opposition clearly outweigh reasons for support of construction of any of the multi-purpose reservoir

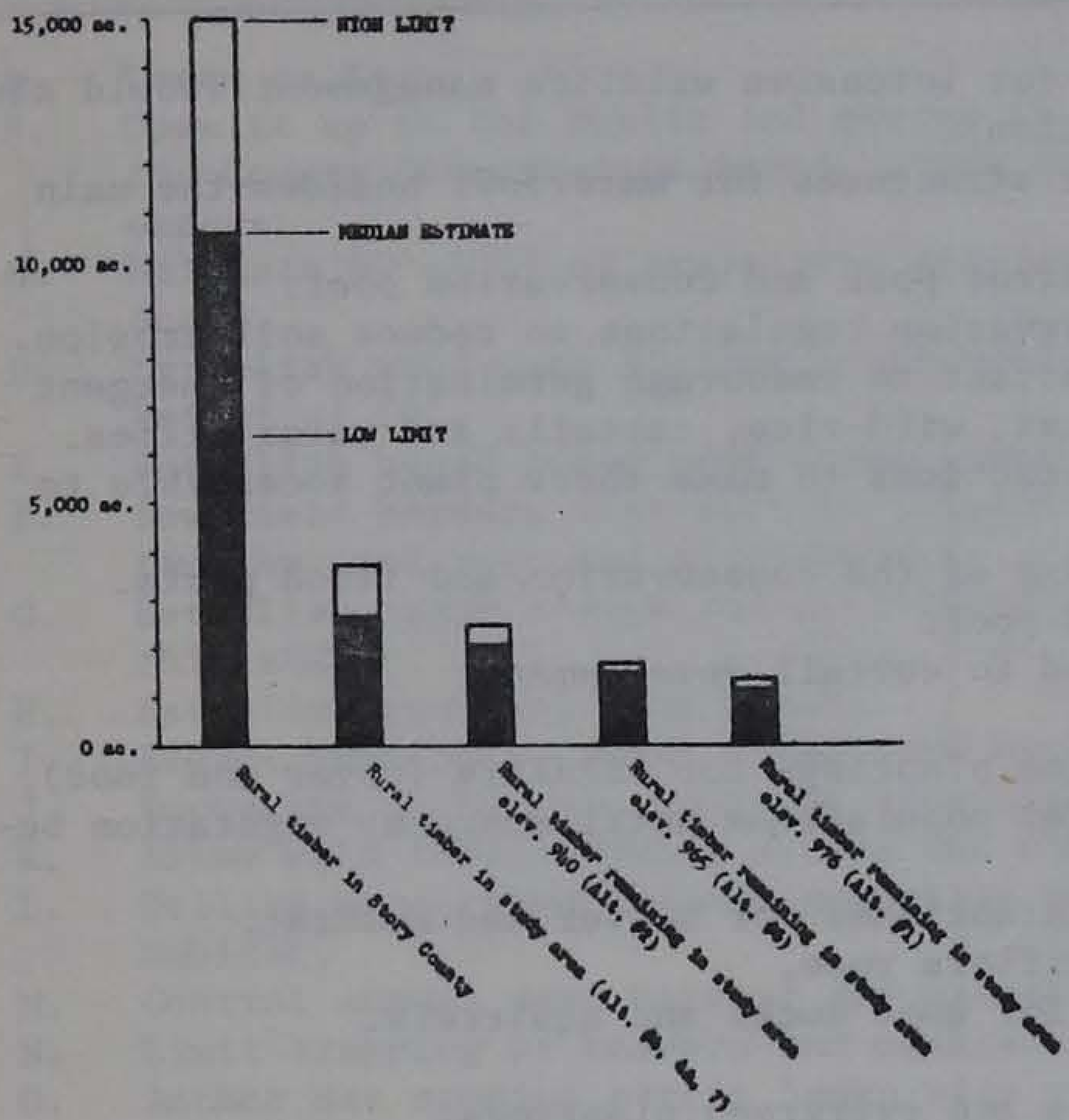

Fig. 6-2. Change in remaining Story County timber resources from Vegetation/Landers data.

alternatives. Trapping income, certain recreational benefits, and approximately 206,000 individuals of various wildlife species would be eliminated, as inventoried in the Category 1 studies.

Wildlife management recommendations are listed in Tables 6-3 and 6-4 for reservoir and green-belt alternatives, respectively.

Mineral Resources

The limestone reserves within the proposed reservoir area are present on the margins of the valley in sections 13 and 24 T84N-R24W and sections 5, 6, 7, and 18 T84N-R23W. Quarrying activities can be carried on adjacent to all reservoir alternatives, but the chances are that the land will not be available for this use because of the demand for additional residential areas around the lake areas. The loss of this resource location will mean that the user of limestone aggregate will have to get the aggregate from a county line quarry north of Roland and pay the additional cost for trucking the longer distance. There is

Table 6-3. Wildlife management recommendations for reservoir alternatives.

A. Purchase bordering land for intensive wildlife management (would also reduce runoff and siltation).
B. Construct subimpoundment structures for waterfowl besides the main reservoir.
C. Reduce size of flood control pool and conservation pool.
D. Impose strict soil conservation regulations to reduce soil erosion.
E. Keep the water level constant to encourage germination of emergent vegetation such as millet, wild rice, cattails, and water lilies.
F. Utilize water drawdown practices to make these plant accessible to waterfowl.
G. Leave trees along the edge of the conservation and flood pools.
H. Leave trees in the flood pool.
I. Purchase surrounding land to curtail development.
J. Maximize edge habitats.
K. Make beneficial vegetation plantings for wildlife (cover and food).
L. Control muskrat and beaver populations until emergent vegetation becomes established.
M. Allow willow to become established for beaver and muskrat.
N. Replace fences with multiflora rose.
O. Establish nesting boxes for wood ducks and squirrels.
P. Leave grasslands.
Q. Establish more windbreaks and evergreen plantings.
R. Control human influences at times of mating and nesting, etc.
S. Provide artificial nesting sites for fish.
T. Plant flood pool land area to vegetation suitable for waterfowl because flooding will occur only once in several years.
U. Restoration of roadside cover, seeded, unmowed with native grass and legumes.
V. Plant hedge species, cereal grain plots, fescue and red top grasses.
W. Establish brush piles.
X. Plant deciduous trees for long-term future use.
Y. Provide emergency winter feeding of wildlife until vegetation plantings can take hold and become substantial.
Z. Plant aspen, maple, willow,or hazel nut for beavers in the small channels.
AA. Establish subimpoundments with stable water levels in a marsh form.
BB. Establish a refuge around the impoundment.
CC. Leave timber standing in the bays and arms of the reservoir.
DD. Allow woody species to grow up in the fence rows.
EE. Maximize shallow areas of the reservoir for waterfowl.
FF. Maintain a 30'-40' grassland border around the reservoir. Protect this area from fire and mowing during the breeding season. Prohibit grazing.
GG. Plant steep banks to grass or grass-legume.
HH. Establish permanent marshes by planting bullrush, cattail, sedges, and arrowhead.

Table 6-4. Wildlife management recommendations for green-belt alternatives.

A. Leave as is.
B. Open it up to the public and manage it under the combined efforts of the County Conservation Board, State Conservation Commission and landowners.
C. Maintain 40'-300' of grass type species around the marsh habitat for ducks.
D. Establish wood duck nesting boxes within 300' of the marsh habitat at a height of 10'.
E. Establish brush cover near other cover.
F. Sow field borders with sericea lespedeza or heavy mixed stands of timothy, red top, and alta fescue.
G. Establish osage orange and multiflora rose fences and blackberry thickets.
H. Establish squirrel nest boxes.
I. Reduce grazing to allow underbrush cover.
J. Encourage better nut crops by tree thinning.
K. Allow wild fruit-bearing shrubs and vines to grow along fence rows.
L. Utilize prescribed burning and share cropping to increase quail habitat.
M. Control annual deer harvest and minimize livestock grazing.
N. Limit trapping of beavers and muskrat.
O. Anchor mat eroding stream banks with willow.
P. Partial clearing to gooseberry thickets around dead elms to create interspersion.
Q. Allow dead elms to remain standing for den trees and woodpecker feeding.
R. Purchase part of the area and manage for wildlife and then open to multiple use.
S. Create small impoundments. Leave brome-blue grass interspersion.
T. Leave a few rows of grain crops standing around the edges of fields.
U. Enhance windbreaks now existing to conform to the formula: shrub — conifer — hardwood.
V. Stop from draining the remaining wetlands.
W. Thin young timber thickets to promote growth and create openings.
X. Cut some dead trees to construct brush piles.
Y. Save den trees.
Z. Create more edge.

a good chance also that the Cook's Quarry location would be lost in the future due to increased urban pressure even without a flood control reservoir (Alternatives 3, 4, 4A, and 7). In this case, there is good reason to believe that a source would open up just to the north if that area is kept free of rural-residential homes.

The sand and gravel reserves are a different story. They are located within the valley and would be lost should any reservoir alternative become a reality. The exact magnitude of this loss cannot be determined without detailed investigations, but approximate tonnage can be determined as listed previously in Chapter 2.

The amount of aggregate produced from the Hallett and Peterson gravel pits averages 200,000 ton/yr and 100,000 ton/yr, respectively. Upland gravel reserves do not look attractive now but could become valuable in 15 to 20 years when the valley reserves are gone. Some of the upland sites are located in the flood pool of all of the multi-purpose reservoir alternatives and perhaps could continue to be worked with the understanding that periodic flooding would occur.

The limestone resources of 200,000 ton/yr could be lost, but not by direct flooding. The use of the land for other purposes could probably drive the limestone operators away from the area and require importing from outside of the county.

Predicted Limnological Character of the Reservoir Alternatives

The assumption has been made that the reservoir will be constructed and operated as described by the U.S. Army Corps of Engineers (1968) in Design Memorandum No. 1 (Alternatives 1, 1A, or 5) with a conservation pool elevation of 950 ft. The limnological character of this impoundment will be evaluated first, followed by differences that might be expected if a smaller alternative or if a green-belt alternative were selected.

Physical Features

The lower end of the pool is relatively narrow and deep. Farther upstream the pool widens and becomes shallower and extends up the valleys of the main Skunk River and Keigley Creek. The average depths at a pool elevation of 950 ft are shown in Fig. 6-3.

Inorganic Turbidity and Turnover Times. The summer winds tend to be from the south and thus will have a long fetch up the long axis of the reservoir. One effect of these winds will be to resuspend the fine sediments and increase the inorganic turbidities in this area. Due to the relative volume of the reservoir, the waters will tend to clear by the time they reach the dam. Thus, on the average there will be a gradient in the reservoir with the shallow, more turbid waters in the upper end and the deeper more clear waters in the lower end, near the proposed dam site.

The fundamental difference between a lake and a stream lies in the flow of water (magnitude of velocity and discharge) through the respective bodies. Depending upon the relative magnitude of the flow, a reservoir can in an ecological sense be either a river, a lake, or something in between. One way of making a quantitative determination for a particular reservoir is to calculate the average turnover time. This is equal to the volume of the reservoir divided by the average discharge of water passing through it and is expressed in units of time such as days. The length of time that a parcel of water remains in the impoundment is of importance because there are a number of chemical and biological processes that act over time to alter the quality of standing waters. These include the development of phytoplankton and the removal of plant nutrients by deposition in the sediments.

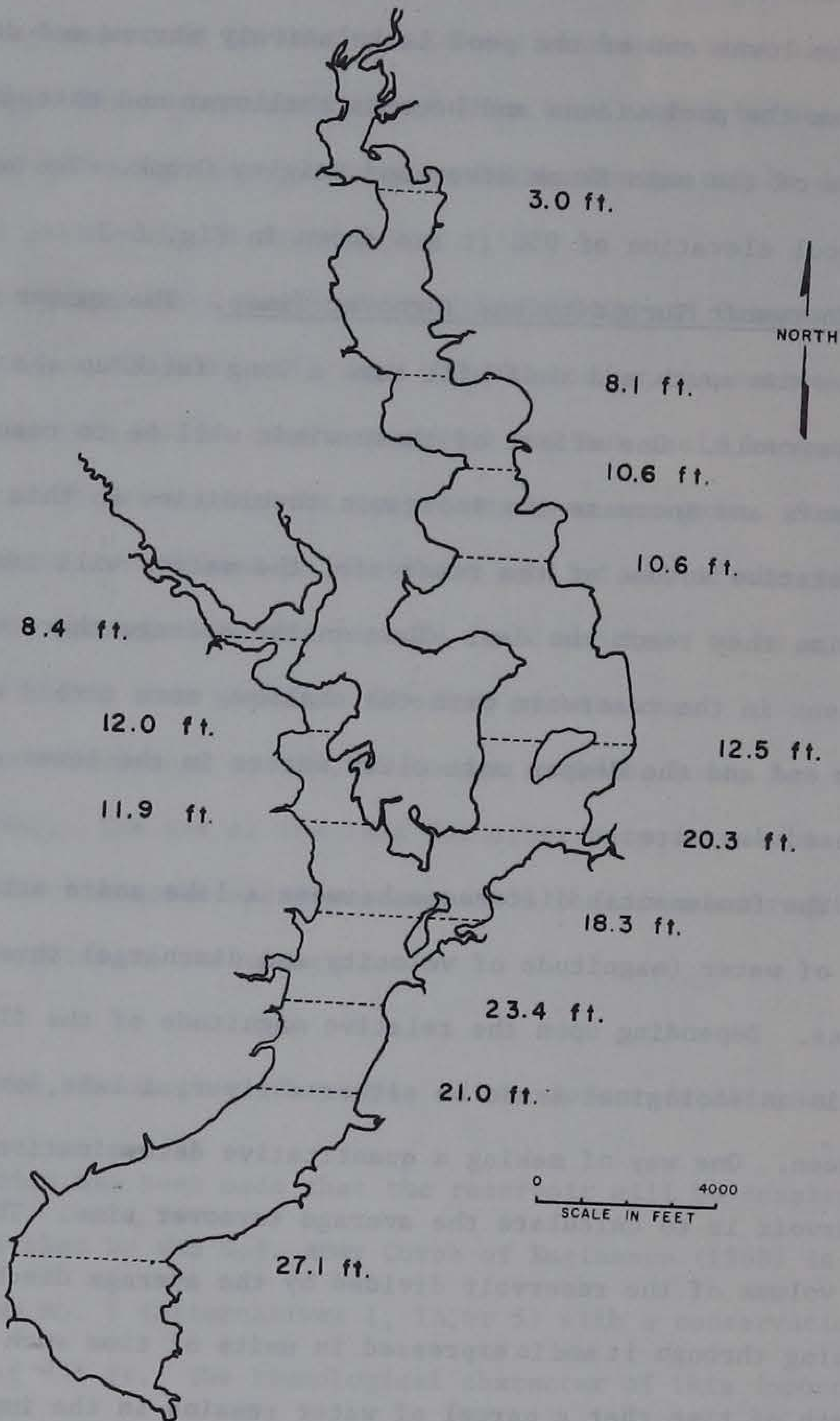

Fig. 6-3. Map of the proposed conservation pool of Ames Reservoir, Alternatives 1, 1A, and 5 with average depths of cross-sectional profiles shown in feet.

For Iowa reservoirs, the calculated turnover time in days for Coralville is 2.6, for Red Rock is 10.5, for Saylorville is 15.6, for Rathbun is 378, and for Ames is 131. These are average values based upon average discharge rates and the storage volumes of the conservation pools. Within a given reservoir, the turnover time will vary during the year depending upon the actual elevation of the water and the actual discharge magnitude at a given time. The average values enable us to compare the Ames Reservoir with other reservoirs in Iowa. The Ames Reservoir has a relatively long turnover in relation to those calculated for Coralville and Red Rock Reservoirs. For this reason we cannot use the conditions in those reservoirs in a direct manner to make predictions about the Ames Reservoir.

A more detailed calculation of the seasonal variations in the turnover times for the Ames Reservoir was made using flow data for the period between 1920 and 1966 along with the calculated pool elevations for the reservoir had it been in operation during that period. In general, shorter turnover times are indicative of periods of high runoff and are found in the months of February through June, reflecting the spring runoff period. There is less seasonal variability in the minimum monthly turnover times, indicating that periods of high water can occur at any time of the year. The range of values for individual months is great, covering four orders of magnitude. This is a reflection of both floods and occasional periods of drought when the river flow was close to zero. This variability in turnover time will induce variability in the various limnological cycles in the reservoir so that in some years or months there will be significant departures from the average predicted conditions.

<u>Thermal Stratification</u>. Thermal stratification in a reservoir can have several ecological effects. For one, it provides a cold water habitat in a warm water lake. If the reservoir has a low-level outlet, lower water temperatures can be provided in the stream below the dam. Also of significance is the loss of oxygen which can occur in the bottom waters of stratified lakes, a common occurrence in artificial reservoirs in southern Iowa. In general, all Iowa lakes produce a sufficient amount of organic materials in their upper waters so that oxygen depletions will result if a persistent thermal stratification is established.

Red Rock and Coralville Reservoirs do not have persistent thermal stratifications. However, they are poor guides for predicting conditions in the Ames Reservoir because of their relatively short turnover times which would tend to prevent the establishment of a stable stratification in these water bodies. Some mathematical approaches have been proposed to determine if a reservoir will experience thermal stratification. These have been applied to lakes and impoundments in Iowa. The Ames Reservoir falls in the stratified to partially stratified category on the basis of this criterion.

Unfortunately, the lakes in this sample have surface areas of 25 to 404 acres and thus do not bracket the area of the proposed Ames Reservoir (2100 acres). For this reason it is not clear if the mathematical techniques can be applied to a reservoir of this size, and its position is somewhat uncertain. It appears that on the basis of area and depth alone it would experience either full or partial thermal stratification.

It is generally thought that the probability of thermal stratification occurring in a given lake becomes less as the lake becomes larger and the wind inducing mixing becomes more effective. At the same time the probability increases as the lake becomes deeper. In general, stratification is more likely in small, deep lakes than in large, shallow ones. The surface areas and maximum depths of a number of Iowa lakes and reservoirs were plotted on a double logarithmic scale, using different symbols to represent those lakes that do not stratify and those that are partially or fully stratified. The agreement is not perfect, but then that is not to be expected since this approach does not take into account many factors that might influence the effectiveness of wind action such as maximum fetch, orientation of the basin in relation to the prevailing winds, and the sheltering action of trees and surface waters after June 1 which might lead to the establishment of a new thermocline. The Ames Reservoir, for Alternatives 1, 1A, and 5, falls into the stratified category in this analysis. For Alternatives 2 and 6, reduced-scope lake projects, partial stratification more likely would occur. Since the outlet for water from the conservation pool is located deep on the face of the dam, the effect of withdrawals will be to remove water from the potential hypolimnion and thus lower the depth of the thermocline.

During periods of stratification, there is a reasonable probability of experiencing oxygen depletion in the hypolimnion due to the breakdown of the organic materials washing into (agricultural or forest residues) or produced within the reservoir (algal blooms, etc.). If an extended period of oxygen depletion occurred, an accumulation of chemically-reduced materials such as hydrogen sulfide, ammonia, methane and ferrous iron could occur and present a toxic environment to fish. The survival of fish in the impoundment would depend largely on conditions existing thereafter in the upper levels, in the

the epilimnion. Most problems experienced in Iowa have occurred in the winter period under ice cover, following fall turnover, and a low probability could be attached to the above chain of events occurring at other times. Some of the downstream effects of stratification include somewhat lowered summer water temperatures in the reach immediately downstream of the dam — this could benefit certain species of fish. Unless the outlet structure is capable of adding oxygen through aeration or water is withdrawn from the higher reservoir elevations through a multi-port inlet, there may be low levels of dissolved oxygen in this reach — this would be detrimental to the fisheries resource.

In addition to the possible loss of oxygen in the deeper waters during periods of stratification, there may also be unpredictable periods of oxygen loss under ice in other areas of the reservoir. This frequently happens in smaller ponds in Iowa. It occurred in the Coralville Reservoir in January 1965 when winter rains on frozen ground caused a heavy flow of runoff rich in organic matter to enter the reservoir. The BOD levels within the reservoir rose to over 20 mg/l, and a nearly complete depletion of the oxygen in the reservoir was noted. This was thought to be responsible for a heavy winterkill of fish in the reservoir in the first three months of that year. COD values in the Skunk River as high as 76 mg/l were found; however, the greater turnover time of the proposed Ames Reservoir would tend to lessen the severity of such an event.

Prediction of Algal Blooms

Another important group of chemical parameters includes the amounts of plant nutrients that will be added to any reservoir alternative by the Skunk River. By determining the total amounts of phosphorus and nitrogen from all sources introduced into a lake in one year and dividing by the lake volume, one can arrive at the potential average concentration.

In the case of a lake or a reservoir where the total annual inflow is greater than the volume of the water body, the potential concentration is equal to the average concentration of the inflows.

The potential concentrations of phosphorus and nitrogen in the Ames Reservoir have been calculated and are tabulated in Table 6-5. Similar values for six other Iowa lakes, based upon a current research project, were also computed for comparison. The potential concentration of phosphate in the Ames Reservoir exceeds that for the other six lakes, while the potential concentration of inorganic nitrogen is only slightly less than that found for the lake with the highest potential concentration.

Two major factors were taken into account in making estimates of the potential crops of planktonic algae in the Ames Reservoir. These

Table 6-5. Potential concentrations of plant nutrients in the Ames Reservoir and some other Iowa lakes based upon the annual input from the tributaries[a].

	Potential concentration (mg/l)		Chl a average Values July-Aug 1971 mg/m^3
	PO_4-P	NO_3-N plus NH_3-N	
Ames Reservoir	0.199	3.89	
West Okoboji L. 1971	0.005	0.110	5
Big Spirit L. 1971	0.012	0.318	63
Upper Gar L. 1971	0.077	1.68	128
Minnewashta L. 1971	0.077	1.68	169
East Okoboji L. 1971	0.077	1.68	89
Lower Gar L. 1971	0.158	4.15	330

[a]Because of the interconnections between East Okoboji, Minnewashta, and Lower Gar Lake, only a combined nutrient budget is possible.

were the effects of turnover time and the influence of nutrient inputs. The turnover time gives us an indication of whether one is working with a lake or a river situation. There are species differences between the phytoplankton in rivers and lakes. The river samples are almost always dominated by diatoms while the lake samples more often are dominated by green or blue-green algal species. One would therefore suspect that as a river flows into a reservoir there would be a tendency for river species to decrease in abundance while lake species would increase. If the turnover time were too short, this process would be only partially complete.

A short turnover time would also tend to reduce the rate at which the lake species could multiply since there would be a constant drain on the population through the outlet. Studies show that there would be relatively little algal growth in the Red Rock and Coralville Reservoirs under average turnover conditions, while the Ames Reservoir would have growths that are close to the maximum that would be found with no through flow at all. In this case, nutrient conditions would play the major role in controlling population numbers.

It appears that the Ames Reservoir can be treated as a lake in projecting the possible algal populations in most years. Empirical evidence shows that concentrations of phosphorus and nitrogen play the decisive role in determining the size of the algal crops of lakes. Phosphorus seems to play the key role in the midwest because many of the blue-green algae have the capability of using molecular nitrogen to meet their nitrogen needs. One approach has been to look at the concentrations of these elements in lake waters in the spring just prior to the growing season.

The lakes that developed blooms generally had concentrations of phosphate phosphorus in excess of 0.01 mg/l and inorganic nitrogen of 0.3 mg/l. The values for the Ames Reservoir (0.199 mg/l P and 3.89 mg/l N), as estimated from the potential concentration, exceed these levels by several times. Another approach includes the calculation of the nutrient inputs to a lake on the basis of grams of nutrient per square meter of surface area per year. This value, in combination with the mean depth of the lake, determines whether it will be oligotrophic (low productivity) or eutrophic (high productivity). For a lake with a mean depth of about 16 ft such as the Ames Reservoir, the critical input values for phosphorus and nitrogen are 0.13 g/m^2 and 2 g/m^2 N. The calculated values for the Ames Reservoir are 0.92 g/m^2 and 17.95 g/m^2 N. On this basis the Ames Reservoir would be well into the eutrophic range. This is the typical state for lakes in Iowa, as evidenced by algal blooms in both natural and constructed recreation lakes.

A more quantitative comparison can be made by using the data for the six lakes cited in Table 6-5. Along with the annual nutrient inputs, measurements were made of the summer algal populations using the chlorophyll _a_ extraction technique. An additional effect of these algal growths is to reduce the water clarity. This is commonly measured by lowering a 10-in. white disc (Secchi Disc) down into the water until it is no longer visible to the eye. The depth at which it disappears is a measure of the clarity of the water. The relationship between Secchi Disc depths and algal populations as measured by chlorophyll _a_ concentration was also studied. From this data it was determined that the summer chlorophyll _a_ values in the Ames Reservoir would be on the order of 400 mg/m^3, as predicted from the phosphorus relationship, and in the summer the disc would disappear from sight at about 1.6 ft. This compares with experimental summer values of 7.2 ft in Lake West Okoboji, 4.3 ft in Rathbun Reservoir, 3.0 ft in Big Spirit Lake, 2.6 ft in Lake East Okoboji, and 1.6 ft in Red Rock Reservoir.

Summary

Using various means of calculation, it is concluded that there will be substantial blooms of plankton algae in the Ames Reservoir and that as a result the water clarity will be quite low. There will, however, be exceptions to this statement. Summer floods can be expected to reduce the levels of the algal populations through the shortening of the turnover times as previously discussed. On the other hand, there will be compensating increases in inorganic turbidities due to the increased load of suspended materials in the floodwaters themselves. This will tend to keep the visibility low. On the basis of observations on other lakes with algal problems, we can also expect unpredictable periods when the waters will clear even though the nutrient levels are high. Looking at the fauna of the lake exclusive of the fish, we can expect a total loss of the benthic invertebrates presently found in the Skunk River. With the creation of a standing water habitat, one would expect to see the establishment of a typical lake fauna in the bottom sediments of the lake. The most important forms in the bottom sediments as predicted would be larval midges (Chironomidae) and small aquatic worms (Oligochaeta). A zooplankton population would also be established in the open waters.

Effects of the Story City Water Pollution Control Plant

The Story City water pollution control plant lies at the headwaters of the Ames Reservoir so that its effluent will be directly introduced into the waters of the lake. This situation is usually undesirable because of the nutrient concentrations in the treated effluent. In this case, however, studies have shown that the nutrient load from the plant is small in relation to the agricultural nutrient load of the stream. On the other hand, it was noted that this plant frequently is very poorly operated; raw sewage was introduced into the Skunk River on several occasions in 1970. This is highly undesirable from a public health standpoint if the lake is to be used for recreational purposes. With proper operation of the plant, however, there is still a possibility of pathogenic organisms being introduced in the waters of the lake through the effluent. Chlorination of the effluent should be considered. Complete diversion of the effluent away from the lake would be a more desirable solution for complete safety, and a solution is included in Appendix 5. The chlorination requirement should apply to all of the nine alternative development opportunities.

Alternatives

Alternative multi-purpose reservoir plans having a lower conservation pool level would reduce the turnover time and reduce the chances for thermal stratification. There might also be some reduction in the algal populations if the turnover time were on the order of those found in Coralville and Red Rock Reservoirs. On the other hand, it would still be a highly fertile body of water with the same potential concentrations of plant nutrients and thus might still have algal problems during periods of low flow. Otherwise, the limnological conditions would not be greatly different from those outlined for the 940 and 950 ft pools.

There was insufficient information available to make an evaluation of the Bear Creek or Dam-site subimpoundments. Presumably, the nutrient concentrations in Bear Creek are similar to those in the Skunk River, so that it would probably be a very productive body of water similar in character to the small impoundments presently operated by the county conservation boards in central Iowa. The greatest similarity which can be suggested is the Hickory Grove Lake of the Story County Conservation Board. It was a sparkling clear lake for the first several years after being completed in the mid 1960's. However, with a large input of nutrients from agricultural lands in its watershed, algal growth and associated blooms and infestations of aquatic weeds have each year increasingly become a nuisance problem. Treatment is being made periodically to combat both aquatic weeds and algal blooms.

Reservoir Fishery Potential

Projected Populations in the Reservoir Pool

When a river environment is altered due to impoundment, certain changes in the structure of the fisheries population are inevitable. Those fish requiring moving water, riffle areas, or holes with rock and gravel substrate will be reduced in numbers or lost entirely. Other fishes which prefer bodies of stationary water will increase in numbers. Because of the large increase in water volume that occurs when rivers are impounded, the total biomass of fish in the area will increase greatly, thus potentially making more fish available to the fishermen.

Of the game fish that are found in the stream at the present time, only the smallmouth bass will suffer due to habitat loss. Unfortunately, this species offers the greatest opportunity for sport fishing in the Upper Skunk River at the present time. The smallmouth bass prefer relatively clear streams of moderate gradient with rock and gravel substrate. These bass are also found in small numbers in clear water natural lakes in Iowa which contain rock and gravel bars for spawning and feeding. Numerous attempts have been made by the Iowa State Conservation Commission to establish this species in various artificial lakes across the state. To date, no success has been realized from these stockings. If built, the proposed Ames Reservoir or one of its alternatives would have a stream entering it of ample size and flow to allow smallmouth bass to naturally reproduce in it. Unfortunately, most of the prime habitat for smallmouth bass that is in the river at present is found downstream from the headwaters of the proposed reservoir site. Because the smallmouth bass habitat in the stream above the reservoir site is minimal, it is felt that any reproduction of smallmouth bass that does occur in this area of the stream will not provide enough fish to create a smallmouth bass fishery.

Certain forage fish will also decrease in numbers due to the impoundment of the river. It should be pointed out, however, that these species will continue to reproduce in the river above the impoundment, because their habitat requirements are not as restrictive as those of the smallmouth bass. There could be token populations of these species present in any proposed reservoir at various times of the year. However, there is an ample supply of forage fish in the river that do quite well in impounded waters, and these fish should supply an ample forage base for the reservoir.

Certain game and rough fish that are now present in the river will increase in abundance greatly as a large void is created with the impoundment of the river. Certain other game species not found in the river would be introduced into any proposed reservoir in hopes of creating a new fishery.

In predicting fish populations of the Ames Reservoir, characteristics from artificial lakes and reservoirs in the state of Iowa were compared with characteristics of the proposed Ames Reservoir. By using only impoundments from one midwest area, it was felt that the variable of growing season, watershed type, and water quality of the influent stream could be considered relatively constant for all impoundments studied.

In reviewing data from Iowa impoundments, it was determined that the variables of turnover rate, watershed-area ratio, and the morphometry of the lake basin are most important in determining differences in fish populations of Iowa's artificial lakes and impoundments. Turnover rate and watershed area ratios express the same basic concept in that they both give indications of the retention time of the water in the impoundment. The watershed-area ratio is expressed as the volume of lake per one square mile of watershed. Smaller watershed-area ratios indicate shorter turnover rates for a lake.

Using the turnover rate alone as an indication of sport fishing that will be available in the Ames Reservoir, it could be said that sport fishing will be somewhere in between that experienced in Rathbun Reservoir and that experienced in Coralville and Red Rock Reservoirs. Sport fishing is considered to be far superior in Rathbun Reservoir as compared to those reservoirs with short turnover rates such as Coralville and Red Rock Reservoirs.

Watershed-area ratios have been calculated for various artificial lakes in Iowa as well as for the proposed Ames Reservoir. A ratio of 80 ac-ft per sq mi was obtained for the Ames Reservoir (Alternatives 1, 1A, and 5) and compared to 36 ac-ft sq mi for Beeds Lake in Franklin County, 85 ac-ft/sq mi for Don Williams Lake in Boone County, and 272 ac-ft/sq mi for Hickory Grove Lake in Story County. The ratio would be about 2/3 of this for Alternatives 2 and 6. Given these ratios, it was decided that Don Williams Lake could be used to best determine fish populations and sport fishing potential of the Ames Reservoir.

Anglers have been experiencing good sport fishing in the 5-year-old lake the past two years. Water clarity is low in the lake because of heavy algal blooms, and it remains to be seen how the fishing holds up in future years. Carp populations are strong in the lake even though a fish eradication program was used on the watershed of the lake prior to impoundment. Although present, the carp population is not thought to represent a threat to sport fishing at the present time.

Analysis of data from Iowa impoundments showed that the relative abundance of shallow water areas was the most important factor of the impoundment's morphometry in determining relative abundance of game and rough fish species. Shallow water areas act as spawning and feeding grounds for many species of fish. Rough fish species favor a mud bottom and most game fish species tend to favor a rock-gravel or sand bottom. Assuming bottom type in a majority of Iowa impoundments to be that of mud, it was determined that an abundance of shallow water areas in an impoundment favored rough fish populations. Data from impoundments in Iowa also show that shallow impoundments tended to have more trouble with rough fish populations than do deeper lakes.

The Ames Reservoir site is characterized by sharply sloping banks and good depths of water in the lower two-thirds of the impoundment. Using appropriate criteria to evaluate the fisheries potential of the proposed Ames Reservoir, predictions have been made concerning the species abundance in biomass of fish present in the reservoir and the species harvest by sport fishing in the reservoir. Listed on Table 6-6 are the main species of fish expected to be found in the reservoir alternatives and their percentage abundance.

Fishing for sport fish, especially those species considered as pan fish, should be quite good in the proposed Ames Reservoir (Alternatives 1, 1A, and 5), especially during the first years after impoundment. The lower two-thirds of the reservoir should provide the best areas for sport fishing because of the sharply sloping banks and because inorganic turbidity will be less of a problem in this end of the lake. Rough fish will be present in the reservoir in high numbers. These fish should be most abundant in the upper one-third of the impoundment because of the abundance of shallow areas in this part of the reservoir.

As impoundments grow older, sport fish harvest tends to decrease. Game fish have good initial year classes in the impoundment because of the large void that is created when the lake is formed. Reproduction of

Table 6-6. Projected rough fish and game fish species in the Ames Reservoir with percent abundance expressed in terms of biomass.

Category of fish	Percent in each category
Rough fish Carp River carpsucker Quillback Highfin carpsucker White sucker Bigmouth buffalo Northern redhorse	75
Game fish, pan Bullhead (black and yellow) Channel catfish Crappie (black and white) Bluegill Green sunfish Orange-spotted sunfish	20
Game fish, bass and pike Largemouth bass Northern pike Walleyed pike	5

rough fish in the impoundment is also good in the initial years after impoundment, and it is not long before the rough fish become so abundant that they cut down on the reproduction of game fish by disturbing nests and by causing increased turbidity due to their feeding habits.

It is hoped that this detrimental interaction of rough fish upon the reproduction of game fish can be confined to the upper one-third of the reservoir where rough fish species will be most abundant because of the abundance of shallow areas. If this proves to be the case, then game fish species could continue to provide good sport fishing in the reservoir, especially in the lower two-thirds of the impoundment.

Ecosystem Summary and Comparison of Coralville and Ames Reservoirs

Ecosystems Ecology

Ecology as a scientific discipline is concerned with the interrelationships among organisms and with the physical environment in which they live. Simultaneous studies of groups of organisms in an area require explanation of principles governing their reproductive success, abundance, interactions with each other, and related processes. The organization of ecological systems is thus deduced, and factors influencing the nature of the structural organization and the functionings of ecosystems are delineated. The philosophy of ecosystems ecology is to ask certain questions regarding the structuring of ecological systems as a function of the species of plants and animals present.

In this summary of the environmental impact study conducted by research teams at the University of Iowa and Iowa State University, two questions were asked. First, what is the extent of environmental degradation expected if the reservoir is constructed? This question was posed in terms of the biological communities present. Studies were conducted at the proposed site of the Ames Reservoir and at the Coralville Reservoir, and some idea of the extent to which ecosystem disruption might occur was obtained. Two ecosystems components were studied. The terrestrial plant communities in flood plain areas of the Skunk River and along the Coralville Reservoir were compared to each other and to a lowland prairie. Comparisons of the vegetation before and after a period of high water were made in order to evaluate the effects of flooding upon the vegetation. The objective of this study was to quantify the effects of environmental perturbations upon the plant community.

The second ecosystem component investigated was the vertebrate communities. Both aquatic and terrestrial ecosystems at the Coralville Reservoir were studied with respect to the structure of the vertebrate communities. These were compared to similar communities in a marsh in which the water levels fluctuate to a much lesser extent. Qualitative differences obtained were related to the environmental perturbations introduced by the construction of the Coralville Reservoir. Predictions concerning the fish communities in the Skunk River following dam construction were made based upon these analyses and also upon those of the Coralville Reservoir fish communities. From all three investigations, the nature of the environmental degradation to be expected upon reservoir construction (Alternatives 1, 1A, 2, 5, and 6) was deduced.

The second question asked was "What is the intrinsic value of upper Skunk River as an area containing natural ecosystems?" Answers to this question were obtained primarily in relation to the fish communities of the Skunk River above Ames and their uniqueness as a natural resource to central Iowa. The fish communities were analyzed with respect to changes that have occurred as a result of dredging the headwaters and alterations of the river below Ames. The complexity of the stream fish communities was analyzed with respect to other aquatic ecosystems and to other stream-river systems. The status of species present was examined in order to discern whether or not any were uncommon or rare in Iowa. The predictions of changes in the fish communities in the Skunk River were used to decide whether or not the natural ecosystems would be severely disrupted by the construction of the reservoir. One cannot really assign an economic value to the natural ecosystems of the upper Skunk River in terms of their intrinsic value. Therefore, a general evaluation was made of the extent to which degradation will occur and what this means in terms of the loss of a natural system to central Iowa, and was reported in detail in Appendix 1.

Environmental Conditions

At present, the Skunk River north of Ames is a relatively undisturbed stream. The headwaters have been dredged, and streams draining those headwaters are primarily in cultivated fields. The headwaters and sandy streams draining those headwaters contain considerable debris and nutrient runoff.

The portion of the stream from about one mile south of the dam site north to about Story City contains the most ecologically diverse and undisturbed habitat in this part of the Skunk River. In comparison with the shifting sand substrates and channelized reaches that characterize the river bottom to the south, the rocky riffles and pools of the stream in the reservoir area support a greater diversity of benthic organisms and fish species. The majority of the game species found in the river in recent years have been found in this portion. This is reflected in the location of the public fishing access at Soper's Mill and the fact that most of the fishing activities have been observed in this area.

If one of the reservoir alternatives is constructed, that area of the river basin to be inundated is that section which presently is relatively undisturbed. Changes will occur in the basic physical conditions including: (1) The open stream system will be converted into an open reservoir system; (2) water levels in the flood pool will fluctuate fairly rapidly; (3) the flood pool area surrounding the conservation pool frequently will be in mudflats; (4) the pool will tend to accumulate nutrients and debris; large phytoplankton blooms and oxygen depletion are expected at times, and the reservoir may become highly eutrophic; (5) some siltation will occur from runoff into the creeks flowing into the reservoir, and erosion of the mudflats and the shifting bottom sand also will result in a silt-sand bottom; and (6) the headwaters will remain relatively unaffected.

Therefore, from the standpoint of game fish populations, ecological diversity, and recreational suitability, the proposed reservoir alternatives would eliminate the best portion of the river in the Ames area. Except for a short reach of about a mile below the dam, the geological character of the valley limits the usefulness of this portion of the river. In addition, the past channelization activities on the river below Ames and the relatively large volumes of effluent from the Ames Water Pollution Control Plant preclude any economic remedial activities that could bring this portion of the river up to the standards of the river in the reservoir area.

The combination of the nutrient levels in the river and the relatively long turnover time of the reservoir will mean that the impoundment will be a fertile body of water. In the summer, it will have heavy blooms of algae that will reduce the water transparency to a couple of feet. Algal blooms of the magnitude expected in the Ames Reservoir when found in other recreational lakes in Iowa have brought public pressures on governmental agencies to "do something about the algae." Where there is no controllable nutrient source to a lake, no techniques are available to solve this kind of problem short of periodic treatments with toxic chemicals.

While the stream fishes such as the smallmouth bass will be eliminated, they will be replaced with a much larger lake-fish population. This will be characterized by a large population of rough fish but should also maintain a substantial population of game species, particularly with intensive management. The poor quality of the river below the reservoir in combination with the variable quality of the outflow will preclude the establishment of a substantial tailwater fishery such as is found below several other Iowa reservoirs.

Plant Communities

At present, much of the river basin between Ames and Story City contains deciduous and flood plain forests. These will be in large part destroyed by the impoundment. In place of the forests, large areas of the flood plain will be mudflats dominated by ruderal plants such as smartweed, sedges, and sour dock. Based upon comparisons with the Coralville Reservoir, it is expected that unpredictable flooding of terrestrial communities will result in retrograde succession to a very simple weedy plant community composed of ruderal species. This plant community will have a small number of species, a low diversity, and a high degree of dominance by weedy species. Such plant communities are capable of withstanding the unpredictable floods but are poorly organized, resulting in an inability to buffer the loss of nutrients, organic materials, and soil to the aquatic systems. Such ecosystems are unstable and fluctuate greatly in terms of species abundance further reducing the protective ability. Such plant communities will have a low esthetic, recreational, ecological, and economic appeal compared to the plant communities now present in the Skunk River basin.

Terrestrial Animal Communities

Comparisons of the Coralville Reservoir to a marsh indicated that the ecosystem simplification affecting the plant communities also affected the animal communities. In this respect, it is expected that massive ecosystem simplification will occur in the terrestrial and semi-aquatic vertebrate communities along the Ames Reservoir. This simplification will be most noticeable in fields and meadows that are periodically inundated. Small mammals and their predators will be very rare or absent, and a very simple food web will exist in these areas. Ecosystem simplification in terrestrial ecosystems will occur by elimination of specialized species, elimination of top trophic levels, and by reductions in the importance or elimination of particular food chains.

Aquatic Animal Communities

Comparison of the fish communities along the Coralville Reservoir flood plain to a marsh also indicated that ecological simplification had occurred in the aquatic communities. The following predictions can be made about simplification in the fish communities in the Ames Reservoir following impoundment. Massive ecosystem simplification will occur in the aquatic ecosystems in the upper Skunk River following impoundment while the basic trophic structure of the headwaters will not be affected. The trophic structure will shift from a benthic invertebrate base in the river channel to a plankton and detritus based food web in the reservoir. The community will decrease in complexity as the system becomes more open, as internal controls are removed, and as the diversity of energy inputs shift towards a more heterotrophic condition. Of the 38 species of fish now present in the area to be flooded, 28 probably will be eliminated. Three or four other species will be present only in the headwaters. The species surviving the inundation will be detritivorous, planktivorous, or omnivorous species. In all cases, highly generalized species will be present, and specialized species will be eliminated. Effects of the dam upon downstream fish communities are difficult to predict. The effects of the silted river bottom and channelization should override effects of the dam. Thus, the downstream fish communities will remain simplified with a low diversity of species present.

The following general conclusions concerning predictions about the Ames Reservoir ecosystems are made:

1) Construction of reservoirs with highly fluctuating water levels results in very simplified ecosystems in and surrounding the reservoir.

2) Such ecosystems are highly unstable.

3) Species with very generalized habits are present in such systems.

4) The ecosystems in reservoir systems lack buffering capacity against environmental changes.

5) Thus there is a tendency for materials, nutrients, and energy to be lost from terrestrial ecosystems and for the aquatic ecosystems to become progressively more unstable.

6) The reservoirs tend to be similar, creating a mono-cultural system out of diversified or multi-cultural systems. Thus, there is less variability available to counteract potential changes and severe alterations.

The unique characteristics of the Skunk River above Ames which deserve protection and conservation are listed below:

1) The Skunk River between the headwaters and Ames exists as a relatively undisturbed stream basin containing a variety of terrestrial and aquatic habitats unique to that region of Iowa.

2) Forests, prairie remnants, etc., act as buffer systems (i.e., as a green belt) that protect the stream basin from the disturbances of man.

3) The stream basin contains fish communities which become progressively more complex between the headwaters and Ames.

4) The fish communities are diverse and tend to become less open as they become more complex.

5) The fish communities along the stream basin are interconnected with internal controls such as predation by specialized species acting to regulate the community structure.

6) There are no endangered species of fish occurring in the stream system of the upper Skunk River basin. Several rare (*Etheostoma flabellare*, *Percina maculata*, *Noturus exilis*) species of fish are present in the Skunk River above Ames. Habitats containing these species need to be preserved in a natural state.

7) Except in the headwaters and below Ames, fish communities in the upper Skunk River are as diverse as those found in unaltered rivers in other parts of the state.

8) Such fish communities as the small mouth bass fisheries are uncommon in central Iowa, and care should be taken that they are preserved in a natural state.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part II. Impact Evaluation of Alternatives

Chapter 7

SOCIAL AND ECONOMIC IMPACTS AND PUBLIC ATTITUDES: CATEGORY 2 STUDIES

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FIGURES

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ARES SUMMARY REPORT

Chapter 7

SOCIAL AND ECONOMIC IMPACTS AND PUBLIC ATTITUDES: CATEGORY 2 STUDIES

Social and economic impacts of the alternative water resource development plans are presented in this chapter. The first section presents a summary of the social impacts and public attitudes, and the second presents a summary of economic impacts. The project benfit-cost analysis is presented in Chapter 11 along with a summary and discussion of all impacts.

Social Impacts and Public Attitudes

This section summarizes the findings of two independent studies as reported in Appendix 2, Parts II and III. The latter study references a larger area and is summarized first. It was conducted by the Dept. of Sociology, Iowa State University. The second report focuses more specifically on the immediate area between Ames and Story City and was carried out by the Institute of Urban and Regional Research at the University of Iowa.

Citizens' Views and Actions

The results of this study follow from interviews with 390 people over eighteen years of age who were selected by a linked process of area-probability and random sampling. The study was made by an Iowa State University research team and reported in Appendix 2, Part III. The sampling area extended upstream to Jewell and downstream to near Bondurant and is shown in Fig. 7-1. This area is in the center of the primary area of influence, including the downstream valley areas receiving flood protection benefits. In this section, the findings are organized by key questions which guided the research. To provide a perspective on the nature of the study, these organizing concepts are listed below:

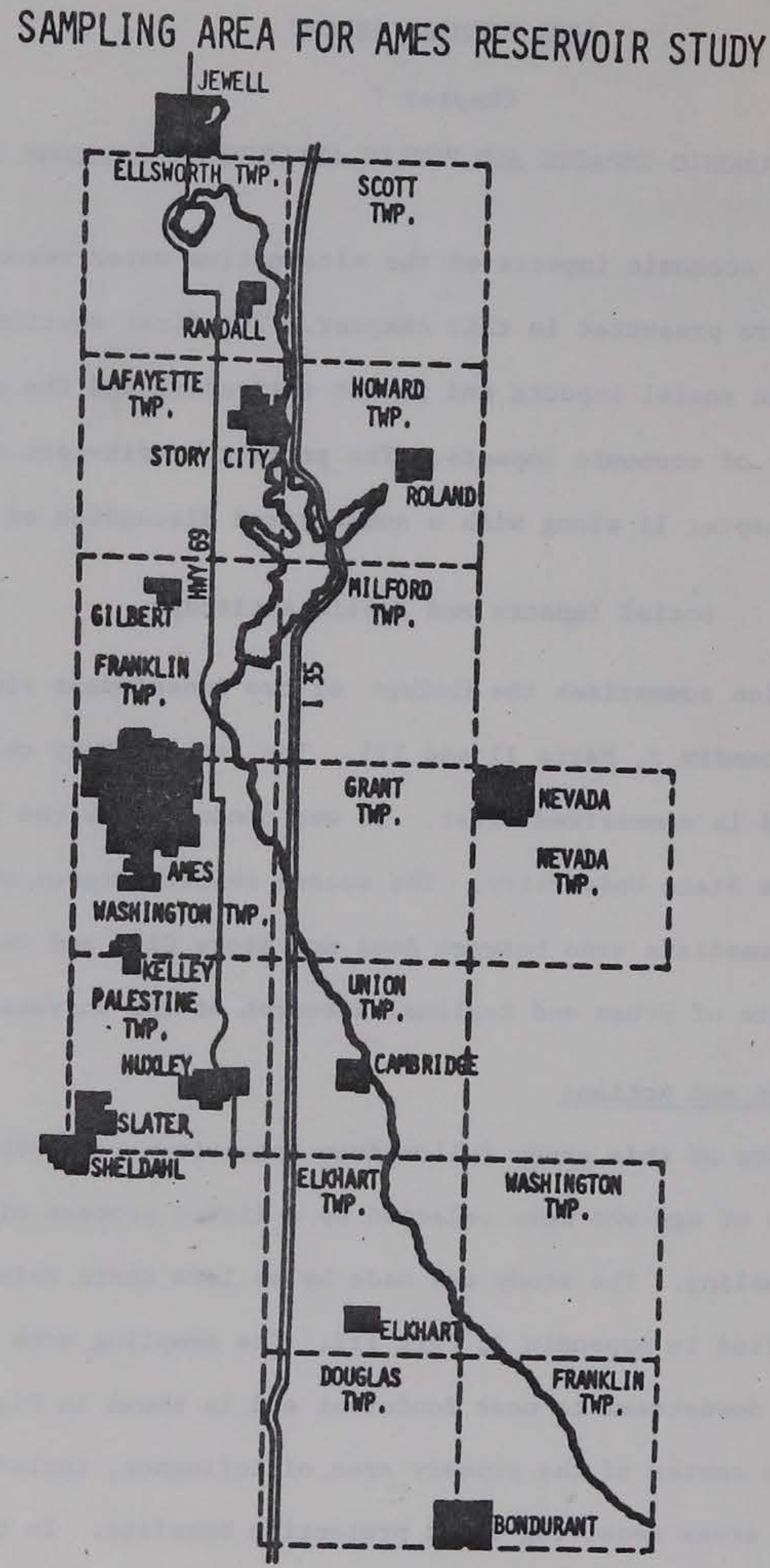

Fig. 7-1. Sampling area for obtaining citizens' views of the proposed Ames Reservoir.

1) What has been the nature of past public response to the Ames Reservoir proposal?

2) What are the present attitudes of local populations toward the Ames Reservoir?

3) What, if any, are the relationships between characteristics of people and their attitudes with regard to the proposed reservoir?

4) What is the nature and level of public awareness about the project?

5) How are the projects' benefits and detrimental effects perceived by the people?

6) What actions have been taken by local people in relation to the reservoir?

These questions, through the concepts they express, were key elements in the construction of the questionnaire. Responses from 390 individuals provide the basis for the summary presented here.

Past Public Response. Information presented by citizens at the 1964 Corps of Engineers hearing on the Ames Reservoir largely dealt with potential personal economic benefits or costs accruing from the project. The 1965 Iowa Natural Resources Council hearings, on the other hand, saw a greater number of noneconomic considerations being raised, such as the possible effects of a reservoir on the natural environment and on local wildlife populations. Outdoor recreation, as a potential benefit or cost of the Ames Reservoir, received little citizen attention at either the 1964 or 1965 public hearings.

Present Attitudes. Approximately 25%, or one-fourth, of the respondents in this study favor building the reservoir; 30% oppose construction; 16% are undecided; and 4% don't care one way or the other. Twenty-four percent of the respondents were unaware of the reservoir project. Using an "upstream/downstream" (from the dam) classification, the sample is split into two groups of 101 and 289 people respectively. Fifty percent of the upstream subgroup oppose the reservoir, 23% favor it, and 8% were unaware of it. Similar data for the downstream group show 24% opposed, 26% in favor, and 30% unaware of the reservoir project. Thus it appears that a large percentage of the population remains unaware or uninformed, except in the immediate reservoir area.

Attitude – Characteristic Relationships. People having favorable and unfavorable attitudes about the reservoir project did not materially differ in their age, sex, income, education, and occupational characteristics. On the other hand, support for the reservoir was found to be positively related to other attitudes. It was found that attitudinal support for the Ames Reservoir was related to a positive attitude toward construction of other reservoirs in Iowa, to a favorable view of the program and operating procedures of the Army Corps of Engineers, and to a developmental orientation toward management of the natural environment.

Public Awareness. One-fourth of the respondents were unaware that a project such as the proposed reservoir might be built; about two-thirds were unaware that the Army Corps of Engineers was the government agency spearheading the project; and about three-quarters of the respondents were unaware that public hearings had been held on the project.

Of those knowing about the project, many respondents indicated that the Army Corps of Engineers had made little effort to acquaint the general public with plans or rationale for the proposed reservoir.

Only a small proportion of respondents felt that flooding and poor water quality were serious problems on the Skunk River. Furthermore, persons who perceived such problems tended to feel that alternative plans posed better solutions to the problems than did construction of the Ames Reservoir.

Perceived Benefits and Detriments. Flood control and recreation are perceived by the people as the two most important justifications given by the government for the Ames dam. Their own opinions about problems are the following: 65% feel there is a lack of water-based recreational opportunities in the local area; 54% feel flooding to be a problem on the Skunk; and 41% feel water quality is a problem. Generally, those who oppose the project agree that it will (a) flood too much farm land (77%), (b) benefit too few people (81%), (c) seriously damage wildlife habitat (79%), and (d) reduce the physical attractiveness of the valley (72%). Conversely, of those who favor construction of the reservoir, only 10 to 20% perceive the above-mentioned social and economic costs.

Only a small proportion of the respondents, about seven percent, had engaged in actions designed to influence governmental decision-making on the Ames Reservoir, such as signing petitions, writing letters, speaking to government officials, or attending public hearings. A larger proportion of persons opposing the project, than of those favoring it, were found to have been active in efforts to influence decisions on the reservoir; the ratio is about four to one.

Proponents of the Ames Reservoir project were more likely than were opponents to feel that opportunities for citizen involvement in government decision-making were adequate, and concomitantly, they were less likely to perceive a need for increased provision for such participation in the future by government agencies.

Local Sociological Impact

Turning now to the immediate impact area, this summary focuses on an interpretation of a nearly complete survey of families in the restricted area of Fig. 7-2. This study was conducted by a University of Iowa research team and reported in Appendix 2, Part II. Data were attained from 92 families representing 361 individuals.

Classification of Respondents. The region surveyed was sufficiently restricted such that the people surveyed will all experience some effects of the reservoir. Broadly speaking, three classes of people can be defined based on these effects, namely:

1. those who will be displaced by the project,
2. those who will not be required to move but who may be required to give up property and/or find themselves very close to a significant environmental change, and
3. those who will experience only external effects.

The latter group consists of those in locations which will experience increased traffic and traffic noise from the lake attractions, loss of neighbors and social ties, removal of an aesthetically pleasing river valley environment, or a dozen other tangible and intangible (sometimes subtle) effects. The category of people defined by the external effects actually is much larger than the number of people interviewed. Theoretically, if recreational benefits are to be derived from a 25-mile radius, then it must be the case that the reservoir exerts some influence over all people within this circle of influence.

There are numerous perspectives from which to view the sociological impact of the Ames Reservoir. Thus, in the above paragraph, a somewhat spatial or geographical tricotomy was suggested. A temporal view is also necessary. Here, also, at least a tricotomous classification is

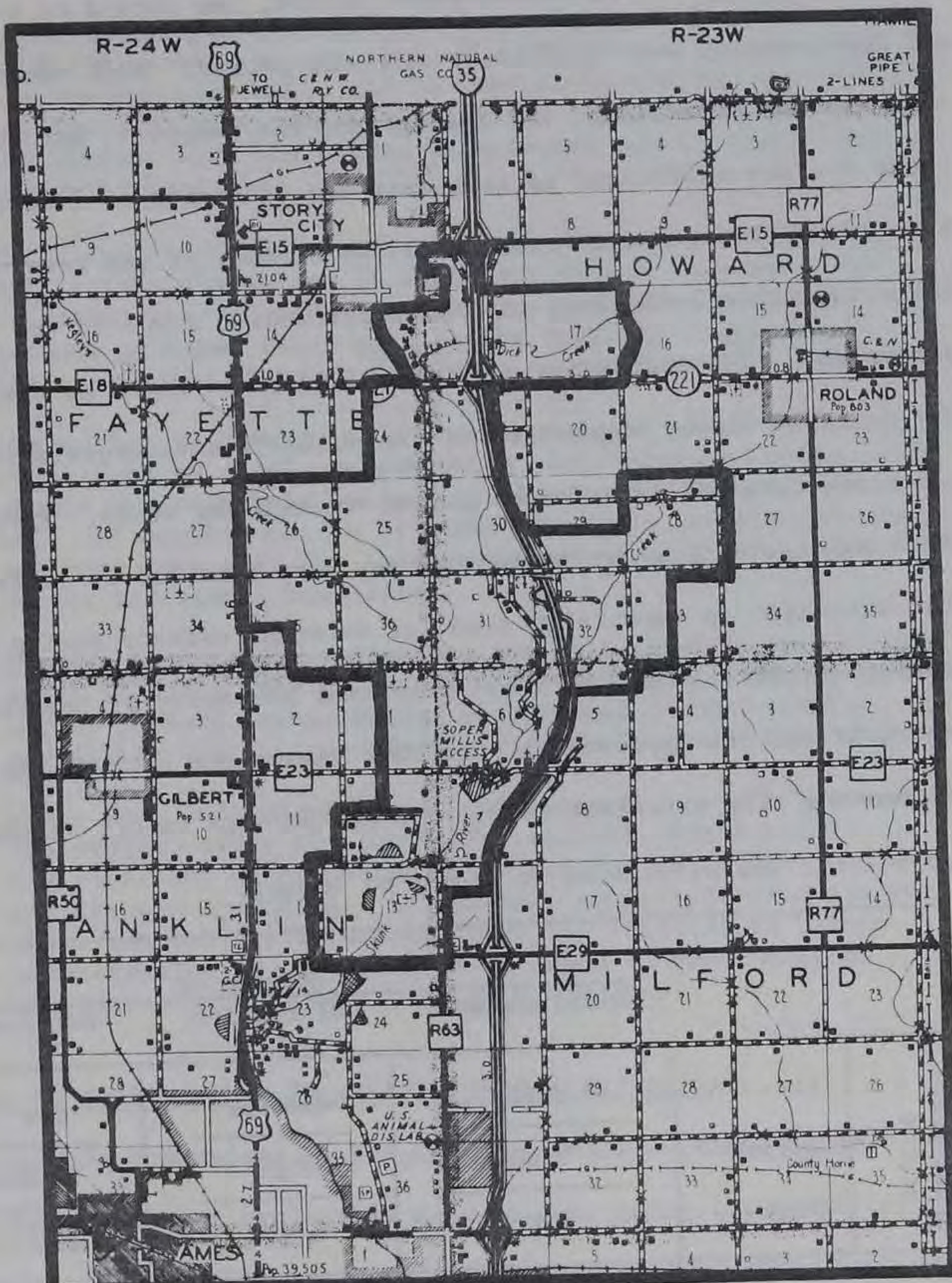

Fig. 7-2. Reservoir area surveyed for immediate impact of the proposed reservoir.

in order namely, the pre-development period, the period of construction and development, and the post-development period. More numerous levels of these two dimensions, the spatial and the temporal, are possible, but these few are sufficient to elucidate the diversity of impacts that have and will occur with respect to the history of the reservoir. The following table symbolizes the characterization drawn in the above paragraphs. The indication of "Low, Medium, and High" as displayed in the table is simply suggestive of the subjective interpretation of interview data and experiences gained through the study. Further, these aggregate or group indicators may vary somewhat by individual. This situation is especially true for external effects during post-development because of the varying spatial proximity of families to the reservoir and its approaches. For this reason the cell of the table referencing this situation is given a Medium/High impact rating.

Table 7-1. Classification of degree of impact.

		Region of		
		Displacement	Disruption	External effects
development status	Pre-	High	Medium	Low
	Active	High	High	Medium
	Post-	Low	High	Medium/High

The survey conducted for purposes of this study reference nearly 460 people. Information given during the interviews indicates that:

1. Anticipated displacees include 173 individuals in 55 households, plus a trailer court with perhaps 100 occupants.

2. An additional 28 households (113 individuals) will undergo a significant disruption in their lives.

3. Twenty households (75 individuals) were interviewed that will notice the presence of the reservoir through external effects.

4. The 55 anticipated displacees interviewed included 20 households that rent who are generally short-term residents of their current dwelling unit and 35 owners who average over 15 years residency in their present location. As a group, the renters are younger than the owners as measured by the age of the household head.

5. While the individual families (both displacees and otherwise) will suffer disruption in their activities and severance of social interactions, that most organized functions (school systems, etc.) will not be severely disrupted in their planning shows an awareness of the impending transition.

6. The valley is undergoing a slow process of conversion from rural-farm to rural-nonfarm which shows signs of increasing should the reservoir project be abandoned. Land is currently held for development in at least two cases and much interest has been expressed for land in the valley for this purpose or for individual home sites.

7. Current land-taking guidelines and past experiences indicate that, if built, the reservoir will eventually become "locked-in" by private developments with public lands becoming physically and psychologically restricted for public use.

8. While many individuals have been opposed to or in favor of the project since its inception, support from elected officials and governmental officials has often been contradictory and confusing. In general, support for the project, which was publically expressed by the legislature before authorization in the mid-1960's, seems to have weakened considerably for a multiplicity of reasons.

Discussion of Sociological Impacts and Public Attitudes

The studies summarized in the two preceeding sections suggest that the Ames Reservoir project is many things, often incompatible, to different people. To some it offers the prospect of their favorite outdoor recreation, but for others the favored pastimes will require travel to another part of Iowa. Through flood control, the reservoir offers more prosperous times to downstream farmers while taking upstream farms out of production. The reservoir would produce desirable lake-side properties for residential development but would displace numerous families from their present homes. Construction and operation of the reservoir would provide a fiscal infusion to the local economy but it would remove thousands of acres from the tax base and valuable agricultural elements from the local economy.

The reservoir has been in the planning stage for many years and has produced a situation that is both unfortunate and noncorrectable. Long-term residents of the project area have lived with (to them) a threatened future for many years and have spent uncountable hours trying to prevent or reverse plans for the reservoir. In contrast, there are many short-term residents of the region who have never heard of the project and neither have been, nor would be affected by it in any significant manner. Yet the presence of a newcomer in the region increases the recreational potential of the project and thus the probability of its eventual construction, while no accounting of the others' discomfort enters the quantitative assessment of the project.

The evaluation of the reservoir project is an exercise in explicit and implied trade-offs. The material summarized in this chapter is meant to convey significant sociological implications of the planning and development of the reservoir. Of all the trade-offs that must be made when evaluating natural resource developments, those involving people seem the most difficult. The general practice of converting the impact, either good or bad, to dollars has not been attempted for many of the people-related issues. This could be accomplished, perhaps, but would require intensive study and questionable assumptions. Those familiar with highway planning are aware of the many years of effort that have gone into the determination of the value-of-travel-time, with as yet inconclusive results. Such efforts invariably increase the importance placed on those issues that can be quantified. But it is not enough to refine the quantitative methods of natural resource development without improving the quality of the planning also.

Two examples have been selected to clarify the above point. Consider first the issue that future recreationists will be disappointed because of inadequate facilities at the Ames Lake public use areas. The quantitative approach might suggest that a lower value be placed on a disappointing recreational experience than on a pleasing one. The second example relates to the contention that, for some, psychological or psychosomatic illness may result from the insecurity of an extended planning period. It might be suggested that such factors could be brought into the monetary evaluation by determining the psychiatric and medical expenses that should normally occur during such a period of stress. These could then be added to the cost of the project. Each example, however, produces a counter-productive theme. The obvious response is to eliminate the situations rather than work to give their existence legitimacy through reparation.

The above discussion and examples serve to illustrate the very real people-related impacts associated with natural resource development. Where appropriate, monetary factors have been calculated for inclusion in the economic analysis, and where not appropriate the situation has been discussed with a view toward enhancing a positive effect of the reservoir or preventing or ameliorating a negative effect. It surely has not been possible to discuss all issues in this manner or even to identify them, but, hopefully, the attempt that has been made will improve our ability to make the required trade-offs.

Economic Impacts

The economic impacts of the Ames Reservoir project are analyzed by assessing the project benefits and costs, the indirect economic effects, and the associated economic impacts. The benefit-cost analysis of the water resource development alternatives are presented in Chapter 11 — Summary of Detailed Project Evaluation — and the indirect economic effects and the associated benefits and costs are discussed in this section. Prior to discussing these economic impacts insofar as they relate to the Ames Reservoir, a brief overview of project impact analysis is presented.

Project Impact Analysis: A Brief Overview

Traditional discussions of evaluating public projects focus on either benefit-cost analysis in its more conventional forms or cost-effectiveness analysis, the latter being distinct from the former by the absence of any requirement to be able to assign monetary values to all project outputs. An extension of cost-effectiveness analysis might be called "impact analysis" (or "trade-off analysis") where an effort is made to systematically account for all of the monetary and non-monetary impacts of a project, by proximity to the project, and by group affected. This follows from the above discussion of the stages in the planning and evaluation process. To implement this sort of an approach — which has been spelled out in Public Water Resource Project Planning and Evaluation: Impacts, Incidence, and Institutions (See Appendix 2) — it is necessary to start from a clear definition of the different types of project impacts.

In the above document it was argued that there should be explicit recognition of two major categories of project impacts: (1) monetary; and (2) nonmonetary. As for the monetary impacts, there are two subcategories, with further definition within each. Specifically, there were said to be two kinds of monetary impacts: (1) those which received their monetary value from workings of the market — called "market-valued;" and (2) those which received their monetary value from other sources — called "nonmarket-valued." Each of these categories will be discussed in more detail below.

As for the "market-valued" class of project impacts, it was argued that there are three possible ways to arrive at estimates of value for project outputs. Where the output is to be used directly in a productive process, it is possible to impute a derived value to the project output based on the market value of the good or service made possible by the project. Irrigation is the standard example here, water not being priced in a perfect market but constituting an important input into commodities that are. This method of arriving at the value of project output (in this case irrigation water) is referred to as the "intermediate good method."

In those instances where the output of the project is not used directly in a productive process, it is impossible to employ the intermediate good method. Instead, it is necessary to improvise in certain ways. One obvious way is to attempt to determine the value of the project output directly through establishment of a demand curve for the output from which value inferences can be derived. The obvious example of this approach is to be found in the area of recreation demand studies;

attempts to determine willingness to pay for a site proceed from the assumption that travel costs to the site portray some estimate of the consumers' subjective evaluation. This approach has been referred to as the "inferences from price-quantity behavior" approach.

The final category of the market-valued monetary impacts is for those situations where the project output is very similar in magnitude and nature to that being produced by the private sector nearby, for which market values exist. The "market analogy" approach employs these "comparable" values to draw inferences about the value of a project output. Again, recreation is a good example; private recreation facilities exist and charge for access to the same sort of services (in some cases) as are available from a public project.

For the second major category of monetary impacts — nonmarket-valued — values are not placed on project outputs from the demand side, however indirect that demand relationship may be. Instead, these values arise either from the political process or from cost estimates for doing similar things in terms of project output in the absence of the federal project.

Taking the latter situation first, the "alternative cost" approach is that method employed to arrive at monetary value for project output using the cost of the "most likely alternative in the absence of the project." The rationale is rather straightforward: if a particular output will be produced anyway without the federal water resource project, then what it would cost to do it by some alternative means provides an estimate of the benefits from doing it with the federal project. That is, this amount represents what would be saved by not having to employ the alternative and is a "benefit." The emphasis in the above on "will be produced anyway" is central here and explains why economists are out of sympathy with agency practice in this regard. Specifically, two issues arise. The first is whether or not the particular output would <u>in fact</u> be demanded in the absence of the federal project. The second is the cost savings inherent in joint production. The latter issue is simple and will be discussed first.

If a reservoir is to be constructed for flood control purposes, the incremental cost of including a little "recreation," or a little low-flow augmentation for water quality improvement downstream, or a little extra capacity for municipal and industrial water supply often is minimal. On the other hand, if an agency gets to count as "benefits" from all of these aspects what it would cost to obtain the same quantity and quality of output in the absence of the project, then the overall economic evaluation of the project is very much biased in favor of high benefits. That is to say that the "most likely alternative" way of providing the above outputs will almost always be more expensive than their inclusion as part of a multi-purpose project — thus guaranteeing that the overall benefit-cost evaluation of the project is biased upward.

Of course, if there were an effective demand for the project output in question then the alternative cost approach is perfectly legitimate. However, the extent to which this is true is open to some question. Indeed, almost no effort is expended to determine effective demand for those project purposes evaluated by the alternative cost approach — precisely because demand estimates are so difficult to undertake. Hence, in the absence of very much information about the demand for many project purposes, they are included on the basis of the alternative cost approach and in the process have a significant impact on the evaluation of the entire project.

The second nonmarket approach to project output evaluation can be referred to as the "administrative fiat" approach. Prices (value) of project purposes are established either by the legislative or the executive branch for widespread application. The classic example of this approach (one mentioned elsewhere in this report) is the valuation of recreation in Supplement No. 1 to Senate Document 97 entitled: Evaluation Standards for Primary Outdoor Recreation Benefits as developed by the Water Resources Council in 1964.

The second category of project impacts, those referred to as nonmonetary, present a slightly different problem in the valuation of project outputs. Here, the problem is not one of determining whether or not market values exist, but of displaying in an accessible fashion those project impacts for which no monetary values exist, and none are likely to exist. For such effects, there is little choice but to articulate them in such physical terms as miles of natural shoreline destroyed, surface acres of a reservoir created, minimum and maximum flows for certain reaches of the river, and minimum and maximum temperatures for both the reservoir and the downstream reaches.

The above discussion emphasizes the need for broad impact evaluation and the inappropriateness of translating all effects to dollars. Nevertheless, economic impacts of the Ames Reservoir project are significant.

Indirect Economic Effects

The literature on economic impacts of water-resources development projects distinguishes between primary (monetary) benefits and secondary (monetary) benefits. Primary benefits refer to physical linkages, either directly between a project and users of its outputs or indirectly via technological externalities. Secondary benefits refer to indirect market linkages or pecuniary externalities of a given project.

This discussion deals exclusively with secondary benefits. Direct primary benefits (i.e., patterns of various beneficial uses) and indirect primary benefits (e.g., reduction in production losses and land enhancement via flood control) are analyzed in various chapters throughout this report. Hence the discussion here focuses on interindustry pecuniary linkages which the literature identified either as "stemming-from" or "induced-by" benefits.

Whether these secondary benefits may legitimately be included within a formal benefit-cost evaluation is a point of controversy in the literature and, indeed, in this particular study as well. The main concern here is merely to determine the rough order-of-magnitude of secondary benefits relating to the major project purpose of flood control, for distributional insights if not for project efficiency appraisals. In any event, the main concern of this discussion requires specific examination of those alternatives which provide some degree of flood protection.

The purpose for estimating indirect economic effects was to develop rough order-of-magnitude estimates of "secondary" economic consequences of flood-protection alternatives. Based largely on anticipated strengths of various industrial interest groups, this selective analysis was limited to immediate linkages of the agricultural sector with the farm machinery and the food and kindred products sectors. Although including these impacts in the project benefit-cost analysis would constitute double counting in this case, the estimates were considered to be of some interest in terms of impact incidence.

Given the limited concern for these effects in contrast to other impacts throughout the study, the analytical methodology employed was quite approximative, involving a host of assumptions which a more intensive inquiry might have relaxed. This methodology yielded first-order estimates, Table 7-2, of "induced-by" and "stemming-from" effects.

Results shown in the table indicate the estimated "induced-by" impact upon output level of the farm machinery sector is quite small, about $1000 per year for the flood control alternatives. Assuming the entire increment in raw agricultural products would be utilized and that all other inputs to the food and kindred products sector would be increased according to corresponding technical coefficients, then the resulting impact is near $80,000 per year. From this perspective, the flood control alternatives of 1, 1A, and 5 are indistinguishable. This is not surprising because the alternatives differ in land-utilization concept rather than in their physical configuration. Alternative 6, the reduced-scope multi-purpose project, shows a slightly lower expected output level for these secondary impacts.

Table 7-2. Summary of induced-by and stemming-from "secondary" impacts.

Alternative	Direct agricultural impact			Output factor		Output level	
	Downstream	Upstream	Net	Induced	Stemming	Farm machinery	Food and kindred products
1	$444,900	$179,593	$265,307	0.0038	0.312	$1,008	$82,775
1A	444,900	179,593	265,307			1,008	82,775
2		(63,705)[a]	(63,705)			(242)	(19,875)
3		Minor impacts					
4		Minor impacts					
4A		Minor impacts					
5	444,900	179,593	265,307			1,008	82,775
6	375,738	123,864	251,874			957	78,585
7		Not applicable		0.00038	0.312		

[a]This project is of a different scope and provides no flood control benefit.

Associated Economic Impacts

In addition to the project benefit-cost analysis and the indirect (secondary benefits) economic effects, the Ames Reservoir project would have a set of associated economic effects that would impact the local economy. Some of these associated economic impacts are discussed below.

An analysis of regional management of water quality in the upper Skunk River basin (see Chapter 7, Appendix 5) indicates the need for a regional sewer system to divert outflow from Story City around the proposed reservoir to Ames and to collect sewage from developing lands in the western portion of the reservoir area. This system would have a capital cost of $1,310,000 (annual cost of $94,400 at 7% for 50 yr) and an annual operations and maintenance cost of $131,000. For water quality reasons, this system is considered essential if one of the reservoir alternatives is selected. Although this cost is not included in the benefit-cost analysis, the ARES review team considers the regional sewer system essential for reservoir alternatives and desirable for all alternatives.

The acquisition of land and improvements for the reservoir and dam will result in significant loss in property tax. The ARES review team estimates the land and improvements acquisition cost to be $4,729,100, which will result in an annual tax loss of $134,000 (based on 27% valuation and 105 mills). This loss in tax revenues compares to an estimated increase in land valuation in proximity to the reservoir of $870,000. This increase in land valuation assumes that 2000 acres of developable land will increase in value from $800 to $1600 due to the reservoir and the regional sewer system. This increase will generate property tax revenues of $27,000 annually. One-third of that increase would probably occur without the reservoir because of general northerly developmental pressure from Ames. It is also assumed that 20 houses per year will be constructed in the area for 50 yr, and that one-half of those are attributable to the reservoir and regional sewer system. This process is assumed to begin in 1976. This cumulative effect of taxable improvements is converted to a present worth of $45,600,000 and an annual taxable income of $103,000.

The annual loss of tax income in the total reservoir area is estimated to be $134,000. This is nearly offset by an increased tax income of $130,000, which occurs primarily in Franklin Township. The tax loss occurs nearly equally in four townships with the increase occurring in only one. Additional costs to service this rural nonfarm population have not been estimated but should be considered. In addition, it should be recognized that growth in the reservoir area is not bringing new growth to the county, but is a redistribution of growth which would otherwise occur, probably in Ames.

No increase in property valuation downstream is attributable to flood protection. Land values in the downstream flood plain do not reflect a serious flood problem at the present time. Because major flooding has not occurred in recent years which would be comparable to 1944 and 1947 floods, land values in the flood plain are considered to be inflated and buyers are not presently perceiving any real threat of flood. If a serious flood were to occur in the near future, land values would probably decline until the flood threat perception would again be forgotten or ignored. Consequently, those agencies constructing flood control projects should guard against people assuming either complete protection or a greater level of protection than will actually occur.

The annual value of production within the take-line is $448,000, with an associated cost of production of $217,000. If land above the maximum flood pool remains in production, the annual value of production removed is $328,189 ($448,761-$120,570) and the cost of production for that amount is $148,598 ($217,236-$68,638). These data can be interpreted in a variety of ways. First, if one assumes that land within the flood pool is to be cropped, when possible, $151,719 in production is estimated to be lost to operation of the flood pool. The difference, $297,042 ($448,761-$151,719), can be viewed as a cost to society for converting the land from growing crops to recreation and open-space use. The second interpretation is to compare the value of production upstream to annual crop loss protection downstream, which is $444,900 (from Table 6-3-8, Appendix 6). This crop loss protection value implicitly contains production costs, however, by inclusion of replanting costs. Consequently, it should be compared to the net value of protection upstream, $231,525 ($448,761-$217,236). Third, the annual value of production in the reservoir area can be viewed from the perspective of local business which will lose sales of goods and services to produce those crops and sustain the farmers. This indirect impact of taking land out of production is a loss to the local area and is offset by protection and increased production downstream.

This discussion of economic impacts emphasizes those that are not normally incorporated into conventional benefit-cost analysis. The implications of these economic impacts are incorporated into the detailed project evaluation presented in Chapter 11.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part II. Impact Evaluation of Alternatives

Chapter 8

REGIONAL OUTDOOR RECREATION AND OPEN SPACE NEEDS: CATEGORY 3 STUDIES

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Chapter 8

REGIONAL OUTDOOR RECREATION AND OPEN SPACE NEEDS: CATEGORY 3 STUDIES

Introduction and Foreword

Americans have placed a great importance on leisure time activities since the end of World War II. Technology combined with affluency has permitted the nation's citizens to travel near and afar and with all the comforts they wish to lavish upon themselves. Outdoor recreation has become a professional area of practice in the technical world, and the burden on this group to provide sufficient open-space and recreational facilities for the masses of people visiting the great out-of-doors is overwhelming. Equally as much a problem as the inadequacy of facilities is the evaluation of the recreational experience enjoyed by each person. The personal benefit may be great qualitatively, but the monetary value of one visitor spending one day at a park (a visitor-day) is much more difficult to ascertain. User fees are becoming increasingly popular in many states and reflect somewhat the value of recreation to the user, but Iowa currently has no such general fee system. Therefore, many problems remain in determining recreational-use needs, the required lands and physical facilities and associated costs, and the related benefits. In an economic environment where benefits are supposed to outweigh the costs, various estimating methods must be employed to obtain results for decision-making and implementing recreational programs.

Studies of the effects of the proposed Ames Reservoir and other alternative development programs upon outdoor recreation and open space were carried out jointly by the Department of Forestry at Iowa State

University and the Institute of Urban and Regional Research at the University of Iowa. This research involved five principal components which are reported in six chapters in Appendix 3. An additional chapter was submitted by the Story County Conservation Board. The principal components of the recreation study are:

1. Measurement of current recreational use of the Skunk River valley near the proposed site by representative survey sampling techniques.
2. Estimation of future recreational use for each of several possible development patterns based upon results of a major study of Iowans' recreational-use patterns and related analyses.
3. Estimation of costs of recreational facilities based upon identification of primary sites, most probable development patterns, and established cost standards.
4. Estimation of benefits of future recreational use based upon dollar values per visitor day for alternative development patterns consistent with standard values suggested by the Water Resources Council (U.S. Senate Document 97).
5. Analysis of the development of an established reservoir (Coralville-Lake MacBride) to discern patterns that might apply to the Ames Reservoir, as well as probable differences.
6. Reservoir impact on Story County Conservation Board to delineate policy and program changes that would be necessary and capabilities to adapt to these changes.

Current Recreational Use

The objectives of the current recreational-use study were to (1) gain an understanding of the study area and determine its capacity for sustaining recreation, (2) categorize the types of existing recreational activities and the response of these to the nine alternative development opportunities and (3) measure quantitatively the amount of current recreational use, including specific activities and locations.

A visitor-day for park and recreation evaluation purposes is also called an activity-day. This is assumed to mean any visit by any person or multiple visits by the same person to a specific site for any length of time during a 12-hr recreation day. A 12-hour recreation day is defined as the time from 8 a.m. to 8 p.m. A recreational opportunity is any activity that the area is capable of supporting or has the potential to support, whether or not that activity is currently taking place on the site.

Description of the Site

The stretch of the Skunk River and surrounding area under study lies in Story County between the towns of Ames and Story City. The river has cut through the recessional moraines of the Wisconsin glaciation in its southward journey to join the Mississippi River south of Burlington, Iowa. The banks of the Skunk River in the study area are lined with various native deciduous tree species and understory vegetation. The area sustains a varied wildlife population, including waterfowl; upland, small, and large game; and several fish species. Much of the surrounding area is under intensive agriculture connoting private ownership of the Skunk River green belt. There are, however, several public access and recreation areas available for use on or adjacent to the site. A brief description of these locations are as follows:

1. Sleepy Hollow Rest Area is a one-acre forested roadside park adjacent to the Skunk River on U.S. Highway 69 north of Ames. River access is provided, as well as several picnic tables and grills. The rest area is maintained by the Story County Conservation Board.

2. Soper's Mill Access is a wooded 18-acre recreation area on the Skunk River approximately 4-1/2 miles north of Ames. The site has historic interest along with its natural beauty. Hiking trails and fire rings are provided. The Story County Conservation Board owns and operates this area.

3. McFarland's Park is the largest park in the rural area and is maintained by the Story County Conservation Board. It covers 94 acres, is wooded, and has an eight-acre pond within its boundaries. The pond provides fishing, and picnic tables and grills surround the water.

4. Story City Park and Golf Course is the only municipal recreation area included in the study. The park and golf course lie on the east edge of Story City. The Skunk River flows through both facilities.

5. Anderson H-Tree Access Area is located 3 miles south of Story City on the Skunk River. This is a new public access point that was completed during the later stages of the current-use study.

To gain a better space perspective of these recreation areas in relationship to each other and to the surrounding area, see Fig. 8-1.

Outdoor Recreational Activities

The outdoor recreational opportunities available to visitors in the Skunk River Valley are very diverse. They include:

*Bicycling
Bird watching
Camping
Canoeing (stream)
*Cross-country skiing
*Driving for pleasure
*Field sports
Fishing (stream
Fossil collecting
Golfing
Hiking
Historic site visitation
Trailbiking and hill climbing
*Horseback riding

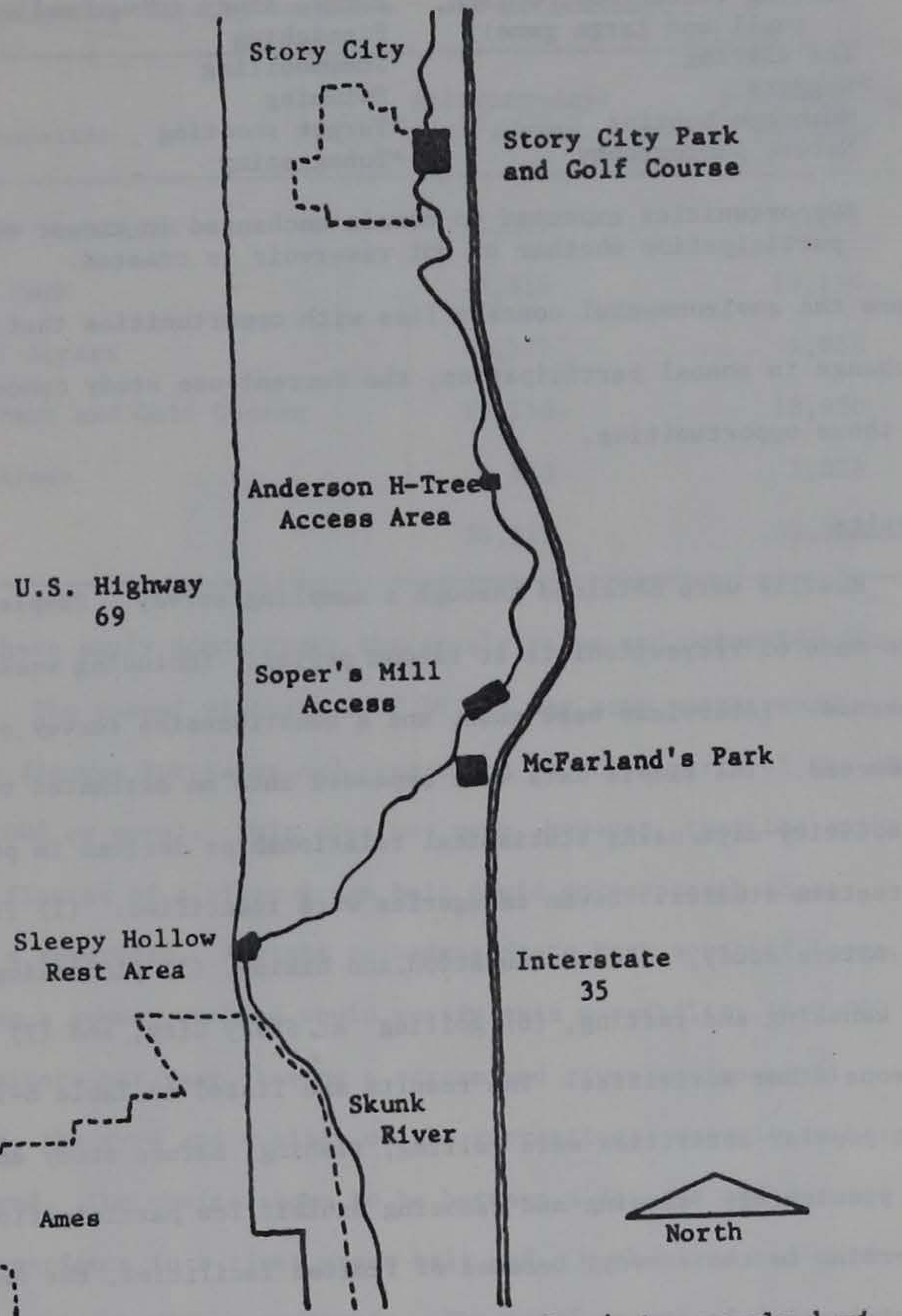


Fig. 8-1. Public access and recreation areas on or adjacent to Skunk River.

Hunting (waterfowl, upland, small and large game)
Ice skating
*Keggers
Mushroom hunting
Nature photography
Nature study (river valley)
Picnicking
Snowmobiling
Swimming
*Target shooting
*Tobogganing

*Opportunities expected to remain unchanged in amount of visitor participation whether or not reservoir is created.

Since the environmental concern lies with opportunities that will exhibit a change in annual participation, the current-use study concentrated on those opportunities.

Results

Results were obtained through a sampling survey. Simple counts were made of recreationists at random periods, including weekdays and weekends. Interviews were made, and a questionnaire survey also was conducted. The sample data were expanded into an estimated total number of activity-days, using statistical relationships derived in previous recreation studies. Seven categories were identified: (1) fishing, (2) nature study, outdoor education, and hiking, (3) picnicking, (4) camping, (5) canoeing and rafting, (6) golfing at Story City, and (7) miscellaneous other activities. The results are listed in Table 8-1. The most popular activities were golfing, fishing, nature study and hiking, and picnicking; camping and canoeing exhibit low participation rates, according to the survey, because of limited facilities, the need for special and expensive equipment, and the lengthy amount of time required for participation. The data are illustrated in Figs. 8-2 and 8-3.

Discussion and Summary

The variety of outdoor recreational opportunities available to the visitor in the Skunk River study area and the diversity of activities

Table 8-1. Activity-days by location — all activities.

Location	Activity-days for summer	Activity-days for year
Sleepy Hollow Rest Area	1,391	1,674
McFarland's Park	8,316	10,156
Soper's Mill Access	3,177	4,058
Story City Park and Golf Course	15,118	18,920
Other Site Areas	813	1,038
Total	28,815	35,846

occurring there amply demonstrate the area's value and potential for recreation. The annual visitation of 35,846 may seem meager when compared to figures for lakes and reservoirs in other parts of the state (up to 500,000 or more). This does not mean, however, that the annual visitation figures of a river green belt could not approach those created by a reservoir. A visit to Ledges State Park south of Boone, Iowa, during a summer weekend would verify this possibility (400,000 to 500,000 visitors per year, having a stream and river environment). Furthermore, the type and quality of the recreational experience has to be considered. The choice seems to be between a diverse and nature-oriented experience in a river green belt and a mechanized and water-oriented experience with a reservoir. The total amount of recreation clearly would increase with the construction of one of the reservoir or recreation lake alternatives. More area would be available for use, and the traditional water-oriented activities would be present to boost participation. However, the reservoir would decrease the number of

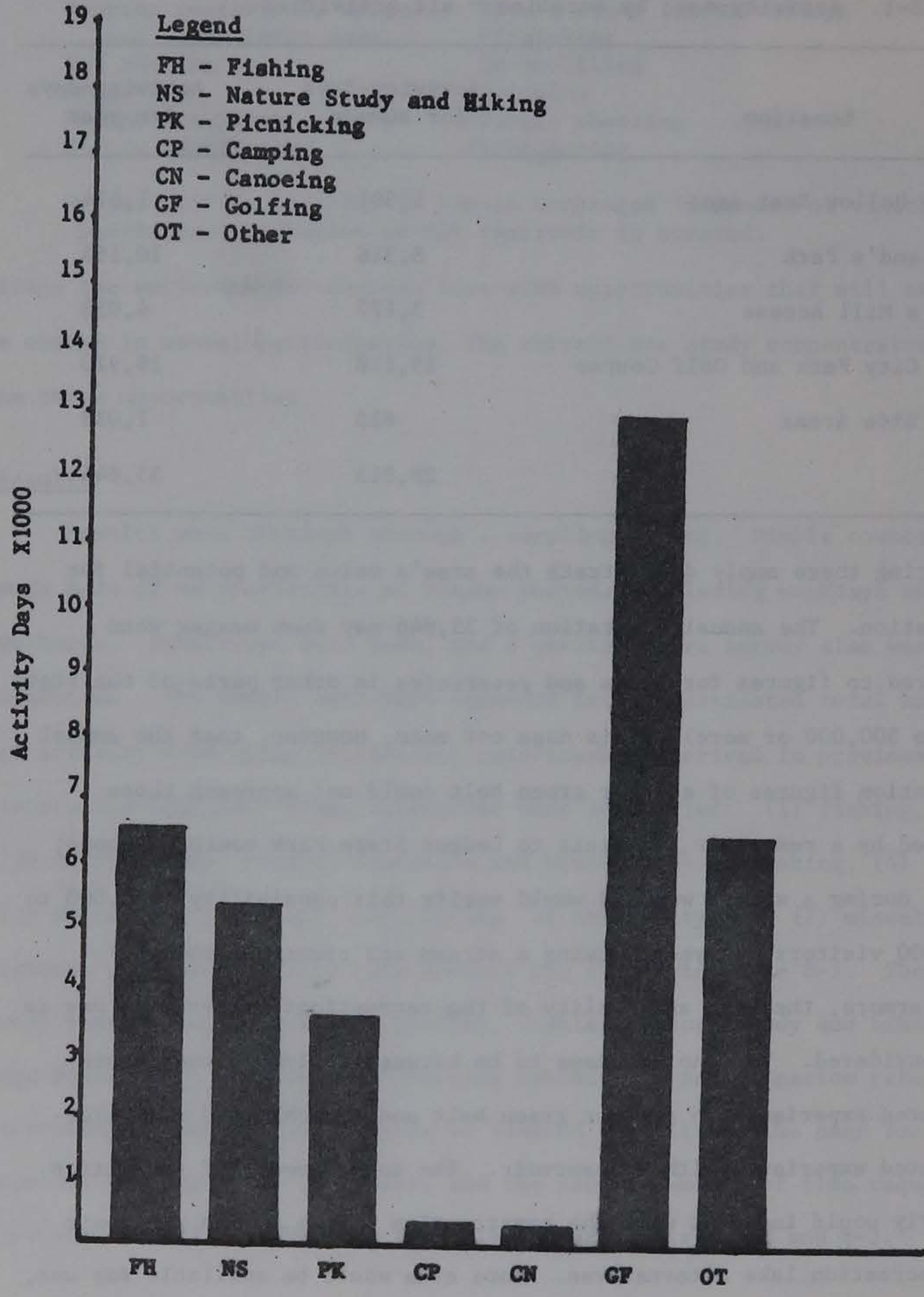


Fig. 8-2. Activity-days of current recreation by activity.

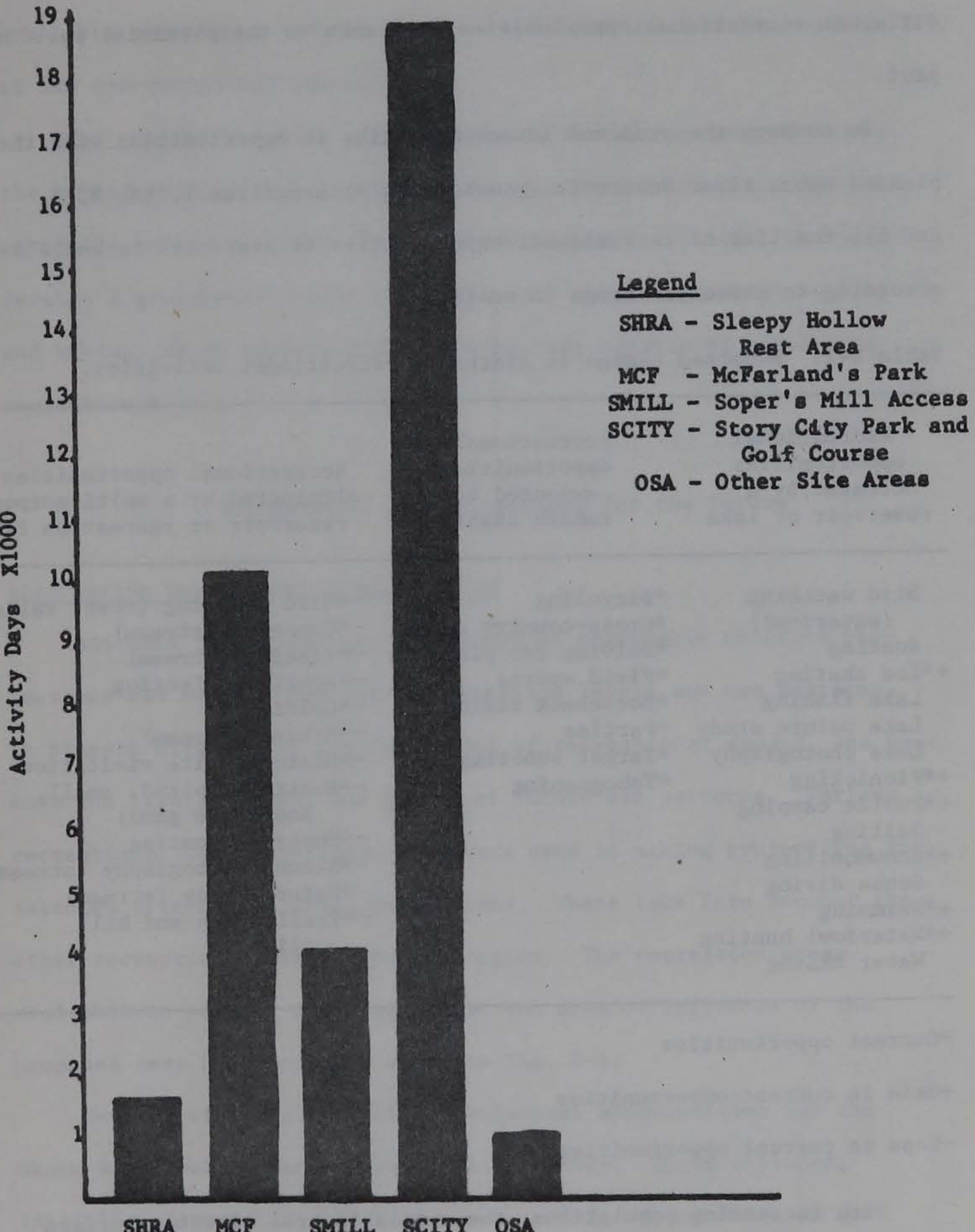


Fig. 8-3. Activity-days of current recreation by location.

different recreational opportunities available to the potential participant.

To compare the proposed losses and gains in opportunities with the planned Skunk River Reservoir (considering Alternatives 1, 1A, 2, 5, and 6), the list of recreational opportunities is presented in Table 8-2, according to expected change in status.

Table 8-2. Expected change in status of recreational activities.

Recreational opportunities created by a reservoir or lake	Recreational opportunities expected to remain stable	Recreational opportunities eliminated by a multi-purpose reservoir or recreation lake
Bird watching (waterfowl)	*Bicycling	—*Bird watching (river valley)
Boating	*Cross-country skiing	—*Canoeing (stream)
+*Ice skating	*Driving for pleasure	—*Fishing (stream)
Lake fishing	*Field sports	—*Fossil collecting
Lake nature study	*Horseback riding	—*Golfing
Lake photography	*Parties	—*Hiking (stream)
+*Picnicking	*Target shooting	—*Historic site visitation
+*Public camping	*Tobogganing	—*Hunting (upland, small, and large game)
Sailing		—*Mushroom hunting
+*Snowmobiling		—*Nature photography (stream)
Scuba diving		—*Nature study (stream)
+*Swimming		—*Trailbiking and hill climbing
+*Waterfowl hunting		
Water skiing		

*Current opportunities

+Gain in current opportunities

—Loss in current opportunities

With increasing populations, the available area of water surface per capita will continue to decrease unless additional multi-purpose reservoirs or recreation lakes are constructed. However, the same percentage decrease holds with respect to the land area of river valleys available per capita and, in fact, is accelerated with the creation of new reservoirs and lakes.

The crucial question with regards to recreation centers around the type of recreational activities the area should provide. The opportunity exists to create more water-oriented facilities, to further develop a green-belt system of traditional uses, such as picnicking and hiking, or to explore other alternatives capable of supporting recreational use.

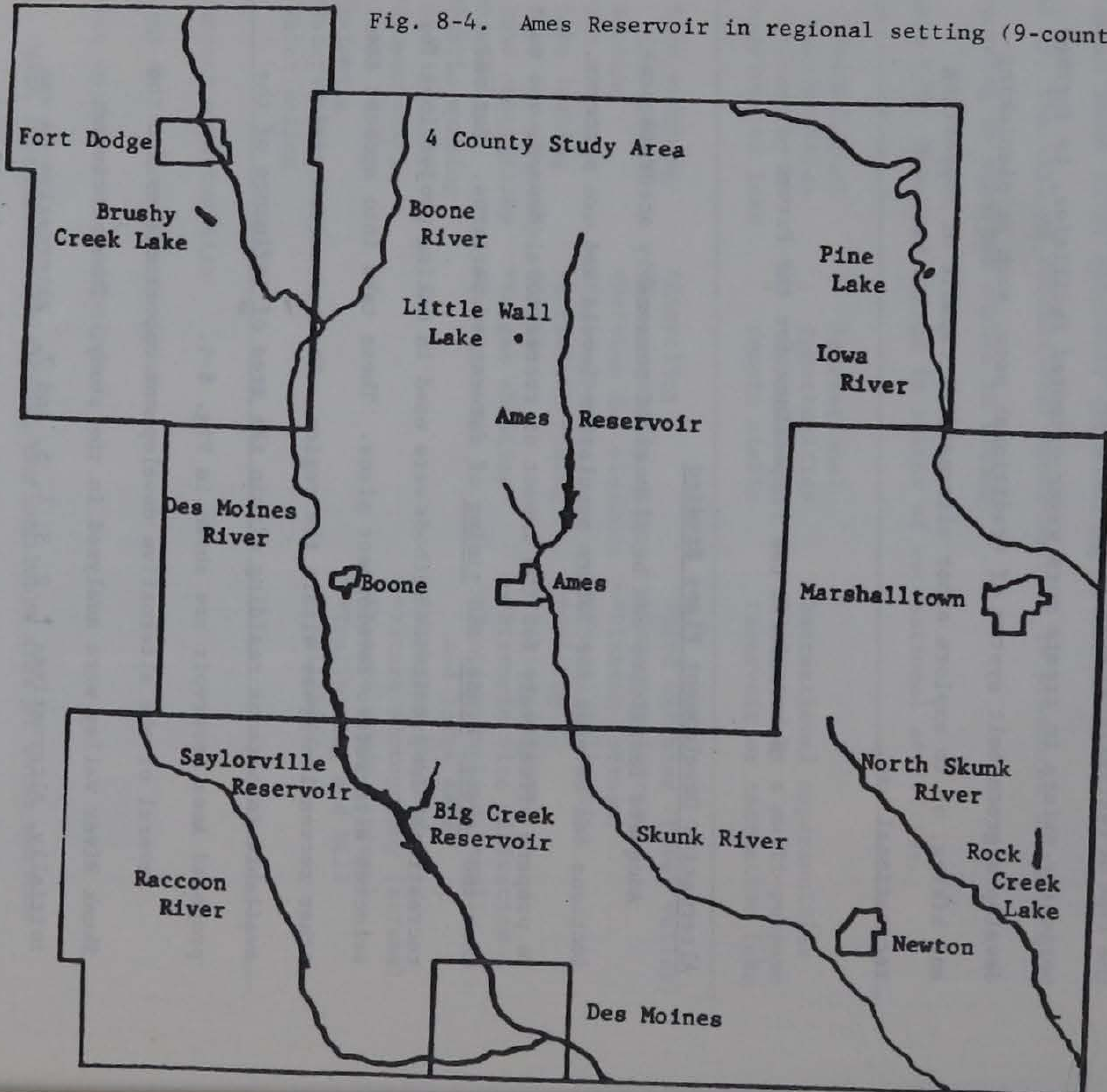
Recreational Use Projections for the Future

Alternative Development Plans Studied

Adequate facilities can be planned if reasonably accurate projections can be made for future population levels and use patterns. To prepare effectively for the impact of recreational demand, one must know the levels, kinds, and timing of future use patterns. Various recreational use prediction methods were used in making projections for selected alternative development plans. These take into account the other recreation areas within the region. The recreation areas available to persons residing within the area of influence of the proposed Ames Reservoir are shown in Fig. 8-4.

Several of the alternative development opportunities for the Skunk River valley were analyzed in the study. These included, initially, Alternatives 1, 2, 3, 4, 5, and 7. Alternative 4A was added at a later date to evaluate the merit of a maximum level, comprehensive green-belt program. The descriptions of each are listed below.

Fig. 8-4. Ames Reservoir in regional setting (9-county study area).



Alternative 1 (Alternative 1 of Appendix 3). Ames Reservoir, as planned by the Corps of Engineers, Design Memo No. 1, with the two subimpoundments.

Alternative 1A (not included in Appendix 3). Same as Alternative 1, but without the Bear Creek subimpoundment. A total of 665 recreational land acres provided.

Alternative 2 (Alternative 2 in Appendix 3). Single-purpose recreation lake of large size, 1400 acres, at the reservoir site, a total of 665 recreational land acres provided.

Alternative 3 (Alternative 3 in Appendix 3). Recreation using the two subimpoundments only for water areas — Bear Creek and Dam-site Lakes, 200 and 50 recreational land acres provided.

Alternative 4 (Alternative 4 of Appendix 3). Minimum green belt, no reservoir or subimpoundment. Use Story City golf course, City Park, McFarland's-County Park, Sleepy Hollow Park, and add 108 recreational land acres.

Alternative 4A (Alternative 4A as addendum to Appendix 3). Maximum enlarged-scope comprehensive green-belt alternative. 1400 acres of recreational lands added by purchase; rental or easements on 2350 acres; Hallett's gravel pit, "used" acres reclaimed as a water area for intensive uses, etc.

Alternative 5 (Alternative 5 of Appendix 3). Ames Reservoir as planned by Corps but with minimum recreation because of lack of cost sharing, minimum facilities for public health and safety only, no recreational land areas provided.

Alternative 6 (Not studied in Appendix 3). Reduced-scope project. Conservation pool of 1400 acres, elevation 940 and flood pool of 3900 acres, elevation 965 with the two subimpoundments. (Recreational opportunities comparable to Alternative 2 in most activities.)

Alternative 7 (Alternative 6 in Appendix 3). Do nothing, status quo alternative, no reservoir or green belt, no further development, use 18 recreational land acres in Soper's Mill area and existing parks as in Alternative 4.

Each alternative has merits and drawbacks in terms of recreational and other potentials. These were discussed in Chapter 4. For instance, Alternatives 1 and 1A (and 5 also with minimum recreation) which optimize flood control and recreation quantity will also produce unsightly mudflats and could cause damage to the golf course in Story City since only its greens are above the proposed flood pool level. These alternatives also create problems in adjusting shoreline developments, such as swimming beaches and boat ramps, to account for the fluctuating flood pool. On the positive side, this alternative provides the greatest surface water acreage for boaters and water sports enthusiasts.

Alternative 2 would provide a stable recreation pool of 1400 surface acres. A better peripheral recreational environment could be developed since periodic inundation of vegetation would be eliminated. At the same time, this alternative would decrease total surface acres of water available to boaters and other water-related sports enthusiasts.

Alternative 3 would provide small lake recreation while removing fewer acres from crop production and evicting fewer residents of the proposed dam area. In terms of recreational values, this alternative might represent a viable compromise for stream valley and lake water recreation proponents. No flood control benefits would result from adoption of this alternative and relative recreation quantity would probably be reduced.

Alternatives 4 and 4A would open up to public use more of the Skunk River valley on the proposed reservoir site. Most of this land is now in private ownership and is posted to prevent trespassing. The green-belt development would provide greater stream access and open up forest land to naturalists and recreationists. Recreation quantity would go down, but many would argue that the recreational environment would be superior to that created by an artificial impoundment. Others would argue, however, that increased fishing and water sports opportunities created with an impoundment would far offset the value of forest land inundated. Alternative 4 would take little or no land out of production. With Alternative 4A more land would be placed in public ownership. The latter, 4A, would do the most to help prevent the proliferation of river corridor housing which could further hinder public access. Alternative 4 would be inexpensive, putting little burden on taxpayers. Alternative 4A is an expensive but positive recreation and open-space plan.

Alternative 5 is the minimum recreation plan and would not increase state or local taxes. However, it would not provide appreciable recreational benefits since it lacks development for recreational use. At the present time, neither state nor local governments have indicated an interest in cost-sharing major recreational developments with the federal government. Therefore, it is possible that this alternative could become a reality. In terms of recreation quantity, any of the above alternatives would be superior to this one, including the relatively low-cost green-belt plan.

Alternative 7 affords no development of reservoirs. The present character of the Skunk River valley is maintained and much of it will remain inaccessible to the public except by canoe. Much of the Skunk River valley in the proposed area of inundation would remain barred to the public. Degradation of existing recreational sites is possible with continued destructive uses. No cropland would be taken out of production, and no residents of the area would be evicted.

In terms of recreation alone or in combination with other benefits, each alternative represents a compromise. For example, without cost sharing for recreational development, a large impoundment would accrue fewer benefits in terms of recreation quantity than would a green-belt development entailing relatively little cost. With cost sharing, the promise of abundant water-oriented recreation created by impoundments could far outstrip any other development alternative in amount of recreational opportunity created.

All of these considerations and many others should be weighed in assessing the impact of each of these alternatives on the total environment. In terms of recreation, there is great potential in several alternatives discussed. Other alternatives exist that were not included in this study. All alternatives, including the alternative of do nothing, have impacts with both positive and negative effects. Hopefully, this part of the Ames Reservoir Environmental Study has aided in clearly assessing the impacts of the proposed reservoir and possible alternatives on recreational use in central Iowa.

Results

Gravity (mathematical) models incorporating distance, population, relative supply, water area availability, and other factors of demand were used in making projections. (See Appendix for details.) Twelve activities were included in the model. These are: swimming, hiking, camping, picnicking, waterfowl hunting, sailing, powerboating, other boating, fishing, snowmobiling, ice fishing, and "others" category.

The results of the study show several interesting facets. The availability of water areas in the 9-county region and its relationship to population and time factors is illustrated in Figs. 8-5 and 8-6. The substantial increase in water area in the early 1970's is due primarily to the construction of the Saylorville Reservoir-Big Creek project of the Corps of Engineers. This adds over 5400 acres in the conservation pool of Saylorville and 885 acres in the Big Creek Lake, a subimpoundment. Unless additional water areas are added in the future, the water area available to each person will decrease, indicating a possible stress potential.

Use estimates for all alternatives studied are shown in Figs. 8-7 and 8-8. These illustrate both the current level of use if any alternative is selected and the growth trend as the urban population increases in the 9-county region. These use estimates for Alternatives 1 and 5 exhibit somewhat less attendance than is estimated by the Corps of Engineers.

Discussion of Results

The difference between use estimates of the Corps of Engineers and those of this study are likely due to several factors: (1) difference

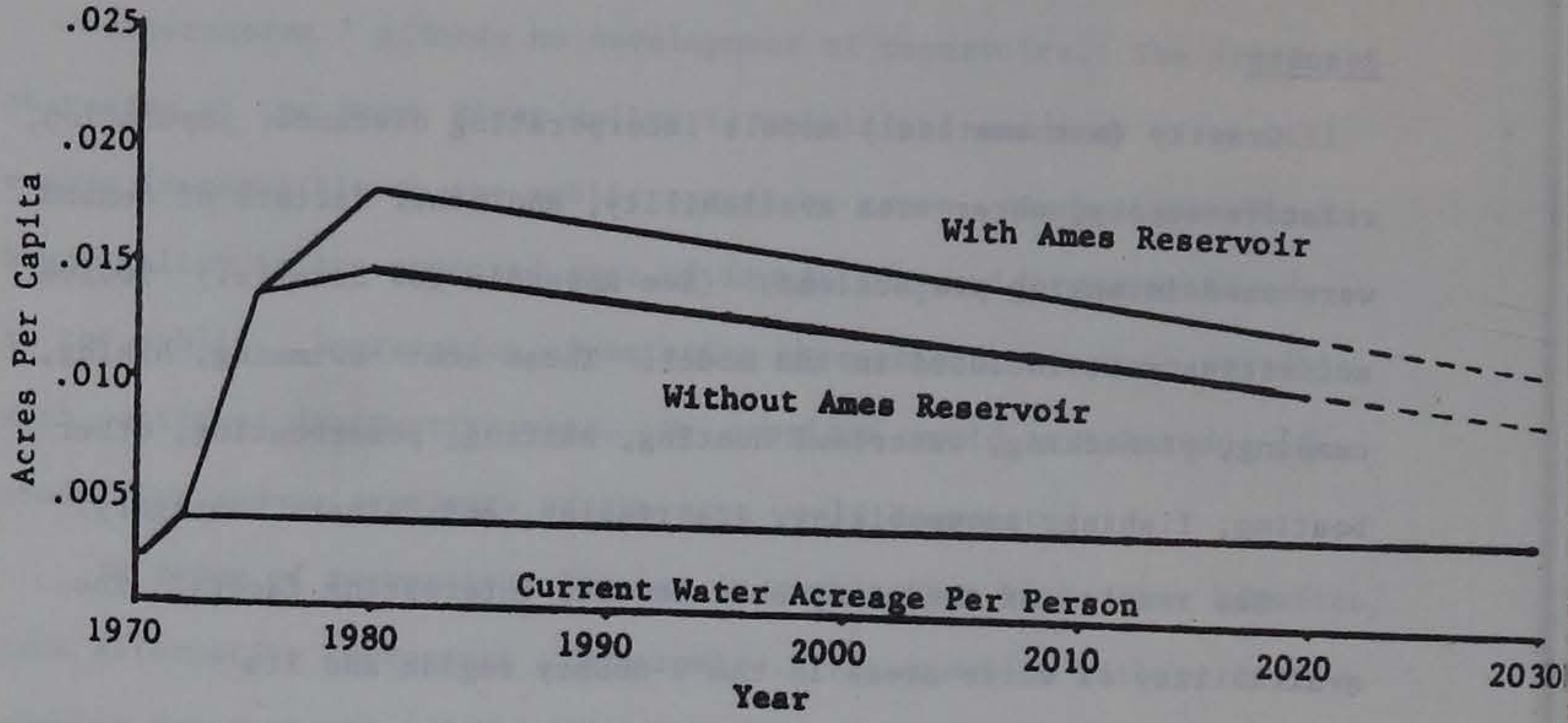


Fig. 8-5. Lake water acreage per capita for low population growth.

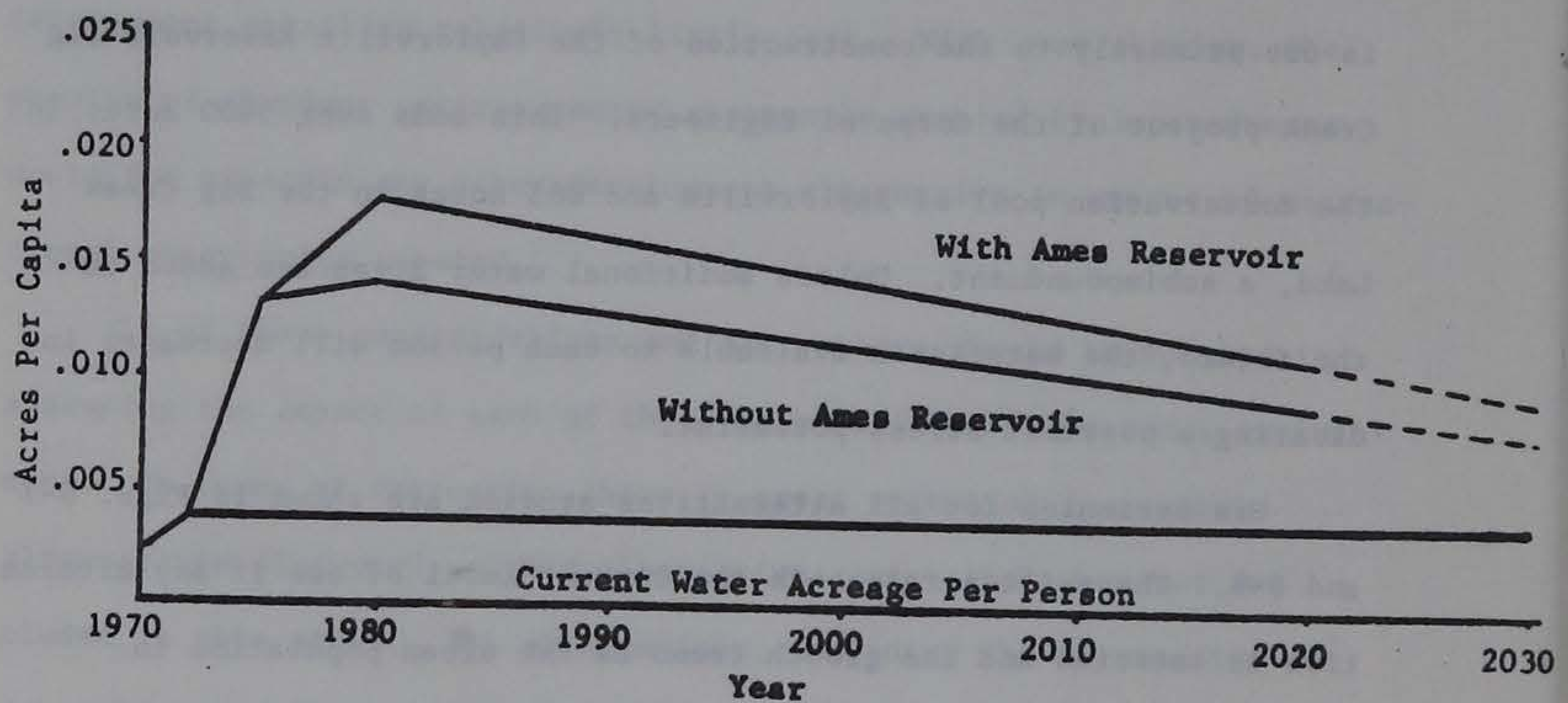


Fig. 8-6. Lake water acreage per capita for medium population growth.

in population projections used; (2) difference in anticipated effect of competing recreation areas for each activity; (3) difference in per capita use figures (user-behavior) assigned to the population.

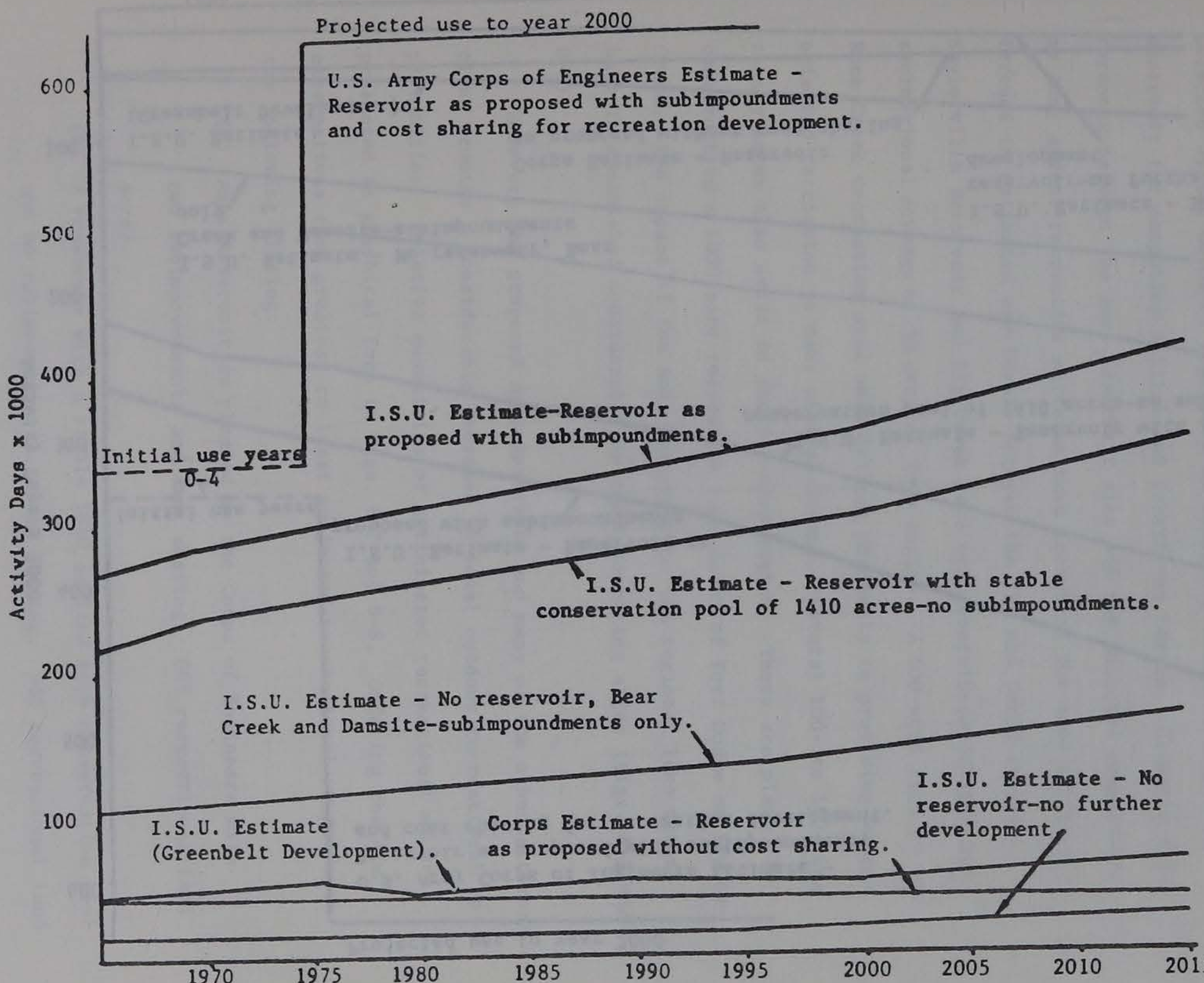


Fig. 8-7. Use projections for low population growth.

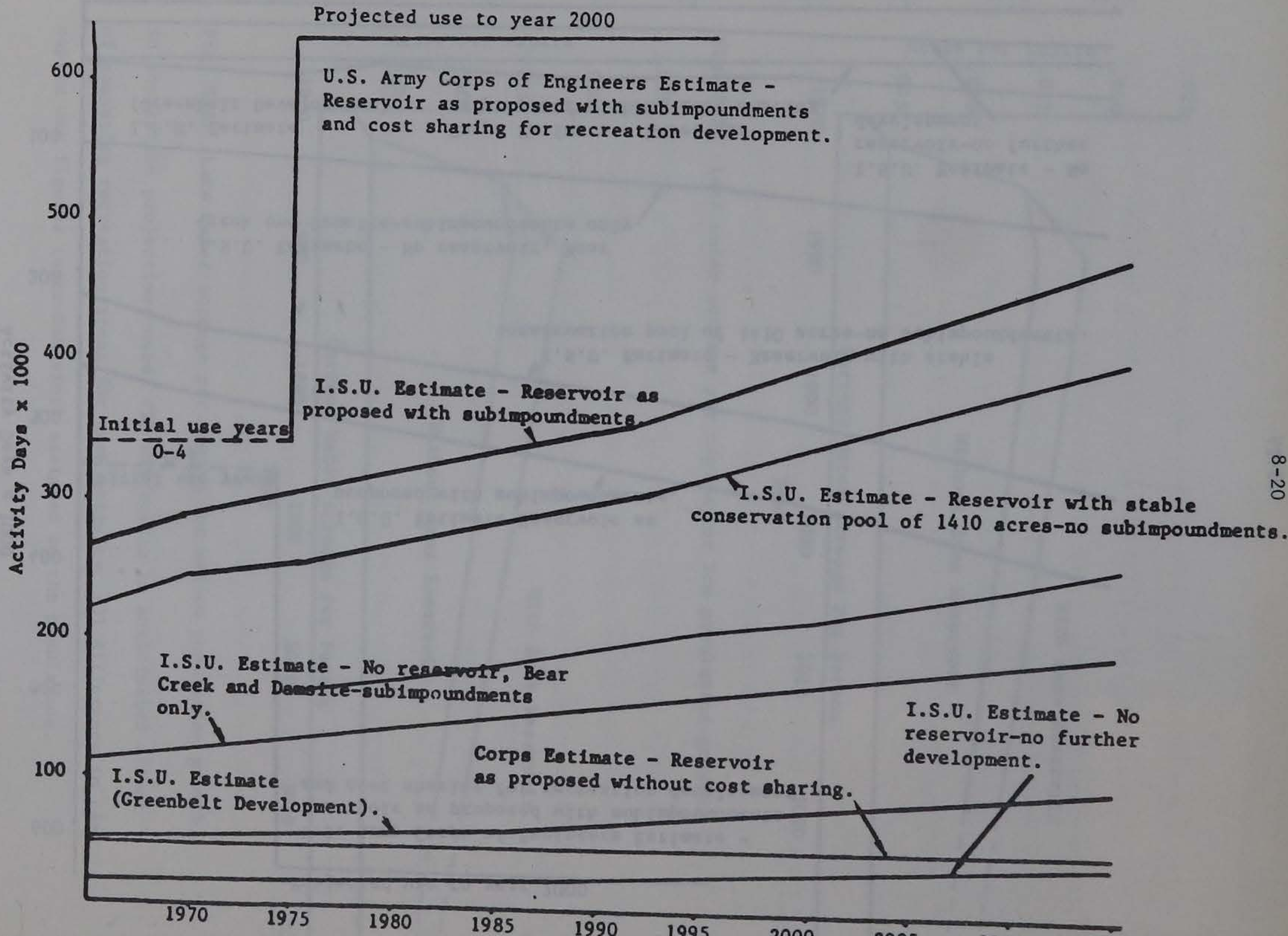


Fig. 8-8. Use projections for medium population growth.

Two projects, one in California and the other in Oregon, were selected by the Corps of Engineers as similar projects to the Ames Reservoir for computing initial and future use levels. Climatic differences between the Ames Reservoir site and the selected comparison as they affect recreation patterns have accounted for some of the difference in estimated use levels between the ISU and Corps studies. Saylorville Reservoir and Big Creek Lake will contribute substantial recreational acreage to the central Iowa region. A 600-acre lake at the Rock Creek recreation area near Kellogg presently is providing water-oriented recreation to many central Iowans. Several 100- to 160-acre county lakes also exist in the 9-county region. There are plans for constructing a 1000-acre recreation lake south of Fort Dodge on Brushy Creek. The impact of the Ames Reservoir on the regional lake water base is diminished considerably by these competing sites (Figs. 8-5 and 8-6).

However, the proposed Ames Reservoir and many of the other alternatives promise a considerable increase in local outdoor recreational opportunities. Relative quantities of anticipated recreational use are presented in graphical form in Figs. 8-7 and 8-8. Ordering the six alternatives from greatest to least projected recreational use produces the following listing:

(1) Ames Reservoir as planned by the Corps of Engineers with two subimpoundments and cost sharing. 665 recreational land acres.

(2) A reservoir with a stable 1410 surface acre conservation pool and no subimpoundments. Cost sharing. 665 recreational land acres.

(3) No reservoir. Dam-site and Bear Creek subimpoundments only. 50 and 200 acre recreational land acres, respectively.

(4) No reservoir, no subimpoundments. Green-belt development with additional river accesses and scenic easements. 108 recreational land acres.

(5) Ames Reservoir as planned by the Corps of Engineers with two subimpoundments. Without cost sharing.

(6) Ames Reservoir study site with no reservoir, no subimpoundments, and no further development.

Cost and Benefit Estimates for Recreational Facilities

Costs

Estimates of the cost of providing for recreational use at the proposed Ames Reservoir or in the area of the Skunk River valley which it would occupy are a summation of several major items, including:

a) costs of additional land

b) costs of roads for access

c) costs of recreational facilities

d) costs of annual operation, maintenance, and replacement of facilities

e) losses of the value of current and future recreational use of the area which would be precluded by any particular development plan.

Facilities required to accommodate expected use levels were estimated in part on an assumption that 50% of total annual use would take place on Saturdays, Sundays, and holidays between Memorial Day and Labor Day each summer. Facilities were planned to accommodate the average use level on these days for the use level expected in 1985. These estimates were modified where necessary to reflect (a) established guidelines and standards for recreational developments and (b) needs for protection of the environment and protection of the health and safety of visitors. In a number of instances, the unit prices have been changed from Corps' estimates to reflect current local experience and standards.

Benefits

A considerable emphasis has been placed on the development of valuation procedures and models. Economists have devised many models designed to measure recreational "benefits" or "values;" but comparison of the models makes it immediately clear that what is defined as a value or benefit differs considerably between models and authors, and it is often not at all clear just what is being measured. In general, the various models measure one of three different things: (1) the cost of providing recreational developments, (2) the value of recreationist expenditures to the local, regional, or national economy, or (3) the value of the benefits of the recreational resource to visitors.

Senate Document Number 97 (U.S. Congress, 1962) directs federal resource development agencies to value recreational benefits in terms of the direct value of recreation to users of the site — approach number (3) above:

> In evaluating outdoor recreation as a project purpose, it is necessary that it be viewed as producing an economic product, in the sense that a recreation opportunity has value and is something for which people are willing to pay...

> Pending the development of improved pricing and benefit evaluation techniques, desirable uniformity in the treatment of recreation in the planning of projects and programs and in cost allocations will be accomplished through the application of unit values that reflect the consensus judgment of qualified technicians. The unit values per recreation day set forth herein are intended to measure the amount that the users should be willing to pay, if such payment were required, to avail themselves of the project recreation resources.

Guidelines for the assignment of unit-day values are also provided in this document.

The guidelines outlined by the federal government and shown above were followed in assigning unit-day values to outdoor recreational use of the Skunk River valley as it currently exists and under alternative forms of development. Specific values assigned for various alternatives are as follows:

Alternative Number	Description	Unit-day values
1 (and 1A)	Ames Reservoir as planned	$1.25
2 (and 6)	Minimum conservation pool only	1.50
3	Tributary recreation lakes only	2.00
4	Minimum green-belt development	2.00
4A	Maximum green-belt development	2.00
5	Ames Reservoir with minimum development	0.75
7	Status quo — no reservoir or other development	1.50

These unit-day values were then multiplied by the medium projection use levels (see tables in Appendix 4 or Figs. 8-7 and 8-8) for various alternative uses of the site to the year 2020. Present worth of these values was determined with a 5.5% and a 7% rate of discount.

The summary information the analyses for benefits and costs are included for a 5.5% discount rate in Table 8-3 and for the 7% rate in Table 8-4.

Table 8-3. Recreation-related benefits and costs for alternative development patterns, using a discount rate of 5.5%[a].

Alternative development pattern	Value of recreational benefits	Cost of recreational development[b]	Benefit/ cost ratio
1. Ames Reservoir as originally proposed, 2100 acres of recreational water area[c]	$6,353,650	$7,166,420	0.887
2 (and 6). Minimum conservation pool, 1400 acres of recreational water area	6,437,690	5,855,830	1.099
3. Two tributary recreation lakes only	4,142,790	2,793,300	1.483
4. Minimum green-belt development	1,544,680	314,180	4.916
4A. Maximum green-belt	3,340,440	3,465,204	0.757
5. Ames Reservoir with minimum development	314,890	926,710	0.340
7. Status-quo, no reservoir or other development	302,490	33,860	8.933

[a]Present worth of future benefits and costs was determined with a 5.5% rate of discount and over a period of 50 years following construction.

[b]Includes only recreational land and facilities costs, not any portion of dam-construction costs.

[c]Alternative 1A presumably would provide slightly fewer benefits and lower initial costs than Alternative 1 of the ARES study.

Table 8-4. Recreation-related benefits and costs for alternative development patterns, using a discount rate of 7.0%.

Alternative development pattern	Value of recreational benefits	Cost of recreational development[a]	Benefit/cost ratio
1. Ames Reservoir as originally proposed, 2100 acres recreational water area[b]	$4,941,700	$6,227,100	0.794
2.(and 6). Minimum conservation pool, 1400 acres recreational water area	4,979,700	4,719,200	1.055
3. Two tributary recreation lakes only	3,204,500	2,442,200	1.312
4. Minimum green-belt development	1,191,500	276,500	4.309
4A. Maximum green-belt	4,251,500	4,410,300	0.964
5. Ames Reservoir with minimum development	243,100	778,100	0.312
7. Status-quo, no reservoir or other development	223,000	27,600	8.460

[a] Includes only recreational land and facilities costs, not any portion of dam-construction costs.

[b] Alternative 1A presumably would provide slightly fewer benefits and lower initial costs than Alternative 1 of the ARES study.

Comparative Studies at Coralville Reservoir

Comparative Recreational Aspects

This section concerns a case study of recreation and recreationists in the area of a man-made impoundment. The rationale for this approach to the Ames Reservoir Environmental Resources Review Study lies in the notion that recreation as described in a "developed" area will allow one to speculate about future recreation in a similar area as yet undeveloped. Although this has been a relatively common approach in the past, it has been criticized. The major criticisms are that the method does not take account of latent demand for recreation in the general population and that it does not directly address the issue of alternative forms of recreation and alternative areas for recreation. The former criticism may be avoided through reference to previous and contemporary surveys of recreational activities and preferences in Iowa. The second criticism is partly answered by reference to the contemporary work on recreational use of the proposed Ames Reservoir site. Hence, the research discussed here should be kept in the context of previous and contemporary research on the issue of outdoor recreation in Iowa.

Within these constraints, then, the study had three primary objectives. The first was to determine the role of the biophysical environment in defining the type of recreational system that has developed in the Coralville-MacBride area. Secondly, the impact of alteration and management of the biophysical resources on the recreational system was examined. The third major objective was to outline the characteristics and preferences of the recreationists utilizing the area. Obviously, these objectives are interdependent to some degree.

Water is the element of the biophysical environment that adds most to the attractibility of the Coralville-MacBride recreation area. This is illustrated in Fig. 8-9. The importance of water is evident in responses to many of the questions included in the questionnaire. Moreover, the presence of a large body of water appears to be significant in that it makes popular activities like boating, swimming, water skiing, and sailing accessible. In contrast, the water element in the Ames Reservoir site is presently not so directly dominant in the recreational

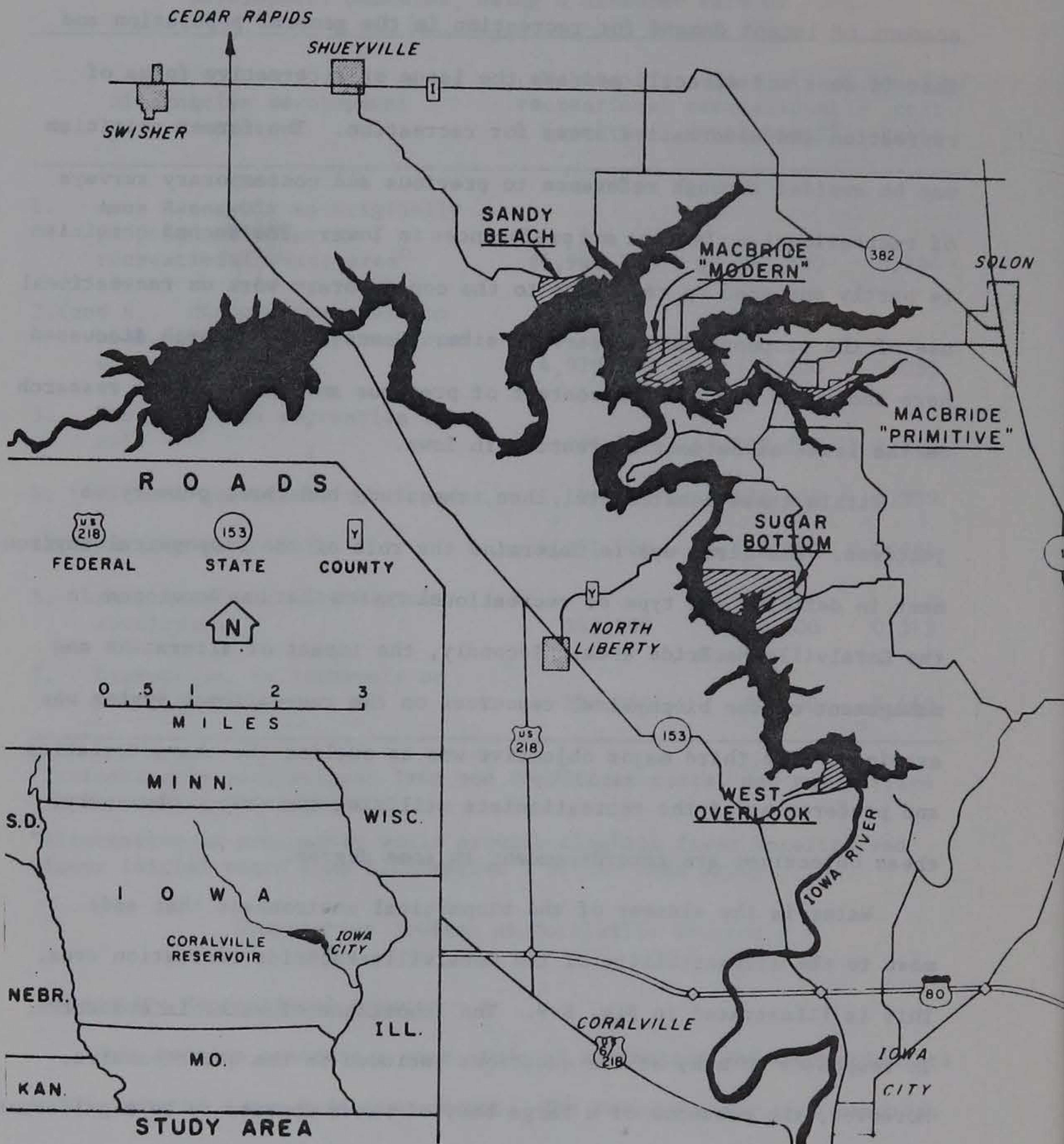


Fig. 8-9. Map of Coralville-MacBride area.

attractibility of the area, and it enters for a different reason, fishing. The quality of the water does not seem to have a great impact on those recreating in the Coralville-MacBride area. Although, from previous work, there is evidence that poor water quality does inhibit some people from using the Iowa River for recreational purposes. There can be little doubt that the creation of a large water body generates a demand of its own in a region devoid of significant areas of surface water. The Coralville-MacBride case supports this notion.

Other natural phenomena, such as vegetation and topography, are of somewhat lesser importance in the attractibility of the Coralville-MacBride area. In some cases, the presence of trees does influence preference for a site, particularly when camping is involved. In contrast, the vegetation and accompanying seclusion have a much greater impact on the recreationists presently utilizing the Ames Reservoir site.

Facilities in and management of the Coralville-MacBride area strongly influence the attractibility. However, it is doubtful that facilities and management override the attraction of a large water body. This statement is made on the basis that the majority of users respond with facilities and management-related factors when asked to list unattractive features of the area. Yet, the same people utilize the area intensively. In most cases, complaints about facilities and management implied the need for more and better of both, supporting the findings of previous research. The activities enjoyed by the group of people presently using the area do not require the provision of additional facilities. However, some unattractive qualities noted by respondents, such as litter and water pollution, could imply a need for better management practices. People with a favorable attitude to the expansion of recreational facilities are often characterized as having a high income, a high level of education, and a high level of participation in outdoor recreation. Although this question is not examined explicitly for Coralville-MacBride, at least a high level of participation and a favorable attitude to facilities co-vary.

The socio-economic characteristics of the recreationists in the Coralville-MacBride area are similar in most respects to those outlined in previous studies. Relatively high income and education levels and primarily urban residencies characterize the respondents. A higher than usual proportion of the respondents are classed in "blue collar" occupations. Most are frequent visitors to the area and thus could be regarded as having a high participation rate in outdoor recreation. The majority live within 50 miles of the recreation area and travel less than one hour to reach it. The recreationists, both through their preferences and activities, are oriented to water-related recreation in association with appropriate facilities for powerboating and camping. While the socio-economic characteristics of the recreationists are important in influencing the type of recreational experience sought, it would appear that, within limits, the accessible and available experience influences the type of people attracted to the area. In a region with few alternative and competing recreational experiences, some individuals are probably responding to the opportunity to recreate because it is the only opportunity. In so doing, they are probably ready to put up with some unattractive features like poor water quality, crowding, and inadequate facilities.

It is noteworthy that the Coralville-MacBride area also attracts individuals who are foreign to the region. This may be explained by the ready accessibility to a major east-west transportation route, Interstate-80. For those visitors, the Coralville-MacBride camping facilities provide a convenient overnight stop.

The recreationists utilizing the Ames Reservoir area at the present time are of local origin. Most drive 20 minutes or less to reach the recreation site. The very local nature of these users is similar to that found amongst users of the Saylorville area prior to impoundment.

Conclusions about the Ames Reservoir Alternatives

The creation of a man-made impoundment on the Skunk River at the proposed site will probably result in a pattern of recreational use not unlike that experienced in the Coralville-MacBride area. This would especially be true with respect to summer recreational use. More specialized activities at other times of the year, such as duck hunting, would probably depend more on contextual factors like migration patterns and availability of feed. Even without the provision of facilities and in the face of questionable water quality and other management problems, the mere presence of the water body will intensify recreational use of the area. It will at once create and respond to what seems to be a latent demand in the population.

With the careful planning and provision of facilities for recreation, specialized activities and the people associated with them will be attracted to the area. Boat landing ramps, well-maintained camping and picnic sites, and supervised swimming areas will generate powerboating and skiing, tent and trailer camping, and swimming. By these means the intensity, pattern, and type of use of the area can be partially predetermined.

It is apparent that the recreation area would serve the nearby urban population and probably draw heavily from the same socioeconomic and preference groups as in the case of Coralville-MacBride. In addition, the recreation area would probably draw from a larger region than the present Skunk River bottomlands do. Included in this audience would be visitors passing through on the nearby interstate highway system, as is the case at Coralville-MacBride. However, a critical question must be the extent to which the needs and preferences of recreationists presently using the area would be served. From their preferences as stated in this study, it would appear they would not be served. Although a minority in relation to the potential recreational audience for a development lake, provisions for minorities are important considerations that a responsible society cannot ignore.

Final Summary

Current recreational use of the Skunk River valley near the proposed site for Ames Reservoir involves approximately 35,000 visitor-days of usage per year. Principal activities are golfing, fishing, nature study, hiking, and picnicking. Together, they account for 80% of current recreational use. One primary factor that appears to restrict current use is scarcity of attractive points of access to the Skunk River.

Recreational use would expand in the future by varying amounts depending upon the development pattern chosen. With no further development, use will grow to a maximum of 65,000 in the year 2020 due to lack of access. The highest foreseeable use would be 479,000 in the year 2020 with full development of the reservoir as proposed and extensive recreational facilities development. The latter would require substantial local cost-sharing which seems unlikely to be forthcoming at the model scale, judging by statements of responsible agencies. For example, see Appendix 3, which contains views of the local Story County Conservation Board. Future use for other alternatives would fall between these estimates. Interestingly, a green belt without reservoir would provide 98,000 visitor-days which is nearly double that provided by much more expensive reservoir construction without local cost-sharing facilities development.

Future use patterns, as well as amounts, would differ substantially from one development pattern to another. For example, the reservoir as originally proposed would provide the greatest amount of land open to the public and the greatest water area useful for powerboating. A smaller reservoir would give up some water area to give a more attractive forested shoreline and save a golf course. Moving to dissimilar alternatives, green-belt development would provide greater access to the natural stream and to forest land at relatively little cost. In short, some development alternatives would provide recreation within the natural character of the stream valley, while others would substantially modify that character. Past ISU analyses of recreational use patterns suggest that quite distinctly different groups of users would benefit.

Costs of recreational land purchase and facilities development were estimated based on probable development patterns and standard cost-estimating procedures. These costs are over and beyond any share of the costs of construction that might be assigned to creation of recreational opportunities. The present value of total costs ranges from $28 thousand to $6.2 million, depending upon the specific development pattern that is chosen. Those patterns which do not involve construction of a dam all have recreation-related costs of less than $300 thousand.

Estimation of benefits of future recreational use based upon dollar values is an inherently different and unsatisfactory area in all analyses. The root fact is that opportunities for recreational activities at public sites are not commonly sold by the unit. Hence, attempts to estimate values as if opportunities were sold by the unit is substantially unrealistic. Nevertheless, dollar values have been estimated. In line with standards suggested by the Water Resources Council (Senate Document 97), these estimates place somewhat higher unit values on recreational use in highly naturalistic environments than in highly manipulated or modified environments (e.g. in order of decreasing unit value: green belt, reservoir with wooded shoreline, reservoir with bare shoreline).

The present value of total recreational benefits ranges from $243 thousand to $4.9 million depending upon the development pattern chosen. Interestingly, when alternative development patterns are arranged in order of decreasing cost, several provide benefits disproportionate to their location on the cost scale. The minimum green-belt development (Alternative 4) is one specific instance of a considerably higher rank or in terms of benefits than in terms of costs. The maximum green-belt alternative (Alternative 4A) offers the best hope of conserving for the greatest public use the natural resources of the valley.

Ratios of benefits to costs for recreational development range from 4.3 to 0.3, as were shown in Tables 8-3 and 8-4. The ratio for recreational development associated with the reservoir as originally proposed by the Corps of Engineers is approximately 0.8. Those alternatives not involving reservoir construction show markedly higher benefit-cost ratios for recreational development.

Analysis of the development of the Coralville Reservoir and adjacent Lake MacBride State Park confirms major aspects of the foregoing analysis. This development suggests that creation of a reservoir will bring a considerable increase in recreational activity in the area adjacent to the proposed reservoir. But perhaps equally or more significant, it will enhance some forms of recreation (e.g. water-oriented activities such as powerboating) at the direct expense of others more in harmony with the natural environment (e.g. canoeing, nature study, etc.).

Additional detailed figures concerning recreational costs and benefits are included in Appendix 3. They suggest that development patterns on a smaller scale than the originally proposed Ames Reservoir can provide more recreational opportunity per dollar expended than would the original proposal. The choice is between alternative forms of recreation involving different segments of the population or a decision among these. Therefore, decision-making is not an easy or simple proposition.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part II. Impact Evaluation of Alternatives

Chapter 9

IMPACT OF AGRICULTURE: CATEGORY 4 STUDIES

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FIGURES

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ARES SUMMARY REPORT

Chapter 9

IMPACT OF AGRICULTURE: CATEGORY 4 STUDIES

Introduction

The regional setting of the proposed Ames Reservoir project is largely agricultural. Whether or not a reservoir is constructed or a green-belt alternative selected, there will be numerous interactions between uses of the river valley and the surrounding agricultural community. Agricultural practices, both in kind and degree, will influence the use of the valley and its resources. Runoff-related water quality parameters such as nitrogen, phosphorus, and pesticide concentrations are dependent on agricultural land use and management. Capital investments in drainage and erosion control alter the rate and distribution of runoff among surface, tile flow, and base flow components. Sediment, largely derived from cultivated land, increases stream turbidity and in time would occupy a portion of the proposed reservoir storage. Downstream flood problems are largely agricultural in terms of crop and noncrop damages.

Costs of and benefits from agricultural operations in the vicinity of the reservoir project would be altered. Land used by the project reduces the amount of agricultural land and the number of farms. Thus farm operators may find it necessary to either cease operations at their present location or compete with other land users for purchase of additional acres. Indirectly, the multi-purpose reservoir or recreation lake alternatives would take additional acres out of production by conversion to recreational uses and construction of additional home or summer cabin developments. On the other hand, if the reservoir is not constructed, a continued intrusion of rural-residential home construction may be expected along the perimeter of the wooded portion of the valley.

Several facets of the relationship of agriculture to the proposed reservoir are summarized in this chapter. These include cropland nutrients, implications of pesticides and herbicides, livestock production, sediment, and erosion as these practices influence water quality and the environment, and agricultural drainage and flood problems. Primary emphasis is given to the impact of agriculture on the proposed reservoir or on the valley in the case the reservoir is not constructed. Discussion of agricultural drainage practices in the reservoir area and of downstream flood problems is found in the last section. The detailed agricultural report is included as Appendix 4 in the publication series, and comparison of agricultural and urban influences on water quality is reviewed also in Appendices 1 and 5.

Agricultural Characteristics of the Basin

The Soil Resource

The soils within the Skunk River basin belong to the Clarion-Nicollet-Webster Soil Association, as discussed in Chapter 2; the parent materials are glacial drift. About 75% of the area has level to gently sloping topography with numerous potholes existing in the flat, upland areas. Landslopes in these soil association areas vary from 0 to 5%, and the major soil types include Clarion loam, Nicollet loam, Webster silty clay loam, and Glencoe (Okoboji) silty clay loam. A high percentage of the soils have poor natural drainage, with permeability decreasing according to the order of listing above. Three to 5% of the acreage is in soils associated with potholes which contain ponded water after heavy rains. With the exception of the Clarion loam soils, the soils are high in total nitrogen. For example, the total nitrogen percent varies from 0.40 at 0- to 8-in. depth to 0.11 at 21- to 26-in. depth for Webster clay loam.

Farming Practices

The land in the watershed of the proposed reservoir is heavily cropped. Seventy to 75% of the land is tilled; 90 to 95% of the tilled land is in corn or soybeans. The average rate of application of fertilizer (125#N-nitrogen, 80#P_2O_5-phosphate, and 80#K_2O-potassium per acre per year) is 10 to 20% above the state average. More details on farming practices are found in Appendix 4.

While about 71 thousand acres of 340 thousand acres of cropland in Story County need better drainage, most of the Webster and Glencoe soils have some tile drainage. The number of feet of subsurface drains per acre varies from zero to about 430. Several miles of drainage ditches have been constructed in the upper portion of the watershed to provide outlets for tile and surface runoff.

Rainfall and Runoff on Agricultural Areas

The mean annual rainfall at Ames is about 31 in., based on 92 years of record. About 23 in. falls from April through September, which is the growing season. The mean annual runoff of streams is from 5-6 in., with approximately one-half derived from direct surface runoff and one-half from subsurface, groundwater contribution. The minimum rainfall at Des Moines, Iowa, was 17.1 in. in 1956; the maximum, 43.0 in 1947 (possibly exceeded in the 1972-1973 period). The mean annual class A pan evaporation for the Ames region is about 50 in., reflecting the annual maximum potential crop evaporation-transpiration rate (about 80-85% of the 50 in.).

Cropland Nutrients

The study results show that in this region relatively high concentrations of nitrogen and phosphorus may be expected in streams draining level, tile-drained land which is high in organic matter. Concentrations of nitrate-nitrogen (NO_3-N) in tile effluent ranges from 6 to 40 mg/l. Phosphate (P) in tile effluent is relatively low (0.03 to 0.3 mg/l) but ranges up to about 2 mg/l in small streams. Rivers and small streams draining farm land vary in NO_3-N concentrations from less than 1 to 15 mg/l. Usually concentrations are less than 10; the higher concentrations are associated with wet years. Ammonia nitrogen (NH_3-N) is highest in the spring during snowmelt runoff and ranges up to 5 mg/l NH_3-N; during the remainder of the season, ammonia levels are usually less than 2 mg/l.

The nutrient load (nitrogen and phosphate) in the Skunk River was closely observed from March 1, 1972 through August 31, 1972. A few measurements were made throughout the fall. Nitrate-N concentrations varied from about 3 mg/l through April to over 10 mg/l most of the rest of the year. Concentrations greater than 15 mg/l were measured in June. Ammonia-N concentrations reached 4 mg/l during snowmelt time, but were less than 1 mg/l most of the year. Phosphate-P ranged from 0.12 to 0.83 mg/l, the highest readings being observed during snowmelt time. About 20 lb/acre of NO_3-N, 1.35 lb/acre of NH_4-N, and 0.8 lb/acre of PO_4-P were removed from the watershed from March 1 through mid-October. About 2 lb/acre of organic N (sediment) and about 0.8 lb/acre of P in particulate matter were added to the flow in the sediment fraction.

Concentrations of NO_3-N in tile effluent sampled in the watershed and elsewhere were high, often being above 20 mg/l. Surface runoff from snowmelt and rain yielded less than 6 mg/l NO_3-N. Tile effluent and subsurface ditch bank seepage apparently were the primary source of NO_3-N in the river in 1972. The concentration and discharge were much higher than normal for the year.

The BOD concentrations varied from 2.2 to 7.1 mg/l at a sampling station above Story City and approached the dissolved oxygen concentrations at times of high discharge.

Nutrient Management

Relatively heavy nutrient loads may be expected in the Skunk River above Ames. Most of the nitrogen will be in the nitrate, NO_3-N, form. Depending on rainfall, somewhere between 5 and 25 lb of N-nitrogen per acre of watershed is delivered by the river to the reservoir area. Little information pertaining to nitrogen concentrations is available for dry years, thus the stated figures must be considered as estimates. Phosphorus loads may range up to 2 lb per contributing acre, about half of which is in the sediment. Nutrients delivered through sediment are relatively small as compared to streams draining more rolling lands.

Several management practices can be used to reduce the delivery of nutrients to streams. Land leveling, retention terraces, and other erosion control measures reduce nutrient as well as sediment delivery. Spreading of fertilizer and manure on frozen soils adjacent to streams should be avoided. Soil nitrogen should be kept to a minimum during cool months and in the absence of a crop. Fertilizer nitrogen should be sufficient, but not in excess of crop needs. Split application of nitrogen, for corn, initially as starter and later as side-dressing, provides for the most efficient fertilizer utilization.

Pesticide Implications

A survey of farmers and chemical dealers in the drainage basin of the Skunk River near Ames taken in June 1972 indicated that 80% of the farmers used herbicides on corn and soybeans; 60% used insecticides. Sixty percent of the herbicides used on corn were atrazine or atrazine combinations. Treflan and amiben were the dominant soybean herbicides. About 30% of the insecticides were chlorinated hydrocarbons and 20% phosphates. Aldrin was commonly used as a row treatment to control insects that attack first-year corn.

Several random samples of water were taken from the river from May 2 to June 15, 1972 and analyzed for atrazine and alachlor. Low concentrations (5 to 10 parts per billion, or ppb) were detected in samples taken during high runoff. No detectable residues were found in samples taken at times of normal flow (groundwater supply and tile flow, no surface runoff).

A review of studies made by others shows that pesticide levels resulting from runoff from treated agricultural land would not exceed maximum permissible values allowed for human consumption and therefore, from the pesticide standpoint, the reservoir could be a safe water supply for Ames. However, the nitrate levels could pose a problem since they exceeded the limit of 45 mg/l as NO_3-N in 1972, a high runoff year. The sediment in the reservoir probably would be contaminated with dieldrin because of the large amount of its parent compound, aldrin, that has been used on the soil in the past years. It is then possible that bottom-feeding fish caught in the proposed reservoir would have dieldrin concentrations exceeding permissible limits for human consumption. The impounding of the Skunk River would not be the direct cause of the contamination as bottom feeders caught from free-flowing Iowa streams have contained excessive amounts of dieldrin, but it is believed that impoundment allows silt to settle out over broader areas, making the pesticide it contains more readily available to fish and thus increasing their chances of contamination.

Recently the Environmental Protection Agency banned all major uses of aldrin and dieldrin; however, this ban is subject to appeal and court action is pending. Should the ban be upheld, the problem of fish contamination by dieldrin would be alleviated with time, as it has been shown that decreased usage of chlorinated hydrocarbon insecticides resulted in decreased levels in streams (see Appendix 4). However, because of the persistence of dieldrin in soils, the ban will not immediately result in zero dieldrin levels in streams; instead, it may be years before the dieldrin in the soil is degraded and that associated with sediment is degraded or covered to the extent that no fish contamination will occur.

An important question that is yet to be answered is what the farmer in central Iowa will substitute for aldrin and dieldrin in insect control. A Kansas-sponsored survey indicates that it will not be another chlorinated hydrocarbon (which might result in a similar problem to that of aldrin and dieldrin) but will be an organophosphorus or carbamate insecticide. These compounds, while generally quite toxic to mammals, are less toxic than chlorinated hydrocarbons to fish and are quickly degraded in the natural environments of soil and water. Additional details are contained in Appendix 4.

Increased utilization of soil and water conservation practices is expected in the future, which will reduce runoff and erosion. Examples are tile inlet terraces or minimum tillage systems. By holding the soil in the field, a major transport mechanism of pesticides is controlled, and thus the quality of surface waters is enhanced. Several Iowa studies have confirmed this.

With the present concern for the environment, the resulting social pressures, economic incentives, and laws have resulted in better ecological practices with respect to pesticides use. Therefore, if the dam is built, after an initial recovery period during which dieldrin levels will decline, there should not be a pesticide problem. However, monitoring of surface waters and related research regarding the fate of pesticides and, in particular, their metabolites should be continued to expose any presently unforeseen problems.

Livestock Production Implications

Livestock Densities

Livestock production in those portions of Story and Hamilton Counties included in the upper Skunk River drainage basin upstream of the reservoir site may be generally described as nonintensive. With a few exceptions, livestock and poultry are maintained in conjunction with other farming operations.

The major portion of livestock and poultry production within the watershed is in the fertile upland areas. For this reason, many facilities are located where slope is very mild and, in some instances, almost nonexistent. In addition, distances from production facilities to streams are often quite large. These two factors tend to minimize the pollution potential of many livestock operations in the watershed.

In general, livestock density throughout the watershed is relatively low, with the exception of a few large operations. Turkey production is high in some areas of the watershed, but the turkeys are not normally placed on range until after snowmelt runoff and the majority of spring rains have occurred. However, intense summer thunderstorm rainfall can cause waste runoff from the compacted feeding areas.

The large cattle operations within the watershed are primarily open feedlots. One large dairy enterprise is located just southeast of Story City. Only two of the cattle-feeding operations were observed to be located on sloping ground near streams. These two apparently fall under Iowa feedlot registration laws and have runoff control facilities installed. Due to their remote location, the remaining large operations pose little or no pollution hazard. Therefore, the physical characteristics of the watershed and current livestock production practices cause the pollution potential due to livestock to be minimal. The use of adequate waste management methods must be continued, however, to prevent significant water pollution of animal waste origin.

Table 9-1 summarizes the livestock population of the basin. The estimated daily manure and constituent productions is presented in Table 9-2.

Table 9-1. Inventory of livestock and poultry in those portions of Story and Hamilton Counties included in the upper Skunk River drainage basin.

Item	Story County	Hamilton County	Total
Dairy cows	225[a]	440	665
Beef cows	480	1,930	2,410
Fed beef cattle	4,420[b]	18,952	23,372
Hogs	19,470	80,868	100,338
Sheep	506	791	1,297
Laying hens	29,040	21,608	50,648
Turkeys	34,830	564,215	599,045

[a]Large portion of these is maintained in one enterprise, southeast of Story City.

[b]Includes four feedlots of over 100-head capacity.

The totals calculated in Table 9-2 demonstrate the large quantities of manure produced in a rural area which must be effectively managed to prevent water-quality degradation. The large number of producers and the relatively small herd sizes make this type of management possible.

Table 9-2. Estimated daily manure, BOD, nitrogen, and phosphate P_2O_5 production by livestock in the upper Skunk River drainage basin.

Item	Production (lb/day)			
	Manure	BOD	Nitrogen	P_2O_5
Dairy cows	49,500	800	180	72
Beef cows	120,000	4,000	385	241
Fed beef cattle	1,160,000	38,600	3,740	2,337
Hogs	1,000,000	38,000	6,000	4,000
Sheep	10,400	290	65	39
Laying hens	15,700	1,270	202	142
Turkeys	96,000	7,800	895	480
Total	2,451,600	90,760	10,967	7,311

Water Quality Implications

The quality and quantity of water stored in any major surface water impoundment is a function not only of the climate and topography of the drainage basin but of the activities within the basin as well. The Skunk River drainage basin above the proposed dam is used extensively for crop and livestock production. Animal manures are the principal concern related to livestock production and their potential contribution to impairing water quality within the reservoir.

The major water pollutants from animal manures are oxygen-demanding matter (principally organic matter measured as BOD), plant nutrients, and infectious agents. Color and odor are potential polluting constituents of secondary importance. Organic matter from livestock wastes, like that from other sources, serves as a substrate for aerobic bacteria when it enters a receiving stream. Associated with bacterial metabolism is the utilization of dissolved oxygen. When the rate of oxygen utilization exceeds the reaeration rate of the stream, oxygen depletion occurs. Further additions of organic matter will reduce the oxygen concentration below the level necessary for fish survival and the maintenance of a desirable aquatic environment. Under severe circumstances, dissolved oxygen is entirely depleted and anaerobic conditions result.

Nitrogen and phosphorus are the plant nutrients of primary concern with respect to livestock wastes. These elements contribute to the accelerated growth of aquatic plants in an impounded water body. In addition, toxicity caused by increased nitrate concentration is important in the groundwater supplies of rural areas.

Livestock wastes are also sources of infectious agents that may infect other animals and in some instances man. Among the potential water-born diseases transmissible from animals are anthrax, brucellosis, coccidiosis, encephalitis, erysipelas, foot rot, histoplasmosis, hog cholera, infectious bronchitis, mastitis, New Castle disease, ornithosis, gastroenteritis, and salmonellosis. Although contractions of water-born diseases are relatively rare in our country, increasing emphasis on water-based recreation creates new opportunities for this mode of infection. Leptospirosis has been spread from cattle to swimmers by the water-born route. These are discussed and referenced in Appendix 4.

Although animal waste may contribute to water quality deterioration in the various methods mentioned above, the escape of these pollutants can be controlled. Pollution is more a result of the livestock production technique and the animal waste management practice being utilized than of the numbers of livestock being produced. Any attempt to estimate the impact of animal production on water quality, therefore, must consider the management techniques in use as well as the location and number of animals involved.

For animals grazing a vegetative land area (range or pasture), little effect has been shown with respect to water pollution. Manure is randomly distributed in a light application, liquids are absorbed by the soil, and the vegetative cover utilizes the added nutrients and inhibits erosion. Unlike the pasture systems, animals produced in feedlots, pens, and other uncovered enclosures, in densities that prevent vegetative cover, present pollution hazards. During and immediately after rain and spring thaws, water may flow over the manure-covered feeding areas, carrying both particulate and soluble manure components with it. This pollution source must be considered in assessing the impact of livestock production on a surface water impoundment.

A limited sampling program was initiated during the spring of 1972 to confirm the predicted impact of livestock production on water quality in the upper Skunk River basin upstream of the reservoir site. This program was designed to gather data during the critical spring thaw and runoff period. Previous experience has indicated spring to be the time of greatest likelihood of detecting the washing of animal manure into streams.

Sampling sites upstream and downstream from feedlots ("paired stations") and pastured areas were established and sampling began as snowmelt runoff occurred. These first snowmelt runoff samples were probably the only ones taken when actual runoff from feedlot surfaces was occurring. Later samples (April and May) were taken during relatively low flow periods to characterize dry weather periods. The last samplings were made immediately after rainfall events in an attempt to obtain rainfall-runoff effects. However, storm and runoff durations were so short that, in each case, runoff had essentially stopped prior to sampling.

The biochemical oxygen demand (BOD) values were too low to be reliable for the second and third samplings. Initial values ranged from 1.5 to 33 mg/l. Kjeldahl values obtained in these last two samplings were very low; the reliability of these low values for the laboratory procedures being used is not great. In general, no concentrations of nutrients or oxygen-demanding materials were found to be particularly high.

Ammonia-N values during snowmelt for all locations varied from 5.2 to 8.9 mg/l except for one station near Keigley Creek at which the ammonia, NH_3-N, measured 20.7 mg/l. Only in the latter case (March 1) was an appreciable increase in NH_3-N observed, 8.9 to 20.7 mg/l. Values observed later varied from 0.35 to 4.3 mg/l. Nitrate-N ranged from 1.1 to 11 mg/l for all sites for the sampling period. Total phosphate-P concentrations were highest during snowmelt and ranged from 1.5 to 5.6 mg/l. No detectable increases between paired stations were observed for NO_3-N nitrate nitrogen and total phosphorus as P.

Summary of Livestock Effects

During snowmelt runoff, values of chemical oxygen demand (COD) at the downstream station of pairs were consistently higher than the upstream station values. This is probably the single most important observation to be made and supports a conclusion that livestock operations do contribute to water pollution under these conditions.

Nutrient concentrations also support this, but are not as consistent. Concentrations during dry weather, low-flow periods serve as good indications of base flow quality with negligible livestock effects. Stream water quality is obviously at its best under these conditions.

Stream quality again deteriorates under high-flow conditions caused by intense rainfall. Differences between paired stations, however, were not obvious under these circumstances. Since runoff from the selected point sources was not occurring during sampling, the true source of the increased pollutants cannot be specified. It is safe to say that many sources are partially responsible, including livestock operations when runoff actually does occur.

The samples collected in this program tended to verify previous experience with animal wastes and the conclusions reached in the literature. Under most conditions of drainage and stream flow, the influence of animal production was not detected in samples collected. Immediately below the cattle feedlot, increased organic matter concentrations were measured under runoff conditions as existed on March 1. Under the still higher flows as existed on March 8, little or no influence was detected. When samples were collected under moderate- to low-flow conditions after March 15, the livestock production sites were not showing a measurable impact on stream quality.

Control and Management of Livestock Wastes

Livestock production is currently of major importance in the upper Skunk River drainage basin. There are a large number of relatively small enterprises, a small number of large turkey producers, and one large dairy. No cattle feedlots or swine operations with more than 1000 head currently exist. Over two million pounds of manure are produced daily. Based on BOD, if all of this manure were discharged directly into streams in the area, it would be equivalent to the discharge of untreated sewage from a human population of approximately 500,000 people. Most of the manure is applied to cropland for its fertilizer value, however, using conventional hauling equipment for housed animals and by natural distribution for the pastured livestock.

Field observations and the sampling program indicate that, under current conditions, adequate pollution control is being exercised to protect water. The exact cost of the pollution control facilities if required is difficult to predict. Typically, costs for providing runoff control from cattle feedlots have ranged from $1.00 to $10.00 per head of lot capacity. Lower costs are generally associated with larger lots and with those located with some previous thought to the addition of runoff control facilities. For lots located immediately adjacent to streams or which pose other critical difficulties, relocation may be the most feasible solution. Manure management associated with confinement livestock facilities also represent a cost of production. The increased cost associated with a higher water quality demand is not readily measured but may be expected to be in the range of 0.5 to 1.0 cents per pound of livestock or poultry produced or 0.1 to 0.2 cents per pound of milk sold. Pollution control associated with pasture operations is most often related to being unable to graze areas adjacent to streams and reservoirs, thus, again adding cost and inhibiting further development.

An impact of reservoir development in areas of livestock production may be anticipated under the category of aesthetic concerns. On the basis of appearance, some recreational interests will object to the presence of livestock production. A more common complaint will be about dust and odors. Increased numbers of people and especially recreational development increase the frequency of odor complaints. The most effective technique for minimizing odor complaints is separation. This again limits both present livestock producers and the economic potential of the area in terms of animal production. Zoning should be a prime consideration in reservoir development plans.

Livestock wastes can be managed so that stream pollution is minimized and the standard indicators of water quality abuse are avoided. The following guidelines are being currently proposed to producers as aids in managing manures to avoid water and air quality degradation.

1. Provisions should be included in every livestock production scheme to prevent the direct discharge of manure to streams and reservoirs.

2. For confinement livestock production units, application to cropland is the only practical means of disposal in current use which can prevent the escape of pollutants. Waste treatment systems are useful to mechanize manure handling, but none of the systems currently in use produce an effluent suitable for stream discharge.

3. Where animals are confined at a density sufficient to preclude a vegetative ground cover, i.e., feedlots, some means of runoff collection and land application is necessary.

4. Feedlot boundaries should be located away from streams a distance of at least two feet per head of cattle, one foot per head of swine, and 0.1 foot per head of poultry.

5. Animals raised in pasture are not generally considered to present a significant pollution hazard. Animals should not be allowed to graze the area within 100 feet of the reservoir flood water line.

6. In those areas where animals are pastured in fields through which streams flow, the animals should be fenced out of the water if their number is sufficient to disturb the stream banks or to prevent growth in the area.

7. When applying manure to cropland, the following guidelines should be considered to avoid water pollution:

a. Manure should not be applied to frozen, snow-covered, or water-saturated soils.

b. Manure should not be applied to land within 100 feet of a stream.

c. Manure should be spread uniformly and at a rate not to exceed the nutrient utilization of the crop.

d. Immediate incorporation into the plant root zone of the soil is advisable whenever manure is applied to barren land or when odor control is important.

8. Distance is the best protection against odor complaints. Known odor sources are best located remotely from housing, commercial, and recreational areas.

Reservoir Sedimentation

<u>General Background Information</u>

Estimates of the long-term average sediment yield of the Ames Reservoir watershed and identification of areas of high sediment contribution were needed to measure the impact of sedimentation on the water quality and life of the reservoir. Estimates of sediment yield were made using sediment yield data from comparable watersheds located in north central Iowa.

Subdivisions of the basin divided according to land resource areas are presented in the Upper Mississippi River Comprehensive Basin Study, Appendix G, which is entitled Fluvial Sediment. These areas have been defined on the basis of similarities in geology. The resource areas are characterized by particular combinations or patterns of soils, slopes, erosion potentials, climate, land use, and kinds of farming. The Ames Reservoir watershed is located in land resource area 103, the central Iowa and Minnesota till prairies. A high percentage of the land is in farms with about 75% of the farmland in cropland.

The Skunk River watershed near Ames is relatively level and has poor natural drainage. Most of the cropland is tile drained. As a result, most drainage from the land passes through tile to tile outlets. Sheet erosion on the flat land does occur, but since surface drainage is so poorly defined, little of the eroded material is transported into the stream system.

Sediment Yields in Iowa

Four stream basins or "watersheds" in central Iowa for which sediment yield data were available were used to estimate sediment loads. These are shown in Fig. 9-1. The four watersheds were the Des Moines River as gaged at Boone, the Iowa River as gaged at Marshalltown, the Skunk River as gaged below Ames, and Four Mile Creek as gaged near

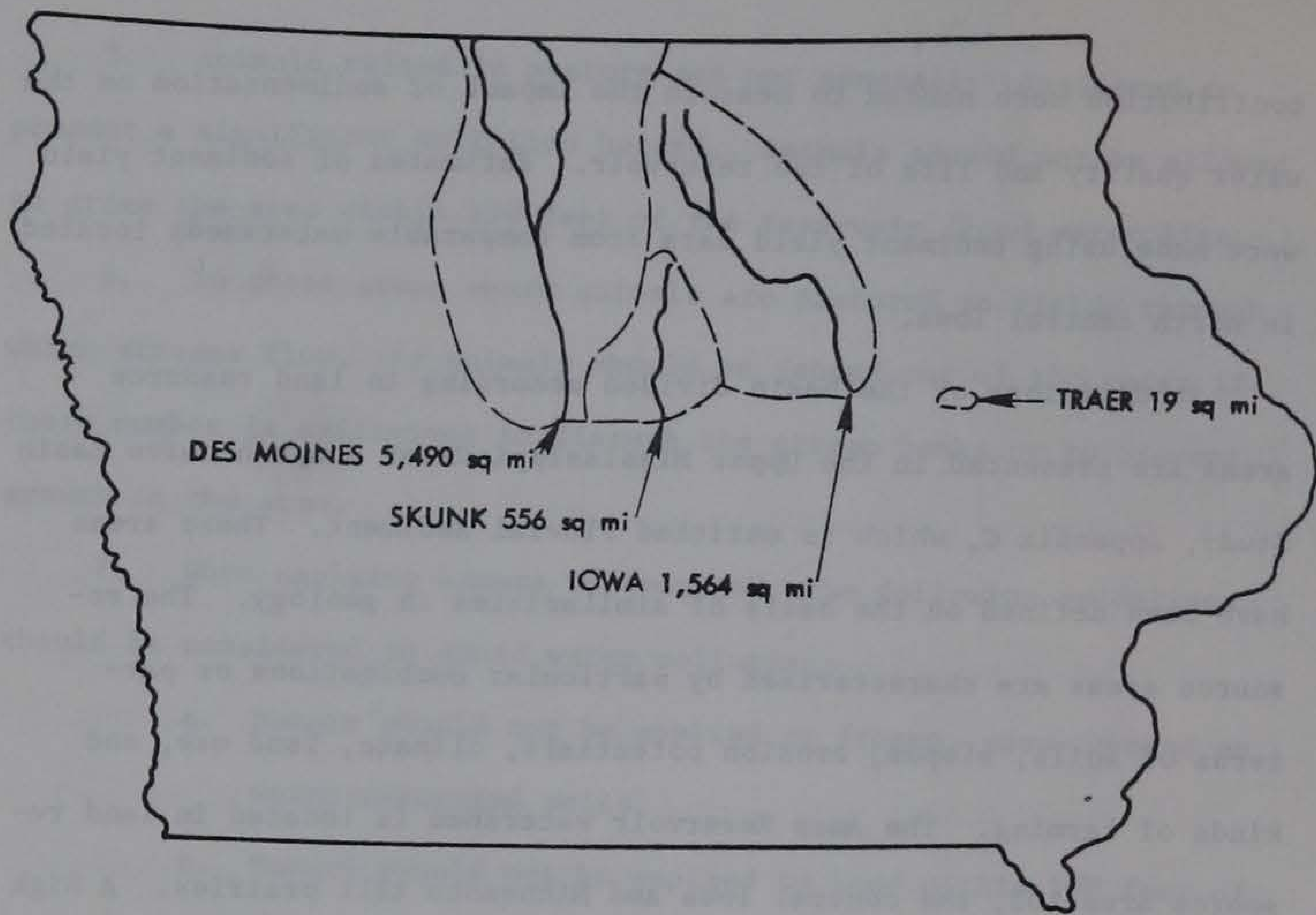

Fig. 9-1. Locations and sizes of watersheds.

Traer. The Skunk, Des Moines, and most of the Iowa River watersheds are in Land Resources Area No. 103. A small portion of the lower Iowa River and the entire Four Mile Creek watershed are in Land Resource Area 108. Area 108 is a dissected loess-mantled glacial plain with rolling to hilly relief with less flat uplands as compared to area 103. Sediment yields are generally higher in area 108 than in area 103. The watershed of the Skunk River as gaged below Ames (556 sq mi) includes all the Ames Reservoir watershed plus the Squaw Creek watershed of 242 sq mi.

Sediment yields of streams vary greatly from year to year due to the large variation in the number, intensity, and types of storms that occur in a watershed each year. To obtain the best long-term average sediment yields, the short-term records for the Skunk River and Four

Mile Creek were extended by the use of sediment rating curves. Sediment loads can be estimated for the same period as flow data are available. Table 9-3 gives recorded and extended yields as obtained from available data.

Table 9-3. Suspended sediment yields, tons per square mile per year.

Watershed	Recorded average Yield — Years record	Extended average Yield — Years record
Des Moines	204 — 31	—
Iowa	291 — 23	—
Skunk	273 — 4	213 — 20
Four Mile	354 — 2	324 — 8

Sediment yield data are derived from measurements of the concentration of sediment suspended in water and stream flow. A portion of the sediment load carried by a stream as bedload, which is material moved along the bed of a stream. No actual measurements of bedload were recorded in stream systems used in this study. However, several sources have recommended using 10% of suspended load as an estimate of bedload for streams in this area, as discussed in Appendix 4.

Many measurements show that sediment yield varies inversely with the size of the watershed area if watersheds have similar physical characteristics. The method used to estimate the sediment yield from the watershed of the upper Skunk River area was correlation of watershed area and sediment yield for the four regional watersheds. The long-term average sediment yield from each watershed was plotted as a function of its area on logarithmic graph paper. A straight line was fitted using the 4 known points (Fig. 9-2). The area of the Ames Reservoir watershed is 314 sq mi. A suspended sediment yield of approximately 270 tons/sq mi/yr is observed from the graph for this area. Adding 10% of the suspended load to allow for bedload, the estimate of the long-term sediment yield for the Ames Reservoir watershed is 300 tons/sq mi/yr.

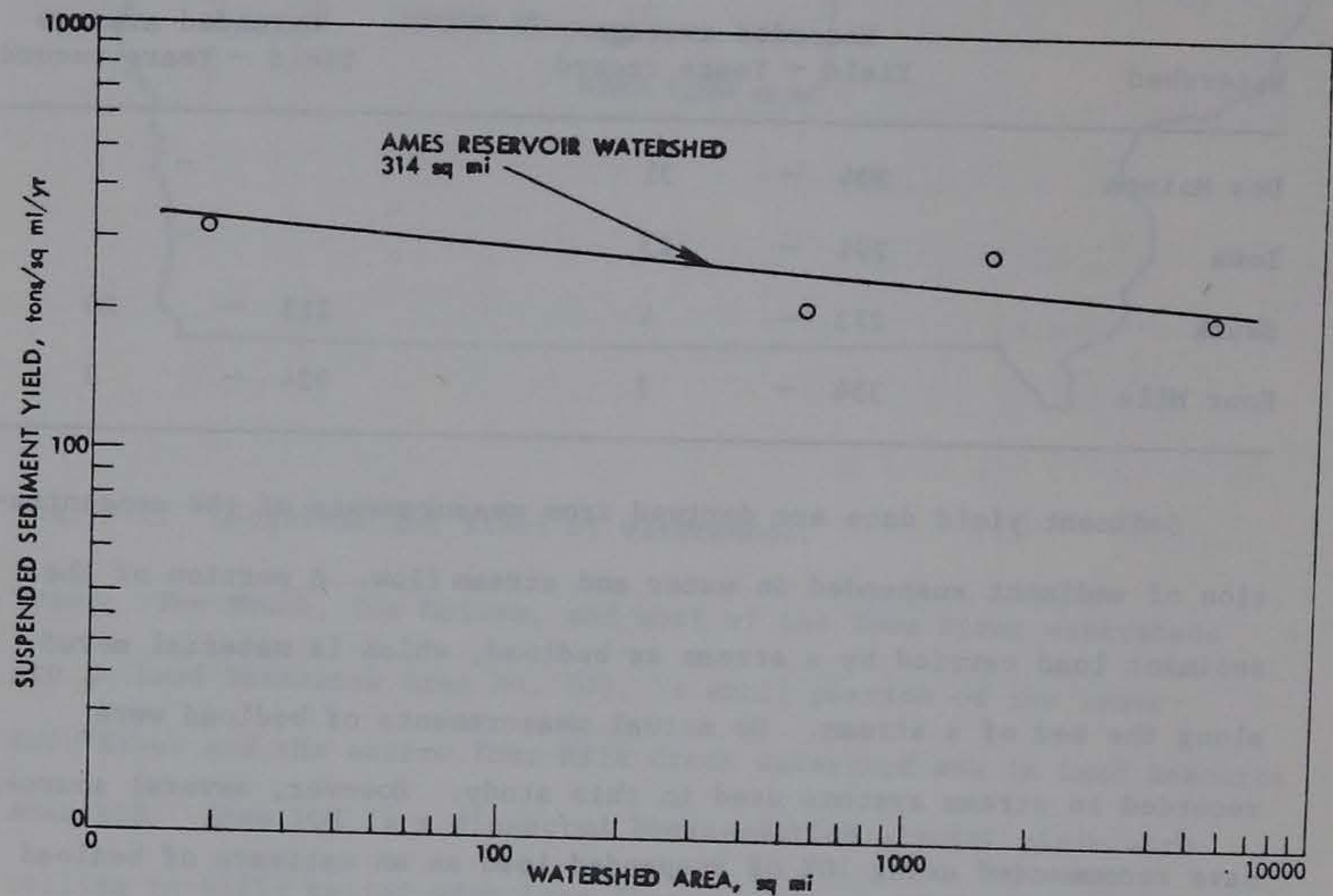

Fig. 9-2. Average sediment yield relationships for four watersheds in central Iowa.

Sediment Sources and Delivery

Most of the upper Skunk River basin including the Ames Reservoir watershed is flat or gently rolling. Research at Iowa State University has shown that the delivery ratio for terraced land with tile inlets is about 5%. Most of the soil loss from the terraced land is removed through the surface inlets (a direct connection between depressions in which water collects above terraces the the tile lines). Observations indicate that all depressions in the watershed are not drained by surface inlets. Therefore, it is reasonable to expect the delivery ratio of the flat portion of the Ames watershed to be less than 0.05.

Sheet erosion does not account for the total sediment yield of the watershed. Some sediment is supplied by channel or bank erosion. The portion of the total load derived from channel erosion is impossible to estimate without some measurements of channel sections made at regular intervals. The intensity of the meanders in the Skunk River and some of its tributaries makes it likely that natural channel erosion is a relatively significant contributor to the total sediment load. In areas where livestock is grazed near the streams, cattle and hogs loosen the soil on stream banks resulting in erosion when stream flow is high but is difficult to predict.

By dividing the watershed into areas of similar gross erosion rates and delivery ratios, an estimate can be made of the percentage that each area contributes to the total sediment load. This approach makes no attempt to relate a specific sediment yield to a specific area of the watershed, but it serves to demonstrate how sediment yields vary between areas. The assumptions made in dividing the watershed into different areas involve an attempt to average the extremely large variation in factors that affect sediment production in a watershed of this size. Assumed conditions were used in conjunction with a soil loss equation (the Universal Soil Loss Equation; see Appendix 4) to arrive at a ratio of sediment production rates from the flat and rolling portions of the watershed.

The 314-sq mi drainage area upstream of the Ames Reservoir site may be divided into two major areas: the flat lands and the sloping stream valley areas. The valley area may be further subdivided into the steep sloping valley sides and the much flatter land characteristic of a flood plain. Measurements using a topographic map indicate the total length of well-defined valley in the watershed is 114 mi with the valley area encompassing 57 sq mi. The valley can further be divided into 10 sq mi of steep sloping area (averaging about 20% slope), leaving 47 sq mi of flatter (around 5% slope) valley floor area. Two independent estimates (one based on a delivery ratio and the erosion equation, and the other based on sediment yields from flatland watersheds) indicate that more than 75% of the sediment contributed to the Skunk River above Ames is derived from the sloping area of the valley.

Measurement Program of 1972

A sediment gaging station was established on a county bridge (mile 231.5) approximately 1.5 mi upstream from the dam site to verify the estimated sediment production. The station consisted of a U.S. D-43 depth integrating sediment sampler and a wire gage for determining river stages. Sediment samples were obtained every other day for a period of six months beginning March 1 and ending September 1, 1972. During storm flows, three samples were taken during rising river stage and two or three samples taken during the recession. Then daily sampling was continued for several days during the recession of the storm flows. The U.S. Geological Survey (U.S.G.S.) at Iowa City determined the sediment concentration. The mean daily flow rate of the river was measured at the stream gaging station north of Ames (designated as

South Skunk River near Ames, Iowa). The minor difference in the flow at the gaging station and the sediment station was neglected because the contributing watershed area between the two stations was small. The sediment rating curve is shown in Fig. 9-3. By combining measured sediment concentrations and mean daily flow rate, the sediment yield was calculated at 270 tons/sq mi/yr.

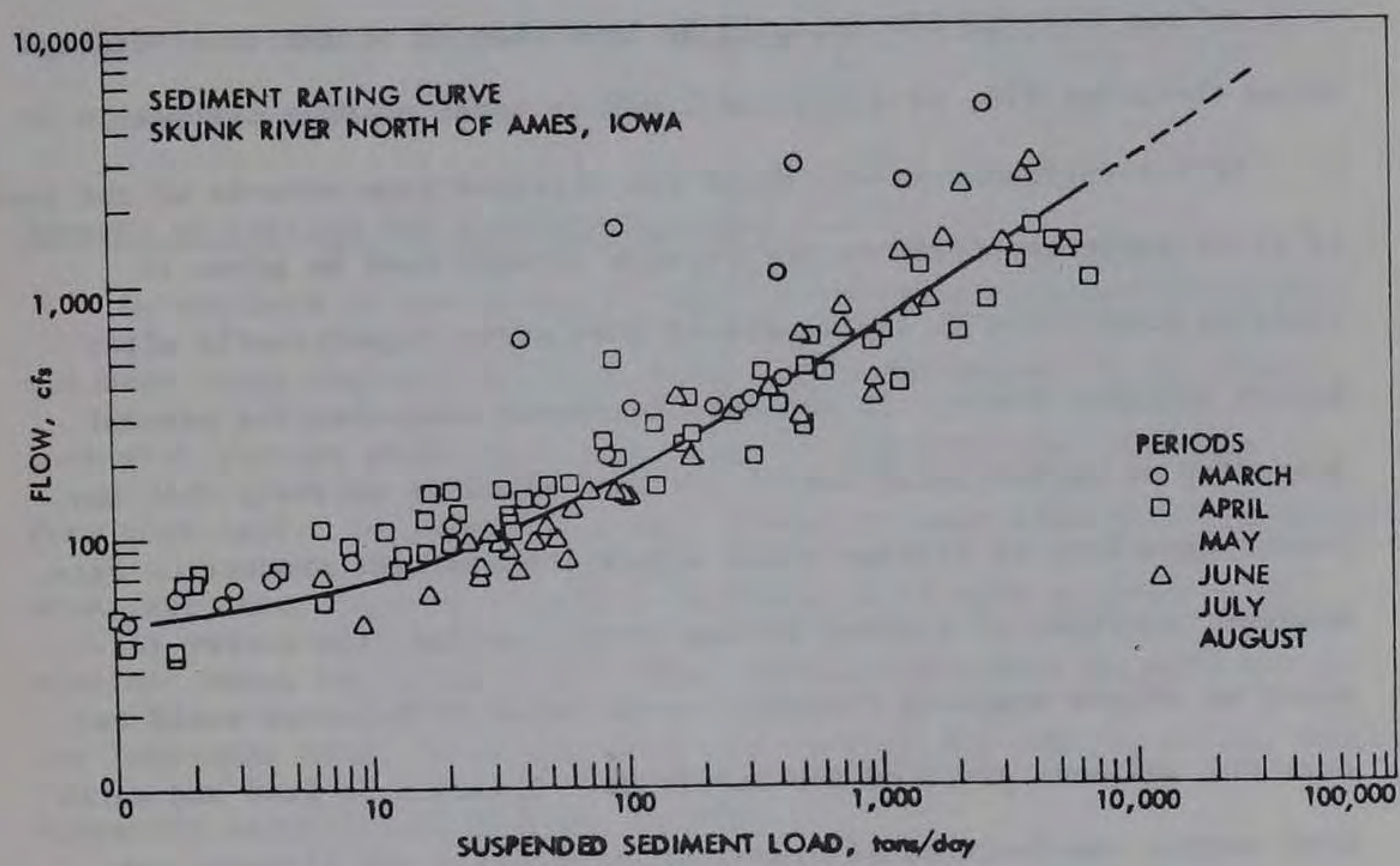

Fig. 9-3. Sediment rating curve, Skunk River north of Ames.

Volume Loss in the Reservoir and Other Effects

The sediment yield estimate for a proposed reservoir is used to calculate the amount of storage that should be allocated to sediment. The deposition of the suspended sediment and bedload in the proposed reservoir was evaluated. Because the reservoir capacity is sufficiently large in comparison to the average annual inflow volume (the capacity-inflow ratio is 0.3 or greater), most if not all of the sediment will be trapped in the reservoir. All of the bedload will be trapped, and a delta region will exist between the headwaters of the conservation pool and of the flood pool of any reservoir alternative (Alternatives 1, 1A, 2, 5, and 6). It is estimated that over 90% of the suspended sediment will be trapped in the reservoir during its design life (100-yr economic life of the Corps of Engineers). However, this amount, converted to a volume loss, in 100 yr, will be less than 7% of the total storage below elevation 976, or a loss of 0.07% of total storage per year.

If the estimated yield which was obtained from records of the past is to be projected into the future, some thought must be given to changing conditions in the watershed that might significantly alter future sediment yield. In the Ames Reservoir watershed, the present intensity of agricultural use of the land makes it unlikely that any future expansion of tillage would affect the sediment production rate. However, adoption of minimum tillage practices and tile outlet terraces on slopes draining directly to the river tributaries would reduce the sediment yield of the watershed. Clearing of land and earth work during construction of urbanization projects and highways can result in large quantities of sediment being contributed to a stream. However, the increased erosion is usually observed for a relatively short period of time.

The construction of a reservoir in a stream system can have long-term effects upstream and downstream from the reservoir. Because the reservoir traps most of the sediment delivered to it, the water downstream from the reservoir carries a reduced sediment load. The riverbed downstream may scour, change its slope, and pick up sediment while approaching the water-sediment equilibrium that was disturbed by construction of the reservoir. While it is difficult to predict the amount, some degradation downstream from a reservoir is common. A reservoir changes somewhat the slope of a river upstream from the reservoir because of backwater effects. This change in slope causes aggregation or deposition of sediment in the river channel upstream from the reservoir. Quantitative evaluation of scour and deposition is difficult.

Summary of Erosion and Sediment Problems

An estimate of the sediment yield of the Ames Reservoir watershed was made using regional sediment data. Four watersheds in northern Iowa with similar physical characteristics and available sediment data were used. Sediment yield was related to each watershed's drainage area; all other factors affecting sediment yield were assumed to be constant among the watersheds. Area correlation yields an estimate of the long-term total sediment production rate of 300 tons/sq mi/yr, including suspended sediment and bedload fractions.

Suspended sediment samples were also obtained from the Skunk River near the dam site. Daily sediment loads were correlated with the discharge rate of the river. The long-term flow characteristics of the stream were combined with the load-flow correlation to calculate a long-term sediment load. Bedload of the river was assumed to be 10% of the suspended load. The actual sediment measurement near the dam site yields an estimate of suspended sediment production rate of 270/tons/sq mi/yr. The estimate of 300 tons/sq mi/yr for total yield is probably the most realistic design value for the long-term sediment yield of the Ames Reservoir watershed. Converted to a volume loss in the proposed reservoir and using estimated trap efficiency data, approximately 0.07% of the volume would be lost annually.

The sediment production potential of different areas within the watershed was estimated. The watershed was divided into the flat to gently rolling uplands and sloping valley areas. A soil loss equation and data from a small watershed comparable to the upland area of the Ames watershed were used to determine that at least three-fourths of the total sediment load is produced by the valley area, a small percentage of the total watershed area.

The estimate of sediment yield of the Corps of Engineers and these independent estimates agree closely. Sedimentation of the proposed Ames Reservoir is a minimal problem. The sediment delivered to the reservoir will be distributed above and below the conservation pool elevation (950 ft). The bedload will form deltas in the headwater areas, with most of the suspended sediment coming to rest in the conservation pool and in the designated sediment storage pool (elevation of 933 ft for Alternatives 1, 1A, and 5). On the basis of the computations made, the conservation pool capacity can easily be maintained without being encroached upon for the planned economic life of 100 yr. Conservation practices applied to the sloping areas of the valley which are forced to row crop would increase the reservoir life, perhaps reducing the annual loss of storage by one-half of the estimated value.

Project Impact on Drainage Outlets

Concern of Landowners and Survey Method

One question of considerable concern to farmers and landowners above the dam site is the effect that water in the reservoir would have on the flow from existing tile drainage systems. On several occasions, the opinion has been expressed that tile drainage systems on watershed lands above the dam site would be adversely affected when the water level rises. A survey of "county" drainage district systems was made to determine the extent of the problem. Since the maximum elevation of the flood pool is at elevation 976, the location and size of all drainage outlets below that elevation was noted. After the outlets had been identified in the drainage record, a field investigation was conducted to determine the exact location of these outlets and if they were functional. The next step in the investigation was the location of drainage systems that drain individual farms. Since the conservation pool of Alternative 1 is at elevation 950, the location of drainage outlets between 950 and 976 was of primary concern.

Table 9-4 summarizes the potential impact on drainage systems of the watershed by the operation of the proposed reservoir, Alternative 1. It will be noted that three zones have been delineated. Zone 1 comprises those lands lying below elevation 976. Zone 2 includes those lands which are drained and which lie above elevation 976 but whose outlet is below elevation 976. Zone 3 comprises those lands drained above 976 which also have their outlet above elevation 976. Zone 1 lands will either be purchased outright or flowage easements will be obtained. Thus, drainage systems must be and will be considered in purchase or easement arrangements.

Table 9-4. Impact on drainage systems, using Alternative 1.

Zones	(Flood pool to elevation 976) Drained land is below 976	Outlet is below 976	Remedial measures needed
1	Yes	Yes	None (land to be controlled by government)
2	No	Yes	Replace tile with open ditch to 976 contour
3	No	No	None

For lands in Zone 2, the drainage system itself would not be inundated by fluctuating water levels in the reservoir, but the outlet to the system would be periodically under water. In Zone 3, no significant problem is anticipated since both the lands being drained and the outlet are above elevation 976.

Impact on Drainage and Recommendations

The areas of concern are in sections 32, 31, 30, 19, and 18 in Howard Township and sections 35, 36, 25, 26, 27, 22, 24, 13, and 2 in LaFayette Township in Story County, Iowa. The remaining areas are either located below 950 ft or have systems that outlet on the valley walls above 976 ft.

The only District Drainage Systems that outlet below 976 ft are LaFayette No. 73 and LaFayette No. 106. The LaFayette No. 73 drain outlets about 300 ft away from the 976 ft elevation in a 22-in. tile. The outlet is located in the NW 1/4 of SE 1/4 of section 24 in LaFayette Township. The exact location is 800 ft south of the east-west centerline and 1800 ft west of that point. The LaFayette No. 106 drain outlets directly into the Skunk River in section 12 of LaFayette Township. The outlet is located in the NE 1/4 of the SE 1/4 of that section and is a 12-in. clay tile. It is about 500 ft laterally below the 976 ft elevation.

It is recommended that certain modifications be made as a part of the project where the outlet to the subsurface drain system is between elevations 950 and 976. The possible problem related to the proper functioning of drainage outlets in this region is that fluctuating water surfaces in the reservoir would permit the deposition of sediment in the outlet, thus restricting its flow over a long period. Even though there is relatively small likelihood of this occurring, any possible problem of this kind could be prevented by constructing a length of open channel from the existing tile outlet location to elevation 976. There is also the possibility of some backwater effect in the streams draining into the reservoir. This backwater effect at times of high flow into the reservoir would increase slightly the stages in the streams for a short distance upstream from the 976 water surface elevation. However, this backwater effect would be relatively minor in the streams of the watershed. When this is taken into account along with the infrequent rise of the reservoir surface to elevation 976, the adverse affect on the drainage systems above that elevation is negligible.

Agricultural Flood Problems

Introduction

Flood control represents a major impact of the proposed Ames Reservoir on the Skunk River valley. Substantial crop and property damage has resulted from floods. In an effort to reduce these damages, landowners along the Skunk River and below Ames have made sizable investments in river training works. Before 1900, a new channel for the river was constructed. Horses and scrapers were used to construct a pilot channel which was then enlarged by the river flow. In the early 1920's, levees were constructed along both sides of the river through Polk County. Both surface and subsurface drains have been installed in the flood plain to decrease crop damage resulting from standing water. Thus, over the years landowners have initiated projects and made substantial investments of their own funds in improving the Skunk River flood plain for agricultural production. The proposed Ames Reservoir project offers the possibility of additional improvements and resulting decreases in average annual flood damages.

Flood control represents a major component of the economic justification for the project. The Corps of Engineers, in its most recent economic justification, shows that flood control represents 49% of the total benefits. The vast majority of flooding in the Skunk River basin occurs in the rural sector, as shown in one of the reservoir documents. The following is an excerpt from this report.

> "Lands most greatly affected by floods are located along that reach of Skunk River between its mouth and Ames, Iowa. Flood damage occurs predominantly in rural areas. Urban damage is relatively small, even in very severe floods."

The Corps of Engineers report listed the damage sustained and areas flooded for six major floods. These are given in Table 9-4. The Corps also has divided the Skunk River valley into four reaches for the purposes of evaluating flood damages extending from Ames to the mouth.

Table 9-5. Flood damage summary (1969 price levels) for the Skunk River basin[a].

Year	Rural property	Urban property	Crop and pasture	Total	Acres flooded
Aug. 1943	$254,000	0	$1,954,300	$2,288,300	49,150
May 1944	827,300	21,700	3,632,000	4,481,000	80,377
May 1945	187,000	0	1,641,200	1,828,200	42,500
June 1946	160,000	1,100	1,488,600	1,649,700	40,600
June 1947	363,300	5,700	3,569,000	3,938,000	78,031
Apr. 1960	686,000	1,100	0[b]	687,100	62,300

[a]From Corps of Engineers Design Memo No. 1, 1970.

[b]Flood occurred prior to normal crop-planting season.

Of the total estimated damages of $14,872,000 from these six floods in the Skunk River basin, only $29,600 was attributable to damage in urban areas. This was less than 0.2% of the total, relegating urban problems to a less important role.

Impact of Frequency Analysis on Benefits

The magnitude of flood control benefits is sensitive to the frequency analysis of the flood flows. Frequency distributions are used by hydrologists to analyze historical records of hydrologic data. The results of the analyses are then used for development of plans and economic analyses for water resources management. Unfortunately, the analysis of the same set of data by application of different frequency distributions can give results that differ widely. The variability of the predicted flood discharges was investigated for the Skunk River basin to show how benefit-cost analyses would be affected.

Statistical Methods. Some of the more frequently used frequency functions are discussed in a bulletin prepared by a national Committee on Water Resources. These statistical methods include the log-normal, gamma, extreme value functions of type I largest and type III smallest, log Pearson type III, and distribution free methods. The methodology of predicting future events from a historical record, regardless of the distribution selected, involves the computation of a mean, $\overline{X}$, and standard deviation, S, of the data. In some cases, the mean and standard deviation will be that of the logarithms of the data. The general equation is then $X = \overline{X} + KS$ where X is the magnitude of the flood discharge, K is a frequency factor whose value is determined by the desired probability level of X, type of distribution used, and the treatment of the coefficient of skew. Applying the above distributions to a common set of data during the committee studies, the results for a predicted 100-yr recurrence interval event range from 213,870 to 830,000 cfs or approximately a 4-fold variation.

Based upon the studies and recommendations of the Work Group on Flow-Frequency Methods of the Hydrology Committee, the Water Resources Council issued Bulletin 15, "A Uniform Technique for Determining Flood Flow Frequencies," in December 1967. The three recommendations made by the Hydrology Committee were accepted by the Council and are summarized below.

1. The state of the art is such that complete standardization is not feasible or appropriate. A base method should be adopted with the provision that other methods be used where justification is presented.

2. Based upon several reasons, the log-Pearson Type III distribution (with the log-normal as a special case) is recommended for adoption as a base method for flood frequencies.

3. Because of the importance of flood flow frequency estimates in the field of water resources development and programs for managing flood losses, member agencies are encouraged to improve techniques and procedures in this field.

Iowa Studies. The Iowa Natural Resources Council (INRC) had been active for a number of years in requesting that federal agencies adopt a uniform approach in calculating flow frequency relationships. Subsequent to the publishing of Bulletin 15, the INRC entered into a cooperative agreement with the U.S. Geological Survey (USGS) in Iowa City to make a study of the rivers and streams in Iowa using the log-Pearson type III method of determining flow frequency relationships.

Flood frequency relations were then developed that were applicable to an entire region so estimates of flood magnitudes at ungaged sites could be made. Several methods were investigated, but the equations developed using the multiple-regression method reproduced the base data with the least standard error. This multiple-regression method is a statistical technique which defines a mathematical equation of the relationship between floods of a given frequency of recurrence to hydrologic parameters and basin characteristics. From this study, a uniform technique (Regional) was proposed by the USGS.

The Skunk River data were analyzed by the log-normal, log-Pearson type III and the Regional method as developed by the USGS. The variability, expressed as the difference between high and low predicted values divided by the low value for a given station, ranged from 27% to 56%. In general, the variability increased with a greater return period, and the log-normal distribution used by the Corps of Engineers gave the largest predicted values.

Since the use of a skew coefficient and the treatment of extremely large or small values in relation to the other data (outliers) in flood frequency analyses can significantly affect the result, an analysis of the record of 170 Iowa streams was made. If the log-normal method is applicable, the coefficient of skew should approach zero as the period of record increases. Table 9-6 gives the analysis for Iowa streams, indicating a definite trend toward negative skew coefficients.

Table 9-6. Selected data from analysis of annual peak flows[a].

Length of record	Average skew	No. of samples	Range in skew
15 yr	- 0.1536	30	- 1.8325 to + 2.0716
15-25 yr	- 0.2491	81	- 2.4004 to + 1.1506
26-36 yr	- 0.4936	28	- 1.1813 to + 0.5297
36-45 yr	- 0.4674	13	- 1.2767 to + 0.3735
46-55 yr	- 0.6140	9	- 1.1180 to - 0.2287
56-65 yr	- 0.5057	5	- 1.2246 to + 0.1438
66-75 yr	- 0.5932	4	- 0.8808 to - 0.3953

[a]Data furnished by Oscar Lara, U.S.G.S., Iowa City, Iowa.

The data show that as the length of record increases (greater than 45 yr) the skew coefficient of the logarithms stabilizes to a value of from - 0.5 to - 0.6 with much less variation than in the samples taken from the shorter period of record. From this analysis of 170 Iowa streams, it seems very questionable whether one can assume the coefficient of skew is equal to zero which is the requirement for use of the log-normal distribution.

The computed coefficient of skew is also extremely sensitive to conditions where an annual peak flow is very low in comparison to the next lowest peak flow. For example, the lowest recorded peak flow for the Skunk River near Ames, below Ames, and near Oskaloosa are 376 cfs, 638 cfs, and 782 cfs, respectively, while the next lowest flows are 600 cfs, 1620 cfs, and 3700 cfs, respectively. Likewise, Iowa studies show the lowest event for the East Nishnabotna River at Red Oak is 355 cfs while next lowest event is 3250 cfs, a 10-fold difference. There would seem to be some justification for excluding the low outliers as not being part of the current population, more so than the high outliers. Also, if one were using the partial duration method, they would likely be dropped. Table 9-7 shows the effect on the predicted value of an annual peak flow for six Iowa stations. The removal of a low outlier produces opposite effects on the predicted values for a 100-yr event when comparing the log-normal distribution and log-Pearson type III distribution. The 100-yr predicted peak increases with the log-Pearson, but decreases with the log-normal.

In a converse manner, it may be concluded that, when low outliers are included, the predicted value for a 100-yr event is much greater for the log-normal than for the log-Pearson type III distribution. This results also in a greater magnitude of annual flood damages for

Table 9-7. Effect of outliers on prediction of 100-yr peak discharge at selected gaging stations.

Station	Coef. of skew of logarithms		Discharge, cfs, for log-normal, 100-yr frequency		Discharge, cfs, for log-Pearson, 100-yr frequency	
	With outlier	Without outlier	With outlier	Without outlier	With outlier	Without outlier
Skunk Rv., N. Osk.	- 2.0518	+ 0.224	28,056	19,280	12,716	20,540
Skunk Rv., N. Ames	- 0.978	- 0.483	11,673	10,200	7,484	8,425
Skunk Rv., below Ames	- 1.893	- 1.377	21,933	16,000	9,543	10,070
Crane Crk., N. Saratoga	- 1.5482	- 0.5733	6,280	3,755	1,961	2,775
Bear Crk., N. Ladora	- 1.3819	- 0.461	15,111	12,100	8,841	10,450
E. Nishnabotna Rv. at Red Oak	- 2.19	- 0.21	63,500	39,000	20,200	34,700

the log-normal method. Additional treatment of the statistical importance of these several methods is contained in Appendix 4. The results listed in Table 9-6 show that, with the low outlier values removed from the data, the estimated 100-yr peak discharge values for each method at a given station do not vary appreciably (± 10 to 20%). Also, the probability meaning of a 100-yr event should be kept in mind. Such an event has an annual probability of occurrence of 0.01, or a one percent chance of occurring in any one year. In a period of 1000 yr, the 100-yr flood would occur 10 times on the average, but there could be 2 occurrences or more in any 100-yr period, and no occurrences in others.

Analysis of Rural Flood Damages

Economic losses are suffered by farmowners and operators when high stream flows occur through flood plains being used for agriculture. Above normal stages, even if the flow is not out-of-banks, cause accelerated channel erosion. The resultant sloughing of banks decreases the size of field areas and increases costs of production by increasing the curvature of field boundaries. When streams go out-of-banks, additional losses occur. Field operations are stopped and decreased yields result because of untimely crop operations. Crop damage may occur due to extended periods of inundation and lodging of plants caused by flowing water. Damage to bridges, transportation rights-of-way, and farmstead structures also occur. In addition, the life of farm machines, the comfort and health of machine operators, and the actual harvest yields are adversely affected by dust and delays in harvest precipitated by flooding.

Method of Study. To test the impact of an alternative frequency analysis on the benefit-cost analysis, the log-Pearson type III distribution recommended by the Water Resources Council was utilized to develop a damage probability curve based on the regional multiple regression analysis approach of the Iowa Natural Resources Council. Revised benefits were estimated for Reaches 3B and 4 as identified by the Corps of Engineers, and the resulting percentage charges were applied to the published project benefits from the remaining reaches. The procedure used to obtain the revised benefits for Reaches 3B and 4 is described below.

In order to estimate crop and pasture damages for the Skunk River valley, the valley was divided into reaches in such a manner that each reach was assigned to a specific gaging station. For the Ames Reservoir project computations, the "Skunk River below Squaw Creek" gaging station was used for Reaches 3B and 4. Reach 3B includes the portion of the valley in Polk County (mile 188 to mile 202), and Reach 4 extends from the Polk-Story County line to the Ames dam site (mile 221).

Discharge vs frequency relations for the "Skunk River below Squaw Creek" station were derived using the log-normal method and the method developed by the U.S. Geological Survey and the Iowa Natural Resources Council using their "regional multiple regression" approach (see Appendix 4).

From the regional data plot of discharge vs frequency, a tabulation was prepared for the array of discharge values associated with one-half foot increments of stage. By use of the damage vs stage relation of the Corps, it was then possible to develop a crop and pasture damage vs probability relation for the "without project" situation. From Plate 1-6, Design Memo No. 1 of the Corps of Engineers, another array of discharge values vs frequency was obtained from the "annual event-all year" curve. This figure, Plate 1-6, is based on the frequency distribution (log-normal) utilized by the Corps modified for length of record. The resulting damage vs probability curve for the log-normal distribution was then drawn. In addition, new damage vs probability curves were similarly prepared for Reach 3B.

The area under the damage probability curves represents the average annual flood damages. The calculated crop and pasture damages from the curves are listed in Table 9-8.

Table 9-8. Comparison of estimated crop damages using two flood frequency methods.

Item	Annual damage for given reach of river	
	4	3B
Without project — Corps analysis	$185,500	$320,600
Without project — regional analysis	102,600	157,200
Estimated damages based on the regional analysis and expressed as a fraction of the Corps analysis values	0.55	0.49
Average fractional value	0.52	

It can be seen that the average annual benefit value is quite sensitive to the frequency distribution assumptions, being about a 2 to 1 effect. If it be assumed that comparable reductions would occur for the other reaches and for the property damages, the revised flood control benefits picture would be substantially altered. The average annual flood control benefit might be reduced from $681,100 to $354,200 if the same percentage applies throughout the basin.

Differences in Crop Yields and Prices. Project reports present separate assessments of flood damages for crop losses and property losses. There seems to be little justification for assuming significant changes in the average annual property losses, as based on 1970 prices, for the next 50 or more years of returns from the project. There does seem to be, however, justification for anticipating changes in the crop flood damages. Costs of production and selling prices will no doubt change, but they are quite difficult to forecast. However, it can be predicted with considerable confidence that crop yields will increase over the life of the project. Thus, based on 1970 dollars, it would be expected that the crop benefits would increase throughout the life of the project.

For the current study, flood control benefits were re-estimated using revised values of yields per acre, selling costs per bushel, and production costs. The most significant change in these variables was the yield per acre. For corn, a value of 135 bushels was used. It will be noted in Appendix 4 of this study that corn yields during the life of the project have been projected to a value of 165 bushels per acre by the year 2020. Interviews with farmers and extension specialists indicate that current average yields in the Skunk River valley are at the 125 bushels per acre level. Average farm yields over the last few years have been in the order of 150 bushels per acre for the better farmers. The selling price for corn was used as $1.25 per bushel, which is the 1970 price-adjusted normalized value based on national indices. The comparable price-adjusted normalized values for soybeans is $2.68, which appears to be quite low in relation to the market prices prevailing early in 1973.

Per acre crop losses were re-estimated for original crops of corn and soybeans and for replanted crops of none, corn, or soybeans. These computations are shown in Table 9-9. Each of the re-estimated per acre crop losses was then divided by the per acre crop losses used to compute the flood control benefits in the 1970 report. Ratios of the two loss figures vary between 1.5 and 1.8. Considering the number of acres in each of the crop categories, a ratio value of 1.7 was selected for further computations.

Revised benefits from flood control were then estimated on the basis of the ratio selected and described in the preceeding paragraph. The crop benefits are shown in the 1970 report for the valley as $503,300. 1.7 times this value gives a benefit of $855,000. If the property values shown in the 1970 report are added (that is a value of $177,800 is added to $855,000), an estimate of the revised average annual flood control benefits is arrived at of $1,032,800. When this value is compared with the original $681,100, it will be noted that flood control benefits occurring to the project have increased by 52%.

Summary of Rural Flood Damages and Benefits

A major component of the economic justification for the Ames Reservoir project is reduced flood damages. The selection of a frequency analysis and method of use thereof can have a sizable effect on the dollar estimate of benefits. Based on the assumption and methodology of this chapter, it was estimated that with the log-Pearson type III distribution, the benefits would be 0.52 times the value originally estimated by the Corps, which was based on the log-normal distribution.

Table 9-9. Revised crop loss estimates.

Original crop	Replant crop	Computations	Per acre crop loss	Ratio[a]
Corn	None	Gross Cash Yield (GCY) = 135 bushels per acre times $1.25 per bushel = $169.00. Production costs per acre = $65.00 (assumed). Net cash yield per acre = $104.00. Harvest cost per acre = $28.00. Weed control cost per acre = $2.00 (assumed). Therefore, for May-June floods, loss = GCY - costs not incurred (CNI) = $169.00 - (28.00 + 2.00)	$139.00	1.8
	Corn	GCY - CNI = $169.00 - 30.00 = $139.00. One-half GCY - total production costs (TPC) = ($169.00 ÷ 2.00) - 65.00 = $18.50	120.50	1.6
	Soybeans	GCY = 52 bushels per acre times $2.68 per bushel = $139.36. Production costs per acre = $41.00. Net cash yield per acre = $98.36. Harvest cost per acre = $12.00 (assumed). Weed control cost per acre = $1.00 (assumed). Therefore, for May-June floods, loss = $169.00 - 30 + $139.00 and (GCY ÷ 2) - TPC = ($139.00 ÷ 2) - $41.00 = $28.50	110.50	1.6
Soybeans	None	GCY - CNI = $139.99 - (12 + 1) =	126.00	1.8
	Beans	GCY - CNI = $126.00 (GCY ÷ 2) - TPC = $69.50 - $41.00 = $28.50		
	Corn	GCY - CNI = $126.00 (GCY ÷ 2) - TPC = ($169.00 ÷ 2) - $65.00 = $19.50	106.50	1.5

[a]Ratio of recomputed per acre crop loss to Corps per acre crop loss. Ratio approximates 1.7 for all crops.

Flood control benefits for flood plain lands in agricultural production are strongly influenced by costs of production, product selling prices, and yields per acre. Using what is considered to be a reasonable set of revised values for these variables, it was estimated that the flood control benefits would be 1.7 times the value originally estimated by the Corps. The combined effect of the frequency and crop studies is the product of 0.52 × 1.7, or a 0.88 factor. This implies that approximately 88% of the flood damages evaluated by the Corps could be realized in the final economic evaluation. Additional sensitivity to a fourth factor, the stage-damage levels estimated by the Corps, was not studied in detail, but differences could exist here also.

For the reduced-scope alternate (Alternative 6), the flood control benefits have been estimated at 85% of the benefits of the full-scale project. The recreation only and green-belt alternates do not have any flood control benefits associated with them. Flood damage reduction presumably would then be accomplished through one of two available methods. An agricultural levee system incorporating necessary interior drainage facilities is a physical alternative. Flood insurance for crops, buildings, and property is an economic alternative. These were not studied in detail but deserve additional attention if the reservoir alternatives are not pursued further.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part II. Impact Evaluation of Alternatives

Chapter 10

URBAN IMPACT: CATEGORY 5 STUDIES

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Chapter 10

URBAN IMPACT: CATEGORY 5 STUDIES

Introduction

There are many identifiable urban needs in the upper Skunk River basin for water or water control. These include: water supply for domestic, municipal, and industrial uses; water pollution control of urban waste discharges; recreation water needs; and flood plain management and/or control of floodwaters. These urban water requirements and related problems are directly dependent on the number of persons to be served, and this required careful projections of population and water demands. All of these factors illustrate the importance and complexities of identifying urban needs within the agriculturally oriented region and the other environmental areas of concern.

The studies of the urban influence on the water resource, urban needs, and related environmental impact are included in Appendix 5 of the ARES project review. Population growth trends, both urban and rural, were studied in depth and summarized previously in Chapter 3. Other studies included evaluation of the needs and problems at Ames and a general review of needs and problems at other urban communities in the upper Skunk River basin. Water supply sources and requirements for the City of Ames are important because of the steady growth of the community and its large size in relationship to the county (two-thirds of the county's 62,000+ inhabitants). Water pollution control is of great importance, not only to the Ames urban area, but also to Story City and the reservoir area. The point source of pollution at Ames was evaluated as it is affected by reservoir capabilities (for various development alternatives) for low-flow augmentation and in view of revised water quality stream standards. Urban flood damages are not severe, and a brief review sufficed for study purposes.

These studies of urban water supply, water pollution control needs, and flood plain management concepts are summarized in this chapter. Outdoor recreation needs associated with the reservoir were studied by the Category 3 research team, using the population projections of the urban study. Ames plays the greatest role in all of these studies, but Story City and developments in the reservoir area also will have an impact on environmental quality of the valley and the river system.

The Groundwater Resource in the Reservoir Area

Background Information

The proposed Ames Reservoir (and all multi-purpose reservoir alternatives) will have a substantial influence on the groundwater system in the Ames area. The surficial aquifer consisting of alluvial and buried channel formations (sands and gravels) is interconnected with the existing stream and valley systems. Impoundment of water in the reservoir will increase the water levels in the surrounding geological formations and the seepage potential around and through the dam. Low-flow augmentation will increase the availability of water during drought periods to ever increasing pumping rates by the city. The city well field is located in a buried channel underlying Ames and is sustained by seepage from the river and the alluvial groundwater system. Releases from flood control storage will result in half-bank to bankfull stages in reaches at and downstream of Ames. Too much increase in stage by these releases will cause the groundwater table in flood plain lands to rise and drown the roots of agricultural crops. Release rates must be limited to nondamaging stages, as related to groundwater effects. These several effects were evaluated in Appendix 5 and briefly summarized in this chapter.

Both improvements and detrimental effects can occur. Quantity and quality aspects are equally important, and each received appropriate attention in the Category 5 studies. Three major areas of study were included in this phase:

1. The effect on the groundwater system at the reservoir site, as determined by continued observation of groundwater levels and dewatering operations in the reservoir area.

2. Further evaluation of the permissive sustained (safe) yield and maximum sustained yield of the aquifer at Ames to supply the needs of Ames and Iowa State University. Both the city's and university's well fields were re-evaluated in the study.

3. The general response of groundwater levels in the flood plain downstream of Ames to rises in stream stage, as reflected in the observation well system installed near Cambridge.

A comprehensive study of the geology and geohydrology of the Ames Reservoir site has confirmed the nature of the surficial aquifers. The existence of a deep bedrock channel bypassing the dam site was confirmed also, as discussed in detail in Appendices 1 and 5, and its permeable sands and gravels were identified as a buried-channel aquifer. This system is interconnected with the valley alluvial aquifers and the stream system, both at Peterson's and Hallett's gravel pits (or quarries). The nature of the buried channel and the piezometric water levels through the aquifer in the reservoir area is illustrated in Figs. 10-1 and 10-2.

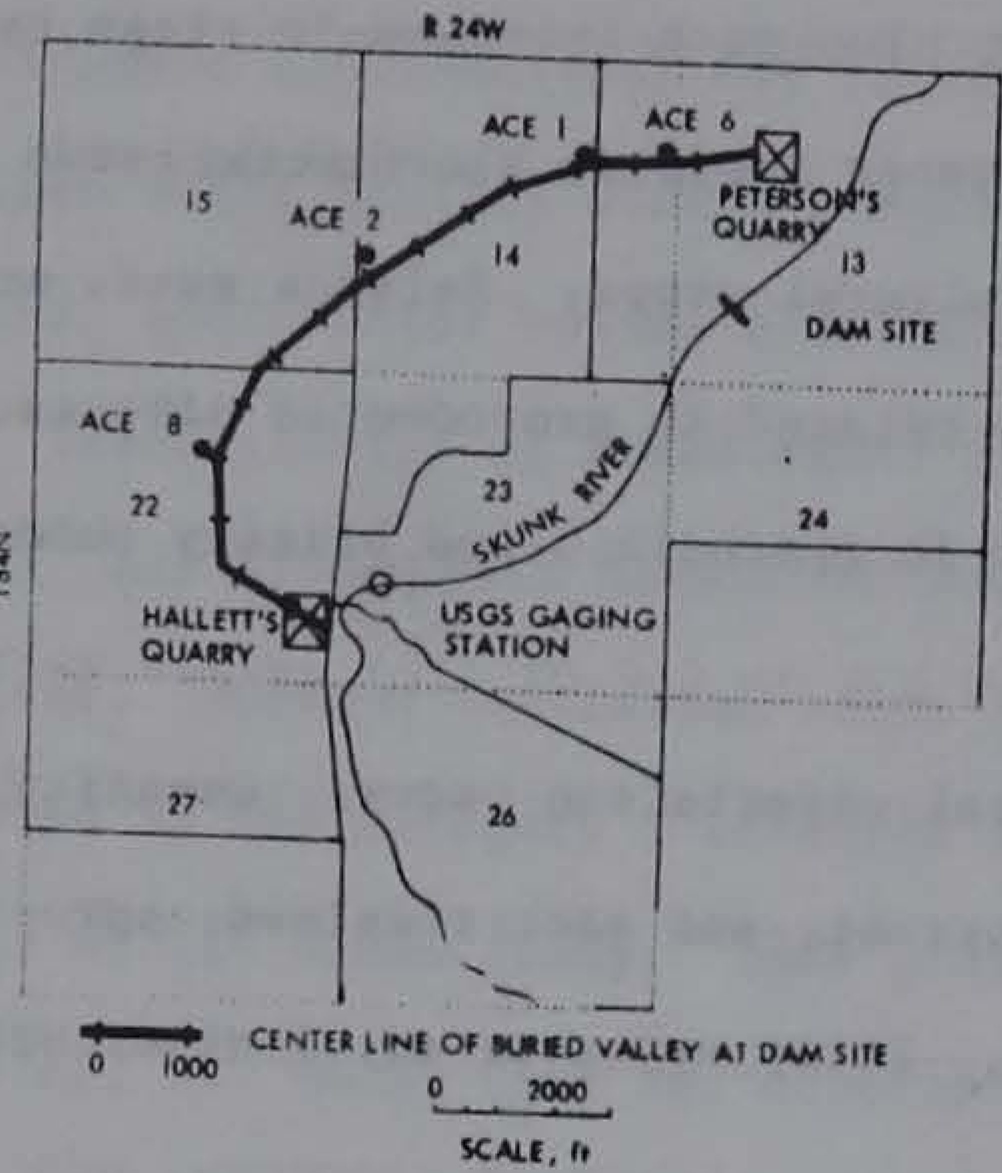

Fig. 10-1. Map view of the bypass valley and buried channel system as used in the seepage analysis.

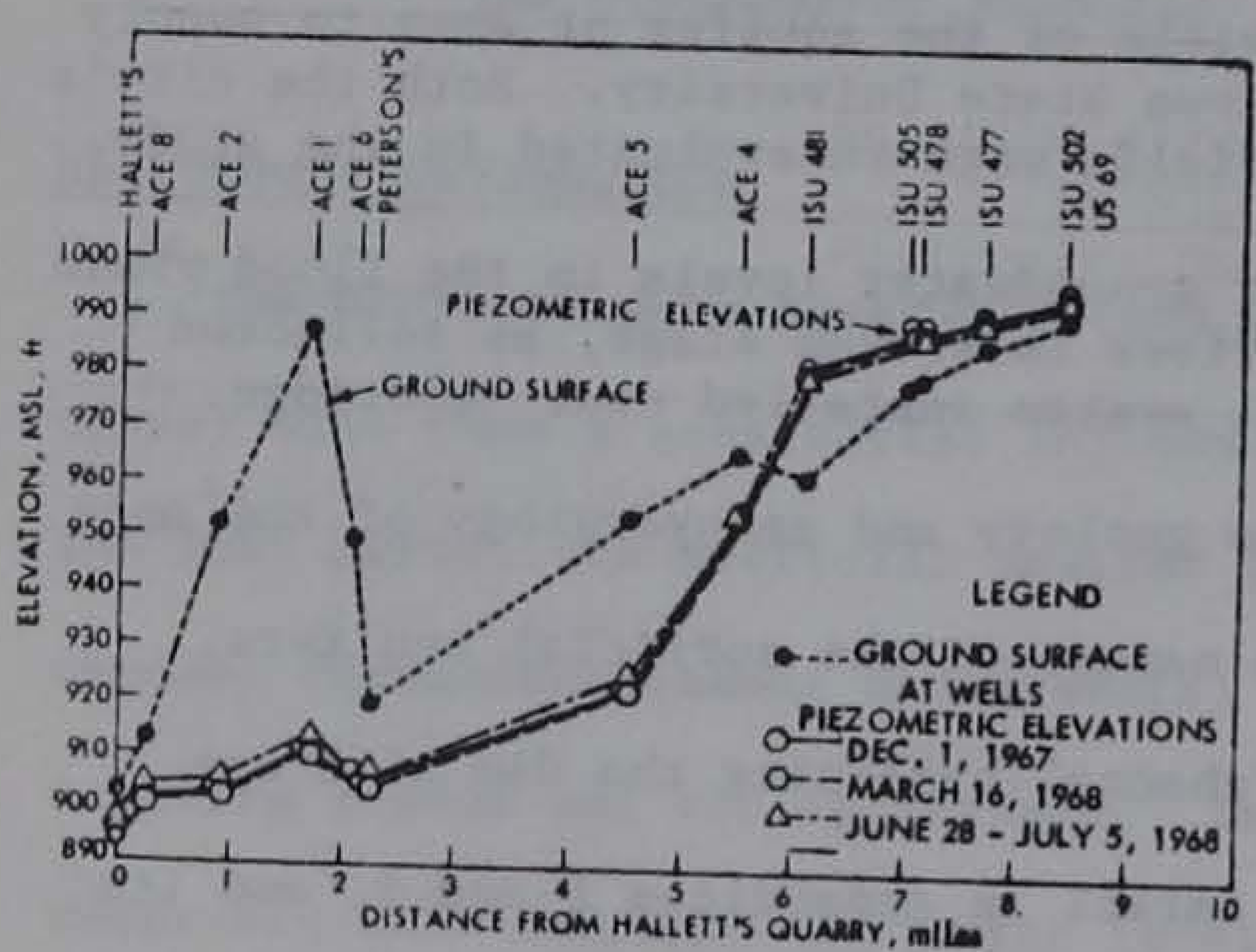

Fig. 10-2. The groundwater piezometric gradient through the Ames Reservoir area.

Impact of the Reservoir

The buried-channel surficial aquifer in the reservoir area can be divided into two segments. The downstream segment which is of most concern extends from the reservoir influent area at Peterson's gravel pit in Section 13-T84-R24 to the discharge section at Hallett's gravel pit in Section 22-T84-R24 (see Fig. 10-1). A direct connection exists between the gravel quarries and the buried-channel aquifer. Once completed and filled, the reservoir can transmit water readily through the buried channel to Hallett's quarry area and then to the Skunk River downstream of the quarry.

Upstream Segment. The upstream segment of the buried-channel aquifer in the Story City area is confined by overlying till strata left by the Wisconsin glacial deposition. The buried channel is connected hydraulically to the adjacent and underlying artesian bedrock aquifer which places it under artesian pressure also. As a result, flowing wells are common in this area. The artesian piezometric head falls below the elevation of ground surface northwest of Soper's Mill access, in Section 31-T85-R23 (see Fig. 10-2).

The effect of the reservoir upon the confined aquifer portion will be considered in a general qualitative sense. At proposed conservation pool elevations of 940 or 950 ft, little effect on the artesian piezometric surface would be expected. The existing artesian heads are greater in elevation than the proposed conservation pool elevations. A small increase in piezometric elevations in the lower or most downstream area of the confined aquifer, in Section 36-T85-R24, might occur.

At the maximum flood pool elevation of 976 ft (Alternatives 1, 1A, and 5) or the reduced-scope project (Alternative 6) flood pool level of 965 ft, the more downstream portions of the confined aquifer area will have a hydraulic loading equivalent to a 20- to 30-ft depth of water. This will reverse the piezometric gradient in some areas and in addition will tend to compress the southern part of the confined aquifer. Some local increase in the artesian piezometric elevations may occur. However, it is believed that the effect would not be substantial in areas outside of the flood pool, because the present piezometric elevations exceed 980 ft. In either case, the effect would be beneficial in increasing the piezometric elevations and possibly providing a slight increase in flowing well discharge. This effect probably would be temporary and would fluctuate with the reservoir water surface elevations during flood operation periods. Little or no effect is foreseen at Story City, which has municipal wells in the confined aquifer.

Downstream Segment Bypassing the Dam Site. The role of the existing piezometric "mound" (see Fig. 10-2) in the buried valley bypass will be overshadowed and reversed by the reservoir seepage contributions. Water levels in the reservoir at the proposed conservation pool elevations (940 or 950) and the maximum design flood pool elevations (965 or 976) greatly exceed the highest existing static water levels in the buried valley (911 to 913 at ACE Well No. 1). The piezometric gradient will thereafter be in the downstream direction.

The results of the seepage study are listed in Table 10-1. They indicate that the seepage discharge will be in the magnitude of 6 to 9 cfs for the reservoir operated at the conservation pool elevation of 950 and from 9 to 14 cfs at the maximum design flood pool of 976. For the

Table 10-1. Estimated seepage discharge values for the bypass channel at the Ames Reservoir site.

Condition	Relative elevations ft MSL		Seepage discharge cfs	
	Reservoir	Hallett's quarry	Average permeability	Maximum permeability
1. a. Alternatives 1, 1A, and 5, design conservation pool operation	950	890	6.4	9.4
b. Design flood pool operation	976	890	9.1	13.5
2. a. Alternative 6 (and 2) reservoir design conservation pool operation	940	890	5.3	7.9
b. Design flood pool operation	965	890	7.9	11.8

alternative reduced-scope project, the estimated seepage discharge will be in the magnitude of 5 to 8 cfs at the conservation pool elevation of 940 and from 8 to 12 cfs at the flood pool elevation of 965 ft. These estimates could vary from 10 to 20% if a weathered rock zone exists at the channel bedrock interface or if additional gravel excavation shortens the present seepage path to a minimum of about 10,000 ft.

Discussion and Summary

The seepage values do appear to be less than the reservoir release discharges desired for water quality control or low-flow augmentation (20 to 50 cfs, etc.). In addition, the velocities of flow are low because of the long flow path which is 2.3 to 2.8 mi, depending upon the assumed entrance and exit sections (bulk velocity of 4 to 5 ft per day under maximum flood pool conditions). Therefore, the seepage discharge does not appear to be detrimental to normal reservoir operation or to dam and reservoir safety conditions.

The effect of the reservoir upon the piezometric elevations is not so easily interpreted. Slightly higher piezometric elevations might occur at the Hallett's quarry area if flood stages in the downstream channel are high. Therefore, a potential exists for a high water table condition in this downstream area from the bluff at Hallett's quarry to the river downstream of it. The effect of the seepage discharge upon groundwater levels in the Hallett gravel pit area may be of more concern than the magnitude of seepage discharge. Careful study and interpretation of the results of these investigations will be necessary in proposed detailed design phases to determine if remedial measures are needed, and if needed, which type might be more effective. It is recommended that the Hallett gravel pit be considered a part of any reservoir project and an outflow control structure be included in the project planning. The construction of a reservoir will therefore add to the water supply inventory, either directly as a surface water impoundment or indirectly through the added seepage contribution.

Aquifer Characteristics at the City of Ames

Sustained Aquifer Yield Concepts

The groundwater studies at Ames were an extension of previous studies of the surficial alluvial and buried-channel aquifer in the Ames area. The Iowa State University well system was studied using a pumping test, and the results of this test were compared with the results of pumping tests conducted previously on the City of Ames municipal well system. A digital-computer groundwater model was used to simulate the response of the surficial aquifer to various situations of stress imposed by pumping, and to determine the reasonable capability of the shallow aquifer system in the Ames area to meet future demands. The objective was the quantitative determination of the permissive sustained (safe) yield of the combined and fully-developed well-field systems of Ames and the university, and the maximum sustained yield.

The permissive sustained yield conforms to the concept of "safe" yield used by many agencies and water resource organizations. It is the greatest withdrawal rate which can be permitted over a long period of time without causing an undesirable or undue effect and can be limited by certain physical, legal, or economic factors. The maximum sustained yield is that withdrawal rate which can be obtained physically from the system without actually "mining" the water or dewatering the formations to the point where serious physical effects would ensue. For confined aquifers, one should not pump water from the formations to lower or depress the piezometric surface (atmospheric pressure levels in the aquifer) below the interface between the aquifer and its overlying confining beds. Periodic or cyclical dewatering of the confined aquifer formations could lead to detrimental reconsolidation, decreasing the storage coefficient and the permeability. Maximum sustained yields frequently cannot be permitted because of legal or economic factors. Water rights of prior or other users may be a factor, and in some locations in the nation, water levels have been drawn down from overpumping to the point where the amortized cost of pumping may exceed the economic value of the water.

The Surficial Aquifer at Ames

The term "aquifer," or "water-bearing formation," is a relative term used to designate a subsurface formation that contains a considerable amount of gravity water. An aquifer is usually defined as a saturated bed, formation, or group of formations which yields water in sufficient quantity to be of consequence as a source of supply. For municipalities requiring substantial quantities of water, alluvial or buried-channel sand and gravel formations and certain bedrock formations serve as the best sources of supply.

In the Ames area, the units which serve as the surficial or "regolith" aquifer are the floodplain sands of modern stream channels, the sheet-like body of fine-grained sand within the glacial till, and the thick sequence of sand and gravel subcropping beneath the surface till. The municipal wells of the City of Ames penetrate this upper till; the screened portion of these wells is located in the buried sand and gravel formations. The University wells penetrate similar till layers, into buried sands and gravels which are further underlain with ancient till deposits. Figure 10-3 shows the relative location of all wells in the combined production well field system at Ames.

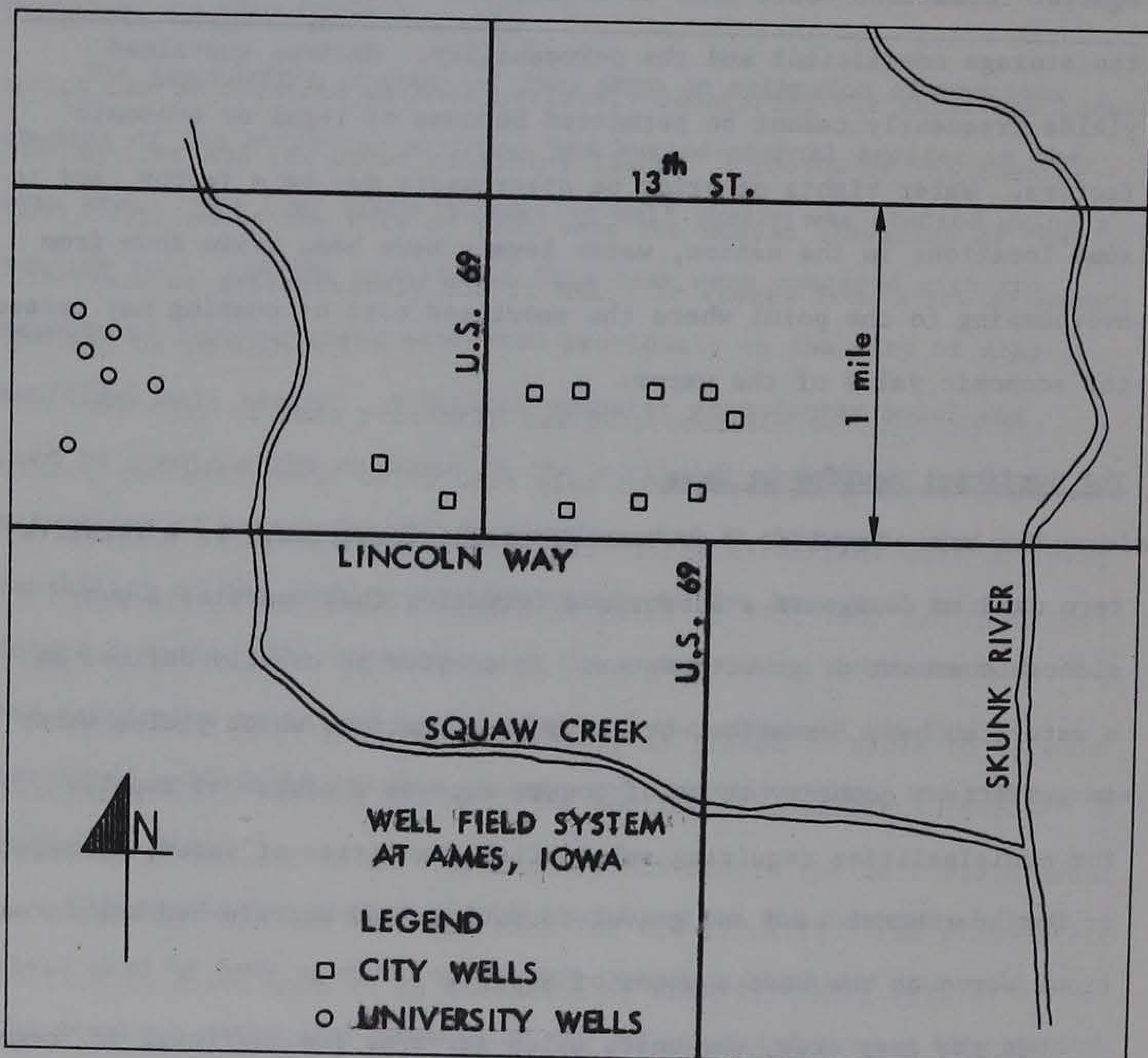

Fig. 10-3. Relative locations of both City and University well fields at Ames, located in alluvial or buried-channel formations.

Hydraulic Characteristics of the Aquifer

Tables 10-2 and 10-3 list the values of transmissivity (coefficient of transmissibility) and storage coefficient determined from several pumping tests of the City and University well fields. Note that all of these studies concerned themselves with that portion of surficial aquifer lying between Squaw Creek and the Skunk River, except for the data of Table 10-3 for the west side of the Squaw Creek valley.

Determining the Safe Yield of the Ames Aquifer

In determining the aquifer capacity, the "safe" or permissible sustained yield is defined in this study to be the maximum rate of withdrawal

Table 10-2. Computed values of the transmissivity and storage coefficient for the buried-channel aquifer at Ames[a].

Well	Transmissivity, T(gpd/ft)				Storage coef., S_c ($\times 10^{-4}$)		
No.	Akhavi	Ver Steeg	Johnson	Wiegand	Ver Steeg	Johnson	Wiegand
CW-2	189,200	178,000			1.73		
CW-5	172,800	141,000			4.88		
CW-6		227,000			1.44		
CW-7	189,000		198,000			2.49	
CW-8	283,900		192,000			2.49	
CW-9	141,400	154,000		147,000			2.30
CW-10	167,300	159,000			2.22		
CW-11	233,800						
CW-12	189,700	188,000	162,000		1.53	2.53	
CW-13	196,300	210,000			2.20		
CW-14			152,000				
OW-1	311,700						
OW-2	188,000		165,000			4.66	
OW-3	150,000		147,000			2.50	
OW-4	159,000						
OW-5	170,000	156,000			1.53		
OW-6	233,800						

[a]Values determined from pumping tests as identified by specified study research at ISU.

Table 10-3. Values of transmissivity and storage coefficient for University well field and confined aquifer.

Well No.	Transmissivity T(gpd/ft)	Storage coef. S_c
ISU #7	59,200	2.71×10^{-4}
ISU #8	61,400	4.00×10^{-4}
ISU #9	55,100	2.78×10^{-4}
ISU #10	71,500	(pumped well)
MU-2	78,900	1.83×10^{-4}

which can be obtained without seriously dewatering the interface between the aquifer and its upper confining layer. A review of the logs of wells drilled in the City of Ames sets the median elevation of that interface at approximately 850 ft MSL. It ranges from a low of about 840-845 up to 860 ft.

The City of Ames presently has 10 production wells. For this study, two additional wells were also considered as a future part of the system, bringing the total to 12. Three situations were analyzed in which all 12 wells were pumped at rates of 500, 750, and 1000 gpm each.

The results of the computer study, as listed in Table 10-4, show that at a daily rate of 8.6 mgd, the aquifer piezometric surface drawdown is reduced to an elevation of 855-860 in the well field area. At a rate of 13.0 mgd (750 gpm each for the 12 wells), the piezometric surface is drawn down to an elevation of 844-852. At a rate of 1000 gpm each, or 17.3 mgd, the aquifer is dewatered to an elevation of 832-842.

Table 10-4. Simulated equilibrium drawdown elevations in the City well field, 12 wells at 3 pumping rates[a].

City well No.	Drawdown elevations, ft MSL for indicated pumping rate for each well		
	500 gpm	750 gpm	1000 gpm
5	859	851	841
6	858	849	839
7	858	848	838
8	858	849	840
9	858	850	842
10	855	844	832
11	859	851	842
12	855	844	832
13	859	851	842
14	855	844	833
15	860	852	843
16	857	847	837

The interface is at an elevation of about 850; therefore, for a permissive sustained yield concept, the data in Table 10-4 show that by limiting the pumping rate to a value greater than 500 gpm but less than 750 gpm would avoid any dewatering whatsoever. A rate of 600 gpm for each of the 12 city wells, or about 10 mgd, would be the interpolated value which represents the <u>safe yield</u> of the fully-developed city well field. The <u>maximum sustained yield</u> would permit full use of the overlying piezometric head and perhaps a very slight amount of dewatering of the interface. This is represented by the 750 gpm pumping rate for each, or a total of 13.0 mgd for the 12-well city system.

Review of the computer output indicates that for the existing University well field equivalent values for the permissive sustained yield would be approximately 3 mgd and for the maximum sustained yield more than 4 mgd. The production wells all exhibit very high characteristic well losses, with very high drawdowns at high pumping rates. Drawdowns exceed 50 ft at production wells for discharges exceeding 1000 gpm (2-3 cfs). To keep drawdowns to a more reasonable value, a future well field of six wells, carefully spaced, is envisioned, which should be limited to 500 gpm each to minimize the characteristic well losses and associated drawdown. This would yield a total of 3000+ gpm, or more than 4 mgd.

Summary of the Yield Studies

This analysis and study of the Ames aquifer shows that the combined yield of both well fields (city and university) fully developed would be 13 mgd for the permissive sustained (safe) yield concept and 17 mgd for the maximum sustained yield. Once the demand for water at Ames exceeds these values, additional sources of supply must be found. Those which have been identified to date include:

a. The valley alluvial aquifer portion of the surficial aquifer located between 13th Street and Hallett's gravel pit in the Skunk River valley.

b. The Hallett's gravel pit area, once gravel extraction is completed, is a part of a storage-surface withdrawal-well seepage system.

c. Bedrock aquifers underlying the surficial aquifer system.

d. The proposed Ames Reservoir as an alternative which would provide the additional supplies (Alternatives 1, 1A, 2, 5, and 6).

Water quality problems also have occurred in the City well field area of the surficial aquifer. These have been identified subsequently through studies by the Department of Chemistry as being aromatic hydrocarbon compounds, which impart a distinct undesirable taste and odor to the water. The source is believed to be an abandoned waste pit south of the present water treatment plant (between the railroad and Lincoln Way at the edge of the Skunk River flood plain). At this point, waste residues were introduced from the former city gas-production plant in which coke was converted to gas for home cooking, etc. This occurred in the earlier part of the century prior to construction of natural gas pipelines into the region in the late 1930's and 1940's. Most of the residue material was excavated and removed from the area in the 1950's.

It appears at this time that control can be achieved through treatment alternatives and/or selected pumping schedules and arrangements. If the situation becomes more of a problem, alternative water supply sources would have increased importance in the future.

Present and Future Municipal Demand for Water at Ames

Future Needs and Economic Values

The combined needs and water supply systems of Iowa State University and the City of Ames must be included in any comprehensive study of future needs and alternatives. The well fields developed by each in the surficial aquifer have a combined permissive sustained yield ("safe" yield) of about 13 mgd. The maximum stress which might be permitted for short-term periods (peak demand periods of a month's duration or less) is 17 mgd. University and municipal needs (domestic, commercial, and industrial) which in the future would exceed these demands, would have to be obtained from alternative sources of supply. Faculty of the sanitary engineering section have evaluated in detail the opportunity to have softened water available at both Iowa State University and the City of Ames, and the alternative of having the City act as the major water supplier for the entire community, including the university.

The four areas of water supply needs were evaluated in the Category 5 studies and are summarized in this section and the following one:

1. Estimates were made of the future demand for water by the City of Ames, including Iowa State University and other commercial and industrial growth requirements.

2. Evaluations were made of the capability of the current and alternative sources of supply to meet these projected demands.

3. Evaluation was made of the maximum economic benefits for water supply which might accrue to the reservoir as a viable alternative, using the bedrock aquifer in an alternative cost comparison study.

4. Additional direction was provided from the study conclusions, which would guide future acquisition, control, and development of groundwater and surface water sources.

In order to determine the adequacy of the water resources of the region, including both groundwater and surface water sources, the demands which will be made upon these sources must be known or estimated. Average daily per capita demand, the amount of water each person will use in a day, is the most common reference level. Total daily demands in the community are then obtained by multiplying the amount of water used by a person (measured in gpcd, gallons per capita per day) by the number of people being served. Future demands are estimated by projecting both the per capita demand rates and population, accounting for expansion of area served, commercial and industrial growth, etc. These techniques were used in the current study to estimate the future demands at Ames. Peak demands also can be analyzed on a daily, weekly, monthly, or seasonal basis; all of these data are needed for determining maximum supply, treatment, storage, pumping, and distribution system requirements.

Demand Studies at Ames

The data in Fig. 10-4 show that per capita water use increased from 105 gpd in 1951 to 126 gpd in 1967. The temporal variations in demand were compared with precipitation trends, and it was observed that demand for water definitely increased during drought periods and decreased during periods of excessive precipitation. Using estimates made by the 1960 Senate Select Committee for 1980 and 2000, it also was found that a linear relationship through these points agreed closely with the high points (drought years) of the Ames data. Using this relationship, an average water use of 150 gpcd was estimated for 2020.

Detailed Projections for the ARES Study

Per Capita Use Rates. Using the above studies as background, the projected water use rates shown in Table 10-5 were used in estimating future demand for the City of Ames, including Iowa State University.

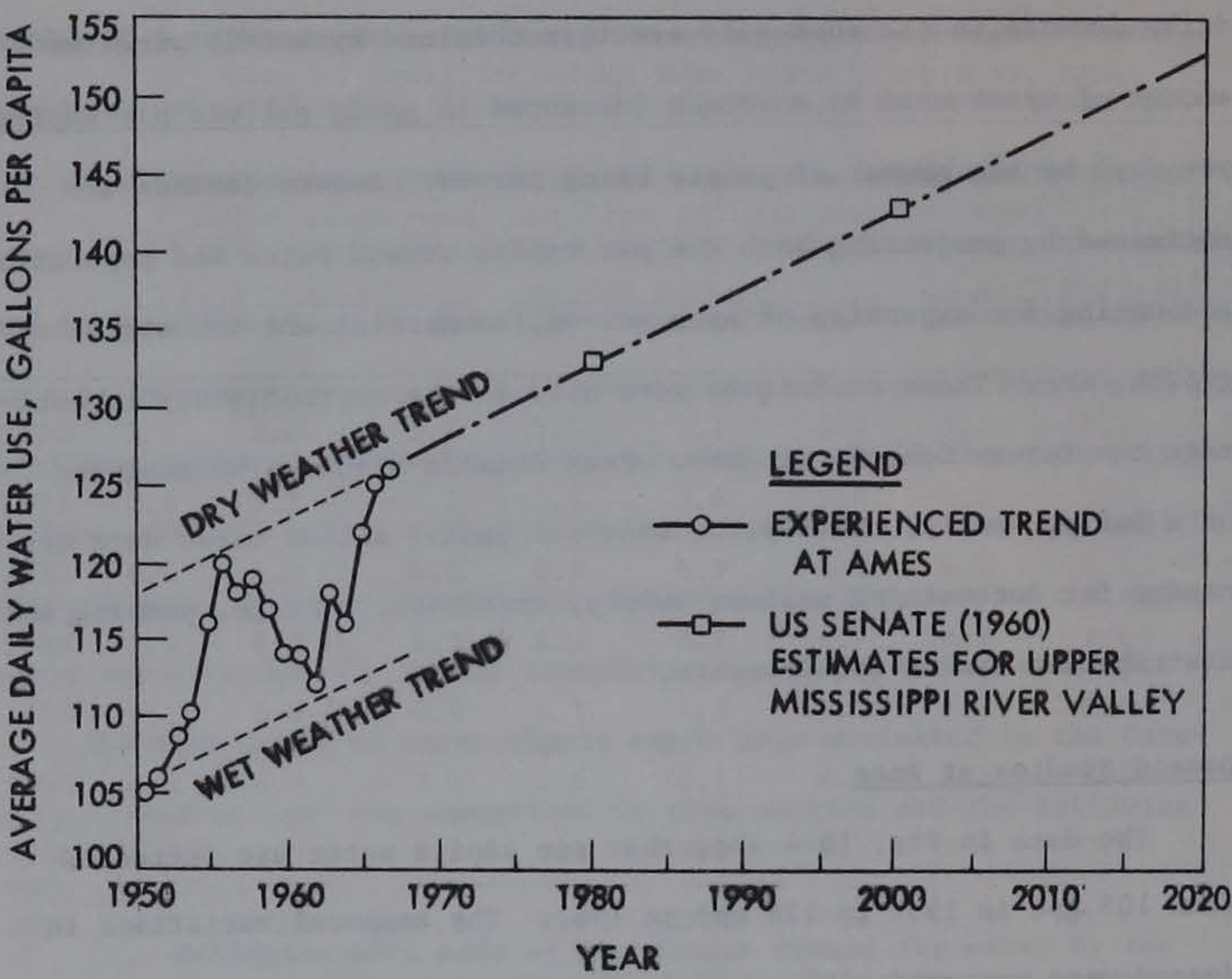

Fig. 10-4. Observed and projected per capita daily water consumption for Ames, Iowa.

These per capita use rates include water for domestic, public, commercial, and municipally supplied industrial purposes.

The low projection shows only a modest increase in water use over the next fifty years. The medium projection will require development of additional water sources sooner than the low projection. The high projection reflects the findings of the population studies that almost all of the growth in Ames must come from increased commercial and industrial activity. The types of industry which might locate in Ames are not expected to require large quantities of water and, presumably, would be supplied from the municipal system. Any large-scale industrial

Table 10-5. Projected per capita use rates for the City of Ames, gpcd.

Water usage projection	Year	Use rate	Increase each 5 years
Low	1970	130	2
	2020	150	
Medium	1970	130	5
	1990	150	0
	2020	150	
High	1970	130	5
	1990	150	3
	2020	168	

demand would have to be met from self-supplied sources not specifically included in this study. However, reservoir storage or development of extensive well systems in the valley downstream of Ames might become more attractive options under such conditions.

Total Demand for the Future. By multiplying the projected use rates of Table 10-5 by the projections (Low-A, Medium, High-B) from the population studies, the total municipal water supply requirements for the City of Ames were computed and are listed in Table 10-6. The range of future water supply requirements for the City of Ames was evaluated using the three water usage projections (low, medium, and high) with the three population projections. The application of these three water use rates with three population projections yields a total of nine combinations. The results are shown graphically in Fig. 10-5. Figure 10-5 indicates that using the low and high water use projections

Table 10-6. Projected total daily water supply requirements for the City of Ames, including Iowa State University, mgd.

Year	Low-A population Low	Low-A population Medium	Low-A population High	Medium population Low	Medium population Medium	Medium population High	High-B population Low	High-B population Medium	High-B population High
	Daily demand for indicated population model and water usage model, million gallons per day (mgd)								
1970	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
1975	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.9	5.9
1980	6.0	6.2	6.2	6.2	6.5	6.5	6.4	6.7	6.7
1985	5.9	6.3	6.3	6.3	6.7	6.7	6.7	7.1	7.1
1990	6.1	6.6	6.6	6.7	7.3	7.3	7.3	8.0	8.0
1995	6.4	6.9	7.0	7.6	8.1	8.3	8.2	8.8	9.0
2000	6.9	7.3	7.6	8.7	9.2	9.5	9.9	10.4	10.9
2005	7.5	7.8	8.2	9.6	10.0	10.6	11.3	11.8	12.5
2010	8.1	8.3	9.0	10.7	11.0	11.8	12.8	13.2	14.2
2015	8.7	8.8	9.7	11.8	12.0	13.2	14.6	14.8	16.3
2020	9.4	9.4	10.6	13.2	13.2	14.7	16.7	16.7	18.7

with a single population projection produces a fairly narrow range of future water requirements. The three population projections are the components responsible for producing the wider range of water requirements for the City of Ames.

As indicated previously, there is a high probability of reaching the low population projections and a reasonable probability of reaching the medium population projections and related water demand. There is a fairly low probability of reaching and needing the highest demand figures. Inspection of Fig. 10-5 illustrates the difficulty of attempting

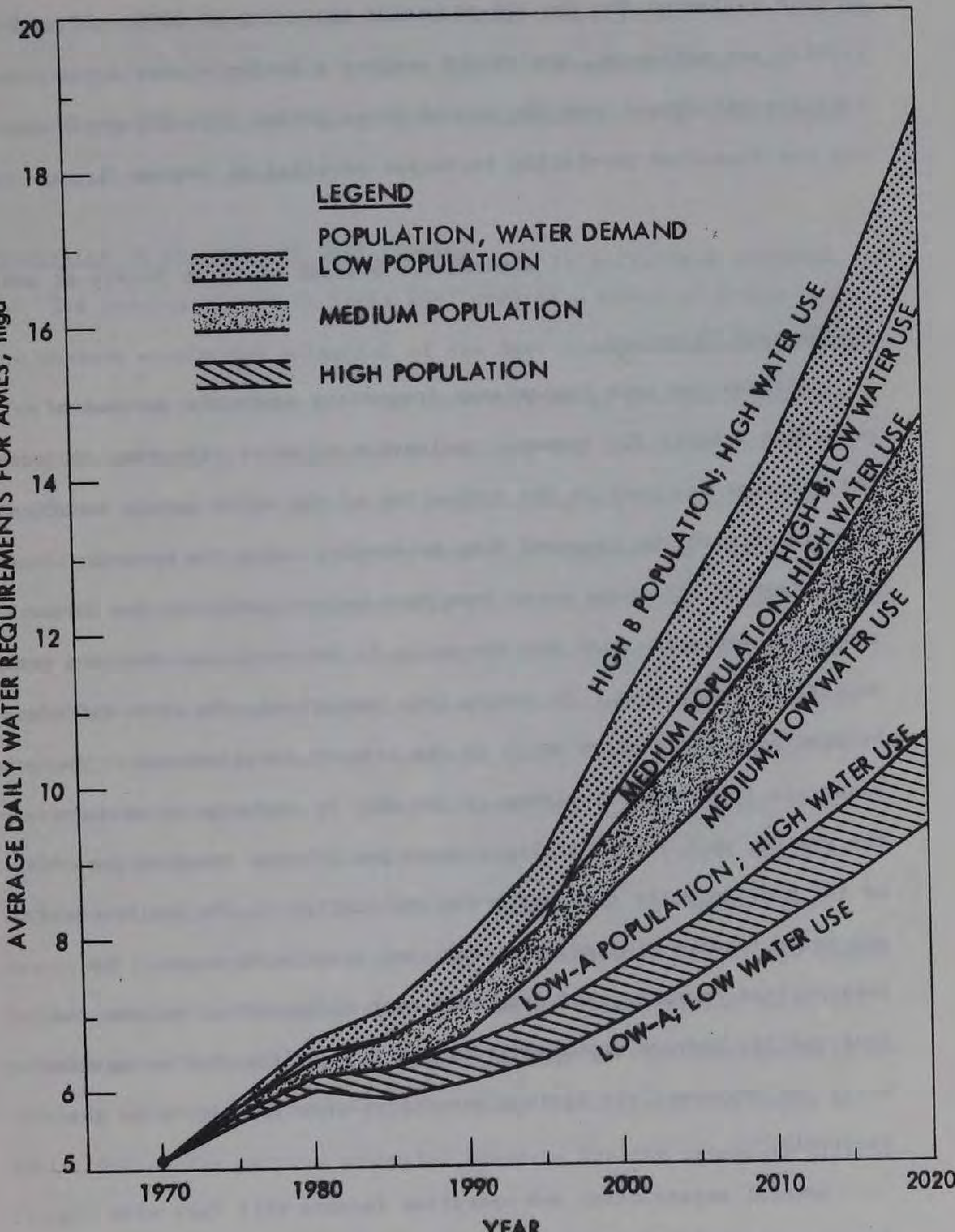

Fig. 10-5. Water supply requirements for the City of Ames, 1970-2000.

to make estimates for the 100-yr period extending to 2070. If such results are necessary, one should project a fairly static daily per capita water demand over the second 50-yr period (150-200 gpcd) and use the suggested population increases provided in Chapter 3.

Economic Evaluation of Alternative Sources of Water Supply at Ames

Purpose and Objective

Alternative cost comparisons frequently serve the purpose of providing a basis for economic evaluation of water resources projects. This concept was used in the evaluation of the water supply benefits associated with the proposed Ames Reservoir, using the economic comparison of obtaining water from deep bedrock wells in the Jordan sandstone formation with shallow wells in the surficial sand and gravel aquifer at Ames, Iowa. In making this comparison, the cost differential between deep and shallow wells is the primary consideration. The reservoir is assumed to either (a) be able to recharge or sustain the shallow well system at its present equilibrium drawdown levels or (b) provide water that has a quality similar to the shallow system and would require similar treatment, and associated costs. The construction, pumping, and treatment cost differential between the poor quality bedrock groundwater and better quality shallow aquifer water can represent the maximum benefit which might accrue to the reservoir.

Several construction and operation factors will vary with the depth of the wells and the level of the water in the wells, but other factors will remain unchanged. Four items were identified as the primary variables and are used for the cost comparison: well drilling and construction, deep-well turbine pumps, electrical power, and chemicals for treatment. These four items constitute a "comparative incremental cost" category.

Discussion of Alternative Cost Studies

The results listed in Table 10-7 provide a means of evaluating the maximum economical potential of the Ames Reservoir as an alternative source of water supply. The reservoir would provide a physical means of recharging or otherwise sustaining the continued use of the surficial aquifer. It also would permit using surface water as a source of supply, either directly from the reservoir or through release to the downstream channel with diversion at or near the municipal water plant location. It was assumed in this study that additional surficial wells, located in the alluvial formations east of the main channel of the Skunk River in northeast Ames, would be recharged by reservoir releases which in addition would leave the existing well fields unaffected. With no interference, both well fields could be utilized to their maximum potential. This makeup in demand from reservoir storage would be a physical alternative to use of the deeper bedrock wells, and presumes that the cost of the surficial wells and related water treatment would remain the same as that experienced in the existing well fields. This permits using the differential costs of Table 10-7 as the maximum potential benefits for the reservoir alternative.

The projections of population and related municipal water demand indicate that needs greater than the maximum sustained yield of about

Table 10-7. Computed total differential costs of obtaining a municipal water supply at Ames from shallow vs deep wells, 1970-2020 period.

Item	Total comparative incremental costs as between shallow and deep wells, dollars, for indicated interest rate		
	3-1/4%	5-1/2%	7%
1. Low projected population and water use levels	None	None	None
2. Medium projected population and water use levels			
(a) Equivalent present worth, 1970	$ 58,580	$ 30,610	$19,790
(b) Equivalent annual cost, (reservoir benefit), 1970-2020[a]	2,170	1,810	1,430
3. High projected population and water use levels			
(a) Equivalent present worth, 1970	228,700	125,400	83,840
(b) Equivalent annual cost, (reservoir benefit), 1970-2020[a]	9,110	7,400	6,080

17 mgd for the surficial aquifer and existing well field system of the City of Ames and Iowa State University are quite distant in the future — at least to 1995-2000. Future needs when placed on an economic basis are discounted substantially when brought back to present worth, especially at the higher interest rates. These concepts are all evident in Table 10-7.

The present aquifer and well-field system would sustain the demands foreseen at the low population projections for the period 1970-2020.

Therefore, no equivalent benefits would accrue as additional sources of water supply are not foreseeable needs.

At the medium population and water demand levels, the existing well field system must be augmented by another source by the year 2000. There is computed an equivalent annual reservoir benefit of $1,430 to $2,170, respectively, for the period 1970-2020. It is estimated that an equivalent average reservoir release rate of 0.2 to 0.5 cfs from reservoir storage is needed to meet this periodic demand and that less than 500 acre-ft of gross reservoir storage need be allocated for such beneficial use.

For the high population projections and associated water demand, much greater stress will be placed on available sources of water supply. Beginning in the period 1995-2000, a steady increase in demand is forecast, and by the year 2020 substantial peaking capacity is needed to meet maximum-day requirements. Equivalent annual benefits of $6,080 to $9,110 could then accrue to the reservoir alternative as a maximum potential. To meet this periodic makeup in demand, an equivalent average reservoir release rate of 2-3 cfs and a gross reservoir storage allocation of 1500 to 2000 acre-ft would be required.

Summary of Water Supply Alternatives

The results summarized in this section are intended to show the maximum potential for the reservoir as a viable physical and economic alternative. There is little doubt that the low-flow augmentation and water supply release schedules as proposed by the Corps of Engineers or as estimated herein would serve to sustain groundwater seepage and equilibrium water levels in the surficial aquifer. Drought effects would be eliminated, which might otherwise require rationing or decreased pumping rates during periods when the stream has no flow. Therefore, low-flow augmentation through reservoir storage releases represents a physical contribution which would be an advantage in managing the municipal water supply system at Ames. The reservoir storage requirements for supplementing either the medium or high population projections and related water demands are quite small, especially in comparison to the proposed storage requirements for water quality or flood control.

If the reservoir is not constructed to provide this level of assurance or a reduced risk of having water shortages, then an alternative plan of action is needed. There apparently are adequate groundwater supplies for the 1970-2020 period, assuming the low to medium population projections are the most meaningful. The plan which would interfere the least with groundwater movement patterns now existing at the municipal well field would involve using the Hallett gravel quarry area. Once materials extraction is completed (or perhaps earlier, with a partial use plan), the water area and surrounding land could be incorporated into a water supply management program. The volume of water available at this location, with some additional interconnection possible with the river, as previously observed, would provide the needed makeup for the demand projections listed above. Wells could be located around the perimeter, or the city could make direct withdrawals and treatment of the surface water. A second alternative is locating a new well field in the alluvial formations east of the Skunk River channel in northeast Ames. Because the valley alluvium would be an unconfined (water table) system, much more water storage is available as pumping dewaters the formation. Therefore, this system could be stressed more than the existing confined system, and might need to become the primary source of groundwater if real competition developed between the two well field systems.

These alternative concepts should be evaluated whether or not the reservoir is constructed. Because of the physical nature of the buried channel and alluvial valley portions of the surficial aquifer system, the community should proceed with an acquisition and management plan to protect, develop, and utilize the available surficial supplies at Ames. These supplies include the Skunk River floodplain alluvial aquifer northeast of Ames, and the Hallett quarry area. The full potential of these sources are being examined in detail through continuing research supported in part by the City of Ames and in part by Iowa State University. Quality problems associated with the groundwater resource were summarized in the previous section and may dictate the location of additional wells much more than they have in the past.

Regional Water Supply Considerations

The 1970 Upper Mississippi River Basin Comprehensive Study (UMRBCS) report lists the following data for the basic municipal and industrial water use in the Skunk River basin:

Source	1960 population served	Domestic and commercial, mgd	Estimated industrial, mgd	Total use, mgd
Groundwater	109,780	8.41		
Surface water	40,900	3.28		
Total	150,680	11.69	13.80	25.5

The total municipal and industrial water use in 1960 was 25.5 mgd, with projections of 47.9 mgd by 1980, 85.2 mgd in 2000, and 142.8 mgd in 2020. The population projections for the 1970 report were 523,000 people in 2020; however, they were only 250,000 by 2020 in a 1966 FWPCA Study.

Because population projections in the 1970 UMRBC study were based on the high birth rates of the 1950's instead of the reduced rates experienced in the 1960's, water use projections probably are on the high side. Therefore, increases in demand definitely will be more modest than presently projected in the UMRBC study. Requirements at Ames were determined in the previous section, which gave a range of projected use of 10-17 mgd in 2020.

An initial concept of a regional water supply system for the upper basin is illustrated in Fig. 10-6. This development pattern is based on having the local municipalities with good groundwater supplies serving as water purveyors for the surrounding agricultural region. Combined municipal-rural water systems would thus become a reality. The communities which have access to the high yielding surficial sand and gravel aquifers, or good bedrock aquifers, are given preference in this system. There seem to be no physical limitations for obtaining groundwater supplies up to at least twice the present water demand in

Fig. 10-6. Service areas for a potential regional water supply system for the upper Skunk River basin above Colfax, Iowa.

the upper basin for all urban and rural areas. Because of the availability of good groundwater supplies in the Ames and Story City area, there appears to be little physical need for water supply storage in the proposed Ames Reservoir at this time. Future growth patterns and industrial expansion could change this situation, and reservoir storage might in the future become a realistic alternative. Because low flows are very low in magnitude and erratic in occurrence, surface storage facilities would be required for development of additional water supplies wherever groundwater sources reach their permissive sustained yields.

Regional Water Quality Implications

Objectives

The objective of the urban-category study group for water quality was to evaluate the impact of the urban communities on river and reservoir water quality. The two communities most directly involved are Story City and Ames. Story City is located at the headwaters, upstream of the proposed Ames Reservoir. Effluents discharged from its water pollution control plant will enter the proposed reservoir only a few miles upstream of the conservation pool and would discharge directly into the flood control pool. The City of Ames, with a 1970 population of about 40,000, is located on the Skunk River a few miles downstream from the proposed reservoir. It would be the primary beneficiary of reservoir releases for low-flow augmentation, serving as an increased supply of water for water quality control and as a water supply source. The location of these communities in relation to the reservoir is shown in Fig. 10-7.

Both agriculture and municipal (including industrial) sources of pollution are found in the Skunk River basin. The summary material in this section includes the results of the stream sampling program conducted during the study, reviews previous studies concerning urban water pollution control, and reflects on the real problems being encountered in municipal wastewater treatment as it will influence the establishment and enforcement of stream water quality standards in Iowa.

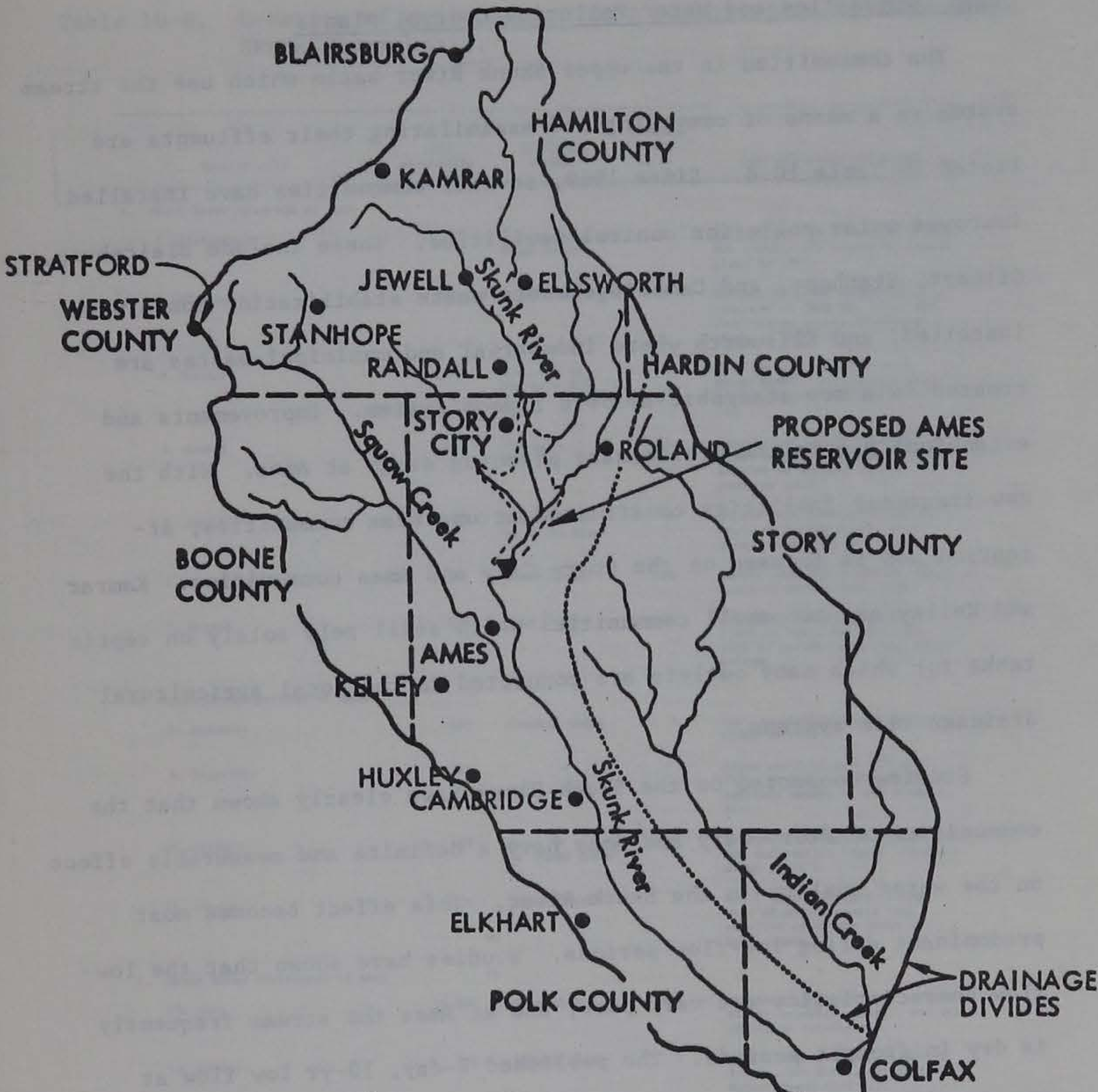

Fig. 10-7. General location map of the reservoir and urban communities in the upper Skunk River basin.

Urban Communities and Water Pollution Control Plants

The communities in the upper Skunk River basin which use the stream system as a means of conveying and assimilating their effluents are listed in Table 10-8. Since 1969, several communities have installed improved water pollution control facilities. These include Blairsburg, Gilbert, Stanhope, and Cambridge where waste stabilization ponds were installed, and Ellsworth where industrial and municipal wastes are treated in a new anaerobic-aerobic lagoon system. Improvements and extensions are in the preliminary planning stage at Ames. With the new treatment facilities constructed at upstream communities, attention now is focused on the Story City and Ames communities. Kamrar and Kelley are two small communities which still rely solely on septic tanks for which many outlets are connected to the local agricultural drainage tile systems.

Studies conducted on the Skunk River have clearly shown that the communities of Story City and Ames have a definite and measurable effect on the water quality in the Skunk River. This effect becomes most predominant during low-flow periods. Studies have shown that the low-flow characteristics are very poor, and at Ames the stream frequently is dry in drought periods. The published 7-day, 10-yr low flow at the gaging station above Ames (315 sq mi) is about 0.1 cfs, and estimates for the lower station at the Ames water pollution control plant are less than twice this (556 sq mi). Therefore, an urban water-quality problem of substantial magnitude exists at Ames, although minimum intensive use is made of either the stream system or the water in the downstream reach.

Table 10-8. Location of municipal sources of pollution in the upper Skunk River basin.

Town or city	1970 population	Receiving stream	Drainage area, sq mi	Identification and notes
A. Skunk River upstream of Ames				
1. Blairsburg	287	County drain to Skunk River	10	Part of town in Iowa River basin. New facultative lagoon treatment plant in 1969.
2. Ellsworth	443	Skunk River	55	Outfall of sewer about 100 ft upstream of Iowa No. 175. New facultative lagoon treatment plant in 1968.
3. Kamrar	243	D.D. 265 to Mud Lake D.D. 71	10	West part of town drains to Boone River. Septic tank overflow to common drain to D.D. 265.
4. Jewell	1,152	Mud Lake D.D. 71	71	Facultative lagoon treatment plant in 1961; raw sewage lift station in shallow valley pumps to pond.
5. Randall	179	Miller Creek to Skunk River	9	Septic tank overflow to county drain to Miller Creek; area around community very flat.
6. Story City	2,114	Skunk River	180	Imhoff tank and trickling filter plant on stream bank, 1964.
7. Roland	803	Bear Creek	20	Facultative lagoon treatment plant in 1963, two cells at edge of stream; city dump across stream.
B. Squaw Creek upstream of Ames				
8. Stanhope	482	Crooked Creek	7	New facultative lagoon treatment plant in 1971.
9. Stratford	710	–	–	Storm water in east 1/2 town flows to Squaw Creek, 16 sq mi; sanitary wastes to Des Moines River.
10. Gilbert	521	D.D. 70 to Squaw Creek	5	Community growing along with ISU; new facultative lagoon treatment plant in 1970.
11. Jordan	50	Onion Creek	3	Small unincorporated village east of Boone; septic tank overflow to county drain to Onion Creek.
C. Skunk River downstream of Ames				
12. Ames	39,505	Skunk River	557	Complete treatment with trickling filter secondary units. Due for expansion immediately.
13. Kelley	235	Walnut Creek	7	Septic tank overflow to county drains, one north, one east to Walnut Creek (1/2 mi).
14. Huxley	937	Ballard Creek tributary	7	Imhoff tank and trickling filter plant, constructed in 1959.
15. Cambridge	661	Ballard Creek and Skunk River	29	At confluence of Ballard Creek and Skunk River; town located on sandy terrace; new facultative lagoon treatment plant in 1972.
16. Elkhart	269	Unnamed creek to Skunk River	14	Facultative lagoon treatment plant in 1961, effluent creek to river.
17. Valeria	96	Unnamed Creek to Skunk River	3	Community about 1 mi from Skunk River; septic tanks overflow to creek.
18. Colfax	2,293	Skunk River	800	Imhoff tank and trickling filter plant on river bank, upstream 2 to 3 blocks from Iowa No. 117.

Potential for a Regional Program

Regional management concepts for water quality control and related water use were a part of the ARES review. The upper Skunk River basin upstream of Colfax (800 sq mi) was selected as a reasonable size intrastate regional unit for water quality operation and management purposes. After completion of interviews and collection of background material concerning 12 water pollution control plants in the upper Skunk River basin, the study results were analyzed in terms of potential for a regional approach to water quality management within the study area. The lack of potential for construction and operation of a single regional water pollution control plant treating municipal wastewater became apparent following a preliminary study. Twelve of the fifteen incorporated municipalities within the study area presently operate water pollution control facilities — many of which were constructed within the last four years (the Cambridge facility began operation in early 1972). In addition, the cost of sewer force mains (which would be required if such a regional facility were constructed) and gravity trunk sewers is substantial. It was concluded, therefore, that as long as the facultative lagoon remains an acceptable method of wastewater treatment (8 of 12 municipalities within the study area utilize lagoons), no potential exists within the basin area for a single- or multi-community regional facility.

The concept of regional operation of separate plants was studied next. This concept offers the advantage of using existing water pollution control facilities. The potential exists for:

1. Performance benefit through regional operation using full-time highly-qualified operation and maintenance personnel and better administration.

2. Economic benefit through reduction in manpower and equipment duplication.

In order to evaluate the potential for regional operation, an operating plan for the 12 municipal water pollution control facilities within the upper Skunk River basin was conceived. Such a plan is briefly presented in Appendix 5, Chapter 7. It is included in the ARES review as an indication of an approach which might be used in the future for operating the basin system from a central headquarters located, for instance, at Ames.

Stream Water Quality Requirements

At the present time (1973), the quality level of water in the Skunk River is specified by the Iowa Water Quality Commission of the Iowa Department of Environmental Quality. The Commission is revising its adopted rules and regulations defining Iowa's Surface Water Quality Criteria. These criteria are "intended as guides for determining the suitability of surface waters in the State of Iowa for various uses, and to aid decision-making in the establishment of waste control measures."

In establishing water quality criteria, a 7-day, 10-year low flow was selected to recognize the variability of Iowa stream flows in the application of water quality criteria and in the economic analysis and evaluation of treatment requirements. The water quality criteria for designated uses will comply with the criteria whenever the flow is at the above level or greater at specified critical points of use, as listed in detail in Appendix 5.

At the present time (1973) it appears that the Skunk River, from its mouth to Story City, will be classified for aquatic life, warm water fish, and that its water quality will be judged on this basis. If the proposed Ames Reservoir is built, the reservoir area itself will be designated for recreational use. In the operation of the reservoir for low-flow augmentation, the 7-day, 10-yr low flow downstream of Ames could be increased from about 0.1 cfs to a range of 20-50 cfs, depending on the final desired operation schedule. The recreational-use criteria are designed to reasonably protect surface waters where the whole-body-contact sports of swimming and water skiing are concentrated during the recreational season. These criteria will affect the future treatment levels at Story City also.

In view of the existing and potential reclassifications of the Skunk River in this reach directly affected by the proposed Ames Reservoir, the study of water quality in the area was directed to those criteria of importance.

Of particular interest in this study are the aquatic life water criteria for dissolved oxygen and ammonia. Ammonia nitrogen limitations appear only under the aquatic life use criteria. The current aquatic life-warm water criteria require that the dissolved oxygen in warm water areas be "not less than 5.0 mg/l during at least 16 hours of any 24-hour period and not less than 4.0 mg/l at any time during the 24-hour period." The maximum ammonia nitrogen concentration of aquatic life waters is fixed at 2 mg/l. The water temperature in warm water areas is not to exceed 73 ^{o}F from December-April and 93 ^{o}F from May-November. The water pH shall not be less than 6.8 nor more than 9.0.

Insofar as recreation is concerned, the waters shall be considered to be of unsatisfactory bacteriological quality when the fecal coliform level exceeds a concentration of 200/100 ml during low-flow periods when such bacteria can be demonstrated to be attributable to pollution by sewage.

Thus, a study of existing water quality in the Skunk River in the reservoir reach should be primarily concerned with:

1. The factors affecting dissolved oxygen levels in the river.
   a. The dissolved oxygen level indicates the concentration of oxygen available and is a direct criteria specified in water quality criteria. The degree of oxygen saturation present is a function of the water temperature.
   b. The parameters which tend to reduce dissolved oxygen are the river BOD, a biological measure of oxygen demand, and COD, a chemical measure of oxygen demand. In addition, the availability of carbon and/or carbon dioxide, soluble phosphorus (ortho-P), and nitrogen (organic N, NH_4-N, NO_3-N) determine the potential growth of total phytoplankton algae which can add to the supply of oxygen daytime hours and exert a demand for oxygen at night. The growth of phytoplankton will be controlled by availability of sunlight, which is limited by water turbidity. Such eutrophication of water will utilize the available carbon dioxide and increase both water pH and the toxicity of ammonia.
2. The factors affecting the toxicity of ammonia to aquatic life. These include those factors affecting the growth of phytoplankton algae and the pH of the water.

3. The factors affecting the existence or probable existence of human pathogens in recreational waters. These include the fecal coliform levels and fecal streptococci levels.

Mathematical Simulation of Stream Water Quality at Ames

Principles and Methodology

The water quality studies conducted for the Skunk River and reported in Appendix 5 have shown that the City of Ames is the dominant urban factor in this part of the basin. This section summarizes the study of the mathematical modeling of the stream water quality of the Skunk River at Ames. Of major concern was the response of the stream to effluents discharged by the City of Ames water pollution control plant. As indicated in previous sections, the low-flow characteristics of the Skunk River at Ames are very poor. Therefore, the degree of wastewater treatment and need for low-flow augmentation from reservoir storage to meet stream and effluent standards are two critical areas of study.

The detailed stream water quality study reported in Appendix 5 accomplished the following:

1. Reviewed the stream water quality studies that have been done previously, to indicate the observed response of the stream to the plant effluent discharged at Ames.
2. Reviewed the development and use of the ISU Water Quality Model, a mathematical simulation model designed for forecasting purposes and estimating water quality levels for selected stream and effluent conditions.
3. Estimated using population, water and wastewater projections for existing and future conditions, the stream water quality levels which might be expected in the future.

4. Evaluated the trade-offs which can take place among the three primary oxygen-demanding parameters — carbonaceous organic residues (BOD_c), ammonia nitrification and associated oxygen demand (BOD_n), algal growths and resultant daytime photosynthesis and nighttime respiration demand for oxygen (P and R factors).

5. Determined the effect that low-flow augmentation may have on stream water quality, as it relates to the potential value of the Ames Reservoir for water quality control.

The ISU Water Quality Model as described in Appendix 5 was used in a water quality study of various seasons and various low flow, with and without low-flow augmentation, and for the years 1970, 1995, and 2020. For a given season most of the input stream parameters were held constant. The low flows were either 7-day, 2-yr low flows or 7-day, 10-yr low flows with and without the augmentation from the proposed Ames Reservoir alternatives (1, 1A, 2, 5, and 6). The simulated effluent flow from the water pollution control plant was the average day flow for the particular season and population being considered. The input variables that were changed for a particular situation (river flow, plant effluent flow, and other parameters were held constant) were effluent BOD_5, ammonia-nitrogen, and phosphate concentration levels. The object of this part of the study was to find the combination of plant effluent BOD_5, ammonia-nitrogen, and phosphate levels, for a given situation (a given year, with or without low-flow augmentation, a given season, and a given population) that would yield a minimum oxygen level of 4 mg/l downstream from the water pollution control plant. Wastewater volumes and organic loadings were estimated for future population levels (and reported in the next section).

The mathematical model input parameters were based on the data obtained in field studies and in model verification runs. The dissolved oxygen, DO, parameter is the major criterion for judging adequacy of treatment, with BOD_c, BOD_n, and ammonia toxicity also included. The variations in season included late summer (August), early fall (September), late fall (October-November), and winter (January-February) periods.

The water quality research studies conducted at Iowa State University included a detailed evaluation of the response of the stream to effluents discharged by the Ames water pollution control plant. The decomposition effects and deoxygenation rates for the carbonaceous organic residues and nitrogenous ammonia-oxidation compounds were evaluated. Stream characteristics, time of travel, reaeration rates, and other hydraulic factors were determined. The problems of algal growths, blooms, and related photosynthesis and respiration rates were evaluated within the overall photosynthesis and respiration concepts. Oxygen contributions and deficit were further evaluated. All of these studies have broadened the knowledge of the stream environment.

Summary of Results

Application of the ISU Water Quality Model permitted mathematical simulation of water quality levels resulting from effluents discharged to the stream environment at Ames. The treatment levels required to meet the minimum dissolved oxygen requirements for a warm-water aquatic environment were evaluated using this model. The established standards for a warm-water aquatic environment include two primary constituents: dissolved oxygen, 4 mg/l minimum at any time or place, and ammonia as a toxic compound, 2 mg/l maximum at any time or place, following mixing. Three constituents in effluents tax the dissolved oxygen resource: carbonaceous biochemical demand (BOD_c) residues, nitrogenous BOD_n from organic and ammonia-nitrogen residues, and nutrients such as phosphates which contribute to luxurious algal growths and resultant daytime photosynthesis and nighttime respiration effects.

The results can be summarized as follows for the effect of Ames on the water quality of the Skunk River:

1. For the existing (1970) conditions and using ordinary secondary treatment processes, the minimum dissolved oxygen and maximum ordinary standards would be violated during late summer, fall, or winter at low-flow conditions both at or more severe than the once-in-two-year frequency events.

2. At the current standard of a 7-day 10-yr frequency low flow (0.1 to 1.2 cfs, depending on month), complete advanced waste treatment would be required. This would include both added carbonaceous BOD, ammonia nitrification and phosphate (nutrient) removal (5, 0.5, and 0.5 mg/l residuals, respectively). The stream standard would be met for all except perhaps winter conditions having severe ice and snow cover.

3. For the projected conditions of 1995, both low and medium population estimates, the warm water aquatic environment stream standard can be met only if complete advanced treatment is provided. Winter conditions would remain a problem at the 7-day, 10-yr low-flow frequency.

4. For the projected conditions of 2020, both for low and medium population estimates and without low-flow augmentation, complete advanced treatment to the level of 5.0 mg/l BOD_5, 0.5 mg/l NH_3-N, and 0.5 mg/l PO_4 would permit meeting the 7-day, 10-yr stream standards for all seasons except winter, when a minimum D.O. of 3 or less might occur.

5. With a reservoir release rate of 20 cfs for low-flow augmentation (reduced-scope reservoir alternative), a somewhat lower degree of advanced treatment (if possible) would permit meeting all stream standards, including winter. This alternative illustrates (see Table 5-5-18, Appendix 5) the physical contributions that low-flow augmentation can provide since the natural low-flow characteristics are very poor.

6. For the 2020 conditions, and with a reservoir release rate of 50 cfs for low-flow augmentation (reservoir project as proposed), an additional reduction in advanced treatment could be realized. Advanced treatment of only a portion of the effluent would be one possibility, if intermediate treatment concepts cannot be utilized to any real advantage.

7. The results for the 2020 conditions show that the greatest benefit that might be credited to the proposed reservoir project (of 50 cfs magnitude) is an in-lieu-thereof for phosphate removal. Ammonia nitrification or removal (air-stripping) is required to reduce the ammonia concentrations (after mixing in the river) to the maximum 2 mg/l limit, even with low-flow augmentation. More than 200 cfs stream flow would be required to dilute the normal ammonia concentration remaining in secondary treatment effluent. Some reduction in carbonaceous BOD removal might also be realized in this process of nitrification. This alternative of not requiring phosphate removal is supported by the observed field data, since at dilution rates of 3.0 or above, no real water quality problems were observed. The 50 cfs reservoir release would, for the projected 2020 wastewater flows of 10 to 15 cfs, provide this amount of dilution.

8. Other water quality characteristics are not as critical as the DO and ammonia levels. The temperature effects are favorable, both summer and winter. With a groundwater source of water supply, the temperatures range from 50 to 60°. Therefore, in the summer the wastewater is cooler than the ambient stream temperature, having a beneficial effect during hot drought periods. In the winter period, the temperature is above the river temperature of 32-34 °F. This maintains an area of open water which aids in reaeration of the stream flow. Reservoir releases, as evidenced at Coralville Reservoir, assist in creating longer stretches of open water in the winter time. This can be an added benefit for low-flow augmentation and should be studied further.

9. Bacteriological control measures (chlorination of effluent) have not been studied in detail. If additional recreational standards were applied, the cost of chlorination would have to be added to the total treatment costs at Ames.

These results served as a basis for additional study of costs and benefits of alternative waste treatment methods. A study of the technical alternatives which might be used to meet the effluent limits established herein is presented in the next section.

Wastewater Treatment Needs and Costs for Ames

Introduction

As discussed previously, state and federal water quality requirements have changed the wastewater treatment needs at Ames considerably over that required only five years ago. The low-flow characteristics of the Skunk River at Ames are such that the efficiency of removing organic carbon material, as measured by the biochemical oxygen demand (BOD) test, must be increased considerably above that presently attainable by the existing, or even a new, trickling filter system. This means, in all probability, that an activated sludge or more advanced system will be required for organic carbon removal.

Ammonia-nitrogen removal also will be required both to meet the 2 mg/l state stream standard for ammonia and to eliminate the undesirable oxygen demand imposed on the Skunk River by ammonia-nitrogen discharges. The required extent of ammonia removal is reduced but not eliminated by use of the proposed Ames Reservoir. Removal of phosphorus will be necessary if there is no reservoir, or with the "small reservoir" construction alternative (Alternatives 2 and 6) if warm-water fishing stream standards are to be maintained at all times. The green-belt and recreation lake alternatives imply, therefore, the implementation and continuance of additional advanced treatment for phosphorus removal.

Predicted Future Average and Peak Wastewater Flows

The projected average annual wastewater flows for dry, wet, and normal years were multiplied by the various ratios of peak-to-average flow to obtain projected peak month, peak day, peak 8-hr, and peak 4-hr flow rates at five-year intervals from 1970 through 2020. These are listed in Table 10-9. Historic data and water use projections were used in making these estimates.

Table 10-9. Projected average peak month, peak day, peak 8-hr, peak 4-hr wastewater flow rates.

Population projection		Average	Peak month	Peak day	Peak 8-hr	Peak 4-hr
High-B	1970	4.35	5.66	7.83	9.71	10.18
	1980	5.66	7.36	10.19	12.64	13.25
	1990	6.79	8.83	12.22	15.15	15.89
	2000	9.14	11.88	16.45	20.40	21.39
	2010	11.28	14.66	20.30	25.17	26.39
	2020	13.43	17.46	24.17	29.97	31.42
Medium	1970	4.35	5.66	7.83	9.71	10.18
	1980	5.42	7.05	9.76	12.10	12.69
	1990	6.11	7.94	11.00	13.64	14.30
	2000	7.79	10.13	14.02	17.38	18.23
	2010	9.20	11.96	16.56	20.53	21.53
	2020	10.60	13.78	19.08	23.66	24.80
Low-A	1970	4.35	5.66	7.83	9.71	10.18
	1980	5.15	6.70	9.27	1.49	12.05
	1990	5.44	7.07	9.79	12.14	12.73
	2000	6.03	7.84	10.85	13.45	14.11
	2010	6.77	8.80	12.19	15.12	15.85
	2020	7.50	9.75	13.50	16.74	17.55
			$\frac{\text{peak mo}}{\text{avg yr}} = 1.30$	$\frac{\text{peak day}}{\text{avg yr}} = 1.80$	$\frac{\text{peak 8-hr}}{\text{peak day}} = 1.24$	$\frac{\text{peak 4-hr}}{\text{peak day}} = 1.30$

Multiplying the projected population (Table 5-6-1, Appendix 5) by the appropriate average and peak load factors for each waste constituent gives BOD and suspended solids loads (Table 10-10). It should be realized that the accuracy of these projections is subject to the accuracy of the projected population and peaking factors for the individual waste components.

Nitrogen and phosphorus data have been collected at Ames only since 1967. Consequently, too few years of data are available from which to develop consistent peak load patterns. However, average concentration and load patterns calculated from the available data provided a reasonably accurate trend of concentration and load variations. Peak concentrations occur in the fall and winter months in a pattern similar to that experienced for BOD and suspended solids. The average annual ammonia (NH_3-N) and phosphate (PO_4) concentrations in the influent wastewater stream are respectively 13.3 and 10.0% of the corresponding BOD load.

Cost of Wastewater Treatment at Ames

Costs of wastewater treatment facilities are difficult to project when treatment for more than one type of pollutant is involved. This occurs because there is considerable interaction between treatment units, and the total cost is not necessarily the sum of the costs for separate treatment for removal of each specific pollutant. For example, phosphorus removal may be accomplished in some activated sludge plants by simply adding a chemical, such as alum, to the aeration tank to precipitate the phosphate which is then removed with the waste sludge. Increased sludge handling facilities would be required, but the major

Table 10-10. Projected BOD and suspended solids load.

Pop. Proj.	Year	BOD_5, lb/day					SS lb/day				
		Avg. Annual	Peak month	Peak day	Peak 8-hr	Peak 4-hr	Avg. annual	Peak month	Peak day	Peak 8-hr	Peak 4-hr
High B	1970	7,790[a]	10,906	12,215	17,467	18,689	7,790[a]	10,672	11,953	17,093	18,288
	1980	9,481	13,273	14,866	21,258	22,745	9,481	12,989	14,548	20,804	22,258
	1990	10,697	14,976	16,773	23,985	25,663	10,697	14,655	16,414	23,742	25,113
	2000	14,402	20,163	22,583	32,294	34,552	14,402	19,731	22,099	31,602	33,811
	2010	17,784	24,898	27,886	39,877	42,666	17,784	24,364	27,288	39,022	41,750
	2020	21,166	29,632	33,188	47,459	50,778	21,166	28,997	32,477	46,442	49,690
Medium	1970	7,790	10,906	12,215	17,467	18,689	7,790	10,672	11,953	17,093	18,288
	1980	9,082	12,715	14,241	20,364	21,789	9,082	12,442	13,935	19,927	21,321
	1990	9,633	13,486	15,104	21,599	23,109	9,633	13,197	14,781	21,137	22,615
	2000	12,274	17,184	19,246	27,522	29,446	12,274	16,815	18,833	26,931	28,814
	2010	14,497	20,296	22,732	32,506	34,780	14,497	19,861	22,244	31,809	34,033
	2020	16,720	23,408	26,217	37,490	40,112	16,720	22,906	25,655	36,687	39,252
Low A	1970	7,790	10,906	12,215	17,467	18,689	7,790	10,672	11,953	17,093	18,288
	1980	8,626	12,076	13,525	19,341	20,693	8,626	11,818	13,236	18,927	20,251
	1990	8,569	11,997	13,437	19,215	20,559	8,569	11,740	13,149	18,803	20,118
	2000	9,500	13,300	14,896	21,301	22,791	9,500	13,015	14,577	20,845	22,303
	2010	10,678	14,949	16,743	23,943	25,204	10,678	14,629	16,048	22,949	24,553
	2020	11,818	16,545	18,530	26,498	28,351	11,818	16,191	18,134	25,932	27,745
			peak mo. / ave. annual = 1.40	peak day / peak mo. = 1.12	peak 8-hr / peak day = 1.43	peak 4-hr / peak day = 1.53		peak mo. / ave. annual = 1.37	peak day / peak mo. = 1.12	peak 8-hr / peak day = 1.43	peak 4-hr / peak day = 1.53

[a] population x 0.19.

cost would be for chemicals. On the other hand, if the biological treatment unit is a trickling filter, a separate phosphate precipitation unit complete with reaction tanks and sludge settling tanks may be required.

Previous research in cost evaluation has shown that, in general, incremental and total costs of treatment systems, including operation and maintenance, power, equipment, construction, etc., can be expressed as a function of the design flow, in MGD. The results include cost data for 1 and 100 MGD plants which include all related treatment costs except the wastewater collection system. Applying the research data to the cost equation, one obtains the cost curves shown in Fig. 10-8. These data were used in calculating the cost of treatment needs at Ames. Sixty percent of the indicated cost for each treatment alternative was considered capital investment; the remaining 40% represented operating and maintenance costs. Capital costs for each case are based on a 7% interest rate and a 25-yr design period.

One problem with defining treatment costs involves the selection of a plant design period and/or construction schedule for implementing treatment. For purposes of comparing alternatives, however, the 50-yr period from 1970 to 2020 was divided into two 25-yr design periods. This period essentially represents the useful life of a treatment plant. Consequently, no salvage value was considered at the end of either design period. A graph of total capitalized cost (50 yr) is shown in Fig. 10-9 comparing the relative cost of each treatment alternative discussed previously at 3-1/4, 5-1/2, and 7% interest levels. A summary of annual cost figures is given in Table 10-11, and a more detailed breakdown of costs analyses is given in Appendix 5 for each interest level considered.

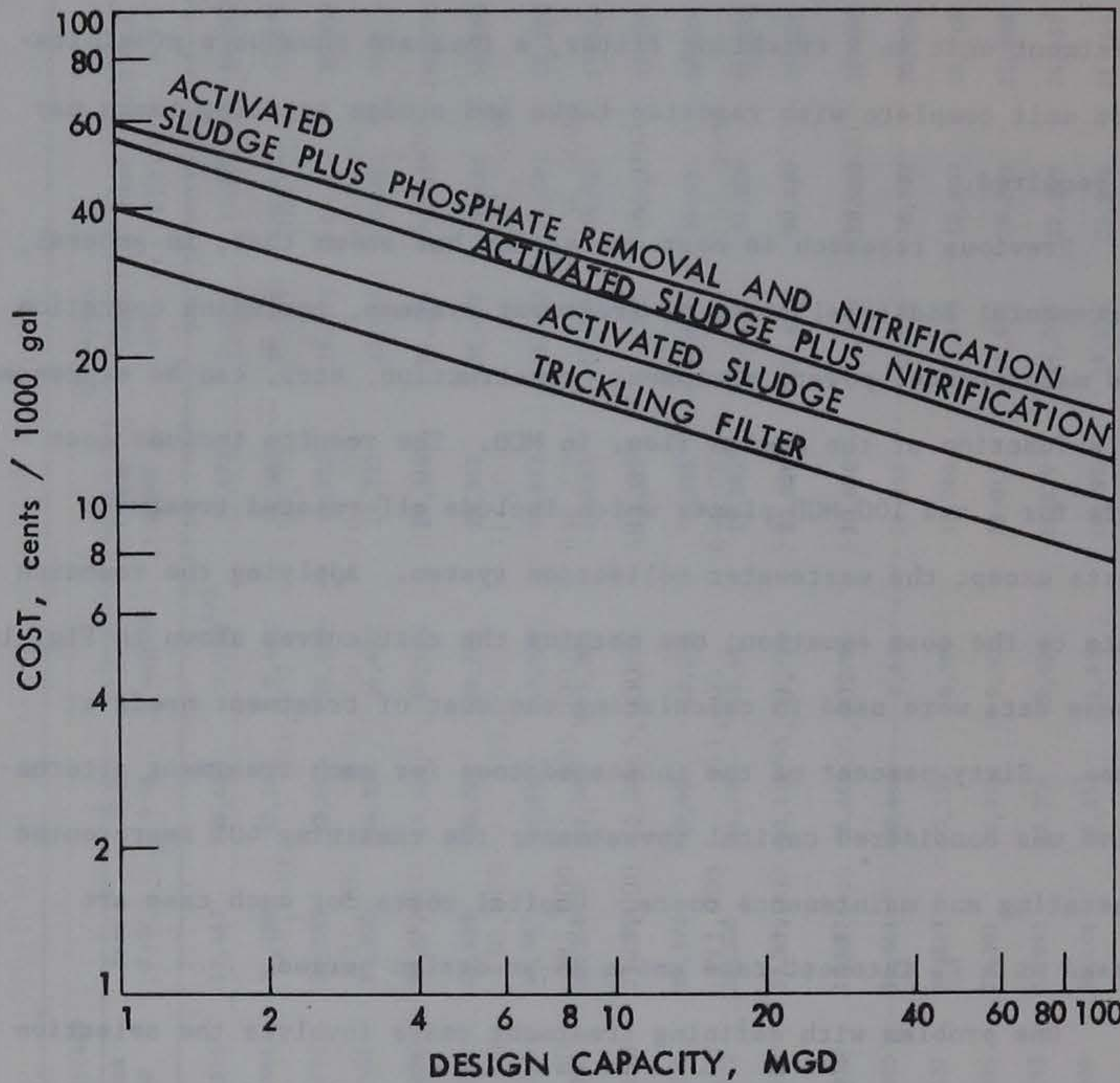

Fig. 10-8. Unit costs of wastewater treatment as related to system capacity. Each curve applies to a 25-yr design period, 7% interest (see Appendix 4, Chapter 6 for references).

Wastewater Treatment Considerations in the Ames Reservoir Area

Housing Trends. Construction of the proposed Ames Reservoir will create the need for additional facilities to handle the wastewaters resulting from human activity in the reservoir area. Although commercial and industrial activity may occur, as it has in the Hallett gravel quarry area, the most likely source of this waste will be extensive residential growth. This residential growth can be divided

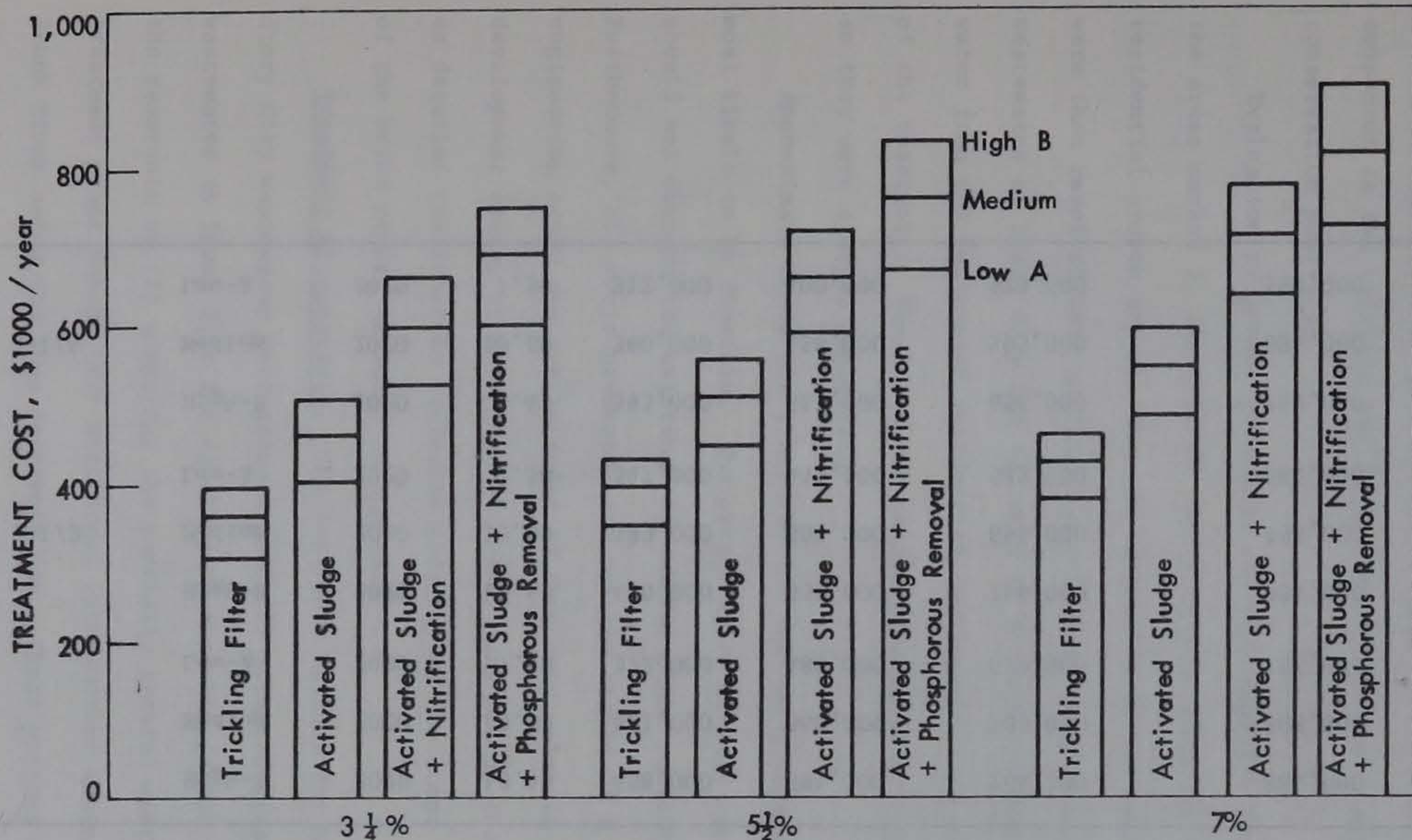

Fig. 10-9. Annual cost of wastewater treatment alternatives at Ames at 3-1/4, 5-1/2, and 7% interest levels.

Table 10-11. Annual cost equivalent of wastewater treatment alternatives at Ames assuming amortization over a 50-yr period (1970-2020) at 7, 5-1/2, and 3-1/4% interests.

Interest level, %	Population level	Design year basis	Design flow, MGD	Trickling filter	Activated sludge	Activated sludge + nitrification	Activated sludge + nitrification + phosphorus removal
	High-B	2020	13.43	458,000	591,000	764,000	884,000
7	Medium	2020	10.60	421,000	540,000	703,000	808,000
	Low-A	2020	7.50	372,000	480,000	629,000	716,000
	High-B	2020	13.43	430,000	555,000	716,000	831,000
5-1/2	Medium	2020	10.60	393,000	505,000	656,000	756,000
	Low-A	2020	7.50	347,000	445,000	583,000	664,000
	High-B	2020	13.43	393,000	511,000	656,000	762,000
3-1/4	Medium	2020	10.60	360,000	458,000	595,000	684,000
	Low-A	2020	7.50	312,000	400,000	523,000	598,000

into two components. The first component is the growth of Story City and its immediate area upstream of the reservoir proper. The second component is the existing and future growth occurring around the conservation pool area.

Evaluation of growth potential and physiographic features pinpointed the areas marked I, II, III, IV, and V in Fig. 10-10 as the most likely residential growth areas. The two components of the wastewater problem were then resolved into questions of (1) what to do with the municipal wastewater of Story City and (2) what to do with the residential wastewater from the designated residential development area on the west side of the reservoir. These are two separate problems not interrelated, so they were studied separately.

Approximate costs are presented for the two alternatives considered most likely to be feasible. The presentation of only two alternatives should not obscure the existence of several other possible approaches. Furthermore, all costs presented are not the result of a detailed engineering study and are intended to show only relative magnitude of development costs, or the range of costs. Any use of these figures as detailed construction estimates goes beyond the scope and intent of the brief report included in Appendix 5.

Treatment Alternatives. The available options for handling the Story City wastewater were grouped into (1) advanced treatment of the wastewater at Story City and discharging the chlorinated effluent into the reservoir or (2) conveying the partially treated waste to a remote treatment plant (Ames) that discharges into another basin or to the Skunk River below the Ames Reservoir dam. These options analyzed in a preliminary engineering study are reported in Appendix 5.

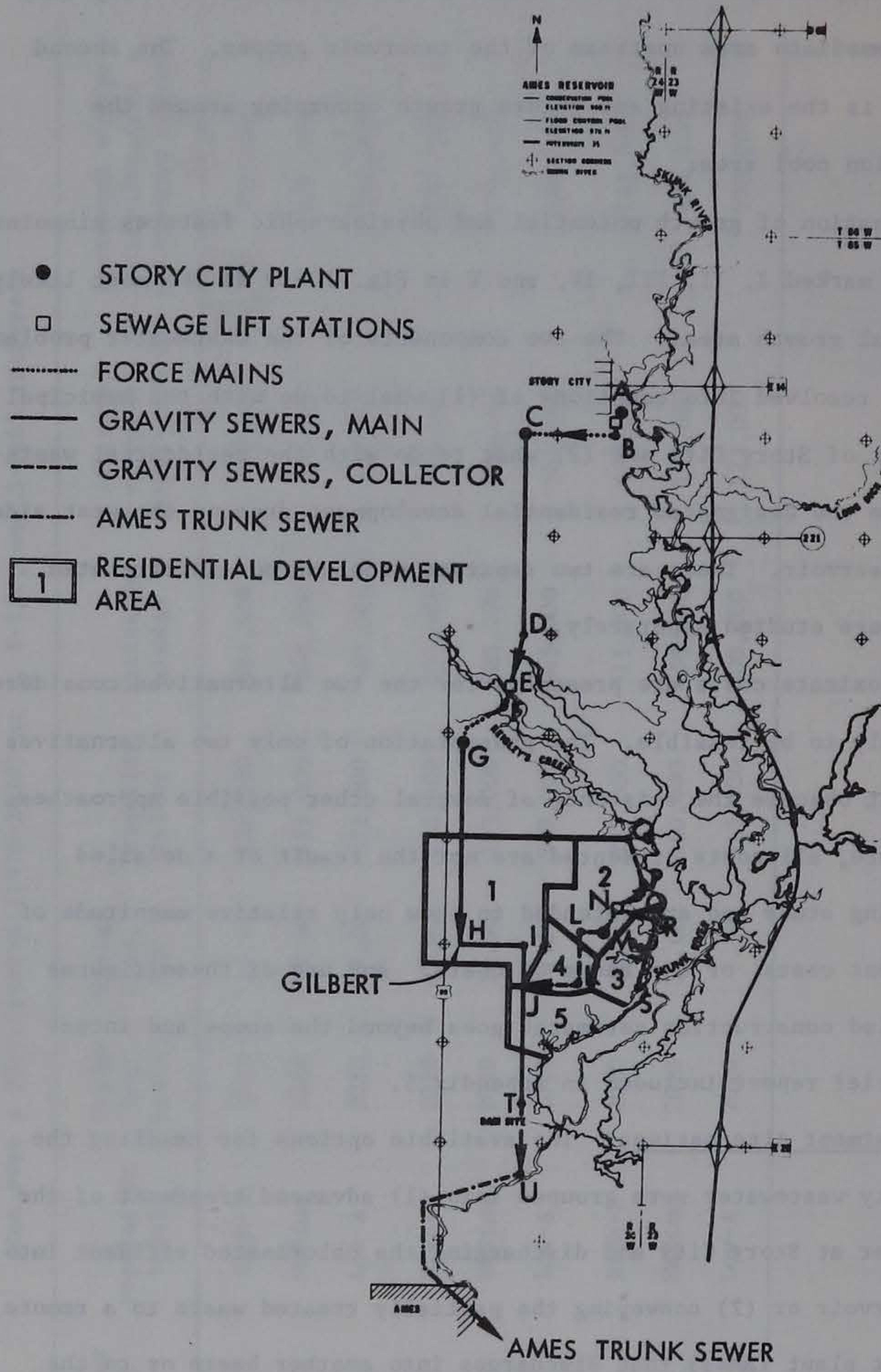

Fig. 10-10. Ames Reservoir area-wide wastewater treatment systems.

The most impressive result of the preliminary analysis was that both systems involve approximately 1.3 million dollars of investment in construction. However, this should not be construed to mean that the two systems are equal in cost, for several reasons. First of all, no operating or maintenance costs were considered. Were they to be considered, the alternative including treatment would undoubtedly be the more costly. Secondly, no time factor has been considered. The future expenditure for the sewage pumping station and the time rate of development of the west bank area could significantly affect both alternatives. Thirdly, the designs are extremely preliminary in scope because of the limited time and resources available for the study. The sewer system for the west side residential area includes the section HIJTU which was sized to accommodate also the Story City flow. There are other significant factors also omitted, meaning that the coincidental equivalence of the two alternatives is not important.

Two conclusions can be drawn from this study. First, the study indicates that the cost of handling wastewater due to more restrictive standards implemented to protect the reservoir or increased development in the reservoir area can be a significant factor in evaluating the impact of the reservoir on a region. Secondly, the analysis indicates that neither alternative discussed is significantly superior to the other. This suggests that, should the reservoir be constructed, both alternatives should be analyzed in considerably more detail.

Regional collection of wastewater would assist in maintaining a quality water environment in the reservoir area. Its physical advantages and environmental enhancement potential has merit for the development of the valley between Ames and Story City, whether for any reservoir alternative (proposed or reduced scope) or for recreation and open space having a measure of residential housing included in the development plan.

Urban Flood Damages

The greatest beneficial or detrimental effects of the dam will be on the four urban areas along the Skunk River which are nearest to the reservoir. These four communities are Story City, Ames, Colfax, and Reasnor. Story City is in the reservoir headwater area where remedial works may be required. The other three are located downstream of the dam, and benefits would accrue to these communities.

Each of these four communities was examined in turn as to its historic flood problems, existing flood plain occupancy, the effects that the proposed reservoir will have on them, and the effects that the alternative proposals will have on them. The elements of a comprehensive flood plain management program, as a substitute for reservoir construction for flood control, were also outlined in Appendix 5.

Story City Flood Problems

The flood pool of the proposed reservoir (Alternatives 1, 1A, and 5) will extend to about two miles north of Story City and would inundate the flood plain within Story City to a depth of several feet. Natural flooding of the Skunk River also has inundated the flood plain during past years. The flood plain within the corporate boundaries of Story

City is devoted to public uses. The land is zoned F-1, flood plain, and is owned in large part by Story City. Existing uses are a park, golf course, athletic field, and the pollution control plant. Future plans call for the construction of a swimming pool south of Broad Street. The natural river stage governs up to about the 20-yr recurrence interval, above which the reservoir elevation governs. Because of this, the Corps of Engineers designed flood control levees and raised road elevations in the Story City area to prevent flooding of the public improvements on the flood plain. The cost of this protection work was estimated at $244,000. The top of these levees were set at elevation 981 MSL, three feet above the 100-yr flood pool elevation. These levees will protect the flood plain improvements south of Broad Street but will not protect the golf course north of Broad Street.

One of the alternate proposals (Alternative 6) is to reduce the conservation pool from elevation 950 MSL to 940 MSL and to reduce the flood control storage from 5.2 in. on the drainage basin to 3.6 in. Flood control storage of 3.6 in. is the amount originally proposed by the Corps of Engineers. The conservation pool would be reduced in size from 2100 acres to 1400 acres, and the flood pool from 5000 acres to 3600 acres.

The main purpose of Alternative 6 is to eliminate the need for any remedial work on the flood plain at Story City. The flood pool elevation would be reduced from elevation 976 MSL to 965 MSL. With a water surface elevation of 965 MSL at Story City, the water is still within the banks of the Skunk River. Thus, no inundation of the flood plain would occur. During the passage of the spillway design flood, the water surface in the reservoir would rise to about elevation 970 MSL.

The other alternatives (green belt, open space, and recreation) are such that they will have no effect on the flood plain at Story City. The natural river stages will govern for floods of all recurrence intervals.

Ames Area

The Skunk River skirts the eastern edge of the City of Ames for about five miles (from river mile 227 to mile 222) which is three to eight miles downstream of the proposed Ames Reservoir. While seven large floods have occurred in the upper Skunk River basin during this century, there has been relatively minor urban damage recorded in the City of Ames. This damage has been sustained by a few low-lying residences, businesses, park facilities, and highways and bridges on the flood plain.

The vast majority of the flood plain land within the City of Ames is devoted to agricultural and park purposes. A few farm buildings and residences exist in the southeast part of the city, near Lincoln Way, and a few businesses in the extreme northern portion of the city either have been or could be subject to some flooding by large floods.

For many years, officials of the City of Ames have been engaged in a modest program of zoning and flood plain management. All recent flood plain construction has been subject to local zoning ordinances and regulation by the Iowa Natural Resources Council. Thus, little opportunity exists in Ames for any large-scale property damage along the Skunk River.

The greatest possibility of large-scale flood damage in Ames lies in the highly developed commercial and industrial area along both sides of South Duff Street (U.S. Highway #69), which is on the flood plain of Squaw Creek just above its confluence with the Skunk River. Based on the flood studies, in all but the most extreme floods which occur on both the Skunk River and Squaw Creek simultaneously, there will be only minor flood damage in the City of Ames under existing conditions.

Flood storage in the proposed reservoir will eliminate the minor urban flood damage which presently occurs within the corporate limits of the City of Ames. Those alternate proposals which include some flood storage will also eliminate the minor urban flood damage which presently occurs within the corporate limits of the City of Ames.

Colfax and Reasnor Areas

The flood potential at these two downstream communities was reviewed briefly as part of the ARES project. The results included in Appendix 5 showed that a flood potential exists in low parts of each community. Further, flood damage reduction could be achieved by the proposed Ames Reservoir project. However, additional detailed studies would be needed to quantify such damages or to outline alternatives. In general, since the Category 4 flood studies of agricultural damages show such a preponderance over urban damages in the Skunk River basin, more detailed studies were not pursued.

PART III. SUMMARY AND FINAL RECOMMENDATIONS

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part III. Summary and Final Recommendations

Chapter 11

SUMMARY OF DETAILED PROJECT EVALUATION

CONTENTS

TABLES

ARES SUMMARY REPORT

Chapter 11

SUMMARY OF DETAILED PROJECT EVALUATION

Introduction

This chapter summarizes both the economic evaluation and the non-economic impacts of alternative plans for water resource development in the Ames Reservoir area of the upper Skunk River basin. Many of the impacts cannot be valued in monetary terms, and the relative importance of these environmental impacts must be evaluated through a broader strategy. To facilitate this, a framework to organize the technical analysis and display the pertinent impact information was developed as described in Chapter 5. Two distinct constructs were advocated, one being a mechanism-based and the other an incidence-based classification. The mechanism-based construct (see Table 5-2) is relatively technical in substance, mainly to serve as an organizational vehicle for the impact analysis itself. The incidence-based construct (Table 5-3) is intended to organize impact information in terms which are more readily understood by various special interest groups participating in a public evaluation forum. This chapter presents the economic evaluation and synthesizes the results of technical efforts concerned with the many impacts addressed by the study. The mechanism- and incidence-based classification of effects are contained in Chapter 4, Appendix 6, from which the material summarized in this chapter was derived.

The following summaries are included in this chapter. First, the project benefit-cost analysis is presented, which consists of reviewing original estimates of the Corps, updating both benefit and cost estimates to 1973, and comparing cost and benefit estimates for alternative water resources, open-space, and recreation development projects. Then, information on prospective impacts for each of these alternatives is assembled. Subsequent discussion highlights the more important trade-offs implied by this information.

Section 102(2) of the National Environmental Policy Act of 1969 requires that an environmental impact statement consider alternatives to a given course of action which is advocated by an agency. Beyond this requirement, any firm declaration regarding trade-off evaluations between economic and environmental objectives requires analysis of a variety of different project configurations, emphasizing different kinds of impacts. Further, such results should be presented in a participatory public forum. With both of these motives in mind, this study has given substantive attention to several project alternatives which merit brief review at this juncture.

The alternatives for which impact information is presented in this chapter are the following:

Alternative 1. Ames Reservoir with two subimpoundments as planned by Corps of Engineers (per Design Memo No. 1).

Alternative 1A. Ames Reservoir as planned by Corps, with optimum recreation facilities, but without the Bear Creek subimpoundment.

Alternative 2. Ames Reservoir, minimum conservation pool for recreation only (no water-quality or flood control storage).

Alternative 3. Tributary recreation lake development only (no reservoir), using the two subimpoundment lakes.

Alternative 4. Green-belt plan under continuation of private ownership, using existing public lands.

Alternative 4A. Green-belt plan encompassing a substantial amount of additional public land acquisition.

Alternative 5. Ames Reservoir with dam-site subimpoundment as planned by Corps, but with minimum recreation development.

Alternative 6. Reduced-scope Ames Reservoir (limited flood control storage, of 3.6 in. of runoff storage from the basin), minimum conservation pool with subimpoundments.

Alternative 7. Status quo, for recreation and open-space use; no capital improvements.

Summary of Benefit-Cost Analysis

Methodology

The project benefit-cost analysis of the proposed Ames Reservoir project reviews the original estimate of benefits and costs made by the Corps of Engineers and synthesizes estimates made in the conduct of this environmental assessment.

For purposes of this study, the ARES review team chose not to limit their analysis to the Corps of Engineers guidelines in assessing benefit-cost. The Corps has evaluated the project using an interest rate of 3-1/4%, a 100-yr project economic life, and the log-normal flood frequency method for analysis of flood damages. The review team evaluated the project for different discount rates, with the major part of the analysis using discount rates of 5-1/2%, the current fiscal year (FY '73) rate, and 7%, the rate proposed by the Water Resources Council in their

1968 Standards for Plan Formulation and Evaluation. The review team feels 100-yr forecasts are too inaccurate in view of recent trends in population, birth rates, and water demand and considers a 50-yr horizon as more appropriate. Also, with a higher discount rate, benefits for the period between 50 and 100 yr are not valued highly in terms of present worth. Finally, the log-normal method of determining flood frequencies, as used by the Corps, is believed to be less satisfactory than the regional method used by the U.S. Geological Survey for the Iowa Natural Resources Council state study, which uses the log-Pearson method advocated by the federal Water Resources Council. In evaluating the benefits and costs of water resource projects, the Corps of Engineers is constrained by their established guidelines, whereas the review team is using criteria which are now becoming institutionalized for new water resource projects.

Review of 1968 Estimates

Table 11-1 summarizes the original estimates of benefits and costs made by the Corps of Engineers in 1968. The first cost estimate of $17,100,000 is converted to annual charges of $866,000 as compared to benefits of $1,390,100 for a benefit-cost ratio of 1.6:1.0. These estimates were revised in 1970 and again in 1972 to reflect reanalysis of requirements and inability to gain assurances of nonfederal participation in recreation facilities. Table 11-2 provides a summary of the 1968 benefits and cost with technical correction deemed appropriate by the ARES review team. These technical corrections are as follows:

1. An interest rate of 4-5/8% should have been employed rather than the 3-1/4% rate. The 3-1/4% rate was in effect when the

Table 11-1. Summary of Corps' estimate of benefits and costs[a].

Estimates of first cost	Original[b]	Revised[c]
Land and damages	$ 5,150,000	$ 5,220,000
Relocations	2,825,000	3,300,000
Reservoir	243,000	280,000
Dam	5,182,000	6,030,000
Recreation facilities	2,000,000	491,000[d]
Buildings, grounds, and utilities	259,000	275,000
Government costs		
Engineering and design	820,000	800,000
Supervision and administration	621,000	845,000
First cost	$17,100,000	$17,241,000
Equivalent annual charges		
Amortization, interest, operation, repair and maintenance charges	826,500[e,f]	792,500[e,g]
Estimates of annual benefit		
Flood control	681,100	681,100
Water quality control	325,200	505,538
Fish and wildlife and recreation	383,800	88,553
	$ 1,390,100	$ 1,275,191
Benefit-cost ratio	1.6:1	1.6:1

[a]Revised data, originally summarized in Table 6-3-1, Appendix 6.

[b]Corps of Engineers, Ames Reservoir, Design Memorandum No. 1, U.S. Army Engineer District, Rock Island, 30 September 1968, pp. 24,31 (excluding $1,100,000 for I-35 relocation).

[c]Corps of Engineers, Supplement No. 1, Project Reformulation and Benefits Analysis to Design Memorandum No. 1, Army Engineer District, Rock Island, 15 July 1970 (Revised 3 November 1970) (excluding $750,000 for I-35 relocation).

[d]Corps of Engineers, Design Memorandum No. 3A, "Land Requirements Plan: Public Use," Army Engineer District, Rock Island, January 1972.

[e]Includes interest during construction and annual maintenance, operations, and replacement values (OMR), with different values for the original versus the revised projects.

[f]Includes OMR of $50,000 for recreation.

[g]Includes OMR of $12,900 for recreation.

Table 11-2. Summary of estimates of 1968 benefits and costs with technical corrections.

Annual costs		
First cost	$17,100,000	
Interest during construction (1/2 of 4 years @ 4-5/8%)	1,617,700	
Gross investment	$18,717,700	
Annual cost (@ 4-5/8% discount rate for 100-yr life)		$ 875,300
Operations and maintenance		102,000
Loss of production[a]		0
Total annual charges		$ 977,300
Annual benefits		
Flood control		537,400[b]
Water quality control		349,000[c]
Fish and wildlife and recreation		368,800[d]
Total annual benefits		$1,255,200
Benefit-cost ratio		1.3:1

[a]Acquisition cost of agricultural land in reservoir area includes income potential of land for purpose of calculating costs.

[b]Corps' estimate of $503,300 for crop loss protection factored by 0.52 for revised flood frequency and by 1.7 to reflect revised estimate of yield and price, and $177,800 for property protection factored by 0.52 for revised flood frequency.

[c]The Corps' estimate of $325,200 for water quality is assumed to consist of initial investment of $7,760,000 and $266,000 operations and maintenance (15% of investment). Discounted at 4-5/8% yields $83,000 plus $266,000 for operations and maintenance.

[d]Recomputation of recreation benefits at 4-5/8% for 100 yr yields $326,000. Fish and wildlife benefits are assumed to remain at $42,800.

project was originally authorized by the 89th U.S. Congress and was continued because the project involved local funding as expressed in a Local Interest Participation Letter from the Story County Conservation Board. However, no assurances of a contractual nature to pay the bulk of the nonfederal share of project costs were made, and the interdisciplinary research team does not find satisfactory compliance with rules and regulations. The 1968 Water Resources Council regulations stated:

"Where construction of a project has been authorized prior to the close of the second session of the 90th Congress, and the appropriate state or local governmental agency or agencies have given prior to December 31, 1969, satisfactory assurances to pay the required nonfederal share of project costs, the discount rate to be used in the computation of benefits and costs for such project shall be the rate in effect immediately prior to the effective data of this section, and that rate shall continue to be used for such project until construction has been completed, unless Congress otherwise decides."

Only a small part of the nonfederal share has been assured; consequently, the project should be re-evaluated, using the 4-5/8% discount rate.

However, the Corps has drawn a different interpretation. In the absence of nonfederal agencies that are willing to share the responsibilities of development, administration, and maintenance of recreation, the Corps, in its Design Memorandum No. 3A in 1972, provided only facilities for public health and safety. After deleting recreation facilities for which nonfederal participation was sought, the Corps continues to interpret that no assurances are necessary, and the project can continue to be evaluated at the 3-1/4% rate.

2. The direct loss of production from land in the reservoir area removed from use by permanent or temporary inundation is included in the cost of land acquisition (assuming all land is purchased in fee title). The price paid for an acre purchased from a landowner for reservoir use represents the

present worth of the future stream of annual amounts of net agriculture income he would otherwise have received. This assumes that the discount rate applicable to agricultural practices is applied in the analysis.

The social cost (to society) of this loss of production (gross production — costs and returns — and net income) is reflected in having no more annual benefits in the future from agricultural crop production (land is abandoned for reservoir water areas, open space and other uses). Other benefits — recreation, fish, and wildlife, water supply, and downstream water quality enhancement and flood damage reduction — must counterbalance this land acquisition cost and all other project construction and ORM costs if a favorable benefit-cost ratio is to exist.

3. Flood control benefits have been revised to reflect use of regional flood frequency results derived by the U.S. Geological Survey, and 1970 adjusted normalized prices based on national indices. Flood control benefit estimates using 1968 prices were not readily available, and 1970 data were substituted for the earlier price schedules.

Application of the above technical corrections result in a reduction of the benefit-cost ratio from 1.6:1 to 1.3:1. Thus in 1968 a favorable benefit-cost ratio existed, using the development criteria most applicable to the project at that time.

Review of 1973 Estimates

Table 11-3 provides a summary of the 1973 estimates of benefits and costs for the project with subimpoundments using 3-1/4%, 5-1/2%, and

Table 11-3. Summary of 1973 estimates of benefits and costs[a], Corps criteria.

Annual costs[b]	@ 3-1/4%	@ 5-1/2%	@ 7%
First cost	$26,519,900	$26,519,900	$26,519,900
Interest during construction (1/2 of 4 yr)	1,684,000	2,997,300	3,842,700
Gross investment	$28,203,900	$29,517,200	$30,362,500
Annual cost (discounted for project life)	1,156,200	1,743,300	2,198,200
Operations and maintenance[c]	128,800	128,800	128,800
Total annual charges	$ 1,285,000	$ 1,872,100	$ 2,327,000
Benefits[b]			
Flood control[d]	1,033,400	1,033,400	1,033,400
Water quality[e]	324,000	363,000	387,000
Water supply[f]	2,200	1,800	1,400
Recreation[f]	414,100	377,400	358,100
Total benefits	$ 1,773,700	$ 1,774,600	$ 1,779,900
Benefit-cost ratio	1.4:1	0.95:1	0.77:1

[a]Using Corps' guidelines for analysis of flood frequency and low-flow augmentation for water quality benefits.

[b]50-yr project life.

[c]Assumed to increase by 6% per year.

[d]Based on Corps' log-normal flood frequency estimation with updated prices and yields. See Table 6-3-8, Appendix 6.

[e]Difference in cost between normal trickling filter secondary treatment, and activated sludge plus nitrification and phosphorus removal.

[f]See Table 6-3-7, Appendix 6.

7% discount rates for a 50-yr economic life. These benefit estimates use Corps criteria for flood frequency analysis and water quality enhancement, and are further updated to reflect current prices, yields, and population estimates (median population projection). Based on these current estimates and the selected Corps criteria, the benefit-cost ratio is 1.4:1, 0.95:1, and 0.77:1 for 3-1/4%, 5-1/2%, and 7%, respectively. Therefore, application of current or proposed discount rates results in an economically infeasible project (benefit-cost ratio less than unity).

The results listed in Table 11-4 show the current benefit-cost situation for the project using the USGS regional flood frequency method and interpretation that new EPA water-quality standards will require

Table 11-4. Summary of 1973 estimates of benefits and costs[a], ARES criteria.

Annual costs[b]	@ 3-1/4%	@ 5-1/2%	@ 7%
First cost	$26,519,900	$26,519,900	$26,519,900
Interest during construction (1/2 of 4 yr)	1,684,000	2,997,300	3,842,700
Gross investment	$28,203,900	$29,517,200	$30,362,500
Annual cost (discounted for project life)	1,156,200	1,743,300	2,198,200
Operation and maintenance[c]	128,800	128,800	128,800
Total annual charges	$ 1,285,000	$ 1,872,100	$ 2,327,000
Benefits[b]			
Flood control[d]	537,400	537,400	537,400
Water quality[e]	89,000	100,000	105,000
Water supply[f]	2,200	1,800	1,400
Recreation[f]	414,100	377,400	385,100
Total benefits	$ 1,042,700	$ 1,016,600	$ 1,001,900
Benefit-cost ratio	0.81:1	0.54:1	0.43:1

[a]Using USGS regional flood frequency and interpretation that EPA water-quality standards will require advanced treatment consisting of activated sludge plus nitrification.

[b]50-yr project life.

[c]Assumed to increase by 6% per year.

[d]See Table 6-3-8, Appendix 6. Based on USGS regional flood frequency estimation with updated prices and yields.

[e]Difference in cost between activated sludge plus nitrification, and activated sludge plus nitrification and phosphorus removal.

[f]See Table 6-3-7, Appendix 6.

advanced treatment, in addition to low-flow augmentation. Using these guidelines, benefit-cost ratios of 0.81:1, 0.54:1, and 0.43:1 for 3-1/4%, 5-1/2%, and 7%, respectively, are determined, which indicate the project is definitely economically infeasible at all discount rates. This illustrates very clearly the sensitivity of economic evaluation to the criteria and standards which may be applicable or appropriate.

Economic Evaluation of Alternatives

Table 11-5 provides a comparison of the alternatives on an annual cost and annual benefit basis and illustrates that the alternatives with a lower first cost are generally more favorable from a benefit-cost standpoint. Alternative 6 is a reduced-scope project for both flood control and recreation, whereas Alternative 2 is a reduced-scope project having only the conservation pool for recreation, and Alternative 5 is the same as Alternative 1, but with minimum recreation development. The results show that no reservoir alternative meets the newer economic criteria. Likewise, single-purpose recreation alternatives have difficulty in the economic arena. Unfavorable benefit to cost ratios imply little justification for present development, and perhaps a future context should be introduced.

Overall Project Evaluation

This section presents a summary of the overall effects of alternative plans for water resources development in the Ames Reservoir area. Table 11-6 displays a summary of the effects of the alternatives.

Table 11-5. Comparison of alternatives, as reduced to annual costs and benefits.

	Multi-purpose reservoir alternatives			Single-purpose recreation alternatives				
Annual benefit/cost[a]	Ames Reservoir with sub-impoundments (1)	Minimum recreation development (5)	Reduced-scope flood control reservoir with recreation[b] (6)	Reduced-scope recreation reservoir[b] (2)[k]	Sub-impoundments only (3)	Green belt concept (4)[j]	Green belt concept (4A)	Status quo (7)
Costs								
Land & Damages	$ 466,410	$ 466,410	$ 341,370	$ 341,370	$ 17,200		$148,000	
Construction & Relocations	872,180	872,180	570,550[c]	570,550[c]	32,520[d]			
Operations & Maintenance	128,775	128,775	128,775	128,775	9,000[e]			
Government Cost	131,830	131,830	96,370[f]	96,370[f]	5,530[g]			
Recreation	442,740	56,380	369,280	369,280	176,960	$20,040	171,000	$ 2,000
TOTAL	$2,041,900	$1,657,570	$1,506,345	$1,506,345	$241,210	$20,040	$319,000	$ 2,000
Benefits								
Flood Control	$ 537,400	$ 537,400	$ 453,790[h]					
Water Quality	105,000	105,000	0					
Water Supply	1,400	1,400	1,400	$ 1,400				
Recreation	358,100	17,630	325,000	360,830	$232,200	$86,340	$308,000	$16,000
TOTAL	$1,001,900	$ 661,400	$ 780,190	$ 362,230	$232,200	$86,340	$308,000	$16,000
Benefit-Cost Ratio	0.49:1	0.4:1	0.52:1	0.24:1	0.96:1	4.3:1	0.96:1	8.0:1

(a) 1973 costs and benefits at 7% discount rate for 50-year project life, without interest during construction.
(b) Both Alternatives 2 and 6 are assumed to cost an amount equal to that estimated by Howard Green for the Modified Design
(c) Modified design from Howard Green report, less land damages and recreation updated to 1973 and discounted.
(d) $330,000 updated to 1973, using 1.36 construction cost index from Howard Green Report discounted, equals $448,800.
(e) 20% of $448,800.
(f) 17% of $7,807,300, discounted.
(g) 17% of $448,800, discounted.
(h) Flood control benefits for reduced-scope reservoir are estimated to be 85% of full-scale project.
(i) A 10% reduction of benefits from Alternative 2 is assumed to reflect a fluctuating water level.
(j) Green-belt concept provides access points, but does not protect the valley through public acquisition of land.
(k) Includes water supply benefits through provision for some low-flow augmentation.

Table 11-6. Display of Effects

EFFECTS	ALTERNATIVE 1: Ames Reservoir with Sub-impoundments	1A: Ames Reservoir without Sub-impoundments	2: Conservation Pool for Recreation Only	3: Tributary Recreation Lake Development	4: Green belt with Minimum Acquisition	4A: Comprehensive Green belt Plan	5: Ames Reservoir with Minimum Recreation Development	6: Reduced-scope Multiple-purpose Reservoir	7: Do-nothing
BENEFIT-COST RATIO	0.49:1	No data	0.24:1	0.96:1	4.3:1	0.96:1	0.4:1	0.52:1	8.1:1
BENEFITS (Annual)									
FLOOD CONTROL	$537,400	$537,400	0	0	0	0	$537,400	$453,790	0
	33% reduction	33%	0	0	0	0	33%	28%	0
WATER QUALITY	$105,000	$105,000	0	0	0	0	$105,000	0	0
Low flow augmentation	Yes	Yes	No	No	No	No	Yes	No	No
WATER SUPPLY	$1,400	$1,400	$1,400	0	0	0	$1,400	$1,400	0
Recharges shallow aquifer	Yes	Yes	Yes	No	No	No	Yes	Yes	No
RECREATION	$358,100		$360,830	$232,200	$86,340	$308,000	$17,630	$325,000	$16,006
Picnicking & Camping	Good	Good	Good	Good	Fair	Good	Poor	Good	Poor
Power boating	Yes	Yes	Yes	No	No	No	Yes	Yes	No
Sub-impoundment boating	Yes	No	No	Yes	No	No	No	No	No
Swimming	Good	Fair	Good	Good	No	No	Fair	Fair	No
FISH									
Stream	decrease	decrease	decrease	increase	increase	increase	decrease	decrease	same
Lake	increase	increase	increase	increase	none	none	increase	increase	none
WILDLIFE									
Waterfowl	increase	increase	increase	increase	same	same	increase	increase	same
Other game	decrease	decrease	decrease	increase	same	increase	decrease	decrease	same
COSTS (Annual)	$2,041,900	no data	$1,506,300	$241,200	$20,000	$319,000	$1,657,600	$1,506,300	$2,000
Non-federal Costs	$238,000	$221,000	$1,506,300	$241,200	$20,000	$319,000	0	$184,000	$2,000
PHYSICAL EFFECTS									
Landscape									
Loss of Natural Areas	Yes	Yes	Yes	Minimal	No	Enhanced	Yes	Yes	Eventual
Scenic Landscape Affected	Yes	Yes	Yes	Minimal	No	Enhanced	Yes	Yes	Eventual
Flora (decrease)									
Woodland-acres	1771	1737	641	140	0	0	1737	1403	0
Woodland-cu. ft.	1,153,200	1,126,400	429,800	92,299	0	0	1,126,400	1,021,100	0
Fauna									
Species Affected	Yes	Yes	Yes	Slight	No	No	Yes	Yes	No
Aquatic									
Impoundment									
Water Surface Area	2100	2200	1410	None	0	0	2200	1410	None
Flood Pool	5000	5000	None	None	0	0	5000	3620	None
Sub-impoundments	185	30	None	185	0	40	30	185	None
Water Quality									
Eutrophication	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
Turbidity	Yes	Yes	Some	No	No	No	Yes	Yes	No
Mud flats	Yes	Yes	No	No	No	No	Yes	Some	No
Sedimentation	Yes	Yes	Yes	Some	No	No	Yes	Yes	No
Fish Population - number	increase	increase	increase	increase	same	same	increase	increase	same
- quality	Fair	Fair	Fair	Good	Good	Good	Good	Fair	same
Downstream									
Flow	improved	improved	same	same	same	same	improved	improved	same
Suspended Solids	decrease	decrease	decrease	same	same	same	decrease	decrease	same
Channel Erosion	Yes	Yes	No	No	No	No	Yes	Yes	No
Geological									
Water Table	Yes	Yes	Yes	No	No	No	Yes	Yes	No
Formations	Yes	Yes	Yes	No	No	No	Yes	Yes	No
Sand and gravel	Yes	Yes	Yes	No	No	No	Yes	Yes	No
Limestone	Yes	Yes	Yes	No	No	No	Yes	Yes	No
Archaeological									
Sites Affected	51	49	4	2	0	?	49	34	0
SOCIAL EFFECTS									
Lands Transferred to Public Domain									
Highgrade Cropland	2210	2193	369	3	0	2053	2193	1370	0
General Pasture	1036	1028	265	88	0	193	1028	718	0
Total Population (Individuals)									
Displaced	300	300	60	Several	None ?	None ?	300	115	0
Disrupted	125	125	250	Several	Several	Some	125	170	0
External Effects	90	90	158	Few	Few	Some	90	80	0
Employment (increase)									
Temporary	Major	Major	Major	Significant	None	Some	Major	Significant	None
Permanent	Few	Few	Few	Few	None	None	Few	Few	None
POPULATION CHANGE									
Short term	Loss	Loss	Loss	Gain	Gain	Gain	Loss	Loss	Gain
Long term	Gain	Gain	Gain	Gain	Gain	Gain	Gain	Gain	Gain
COMMUNITY STABILITY	disrupted	disrupted	disrupted	some disruption	No change	some disruption	disrupted	disrupted	No change
POLITICAL EFFECTS									
Roads Affected (miles) Abandoned	9.5	9.5	3 to 4?	Minor	None	None	9.5	4 to 5?	None
Utilities Affected	Yes	Yes	Yes	No	No	No	Yes	Yes	No
School Systems Disrupted	Minor	Minor	Minor	No	No	No	Minor	Minor	No
Cemeteries disturbed	1	1	0?	0	0	0	1	0?	0
Waste Disposed Problems	Yes	Yes	Yes	Possibly	No	Possibly	Yes	Yes	No
Taxbase reduction (immediate)	$134,000	$134,000	$98,000	$5,000	$0	$43,000	$134,000	$98,000	$0

Chapter 4, Appendix 6, provides a more detailed display of effects; a summary of those effects is discussed below.

Alternative 1 — Ames Reservoir with two subimpoundments, as planned in Design Memo No. 1.

This alternative is the Ames Reservoir project as proposed by the Corps of Engineers in Design Memorandum No. 1 (prepared in 1968). It includes the two subimpoundments to the main reservoir project, both directed to and enhancing water-oriented outdoor recreation. The main reservoir contains a large-scale conservation pool of 2100 acres at elevation 950 ft and a fluctuating flood control pool having a maximum elevation of 976 ft for which the temporary flood stage would cover a total of 5000 acres.

Agricultural interests residing or doing business in the flood plain between Ames and Colfax (and to a lesser extent from Colfax to downstream of Oskaloosa) are the chief beneficiaries of this flood storage, which is equal to 5.2 in. of runoff from the 314-sq mi drainage area. At a discount rate of 7%, annual benefits of $537,000 would accrue to these landowners, with no reimbursement of related costs required under current Congressional policies. However, this alternative dislocates persons residing in, and affects persons doing business with those residing in, the reservoir area. Two thousand seven hundred and eighty (2780) acres of crop landare removed from production, which amounts to $448,000 production loss, less a production cost of $217,200. This compares to an annual crop protection downstream, in the most protected reach, of $444,900 and a property damage estimate of $177,800. This downstream protection is partially offset by the loss of production in the reservoir and by reservoir operation policies, whereby less cropland may be flooded and some crop and pasture land flooded for longer durations.

Recreation interests, particularly waterborne recreation, are served by the 2100-acre conservation pool, the 155-acre Bear Creek impoundment, and the 30-acre dam-site subimpoundment. Six hundred and sixty-five (665) land acres are provided in Alternative 1 for recreation to serve the estimated 290,000 annual visitations initially, which will grow to 480,000 in 2020. The equivalent annual worth of recreation is evaluated at $358,000 for the 7% discount rate. A chief difficulty in implementing this alternative is obtaining nonfederal participation for the development and operation of recreational facilities.

The reservoir is designed to sustain minimum discharges of 40-50 cfs to augment downstream flows for the purpose of water quality enhancement. This low-flow augmentation is beneficial to the City of Ames in that it would be unnecessary to treat wastewater for phosphorus removal. This savings is estimated at $105,000 per year, at a discount rate of 7%. It also sustains the ground water levels in the surficial aquifer from which Ames obtains its water supply, an additional annual benefit of $1400 for the 7% discount rate. Neither is a reimbursable feature under the proposed project guidelines. Using the criteria introduced by the study team, the benefit to cost ratio is 0.49:1.0, or a return of 49¢ per dollar invested. Using every criterion available to the Corps, a benefit to cost ratio of 1.4:1 is obtained for 1973 conditions, including current estimates of costs and values.

Environmentalists, conservationists, and nature-oriented recreationists fear the loss of the natural valley and stream system and are concerned about debris, a fluctuating flood pool creating unsightly mudflats when the flood pool is lowered, and difficulty in access when the level is high.

The major impact of this alternative is in the reservoir area. The reservoir will affect 2905 acres of woodland along the Skunk River. In the context of Story County, almost one-seventh (15%) of the woodland area will be removed or seriously altered by the presence of the impoundment described in Alternatives 1, 1A, and 5. Alternatives 1, 1A, 5, and 6 and the larger recreational lake of Alternative 2 will have severe irreversible effects on many existing plants and wildlife communities. In addition to land which would be permanently inundated by the conservation pool and lost forever from its present use, there are areas which are located upon the higher valley slopes which will be flooded less frequently. Flooding may occur less frequently than once in ten years in these areas, causing plant communities to progress to shrubs and pioneer woody species offering increased wildlife habitat. Where no inundation occurs there may be eventual progression to mature upland timber. In the most active flood pool, with an increased frequency of inundation, there will be a halt in successionary trends, killing the existing vegetation and initiating once again the early stages of succession. Land released from intensive farm practices in all the alternatives can result in an increase in wildlife habitat, the formation of more open-space recreation area, and the re-establishment of natural plant communities. Plant succession on relatively low flat areas, such as the plateau between Keigley Creek and the Skunk River and the more upstream flood plain areas, will be frequently, but irregularly, interrupted. Even the lowland marsh species cannot thrive during frequent fluctuations of the water level, if deep submergence is prolonged. Upland plant species may disappear because frequently they cannot survive even a short period of inundation. The weedy species gain a foothold first, until the next flood submerges them, often killing the new growth, also. These flood-prone lands, on the flat flood plain or gently sloping terrace areas, are subject to "mud flats" typified by the lack of permanent vegetation on areas of exposed soil and additional sediment accumulation.

When compared to other Iowa reservoirs, particularly Coralville and Red Rock, the water of the Ames Reservoir will have a relatively long turnover time, approaching that of the Rathbun Reservoir. Turnover time is the average length of time a parcel of water remains in the impoundment (usually computed for average discharge conditions) and is of importance because there are a number of chemical and biological processes which, given sufficient time, alter the quality of standing water. These include the development of phytoplankton and the removal of plant nutrients by deposition in the sediment. Having a long turnover time and sufficient depth suggests that the Ames Reservoir could experience periods of thermal stratification. Also, it is expected that periodically there might be a loss of oxygen due to the breakdown of organic materials washed into or produced within the reservoir, such as has occurred at Coralville. Stratification, depletion of oxygen, and related chemical reactions could be detrimental to fish and might also affect downstream water quality, as withdrawal from the reservoir is from an outlet deep on the face of the dam.

Empirical evidence indicates concentrations of phosphorus and nitrogen play a decisive role role in determining the size of algae growth in lakes. In particular, phosphorus seems to play a key role in the midwest because many of the blue-green algae have the capability of fixing molecular nitrogen to meet their nitrogen needs. The Ames Reservoir has estimated values of input for phosphorus and nitrogen in excess of the critical input values, suggesting the lake will be within the eutrophic range. Using various means of calculation, it can be demonstrated that there will be substantial blooms of algae in the Ames Reservoir. If this occurs, the water clarity will be quite low.

The Story City water pollution control plant lies at the headwaters of the Ames Reservoir, so its effluent and nutrient concentrations will be directly introduced into the reservoir waters. It is desirable from a public health standpoint to completely divert the effluent away from the reservoir to avoid the possible introduction of pathogenic organisms into the water. A less positive method is chlorination of all effluent, since storm water inflow into the sewer system poses a problem. The water-contact recreation expected for the lake would seem to demand the protective measure. The diversion of effluent from Story City could be part of the regional sewer system serving development that will likely occur adjacent to the reservoir.

If the Skunk River environment is altered due to impoundment, certain changes in the structure of fisheries population will occur. Those fish requiring moving water will be reduced in numbers or lost entirely. Other fish which prefer bodies of stationary water will increase in numbers. Because of the large increase in water volume that occurs when the river is impounded, the total biomass of fish in the area may increase greatly, thus potentially making more fish available to the fisherman. Of the game fish that are found in the stream at the present time, only the small mouth bass will suffer due to habitat loss. Unfortunately, this species offers the greatest opportunity for sports fishing in the upper Skunk River at the present time. Reproduction of rough fish in the impoundment also will take place in the initial years after impoundment. In the upstream shallow areas, it may not be long before the rough fish become so abundant that they cut down on the reproduction of game fish by disturbing nests and by causing increased turbidity due to their feeding habits. However, the game fish species could continue to provide good sport fishing in the reservoir, especially in the southern two-thirds of the impoundment.

From the standpoint of game fish populations, ecological diversity, and recreational suitability, the Ames Reservoir will eliminate many features in the last remaining natural reach of the Skunk River in the Ames area. Previous channel alterations on the river below Ames and the relatively large volumes of effluent from the Ames water pollution control plant would require advanced treatment and related economic remedial activities to bring the downstream reach of the river up to the standards of the river currently found in the reservoir area. Therefore, the reservoir reach has special attributes worthy of inventory and protection.

Of all alternatives studied, this originally authorized project has the most significant impact on the valley's people. It has the greatest scale and offers the most physical advantages of which a reservoir is capable in terms of water resources development. The full-scale project will have significant impact on over 500 people residing in the reservoir area. Nearly 300 individuals will be required to move from their current residences. Takings not necessarily involving people's homes will pact on 125 other individuals, and the newly formed lake will be a major physical stimulus in their environment. External effects are those such as increased traffic, route alterations, loss of neighbors, or others causing adjustments in daily or weekly patterns of behavior. This type of effect will be noted by at least 90 people in the area of the new reservoir. In this context, it is of interest to note the 25-mi distance established as the maximum recreational drawing area. If this distance has meaning for recreational purposes, then we must also assume that other aspects of the project would be felt within this area. If so, thousands of people, not hundreds, will experience external effects of the project. However, the numbers given above for individuals classed by effect refer to those people near the Skunk valley and between Ames and Story City, exclusive of the urban residents. The effects are relatively much greater within this restricted area.

Alternative 1A — Ames Reservoir as modified by Design Memo No. 3A, with optimum recreational development.

This alternative maintains the same maximum conservation and flood pool elevations as Alternative 1 with an optimum plan of recreation development, but eliminates the Bear Creek subimpoundment. Essentially this alternative is the same as Alternative 1, but the elimination of the Bear Creek subimpoundment is a significant loss to the recreationists in that a moderate size (155 acres) constant-level body of water would not be available. Also the Bear Creek area would be subject to periodic fluctuations of water level and would not be particularly suited to recreation. Experience in Iowa with the Coralville, Red Rock, and Saylorville Reservoirs has shown that off-reservoir subimpoundments are a desired adjunct to multi-purpose reservoirs, if water-oriented recreational uses are to receive favorable consideration.

The chief difficulty with both Alternatives 1 and 1A is in obtaining nonfederal participation in the development and operation of recreational facilities. Alternative 1 calls for $1,140,000 for net nonfederal cost sharing, principally for recreational facilities. Alternative 1A calls for $2,715,000 subject to cost sharing. There has been insufficient commitment to and priority for the Ames Reservoir project at both the state and local levels to obtain local assurances for cost sharing. Consequently, the Corps is now directing its attention to Alternative 5, which calls for a minimum of recreational development. Other reservoir impacts remain unchanged from those described in the previous section.

Alternative 2 – Ames Reservoir smaller conservation pool for recreation only, no flood control.

This alternative is a reduced-scope recreation-only lake and provides no flood protection downstream. It does, however, have a lower elevation conservation pool and requires less land for the reservoir. Also, there is no flood pool, which eliminates those problems occurring when agricultural land is subjected to damaging fluctuations. Flood plain management and agricultural levee programs would be necessary to solve the valley's flood problems downstream of the reservoir.

The constant level 1410-acre lake would be ideal for boating, fishing, swimming beaches, and other recreational pursuits. Operation of the dam for recreation only may pose water quality problems, however, both in the lake and downstream. During drought periods there will be little inflow but high and continued algal productivity; unless releases are made water quality problems and shortages might be created downstream. In contrast, the multiple-purpose reservoir alternatives augment low flow from reservoir storage. The chief drawback to this recreation-only alternative is that the Corps of Engineers could not participate in a recreation-only development, given the guidelines under which they operate, and this would be an extremely costly project for state and local agencies to undertake. The City of Ames would need to introduce complete advanced treatment of its urban wastewater, including ammonia nitrification and phosphate removal.

This alternative differs from the former in a substantial way; it results in far fewer people being completely displaced from their homes. Instead, a greater number of people now fall in the other categories of effects. The impact is as follows: 60 people will be displaced, 250 disrupted, and 158 will experience external effects.

Alternative 3 — Tributary recreational lake development only.

This alternative provides two recreation impoundments, one on Bear Creek and one east of the dam site. Bear Creek Lake would have a surface area of 155 acres, and the smaller Dam-site Lake would have 30 water acres. The park areas would have 200 and 50 recreational land acres, respectively. The main valley is left to private ownership and all existing public parks and access points remain essentially the same. These small water areas would not serve the powerboat enthusiasts, but would add generally to the recreation inventory of Story County. This alternative attempts to serve some water-contact sports and fishing, while preserving the nature-oriented recreational sites.

This alternative provides no water supply and water quality enhancement, and no flood protection. However, it takes very little land out of production. Neither does it provide assurance against encroachment by urban development of agricultural and recreational land in the residential area. In fact, continued encroachment by rural-residential developments can be expected unless stringent land-use controls are instituted. This alternative also requires considerable local commitment of financial resources. It is unlikely that the Corps of Engineers could participate in the recreation-only development unless it became part of a comprehensive basin-wide water management program.

These relatively small lakes would have little impact on the people of the area. Several families would be displaced and several more would experience external effects from recreational use of the lakes.

<u>Alternative 4</u> – Green-belt, open-space plan with minimum acquisition, continuation of private ownership.

This alternative utilizes only the stream system in a green-belt program of modest scope locally financed, developed, and operated. It achieves a high benefit-cost ratio, 4.3:1.0, but is of very limited scope and would serve very few persons in comparison to regional population and needs. It assumes that most of the vegetation and open space would be preserved and managed by private landowners with 108 acres of land being purchased for public use and access to the river. It is foreseen that the minimum acquisition of land might invite a more intensive use of the Skunk River valley between Ames and Story City and increase conflicts between recreationists and landowners. Again, it is questionable whether existing land-use regulations can control the residential development pressures. Its lack of water supply, water quality enhancement, and flood control benefits is similar to that expressed with Alternatives 2 and 3.

Alternative 4A — Comprehensive green-belt, open-space plan with public control or acquisition of land.

Much more land acquisition is required in this alternative compared to Alternative 4. The stream channel and a strip of land on each side would be purchased from Story City to the Hallett gravel pit area. Additional wooded tracts, specific areas of ecological value, and some additional land would be controlled through rental or easement agreements. Achievement of this alternative would require substantial local commitment of resources and a strong measure of land-use control. Positive zoning is required to keep the west side of the valley in a wooded, lightly used state for optimal visual aesthetics of the natural valley.

The comprehensive green-belt concept removes land from agricultural use between Ames and Story City, but leaves much of the better cropland intact. Provision of a significant amount of open space may, however, remove some of the pressure from private lands and reduce trespassing by recreationists. Loss of reservoir advantages to water supply, water quality, and flood control is the same as with Alternative 4; as a single-purpose recreation project, it would return almost a dollar's value for each dollar invested in the project.

Alternative 5 — Ames Reservoir as modified by Design Memo No. 3A with minimum recreational development.

This alternative is probably least attractive to recreationists. It is the same structurally as the flood control reservoir with dam-site impoundment (Alternative 1A) — but with minimum recreational development. Not only are the existing recreational opportunities in the valley lost, but they are replaced by facilities inadequate in number and in quality. This alternative is the present Corps proposal and leaves many important issues in an uncertain status, such as extent of local participation in recreational facilities, diversion of Story City effluent, implementation of a regional sewer system, and controls on land development in the reservoir area. Pursuit of this alternative requires greater commitment and participation at the local and state levels to achieve an environmentally sound project. The "go it alone" approach by the Corps will result in remedial costs to local and state governments. These costs can be anticipated and should not be ignored.

This alternative maintains the reservoir's ability to assist in solving water supply, water-quality control, and flood control problems. An obvious issue with this current Corps proposal is that the major project benefit, flood control, occurs downstream of the dam site, while the major detriments occur upstream. This, then, becomes a regional or state issue, and an additional reservoir of this nature is not believed to be among the highest priority needs of public open space in Iowa. This is not an argument that such a reservoir would not be used, but rather, it is an argument that a variety and balance of recreational opportunities cannot be achieved if a proliferation of major reservoir projects drains the limited fiscal resources for recreational development.

Therefore, if the local, regional, and state agencies are unwilling to participate in order to achieve a "full benefit" project, it is questionable whether the federal investment is properly channeled. Other projects, more highly placed on a list of national priorities, are more deserving of a federal investment than one in an area unwilling to participate to achieve the many secondary benefits feasible through such an endeavor. According to the study results, the benefit to cost ratio is reduced further to 0.4:1.0.

Alternative 6 — Reduced-scope multi-purpose project for Ames Reservoir.

This alternative is a multiple-purpose reservoir which reduces the conservation pool from 2100 acres to 1410, and the maximum flood pool from 5000 to 3620 acres as compared to Alternative 1. The conservation pool would be the same size as in Alternative 2. Again, as listed with Alternative 1, operation of the flood pool would result in mud flats in some areas and other conflicts between recreation-oriented use and flood control objectives. This alternative represents a compromise to lessen project impacts on natural habitat, dislocation of farms and residents, and flooding of the Story City area. This alternative provides flood storage for 3.6 in. of runoff in the basin above the dam as compared to 5.2 in. for Alternative 1. Consequently, this project is estimated to be at about 85% as beneficial to downstream agricultural interests as is the full-scale project. However, agricultural land taking in the reservoir area is reduced from 2780 acres to 580 acres of cropland. This permits much of the agricultural land in the Keigley Creek-Skunk River plateau (Story City "flats") to remain in production.

This project assumes an intent to hold to a minimum the impact of the reservoir on the people in the area. However, it seems likely that displacees cannot be reduced below 110-120 individuals. This places about 170 in the "disrupted" category and 80 individuals in the "external effects" category. The benefit to cost ratio of this alternative is improved only slightly compared to Alternative 1, from 0.49:1.0 to 0.52:1.0, at the 7% discount rate.

Alternative 7 — Do nothing or status quo.

This "continuation of present trends" alternative implies continued private ownership of lands and minor planned changes in recreational opportunities. Continued and increasing pressure for residential development will be felt, and it is unlikely that the area can be retained in its present state without more stringent land-use controls. Recreationists would continue to place pressure on the few public sites and rely upon the good will of private landowners for access along the stream valley. The alternative also does not deal with water supply and water quality problems or with flood hazards downstream, and other solutions would be required. Its high benefit to cost ratio has little meaning, since it serves such a small portion of the population and fails to solve any of the existing problems.

Discussion of Trade-Offs

Comparison of the alternatives is difficult because they do not all achieve the same set of objectives. Some are primarily flood control projects with incidental, though large, recreational benefits while others are primarily recreation and open-space preservation projects.

Essentially, there are several major objectives of the alternative water resource development projects in the reservoir area of the upper Skunk River basin — flood control, water supply and water quality enhancement, land development control, and recreation. Which should have highest priority? Multiple-purpose reservoirs achieve all objectives to some extent although flood control predominates as a beneficiary in the proposed Ames Reservoir, with water quality control being a second important phase.

The difficulty is that alternatives which de-emphasize flood control and water quality enhancement through low-flow augmentation objectives are not as easily financed. In this case, the proposed Ames Reservoir precipitates discussion of land development controls, agricultural levee programs, advanced waste treatment facilities, and recreational/preservation alternatives to forestall the effects of a large-scale capital intensive project. Yet, those alternatives may not be viable because technology may be limited or resources may not be available.

The choice currently appears to be between a large-scale multiple-purpose project, which has been scaled down to include only minimum recreational facilities (Alternative 5), and continuation of present trends, which will result in encroachment by piecemeal urban development (Alternative 7). Either is possible under existing programs. Open-space acquisition and controls on urban development will require new programs and resources.

The proposed Ames Reservoir will have certain irreversible effects on the natural resources in the valley of the upper Skunk River, although no catastrophic effects are anticipated if adequate reservoir management practices and reforestation and revegetation programs are included as dynamic elements. Acceptance of the project provides a fairly financially painless way to gain a large body of water, but requires local financial participation to provide adequate facilities to use it. Ideally, the community would select the "best" alternative without being constrained by financial resources pointing in one direction. If other alternatives are preferred, can they be funded adequately to insure successful implementation, or will there be a shortfall and the status quo or continuation of present trends alternative be selected by default?

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part III. Summary and Final Recommendations

Chapter 12

FINAL RECOMMENDATIONS

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ARES SUMMARY REPORT

Chapter 12

FINAL RECOMMENDATIONS

General Accomplishments

The environmental study team has accomplished one of its primary objectives in conducting the review study of the proposed Ames Reservoir. As expressed in the National Environmental Policy Act of 1969, this objective was to "... utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which have an impact on man's environment." The review study has shown the depth to which environmental impact studies should be carried and what natural resource inventories and land-use analysis must be made. It has evaluated social influences, public response, and physical needs of people in the region of resource use and has shown the economic viability of and the trade-offs identified with various alternative development patterns. The nine alternatives introduced into the review study indicate the extent to which a scarce natural resource such as a scenic river valley may be subjected to development stresses. The results of the review study supply a thorough body of knowledge with which final decision-making can take place within a public-participatory forum. Although some alternatives were not pursued to the extent that detailed and complete basic planning and economic programs were evolved, this was not the intent of the study nor was it necessary to extend the studies to this degree to provide impact results for the area of the reservoir site. The results show that long-range planning for the valley is needed and can be accomplished if it is the will and desire of the residents of the region to work toward this goal.

The recommendations of the study group will be formulated in this chapter as a series of findings and final recommendations for an action plan. The population growth in the Ames area and its associated economic level of affluency automatically imply a stress on the natural and scenic resources of the Skunk River valley. A comprehensive development plan is an urgent need, and an action plan must be part of it. To offer less would be to leave the review study group derelict in its professional duties and ignorant of the environmental implications of the current situation. The nine development alternatives illustrate quite clearly the magnitude of the problems associated with making recommendations and are listed in Table 12-1 for reference in using this chapter.

The relative scales, very low to very high, are qualitative indications of the complexity, relative federal versus state and local funding requirements, and general usefulness in providing solutions to water problems and open-space and recreational needs.

Findings

Natural Resources

The reach of the Skunk River located in and immediately north of the reservoir area is the only natural meandering channel reach remaining in the Skunk River valley, between the headwater drainage ditches and the straightened main channel reach extending from Ames to the Mahaska-Keokuk County line.

Table 12-1. General accomplishments and complexity of alternative development opportunities.

Designation of alternative	Description of alternative	Overall complexity of achieving this alternative	Relative cost level: Federal	Relative cost level: Local & State	Relative level of accomplishment of the alternative: for public open-space use of valley	for downstream flood protection	for water quality	for water supply
1	Ames Reservoir with 2 subimpoundments, as planned in Design Memo No. 1 of the Corps of Engineers	Very High	Very High	High	High	High	High	High
1A	Ames Reservoir as planned, but with no Bear Creek subimpoundment	High	High	Medium	Medium	High	High	High
2	Ames Reservoir, smaller conservation pool for recreation only, no flood pool	Very High	Low	Very High	Medium	Low to None (1)	Medium	Low to Medium
3	Tributary recreation lake development only — Bear Creek and Dam-site Lakes	High	Low	High	Medium	None (1)	Low to None (2)	Low to None (3)
4	Green belt, open-space plan with minimum acquisition, continuation of private ownership	Low	Very Low	Medium	Low to Medium	None (1)	None (2)	None (3)
4A	Comprehensive green belt, open-space plan with public control or acquisition of valley land area between Ames and Story City	Medium	Low	High	High	None (1)	None (2)	None (3)
5	Ames Reservoir as planned, but with absolute minimum recreation development, and no subimpoundments	Medium	High	Low	Low to Medium	High	High	High
6	Reduced-scope multi-purpose project for Ames Reservoir, including 2 subimpoundments	High	Very High	High	High	Medium	Medium	Medium
7	Do-nothing, or status quo, for recreation developments; no capital improvements, use existing McFarland Park and other river access areas continued uncontrolled rural residential development	Very Low	Very Low	Very Low	Low	None (1)	None (2)	None (3)

Footnotes: (1) Requires implementation and funding of a flood plain management program, incorporating agricultural levees as necessary
(2) Requires using advanced waste treatment at Ames at greater cost than with reservoir alternative
(3) Requires additional sources of supply beyond the year 2000

The topographic and geologic characteristics of the narrow, incised valley in this reach, when compared to the level, upland agricultural farmland, make the valley eligible for a green-belt or scenic-river reach designation for this central-Iowa area. Approximately 25% of the timber area of Story County is contained in this valley area, and 15% of the county total would be directly affected by any major reservoir alternative. The preponderance of vegetation is accompanied by an important wildlife inventory. Usable sand and gravel deposits exist in the flood plain and terrace areas, with a minimum 20-yr supply available at present extraction rates in the immediate reservoir area. Archaeological resources of primarily local significance are also identified and inventoried with a minimum of 51 sites existing in this valley area.

The natural stream fisheries are unique in this reach for smallmouth bass, and the unstraightened, natural channel segment must be assigned a greater importance for a warm-water aquatic habitat designation than the straightened reaches upstream and downstream. Vegetative inventories for grasses, shrubs, and trees show a quantitative level commensurate with the natural physical features and have increased importance because of the high percentage of cropland in the upland level farm areas of the upper basin.

Population Growth

A four-county area is recognized as the primary area of influence for the reservoir site (Story, Boone, Hamilton, and Hardin Counties); a nine-county area is designated in the regional analysis (including, in addition, Polk, Dallas, Jasper, Marshall, and Webster Counties).

The study finds that Story County has a very high percentage of its population living in incorporated cities and towns. Over 53,500 of the 62,800 residents in 1970 lived in urban incorporated areas, while only 9,300 lived in rural unincorporated areas. Approximately one-half represent the actual farm population, and the other half represent the rural residential dwellers (about 4600 persons).

The review study finds that continued population growth can be expected at Ames, where 40,000 persons resided in 1970. The rate of growth is difficult to forecast even though student enrollment at Iowa State University and employment at the Iowa Highway Commission have stabilized. If rates greater than in the past are to occur, additional commercial and industrial growth will be required. Population levels by 2020 could vary from 50,000 to 140,000, with a medium projection of 80,000-90,000 persons. For the 4-county "primary influence" region, the population could increase from the current 130,000 to a level of 170,000, and for the 9-county "total-area-of-influence" region it could increase from 567,000 to 980,000 for medium level projections. These results show a trend for urban communities and counties to double in population in the 50-year study period. Associated needs must be identified and recognized for water supply, water pollution control, flood control and flood plain management, outdoor recreation and open-space areas, fish and wildlife propagation, and waterfowl enhancement.

Agricultural Influence

Agriculture will continue to exercise a dominant influence on the regional economy of the upper basin and on water quality in the stream system. The review study team finds that nutrient input into the stream system (and into any of the proposed multi-purpose reservoir or recreation lake alternatives) will be substantial. Nitrogen and phosphorus contributions will be sufficient to cause algal growth and "algal bloom" problems in any proposed impoundment.

Heavy use of pesticides is recognized, but concentration levels in streams have, in general, been less than those permitted in sources of water supplies. Pesticides may settle to the lake bottom with sediment particles and subsequently be picked up by bottom-feeding fish. No serious problems are foreseen with implementation and use of present or proposed control measures, especially if the chlorinated hydrocarbons are banned. Livestock production is sufficiently dispersed and is of sufficiently low concentration to preclude any waste water or water quality problem of large magnitude. Local feedlot runoff, especially during snowmelt, or runoff from frozen or impervious surfaces can contribute nutrients and ammonia nitrogen to the stream system at localized points but the magnitude is not large in comparison to the total stream flow on a basin-wide scope.

Sediment production from sheet erosion, bank scour, and other processes is low, because of the extremely flat topography of the upper basin upstream of the reservoir site. The sediment production of 300 tons/yr/sq mi (0.5 ton/ac/yr) is less than one-fourth the established Iowa soil loss limit for flat areas in Iowa. As a result, a minimum of sedimentation problem is foreseen with any reservoir alternative. Approximately

75 percent of the sediment production originates from the valley slopes along the river and could be further controlled by conservation practices which could reduce the reservoir sedimentation loss by one-half or more.

Urban Needs at Ames

The continuing population and economic growth at Ames requires meeting water requirements in three categories — water supply, water pollution control, and outdoor recreation needs. The review study team finds that the existing surficial aquifer and City and University well fields have the yield capability of 13 to 17 millions of gallons of water per day — sufficient to serve the projected demands to the period 1990-2000. Additional supplies can also be found in the alluvial aquifer extending from 13th Street to Hallett's quarry.

The surficial aquifer system is fed by the stream system. Some yield disruption may occur during drought periods of low stream flow which could be alleviated through reservoir storage and release. Alternate sources in the valley and in the bedrock aquifers preclude the absolute necessity for reservoir water supply — however, the latter offers a replenishment source having a physical advantage in that higher water levels can be maintained through augmented stream flow and less spatial dispersion of wells would be required.

Water pollution control and waste treatment requirements at Ames will become critical items as the Skunk River is reclassified (in a new 1973 state reclassification) as a warm-water aquatic habitat for fisheries production. The review study team finds that in the absence of low flow releases from reservoir storage complete advanced treatment will be required to remove ammonia, nitrogen, phosphorus, and practically all carbonaceous organic compounds. In addition, the use of tertiary lagoons both for temporary storage and for additional time for effluent assimilation may be required. The study reveals also that the reservoir alternatives will not eliminate the need for ammonia removal and that advanced treatment is required for ammonia nitrification. These reservoir alternatives could elminate the need for phosphorus removal. If stream standards were less strict (ammonia primarily) downstream of Ames, then the proposed reservoir would provide a minimum of 3:1 dilution for continuance of normal secondary treatment. Cost differences are substantial among these several alternatives. Primary and secondary treatment has been sufficient under the standard of no permissible or obvious pollution. Establishment of a warm-water aquatic habitat requires further advanced treatment measures to meet dissolved oxygen criteria, limit ammonia concentrations to non-toxic levels, and control phosphorus and other nutrients which lead to algal growth and decay problems. Regional water quality problems occur also at Story City and in the reservoir area, especially in terms of future growth and implementation of any realistic development alternative.

The review study team finds that outdoor recreation needs are not being satisfied by the present land-use arrangements in the valley. The limited public park areas and lack of facilities do not adequately serve the public, and a greater potential can be realized. Persons using the valley and stream for canoeing, hiking, picnicking, etc. are, in general, trespassing on private property, as witnessed by the many no-trespassing signs. The study results show that increased use would be made of the area if additional lands and facilities are provided.

The greatest opportunity for recreational growth exists with water areas incorporated into either reservoir or green-belt programs. The study results show that in central Iowa the construction of Saylorville Reservoir adds appreciably to the available water area and within close proximity (25-30 miles from Ames); water area availability increases from 5 to 15 acres per thousand persons in the 9-county central Iowa region encompassing both reservoir areas. The Saylorville Reservoir and Big Creek Lake projects add 6,200 acres of water area to the regional inventory for water-oriented recreation. The population growth pattern shows that not until the year 2000 would population increases require adding the Ames Reservoir to regain the same water area per capita for outdoor recreation as will exist on the completion of Saylorville. From 400,000 to 500,000 visitor days of outdoor recreation could be realized by the year 2020, about 5 to 10 times the limited use which will occur under continuation of the present limited amount of open-space and general lack of recreational facilities.

Flood Problems Downstream of the Reservoir

The review study finds that the urban flood damages along the Skunk River are very small, being less than 0.2 percent of the total average annual flood damages for the basin. At Ames, the flood damage potential along the Skunk River is low, principally because the city and state exercise control over flood plain development. Most of the flood plain east and north of the city has been purchased by the city for open-space and parks. Other areas were filled prior to building of commerical and

Findings Related to Alternatives Development Opportunities

Alternatives 1, 1A, 5. Full-scale Reservoir Alternatives

1. These alternatives differ by the extent to which recreation facilities are provided, and the project has retracted from one containing two sub-impoundments and extensive recreation facilities to an alternative containing minimum recreational facilities, which will be wholly inadequate to meet needs for water-related recreation. The inability of the Corps of Engineers to obtain local assurances for sharing in the cost of recreation facilities as required by federal regulations implies that state and local governments place a low priority on preserving open space and providing water oriented recreation opportunities through reservoir construction in the upper Skunk River basin. If a reservoir with minimum recreational facilities is constructed, political pressure to improve facilities can be anticipated.
2. The full-scale reservoir alternatives will result in significant loss of forest in Story County. As much as fifteen percent of the natural woodland in Story County would be subject to inundation. Approximately 1300 acres of woodland would be taken by the conservation pool. Clearance of that portion of the flood pool within a five year flood frequency will result in the loss of an additional 150 acres of woodland. The remainder of forest at the periphery of the flood pool may survive.
3. Considerable conflict can be anticipated between reservoir recreationists and those benefiting from the flood control objectives. The former group prefers a stable, full pool and the latter objectives require a low pool with all available flood storage. To alleviate this conflict

partially, the sub-impoundments are desirable for separating intensive-use recreation groups from the flood control operations.

4. Hydrologic studies and interviews of downstream interests indicate that flood damage may not be as much a hazard as originally estimated. A lesser flood frequency and the development of low levees reduce the flood damages that can be computed as based on available hydrologic data.
5. The reservoir alternatives will augment low flow and consequently improve downstream water quality. However, water in the reservoir itself will be eutrophic and subject to algal blooms.
6. The reservoir alternatives are not economically feasible using current criteria for evaluating water resources projects. The anticipated costs exceed the anticipated benefits. However, at the 3-1/4% interest rate which the Corps contends is still valid for "authorized" projects, and with its other criteria for beneficial use and flood damage evaluation, the project <u>is</u> economically feasible. The ARES team finds the project should be evaluated using current criteria, because actual construction of the project has not been initiated beyond the relocation of I-35 and acquisition of a few right-of-way parcels along the former highway alinement.

<u>Alternatives 3, 4, 4A.</u> Green-Belt Alternatives

1. Alternative 3, tributary recreation lake development, and the green-belt alternatives (4 and 4A) minimize impact on the landscape and protect the valley from development, to varying degrees. Although these alternatives do not serve power-boaters, significant recreational facilities would be provided.

2. The green-belt alternatives do not provide flood protection, nor do they provide for low-flow augmentation for aquifer recharge or for water pollution control. A positive flood plain management program with agricultural levees would probably be needed. This places the cost burden on individual landowners and/or local units of government.
3. Alternative 4A is preferable to Alternative 4 with respect to preserving the remaining natural landscape, and Alternative 3 provides the greatest diversity for recreationists.
4. The green-belt alternatives also place a great burden on state and local governments for funding with which to achieve the intended results. Presently, sufficient resources and programs are not available to achieve these alternatives. They represent a long-range program, with many complexities foreseen, including introduction of land-use policies and controls.

Alternative 2. Major Recreation Lake Only

1. This alternative serves primarily the outdoor recreation demand oriented towards waterborne activities, with significant recreational facilities for all users.
2. This alternative provides for low-flow augmentation for water quality control and aquifer recharge for water supply.
3. There are no flood protection benefits and federal participation is not easily obtained.

Alternatives 6. Reduced-scope Reservoir Alternative

1. The reduced-scope reservoir alternative reduces the impact on the stream valley and people residing in the reservoir area. However, the reduced

scope alternative also is not economically feasible using the current discount rate for water resources projects of nearly 7%.

2. The reduced-scope alternative might require low agricultural levees and would require a flood plain management plan to achieve a viable flood damage program.
3. The necessity for remedial works at Story City is eliminated by the reduced-scope alternative.
4. The reduced-scope alternative augments low-flow discharge to a lesser extent than the full-scale alternatives, but would replenish the surficial aquifer and offer a water supply enhancement measure.

Alternative 7. Do Nothing

1. The "do-nothing" alternative is not a status quo where the existing use of the Upper Skunk River would remain stable, because urban development pressures and mineral extraction are already changing the valley. This could be expected to continue or even accelerate if the reservoir is dropped from the scene.
2. The latent demand for recreation and open space in the region is placing pressure on private lands and will lead to increased trespassing. Considerable conflicts are foreseen between landowners and individuals desiring to use the area for recreational pursuits.

FINAL RECOMMENDATION

The green-belt or tributary lake alternatives are preferred over the reservoir alternatives by the ARES Review Study Team upon considering the environmental impacts, costs, and benefits of the various projects.

However, resources to achieve the alternatives are not equally available. It is questionable whether the green-belt alternatives can be achieved by the local units of government, even with state assistance. There is a serious risk of achieving the "do nothing" alternative by default. A reservoir alternative having adequate recreational facilities and long-range plan for housing development control and reforestation is preferred to the "do nothing" alternative.

The following questions and implications must be addressed:

1. Can an achievable green-belt plan be developed? Can it be financed with existing resources and programs? Can new programs be introduced at the state or federal level to aid in this?

2. If an achievable green-belt plan cannot be developed are state and local governments willing to provide assurances for the sharing of cost to provide adequate recreational facilities for a reservoir project?

3. Can a green-belt program be envisioned, planned and implemented which would include reservoir site preservation as an added feature, thus permitting sequential extraction of mineral resources, control of development, reforestation, open-space use, and future review for utilization as a reservoir if needs are apparent (after "X" years)?

Positive answers to (1) and (3) would favor acceptance of Alternative 4A, as expressed by the review study team, or lesser green-belt opportunities if less financial assistance is realized. The review study team would prefer this alternative if it has a reasonable chance of success and would recommend other physical alternatives for solving the remaining water problems — flood damage, water pollution control, and water supply needs. The study team believes that public interest is high and that local and state support and partial federal funding assistance could be obtained to achieve this proposed plan of action. The reservoir alternatives, if they have a real physical and economic potential, are in the more-distant future — the next generation, if not beyond. In addition, development of a comprehensive basin plan which emphasizes water resource policies and programs for water and related land and natural resources should precede further study of projects. The latter, a means of solving program needs, should be relegated to a secondary position. Primary efforts should be directed to the basin-wide planning phase.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part III. Summary and Final Recommendations

Chapter 13

STUDY IMPLICATIONS AND PUBLIC DECISION-MAKING

CONTENTS

ARES SUMMARY REPORT

Chapter 13

STUDY IMPLICATIONS AND PUBLIC DECISION-MAKING

Project Evaluation Today

Since the summer of 1969, four years after the initial Congressional authorization of the proposed Ames Reservoir, the issue of proper planning and evaluation for water resource projects has been the center of considerable agency and academic discussion. At that time a report of a special task force of the Water Resources Council — a report prompted by Presidential pressure for a higher discount rate for federal projects, and Congressional reaction to this demand by insisting on more "expansive" evaluation criteria — was published. Following the lead taken by Senate Document 97 in 1962, this 1969 WRC report, Procedures for Evaluation of Water and Related Land Resource Projects, proposed that there be four "objectives" to guide the planning and evaluation process. These four were: (1) national economic development; (2) regional development; (3) environmental quality; and (4) social well being. Each "objective" was, in actuality, an "account" where beneficial and adverse effects were to be tallied. The accounts were said to be non-mutually exclusive, yet for a project to be justified it was necessary for the beneficial effects to each objective to exceed — or at least equal — the adverse effects to each objective. The Task Force Report was given considerable publicity and reaction to it was sought from the public, from water resource agencies, and from the research community involved in traditional benefit-cost methodology and analysis. The reaction was very mixed. Some of the formal comments made in response to this initial report were published in 1970 by the Water Resources Council as: A Summary Analysis of Nineteen Tests of Proposed Evaluation Procedures on Selected Water and Land Resource Projects. Approximately 2-1/2 years after the Task Force Report was made public, the Water Resources Council in 1971 published — in the Federal Register — its Proposed Principles and Standards for Planning Water and Related Land Resources. Perhaps the most significant change from the 1969 document was the dropping of the "social well being" objective. The later document also did a much better job of defining a set of regions for project evaluation so that regional beneficial effects do not become confused with beneficial effects for the nation as a whole. Additionally, agencies are not permitted to "use" the regional development objective without prior approval by the Congress. Thus, what the Council is left with — reportedly at the insistence of the Office of Management and Budget — is really a "two-account" format instead of the "four-account" approach initially proposed by its Special Task Force.

The guidelines now proposed in the principles and standards document assert that the paramount task of the water resource planner is to formulate courses of action that effectively contribute to the multi-objectives — national economic development and environmental quality. Additionally, the nonmutually exclusive nature of the accounts is preserved, as is the requirement that the beneficial aspects of each account equal or exceed the adverse effects of each account for a project to be considered justified. Finally, while the Council admitted earlier that a discount rate of 10% would closely approximate the current opportunity cost capital, it also is argued that the political process has given tacit approval to a subsidy for water resource projects, and one way to implement this mandate — though it admittedly biases projects towards capital intensity — is to use a lower rate for discounting future benefits and costs. The preferred rate is 7%.

The fate of the Proposed Principles and Standards is uncertain as of mid-1973, so it is impossible to say when or if the suggested changes will ever become adopted — formally or otherwise* But the tenor of the proposed changes is troublesome to some who have been involved in the development of planning and evaluation guidelines.

Another significant factor in the evaluation and planning of future water resource developments is the recently-released recommendations of the National Water Commission (see Appendices 2 and 6). The Commission was established by a 1968 Congressional Act which stated in part that:

> "The Commission shall (1) review present and anticipated national water resource problems, making such projections of water requirements as may be necessary and identifying alternative ways of meeting these requirements — giving consideration, among other things, to conservation and more efficient use of existing supplies, increased usability by reduction of pollution, innovations to encourage the highest economic use of water, interbasin transfers, and technological advances including, but not limited to, desalting, weather modification, and wastewater purification and reuse; (2) consider economic and social consequences of water resource development, including, for example, the impact of water resource development on regional economic growth, on institutional arrangements, and on esthetic values affecting the quality of life of the American people; and (3) advise on such specific water resource matters as may be referred to it by the President and the Water Resources Council."

The Commission released drafts of its final report early in the fall of 1972, and the Water Resources Council has recently published a compendium of the 290 recommendations in the proposed report of the

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*In late summer, 1973, the Water Resources Council adopted, and the President accepted, the Principles and Standards for Planning Water and Related Land Resources (WRC). The adopted official discount rate is now 6-7/8% — Ed.

Commission. Therefore, several new directives have been issued which will influence future planning of water resources projects, but are less clear as to their applicability to authorized projects for which no real construction has been undertaken. These implications, interpretations, and public decision-making factors will be summarized in this chapter.

Interpretations

First, and of most relevance to the proposed Ames Reservoir project, the National Water Commission is recommending that the flood control strategy of the nation be moved away from structural alternatives and towards greater reliance upon nonstructural alternatives such as flood plain zoning, flood insurance, and flash-flood warning systems. If there must be structures, then an "appropriate share" of the costs must be borne by local interests — based on the expected benefits. Additionally, state and local governments are expected to better regulate the use of the flood plain to prevent the circularity (discussed in Chapter 4 of Appendix 2) whereby urban development is spurred by the potential usefulness of an engineering structure (such as reservoirs or levees) until a point is reached where the damages that could be avoided with a structure (called benefits) are so high as to justify that structure, which spurs additional development which then justifies more structures. Finally, state and local governments are to regulate land-use activities in those areas still susceptible to flooding — those areas not protected by the "designed-for flood" and the structure that is built for that "design-flood."

The second point of relevance to the Ames Reservoir project concerns the provision of municipal and industrial water supply. Basically, the Commission is arguing that nonfederal entities should assume a much greater role in the supply augmentation of municipal and industrial water and that industry should not get any water which involves a subsidy. Furthermore, it is urged that water supply projects not be authorized until there has been an evaluation of the present efficiency of water use and until all water-saving innovations have been explored.

As indicated above in different contexts, the era of subsidizing various producer and consumer groups via water resource projects is very likely past — now those who benefit from such projects are to be expected to pay an "appropriate share" of the costs. Thus a greater concern has emerged about the incidence pattern of project impacts for this reason alone.

In contrast to present practice, the regional development effects of projects must not be treated casually, but with increased depth and perception of real benefits. Before beneficial analysis can begin, there must be studies of the supply and demand conditions for the various outputs of the project, analysis of substitutes, and the comparative advantage of the region. Until this type of analysis is conducted, regional benefits are "not legitimate."

It can be seen from these recommendations that the construction of water resource projects for the protection or enhancement of agricultural areas is subject to serious question. The productive capacity of the Nation is such that the present level of production has been said to be producible with 25% fewer resources than are currently in agriculture. Hence, to count benefits from protection of agricultural losses in terms of conventional crop prices alone ceases to be legitimate. This point argues for an evaluation process which invites explicit political judgments as to the social worth of such economic benefits.

Another recommendation of the National Water Commission is that recreation as a project purpose be elevated to a position of more prominence. Water resource projects in the past have often included recreation as "an afterthought" to help in local repayment. This has resulted in some state conservation agencies balking when it comes to bargaining over reimbursement. If recreation were a central purpose — instead of an incidental addition — the project could possibly better serve the recreational needs of the local area. Correspondingly, local cost sharing would then become less of a problem than it is now, since the agency would be more satisfied with the nature of the project's recreational output. Again, this point argues for more detail on the incidence of recreational benefits, and for an evaluation process which explicitly provides for local participation.

Another recommendation of the Commission is that future planning and evaluation develop better ways to clearly articulate the nature and extent of both positive and negative impacts from water resource projects not only on local people, but on those in other regions as well. Hence, the concern for impact incidence is reinforced.

This is related to another recommendation of the Commission — that the agencies become serious about public participation programs. In the past, a maximum of two public hearings has usually sufficed. One has usually been held as the study begins and the second after the project was basically complete. This technique offered those already convinced of the "goodness" of the project a chance to expound its attributes; it provided little opportunity for others to offer or work out alternatives. As should be obvious, the local chamber of commerce does not constitute the only local interest group; it supposedly represents local business. There are others, in addition to elected or appointed officials, who have a right to know about project effects. A meaningful public participation program would facilitate interaction with a broad spectrum of local interests. Finally, in this regard, project planning and evaluation that is not specific with respect to groups of local people — as well as nonlocal people — will not be successful in terms of enhancing public participation. Again the joint need for incidence analysis and participatory process is apparent.

Finally, the National Water Commission recommends that nationally the Corps of Engineers become a course of last resort for structures — called in only when all other avenues have failed. Whether it be in municipal and industrial water supply, flood protection, water quality control, fish and wildlife enhancement, or hydroelectric generation, the Corps should view construction as the last alternative.

As the above interpretations are considered, it can be seen that their adoption would have a most dramatic impact on the operation of the major water resource development institutions as we know them today. Whether or not any of them stand a chance of becoming law is difficult to ascertain, but many of them are consistent with our judgments as to desirable changes. One aspect that was mentioned is worthy of elaboration here; that is the issue of public participation in the planning and evaluation process.

Past efforts at facilitating greater public participation have consisted largely of announcing public hearings to initiate a project study and then to review a project proposal that was basically complete. That these hearings have not been particularly useful in the planning process seems to come as a surprise to agency personnel. A meaningful program of public participation would consist of the following aspects. It would: (1) permit the public to interact with the agency early to establish the nature of water-related problems in the watershed; (2) permit the public to participate meaningfully in defining the cause of those water-related problems identified in the first step; (3) permit public participation in the development and evaluation of alternative objectives for water development; (4) permit public participation in the development and evaluation of alternative plans to meet the objectives; and (5) employ a project impact display format which permits each group of individuals potentially affected by the objectives, or the means to achieve those objectives, to be well informed as to the likely nature and extent of that impact (as discussed in Appendices 2 and 6).

This view then starts from the assumption that it is the job of the water resource planner to effectively interact with the public to aid in the solution of water-related problems. In the course of his work it is most imperative that careful attention be paid to the national income, the regional income, and the environmental quality implications of the various plans being given serious consideration — and that these effects be ascertained with as much accuracy as possible. This is far different from the position taken by the federal Water Resources Council in its Proposed Principles and Standards where the argument is made that the paramount task of the planner is to formulate plans that will effectively "contribute to the attainment of the multi-objectives."

Traditional Water Resource Project Evaluation

The traditional water resource project grows out of a coalition of local interest groups and the local or state office of a water development agency. Assistance of national special-interest groups frequently is solicited and obtained. Depending upon the location and the nature of the perceived water-related problems, these groups might be barge-line operators, farmers, private or public utility companies, flood plain residents, or local businessmen that suffer periodic flood losses. The basic purpose for the banding together is to obtain federal authorization and subsequent appropriations for the construction of a project. The "local" or "state" office of a water development agency has a very real interest in such a coalition — for the obvious reason that such projects tend to direct attention to, lend importance to, and guarantee a future workload for the agency.

This local initiative takes the form of informal as well as formal meetings between the federal agency and the groups most directly interested in a project. Once a general feasibility study shows the project to be "economically viable," it becomes important to move ahead on several fronts: First of all, it is imperative to have near unanimity among the Congressional delegation from the state. As project authorization is sought, it is often helpful to have testimony from important individuals in the project area. Finally, when it is time for appropriations hearings, the commitment of local entities for cost sharing is crucial. A parallel pattern of obtaining input from appropriate state agencies and organizations also is solicited.

Throughout this entire process, the federal agency concerned with project development is faced with an economic justification of the undertaking. This consists of assigning values to the different project outputs. The area of project justification has been the subject of numerous papers by economists — critical of the use of economics in certain instances, and incensed at the lack of its use in others. Much of the reason for this criticism is that this process takes on the flavor of project justification instead of project evaluation. That is, once the local "power structure" favors a project, the burden is upon the agency to insure its economic viability.

Criticism of this practice has come from many quarters, including economists, conservationists, and politicians. One of the traditional targets for these critics has been the discount rate. Critics have maintained that most any project can be made to look viable with a low enough discount rate, and that the way to interfere with the almost automatic allocation of public works funds to different regions of the country is to raise the rate at which future benefits are converted to present values. While the obvious intent is to make it more difficult for projects to be authorized, the relation to the "water budget" was never very clear. That is, if the "water budget" is taken to be rather stable over time, then bringing about an increase in the discount rate will not affect the amount spent on water resources, but will influence the nature of projects which are built. Specifically, a low discount rate will bias projects toward high capital intensity and long life.

Therefore, as the discount rate decreases, the benefit-cost ratio increases most rapidly for projects that are very capital intensive. For projects of smaller capital intensity, the benefit-cost ratio rises faster for those projects which are designed for a 100-yr period than it does for those which are designed for only 50 yr, as the discount rate decreases.

On the other hand, if the "water budget" is not taken as a parameter, but is instead a function of the number of "viable" projects, then a higher discount rate can have a profound impact on the nature and the scope of the nation's investment in water resource projects.

It seems reasonable to argue that the planning and evaluation process for water resource projects ought to be structured along the following lines. First, project development should proceed from established and adopted broad-based programs which include alternative methods for solving water resources problems and entertain long-range objectives. Second, the process should reveal positive and negative impacts which impinge on various groups of individuals within close proximity of the project (the project region). Third, the process should reveal both positive and negative impacts on groups of individuals outside of this immediate area. Fourth, the process should facilitate discussion and consideration of these impacts at all levels — that is, local and nonlocal. And, finally, the process should permit the participation in the decision process of those who stand to be "significantly" affected by the project under consideration.

The rationale for the above focus on groups is found in the political philosophy referred to as "analytic pluralism." Basically, the analytic pluralists argue that: (1) society is structured around groups of people that are unified by common values and goals; (2) the more complex a society, the greater the role of these group affiliations; (3) public action results from the balancing of force among opposing groups; (4) groups are successful if they can muster not only numbers, but intensity as well as finesse; (5) political stability results from the exercise of mutual restraint by all groups in a society; and (6) there is no such thing as the public interest.

While water resource agencies have always pointed to their public hearings when accused of not involving the public in the planning and evaluation process, that defense is no longer admissable — and the agencies know it. One planner for the Corps of Engineers recently outlined how the Corps intends to respond to the insistence for greater public participation (see Appendix 6). Specifically, it was indicated that the Corps would:

> "1) allow the public to establish its own goals and priorities early in the study; 2) let the public clarify and define their own problems; 3) permit public participation in the development and investigation of alternatives; 4) allow open public debate of conflicting views; 5) encourage two-way communication between the planner and the citizenry; 6) demonstrate that public comment had an effect on the proposed action; and 7) above all, keep the public involved from beginning to end."

If the advice of the National Water Commission is followed, authorization for projects will be withheld until agencies report on their public participation programs. Specifically, this report will show compliance with agency procedures as regards the questions considered, the viewpoints expressed, and supporting information for decisions made on controversial issues.

The exact nature of a public participation program is best described in the context of a particular agency, but it is possible to generalize somewhat. Specifically, it would seem that a comprehensive program ought to include at least eight steps. These steps are: (1) problem identification; (2) problem definition; (3) setting of objectives; (4) plan formulation; (5) evaluation of alternatives; (6) selection of alternatives; (7) plan implementation; and (8) monitoring and feedback.

The preceding discussion focused on the process of planning and evaluating water resource projects and emphasized the need for all those potentially affected by a project to be apprised of their probable fate. The nature and extent of that informational imperative is the subject of the next section.

Project Impact Analysis: A Brief Overview

Traditional discussions of evaluating public projects focus on either benefit-cost analysis in its more conventional forms or on cost-effectiveness analysis. The latter is distinct from the former by the absence of any requirement to be able to assign monetary values to all project outputs. An extension of cost-effectiveness analysis might be called "impact analysis" (or "trade-off analysis") where an effort is made to systematically account for all of the monetary and nonmonetary impacts of a project — by proximity to the project and by group affected. There should be explicit recognition of two major categories of project impacts: (1) monetary and (2) nonmonetary. As for the monetary impacts, there are two subcategories, with further definition within each. Specifically, there are two kinds of monetary impacts: (1) those that received their monetary value from workings of the market, called "market-valued;" and (2) those that received their monetary value from other sources, called "nonmarket-valued."

It would seem appropriate to specify the role that groups in a project region might play in planning and evaluating a project. This discussion can be facilitated by making reference to, say, four possible groups that might become involved. For this example we might consider as relevant groups: (1) farmers; (2) conservationists; (3) businessmen; and (4) local officials.

As indicative of the way in which each might identify a different sort of "water-related" problem, farmers might be inclined to see the problems as those of crops being destroyed, buildings and equipment being flooded, and their fields being silted in from upstream erosion. On the other hand, conservationists would likely be concerned about the lack of water for fish and wildlife (both quantity and quality) and erosion. Local businessmen would see water-related problems in terms of buildings and inventories destroyed by floods, and a declining population base to support local business activity at a "desirable" level. Finally, local officials might be concerned that there are no public recreational facilities and that the tax base of the area is declining.

The above are merely illustrative of how different groups might perceive water-related problems differently, but they are an insight into a more substantive difference — that of problem definition, identification of cause. For instance, it is not unreasonable to expect that both farmers and businessmen would view the cause of their flood problems as arising from a river flowing where "it doesn't belong." Likewise, erosion might be viewed by farmers as arising because of "above average rainfall" or sloppy land-use practices by someone upstream — never themselves. On the other hand, conservationists would be inclined to view flooding as a result of towns and farms having been built in natural flood plains.

Hence, different groups are going to demonstrate considerable disparity in the first two steps of the eight-part planning model described earlier. When it comes to the third step, setting of project objectives, this disparity will continue to exist. It therefore is imperative to make an early distinction between the objectives of a water resource project and the means whereby those objectives are achieved. As possible objectives, the above groups might demonstrate the following: (1) farmers would like crop damages to be reduced to a certain level — perhaps zero; (2) farmers would like building and equipment damage to be reduced to a certain level — again, perhaps zero; (3) farmers would like to see upstream erosion reduced to a certain fraction of its present level; (4) conservationists would like to see the minimum flow in a certain reach of the river set at some level; (5) conservationists would like to see an upper limit on stream temperature in the summer time for certain reaches of the stream; (6) conservationists would like to see erosion reduced to a fraction of its present level; (7) businessmen would like to see present flood damages reduced or eliminated altogether; (8) businessmen would like to see a viable recreation industry; (9) local officials would like to see more water-based recreational facilities; and (10) local officials would like to see the tax base of the area enhanced in some fashion.

The above are merely examples of how the different groups might articulate their preferred project objectives to the construction agency. Of course, the affected federal water resources agency itself may have some objectives which may or may not coincide with those it receives from the various publics in the project region. It is at the next stage, plan formulation, that the specific means for reaching these objectives are developed. It is this stage that involves the "means" discussed above. For dams, levees, recreational facilities, etc. are not rightfully objectives, they are merely means. And there are alternative means of achieving specific objectives. Farmers and businessmen will probably prefer an engineering structure such as a dam, while it is possible that conservationists would view a better alternative as being a change in land-use and/or an insurance program to compensate those who incur flood damage. As regards flow augmentation in a reach of the river, conservationists might prefer the prohibition of withdrawals as an effective means. On the other hand, a dam and reservoir would permit the maintenance of a certain minimum flow during the summer months — and possibly the maintenance of a certain maximum downstream temperature through reservoir releases from the cooler hypolimnion.

Hence, the impact approach to planning and evaluating water resource projects starts from the premise that the water development agency will desire to implement a project which will meet many of the objectives of those in the immediate proximity of the undertaking. A viable public participation program will facilitate a public input into not only problem identification and problem definition, but also into objective setting, plan formulation and evaluation of alternatives. This latter step will involve the generation and display of relevant information not only for those in the immediate area, but for those in contiguous regions affected by the project. In this instance, it is important to have not only many of the traditional indicators of the economic viability of a project, but also additional information of relevance to those who have become involved in the process. As indicated in the introductory chapter, the temporal aspect must also be introduced. What is the "proper" time at which development should take place?

Public Decision-Making and Implications of Alternative Development Plans

The reach of the Skunk River valley on which the reservoir is proposed is the last remaining natural section of the upper basin. Although the reservoir poses no likely ecological catastrophe, and the Skunk River valley between Ames and Story City is not a priceless national resource, it does assume significant value because this area of Iowa is devoid of natural features of significance and pressures exist for its preservation. The study team concludes that two scenarios are possible given present programs and controls; each presents unique and difficult problems and each arrives at a different solution.

No-Build Scenario

One scenario is to request the Corps of Engineers to drop plans to construct the Ames Reservoir and attempt to retain the reservoir site in its present undeveloped state. This action would serve to benefit those persons subject to relocation, those desiring to retain the valley in its natural state, and local agricultural businesses catering to farmers in the reservoir area. This decision would also avoid the immediate environmental impacts, but, given existing pressures for sand and gravel excavation and for urban development in the area, avoidance of environmental impacts would be short lived.

A decision to continue the status quo would adversely affect those persons downstream who would benefit from the flood protection aspect of the reservoir and those active "water-oriented" recreationists who desire additional facilities for boating, fishing, camping, and picnicking in a lake environment. It would also displease those businesses who would benefit from increased economic activity due to construction and operation of reservoir-related facilities. The decision to forego the dam site would also displease those persons in firms who would develop uplands adjacent to the reservoir for home sites. It also would require Ames to invest additional funds in wastewater treatment facilities and possibly deep wells or other surficial sources for water supply to handle future growth. But most importantly, if the decision not to build the reservoir is made without simultaneous development controls and public acquisition of land, this natural resource will be lost to piecemeal development. Unfortunately, development controls have not proved very effective here or elsewhere, and present local public open-space and recreational area acquisition programs are not commensurate with the task. Further, the state does not presently rank the Skunk River valley high in their acquisition and development plans for outdoor recreation.

If it is the consensus of local residents and responsible state agencies and officials that they do not desire a multiple-purpose reservoir, they must assume the responsibility for supporting measures to ensure that the valley will not be encroached upon by residential growth and uncontrolled quarrying. In rejecting the reservoir, without a definite plan of control, these decision-makers should be aware that environmental values are in jeopardy of being lost piecemeal.

These measures to protect the natural valley would probably take the form of action at the county level:

(1) A zoning ordinance with sincere effort to avoid residential construction or to disperse it through large-area lot requirements, and to discourage requests for zoning changes from agriculture and open space to residential uses.

(2) A subdivision ordinance with area and construction standards to insure a high-quality residential environment that can live in harmony with and retain the natural resources that are being conserved.

(3) A bond issue for substantial land acquisition and development of facilities for outdoor recreation by the Story County Conservation Board, supplemented by other state and federal funding programs for open-space acquisition. Stressing the natural resources of the area is absolutely unavoidable in the Skunk River valley if recreationists are not provided with sufficient open-space, recreational facilities and if they continue to be met with "no trespassing" signs.

(4) The State Highway Department and the Iowa Conservation Commission have a responsibility also to provide open space in this area to serve visitors utilizing Interstate 35, if such stress is an imposition on the local economy and is not met by private enterprise.

Build Scenario

The second scenario has the Corps of Engineers proceeding with construction of the proposed Ames Reservoir (Alternatives 1, 1A, or 6). The first issue is to finalize local participation in recreational facilities and to determine whether or not the Bear Creek subimpoundment is to be included in the project. Unless recreational facilities commensurate with the demand for recreation are provided, plans should not continue. The original plans assume the Iowa Conservation Commission, in addition to the Story County Conservation Board, would participate and construct a state park; this now appears unlikely. If the local or state participation in recreational facilities can be resolved and the reservoir constructed, then it can be anticipated that the interest of the following groups would be served:

(1) Recreationists favoring water-oriented activities and persons seeking residential land and home sites near a large body of water.

(2) Ames residents benefiting from municipal water supply and water pollution control features of the project.

(3) Businesses benefiting from additional income received from reservoir construction and operation, and from construction of recreational facilities and subsequent recreation visitors.

(4) Downstream residents, particularly farmers, who would benefit from additional production because of flood protection.

On the other hand, this choice would adversely affect these groups:

(1) Those persons dislocated from the reservoir site or disrupted.

(2) Those persons concerned with ecological disruption and environmental impacts of reservoirs.

(3) The present recreationists, using the site, who favor an open-space, natural valley and river environment.

(4) Citizens concerned that public funds are being used for an uneconomic project, when evaluated using current discount rates, cost estimates, and flood-frequency estimates.

Public Decision-Making Considerations

Although the reservoir will have significant undesirable environmental impacts, undesirable environmental impacts will also, in all likelihood, accompany the "no-build" alternative in that the natural resources will be eroded by piecemeal development. The more serious objection to the project is based on economic, not environmental, grounds. Is it a good investment? When using current estimates of cost, interest rates, and population growth, and flood frequency the answer is no. However, the Corps of Engineers, according to their guidelines for project evaluation, would compute a benefit-cost ratio of approximately 1.4:1, which would allow construction.

This report should be distributed to and discussed by local and state planning agencies, the natural resource agencies, and the Governor's Inter-Agency Resource Council. The Council, through its participating state agencies, should recommend to the Governor of Iowa a state position, considering the water supply, water quality enhancement, flood control, recreation needs, and financial investments which will be affected by that position.

This report should receive wide distribution and opportunity for discussion within the upper Skunk River basin. Particularly, local citizens and the Story County government, the Story County Conservation Board, the City of Ames, Story City, and other communities near the reservoir or affected by it should identify their preferences and commitments to the various alternatives.

The Corps of Engineers appears willing to place considerable weight on the preferences of local citizens, local government, and state government in their decision whether to proceed with the Ames Reservoir project. It is incumbent on those expressing their preferences to carefully consider the alternatives and the nature of the resulting impacts of each possible future system.

It is believed also that the study methodology, the depth of the environmental analyses made by each study category, application of planning and development principles, evaluation of alternatives, and environmental impact analysis will serve as a guide in the future for those working in the arena of natural resource development. This is an equally important objective of the ARES project review and ultimately may be its greatest contribution. Before any major project involving the use and development of natural resources is proposed, studies similar in type and depth to the ARES review should be undertaken, completed, and subject to review and discussion.

AMES RESERVOIR ENVIRONMENTAL STUDY

Summary Report

Part III. Summary and Final Recommendations

Chapter 14

ACKNOWLEDGEMENTS AND STUDY PARTICIPANTS

Chapter 14

ACKNOWLEDGMENTS AND STUDY PARTICIPANTS

The Ames Reservoir environmental study group has completed a review of the environmental impact related to the proposed Ames Reservoir project of the U.S. Army Corps of Engineers. This study has been prepared for the Rock Island District, U.S. Army Corps of Engineers which supported the study through an initial research contract DACW 25-72-0033, between the Corps of Engineers and the Iowa State Water Resources Research Institute at Iowa State University, Ames, Iowa, with the additional assistance of the University of Iowa through the Institute of Urban and Regional Research.

Partial administrative and publication assistance was furnished also through the Office of Water Resources Research, U.S. Department of the Interior through federal funds administered by ISWRRI (PL 88-379). The purpose of the project review was to provide a comprehensive and authoritative basis for preparation of an adequate environmental impact statement by the Corps of Engineers in compliance with the National Environmental Policy Act of 1969.

The studies represented in this report have received administrative support from several groups at Iowa State University and the University of Iowa. At Iowa State University these include the Office of the Vice President for Research, the Iowa State Water Resources Research Institute, the Engineering Research Institute, Colleges of Engineering, Science and Humanities, and Agriculture, the University Physical Plant, and other arms of the University support services. At the University of Iowa support and coordination was achieved with the assistance of the Institute of Urban and Regional Research, Iowa Institute of Hydraulic Research, and the Departments of Civil Engineering and Economics. Several communities, including Ames, Nevada, and Story City, also co-operated in the study by supplying information and by assisting in evaluating and reviewing the results. The involvement and assistance of all these groups are gratefully acknowledged by the editors and authors of the respective chapters of each appendix. The efforts of key individuals involved with coordinating the various studies and providing assistance in preparing and printing were essential to the successful completion of this report.

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The assistance and participation of the local and state agency coordinating committee is also recognized. This included representatives of the landowners group in the reservoir area, community representation from Ames and Story City, and technical representatives from the various natural resource agencies of the State of Iowa.

A special acknowledgment by the two universities is extended to the U.S. Army Corps of Engineers for the opportunity to conduct the intensive investigation and review of a water resources project. The following Rock Island District Corps of Engineers personnel are recognized for their administrative and technical input into this study:

Col. Walter H. Johnson
Contract Officer and his predecessor at the time of contract initiation, Col. James E. Bunch

Mr. Robert H. Hurlbutt
Contract Administrator

Mr. Frank W. Collins, Chief
and
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Credit is given also to the ISU Engineering Research Institute Editorial Office for their assistance in final publication. Personnel who assisted include Jerry Kern, James Tarbox, Debbie Dillon, and Bonnie Harmon. The assistance of the ISU Printing Service in final printing and binding is also recognized.