

Suggested Structure Site No. 11

ECONOMIC FEASIBILITY OF SMALL UPSTREAM IMPOUNDMENTS IN THE BIG CREEK WATERSHED

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SUMMARY

The Big Creek watershed comprises 420 square miles in four west central Missouri counties and is part of the larger South Grand River Basin. The area is faced with several watershed problems; however, severe flooding, the more important problem by far, occurs along most of the streams, causing substantial crop and property damage annually.

This study was designed as a step toward alleviating some of the problems faced by the residents of the watershed area. The research pursued was primarily exploratory and concerned with determining the economic feasibility and location of upstream impoundments in the Big Creek watershed area.

A number of tentative floodwater retarding structure sites were selected over the area. Preliminary analysis reduced the number to 12. After further analysis four of these were omitted as not being feasible at the time. The remaining eight sites set the basis for the analysis of the feasibility study. Seven of the suggested sites are located on tributaries of Big Creek and one is located on the main channel of Big Creek just south of Strasburg. Six of the sites are in Cass County and two are in Johnson County.

The Big Creek watershed area was divided into eight sub-watersheds and the floodplain into eight secondary reaches. These reaches were then combined into the four primary reaches discussed in this report.

Seven of the suggested structures gave a favorable benefit-cost ratio. One did not, but,

this structure is believed necessary to give desired protection to the respective reach.

These structures appear to be economically feasible. The engineering feasibility of the precise sites remains to be evaluated. If the sites are feasible on this basis about 22,000 acres of land in the combined reaches would receive floodwater protection from construction of the eight suggested retarding structures. The Big Creek watershed should be viewed as a unit in the analysis, rather than from the viewpoint of the individual structures' potential floodwater reduction to their floodplains. The benefits derived from a reduction of flood damages varied by individual structure, and by individual reach, with the benefits accruing to the total floodplain acreage protected amounting to \$180,249, based on a 70 percent reduction in flood damages with all eight structures in operation. Total annual costs for the structures including the cost of land in the inundated areas, and the cost of constructing the floodwater retarding structures, were estimated at \$108,065.

The ratio of benefits to costs for the entire project was a favorable 1.67 to 1. Other benefits, such as urban water supplies from the permanent pools of some impoundments, increased and improved recreational facilities for the area residents and tourists, and a general improvement of economic conditions of the area were not included in the benefits used in calculating the benefit cost ratio.

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The Big Creek Watershed

INTRODUCTION

Watersheds vary in physical and economic characteristics as well as in the amounts of needed and available data. It seldom is practical to set up or follow a single procedure for economic evaluation of them. Estimates of the type and number of justified improvements in meeting the needs of a watershed should be in line with specific objectives in which the total welfare of the people is taken into consideration.

Development of a watershed usually involves production, marketing, conservation, and sociological problems in the area. It is not the purpose of this study to provide a detailed analysis in any of these various fields of inquiry, but rather to explore the economic feasibility of establishing upstream impoundment structures adapted to multipurpose use.

The study is not to be taken as a watershed project formulation or plan. While engineers, hydrologists, conservationists, and other specialists were consulted on their specific subjects, the study lacks the detailed analysis which they could have contributed on a long-term basis. This report is primarily concerned with determining the feasible location of upstream impoundments within the Big Creek watershed area in Johnson and Cass Counties.

Funds for the research were provided by appropriation of the General Assembly to the Missouri Soil and Water Districts Commission. Research was activated in 1962 to determine the feasibility of water impoundment upstream from the proposed Kaysinger Bluff Reservoir floodplain.

Selection of a number of probable sites in the area was made from secondary data. Visits were then made to each site. The final selection of study sites was based on the availability and nature of primary and secondary data. Three watershed areas were selected and from these the Big Creek watershed was chosen for upstream impoundment investigation. This choice was partly based on the area's proximity to the South Grand River and the proposed Kay-

singer Bluff Reservoir.

The primary objectives of the study are directed toward determining the physical and economic feasibility of constructing small impoundment structures along Big Creek and its major tributaries for the purposes of flood control, urban water supplies, wildlife preservation, and recreation. The Big Creek watershed does not lend itself economically to a major multipurpose structure. There are eleven towns and villages in the watershed and four railroads traverse the area with about 100 miles of track. The tracks for the most part are laid parallel with the major streams and would be inundated by any major reservoir. Costs of moving and re-routing the railroads become prohibitive in most cases.

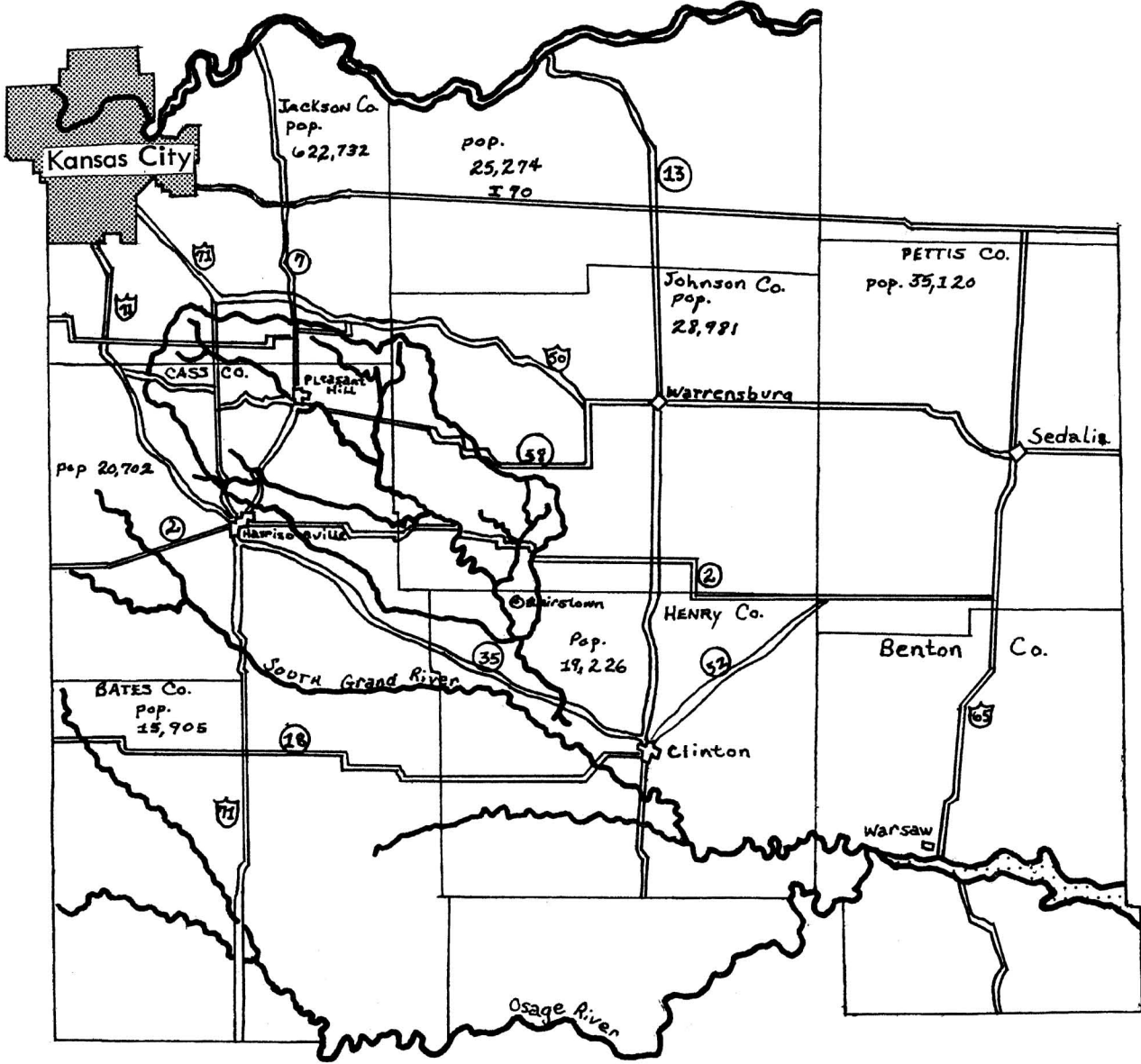
Watershed Characteristics

Location. The confluence of Big Creek and the South Grand River is about eight miles west of Clinton at an elevation of 710 feet m. s. l.* The Big Creek watershed makes up part of the larger South Grand River Basin. (Figure 1) Reaching into parts of four west Missouri counties, Henry, Johnson, Cass, and Jackson; the Big Creek watershed covers approximately 269,000 acres, or 420 square miles. Nearly 95 percent of the total area lies within western Johnson and eastern Cass counties. The watershed extends in a northwesterly direction from the point of confluence of Big Creek and the South Grand River; the farthest downstream extremity is about 60 miles south and east of Kansas City, while its northwest limits are within about 15 miles of the metropolitan area.

Population. Within the watershed area are 11 towns: Raymore, Strasburg, Pleasant Hill, Greenwood, East Lynne, Gunn City, Latour,

* Mean sea level

Figure 1. Big Creek Watershed Region, Watershed Location and County Population - 1960



Kingsville, Quick City, Blairstown, and Garden City. The largest of these towns is Pleasant Hill, with a population of 2,200. The population of the total watershed area is divided about equally between urban community and farm rural residents. (Table I)

TABLE 1 - BIG CREEK WATERSHED AREA POPULATION¹

Towns	Urban
Blairstown	199
East Lynne	204
Gunn City	63
Greenwood	400
Garden City	590
Kingsville	207
Latour	88
Pleasant Hill	2,200
Raymore	208
Strasburg	180
Quick City	31
Urban	4,370
Estimated Rural	4,100
Total	8,470

¹ U. S. Bureau of the Census, U.S. Census of Population, 1960, Missouri. Washington (Government Prtg. Office), 1961

Topography. The topography of the watershed is primarily rolling hills, intermittently separated by numerous tributaries of Big Creek. The watershed varies from a relatively level terrain to rolling hills. There are considerable acreages of creek bottom lands along the major streams; substantial parts of the bottoms are susceptible to frequent flooding which damages crops, livestock, and farm improvements.

Land Use. Land use in the area is varied: About 52 percent is devoted to cropland, 20 percent to pasture and meadow, 9 percent to woodland, swamp, and wildlife, and 19 percent to other uses. The bottom land, for the most part, is being farmed with over one-half in row crops and small grain, 27 percent in meadows and pasture, slightly over 8 percent in timber, and 13 percent in "other" or unclassified uses.

Total cropland acreage in the watershed is estimated to be 154,147 acres, including about 20,687 acres not in harvested crops. A total of 54,570 acres of land are not in use because of

poor drainage, severe erosion, rock out-croppings, or inaccessability. (Appendix Table I)

Crop yields in the area are slightly below the state average. Adequate drainage, land treatment practices, and water retarding structures would reduce flood damage substantially, increase yields, and permit a higher net return per acre of harvested crops.

Climate. The climate is mild and suited to general agriculture. The rainfall is sufficient for corn and small grain production. The mean annual rainfall of 36.5 inches compares to 39 inches for the state average. The average rainfall during the growing season is about double that of the other months of the year. There are frequent periods of wet weather in the spring which often delay planting or cultivation of crops, particularly on those soils which are heavy and poorly drained. The average date of the last killing frost is April 18 and the first frost in the fall is usually around October 17, allowing an average growing season of 182 days. The mean summer temperature, June, July, and August, is 76.3°. Although there are extremely cold winter periods they are generally of short duration and create very little severe farm damage.

Soil--Cass County. The upland soils of Cass County are of residual origin, a direct product of the weathering of the local rock.² The rock consists of strata of intermingled limestone, shale, and sandstone.

The largest part of the upland soils is classified as Summit silt loam; productivity ranges from moderately high to low. The creek bottoms are made up of the more productive soils classed as Osage silt and clay loams and Crawford silt loam, which require from moderate to heavy fertilization for best crop yields.

The surface configuration of Cass County is predominantly gently rolling, with occasional hills of moderate height and narrow to broad, level bottom land along the larger streams.

Soil--Johnson County. Johnson County is predominantly upland; about 90 percent of the

² U. S. Department of Agriculture, Bureau of Soils, Soil Survey of Cass County, Missouri. Washington (Government Prtg. Office).

total land area is in this category. The topography is rolling; however, there are a number of comparatively level areas. The soils are of residual origin derived from the underlying rock consisting of strata of limestone, shale, and sandstone.

Summit silt loam soils make up by far the largest part of the uplands. These soils are of low to moderate productivity and require relatively heavy applications of fertilizer. The bottom land soils are the most productive. They are primarily of the Osage silt and clay loams. The Osage silty clay loam soils are more concentrated in the lower reaches of the Big Creek bottom lands; these soils are not generally well drained and are subject to substantial overflows. The heavy texture of Osage silty clay loam is not easily worked. These soils of the Big Creek bottoms are only moderately productive.³

Watershed Problems

The watershed is confronted with several major problems. Seasonal flooding of agricultural land and communities and road inundation most frequently occur in the spring but fall flooding is not uncommon. A major problem faced by some communities in the area is that of obtaining adequate water supply for human and industrial consumption. This problem particularly applies to Pleasant Hill, perhaps more so than to any other community in the watershed.

Crop damage resulting from floods is probably the most important single problem related to agriculture in the watershed. Big Creek's floodplain and those of its tributaries vary in width from an estimated 1,000 feet to about 7,000 feet. Although the entire floodplain is not usually completely inundated, the frequency of damaging floods is such that a serious problem does exist within the watershed.

Severe flooding ordinarily occurs at least once every year with damaging effects. Most frequently, floods occur during March, April, May, or June, causing damage to newly planted crops or delaying their planting, destroying fences, and inundating rural roads. Floods also occur during October or November, resulting

³ U.S. Department of Agriculture, Bureau of Soils, Soil Survey of Johnson County, Missouri. Washington (Government Prtg. Office).

in partial and sometimes complete loss of standing crops. Floods occurring this time of the year always cause some degree of reduction in the quality of harvested crops. Flood damages to fences, machinery, and buildings are less significant monetarily than damages to crops and meadows.

Temporary inundation of roads, both dirt and hard surface, is common but actual physical damage is usually limited to rutting of the dirt roads. The inconveniences of being temporarily stranded, long detours to towns or schools, plus the spread of flood-borne debris, unwanted crop pests, and weeds, are examples of indirect damages caused by flooding.

Sedimentation and sheet and gully erosion damages caused by flood conditions also present problems in the area. Reduction of damages of this type requires land treatment measures which were not considered directly in this study.

Determining Location of Probable Structure Sites

Methods: Methods employed in analyzing the watershed were based on "Economic Guide for Watershed Protection and Flood Prevention."⁴ The amount of damage with and without water retarding structures was estimated in determining the economic feasibility of constructing small impoundment dams in the watershed area. Interviews were conducted with rural residents in the floodplains along the streams to determine the extent of flooding, land use, crops and crop yields, sedimentation, and damages to fences, buildings, and other farmstead improvements.

Evaluation of floodwater damages to crops and pastures was arrived at primarily by using the Milwaukee E & WP Unit Memorandum-Economics No. 3, "Evaluating Floodwater Damages to Crops and Pasture." Damage values for each crop were determined for 0-2 feet and over 2-foot depth categories. These derived damage values were weighted and converted into a composite cropland damage value, permitting the

⁴ U.S. Dept. of Agriculture, Soil Conservation Service, Economics Guide For Watershed Protection and Flood Prevention. Washington, D. C. (U.S. Dept. of Agri., Soil Conservation Service), 1958.

determination of an average annual damage for each "reach" in the study.

After a tentative analysis of the flood problems in terms of annual cost in crops lost and other damages, a step by step consideration of flood control structures along Big Creek and its tributaries was begun starting at Blairstown, about four miles north of the flood pool level of the proposed Kaysinger Bluff Reservoir. Figures 2 and 3 give the location and general cartographic features of the Big Creek watershed.

Twelve tentative and possible impoundment sites were identified by the use of secondary data, topography maps, aerial photographs, and on-site inspection surveys. The selection of these sites depended primarily upon expected runoff and terrain features that indicated a likelihood of supporting a structure and impoundment area significantly large enough for further consideration and economic analysis.

After careful consideration and on-spot inspection, two of these potential sites, numbers "4" and "8", were dropped from further study. After a preliminary analysis, numbers "9" and "10" were excluded for reasons discussed below.

Thus, the Big Creek watershed was eventually divided into eight sub-watersheds, and subsequently into four primary reaches. The analysis was continued and carried out on these eight sub-watersheds and their suggested flood retarding structures.

Rejection of Sites "9" and "10"

Structure sites "9" and "10" are located on Big Creek approximately 11 miles above the watershed base point at Blairstown. Retarding structure "9" would control runoff from a sub-watershed of approximately 130,763 acres. To retain runoff from the watershed a flood pool capacity of 126,295 acre feet would be required, creating a temporary lake of about 14,000 surface acres. The sediment pool for the retarding structure was calculated on the basis of the amount of storage capacity necessary to accommodate silt accumulation for a 50 year period. A permanent pool capable of impounding 5,448 acre feet was estimated as necessary to meet the requirement. The topographical features at the site and sediment area indicated about 950 acres would be permanently inundated.

Selected site number "10" was located on Camp Branch, a major tributary of Big Creek

about three miles south of retarding structure number "9". About 1 1/2 miles from the confluence of Camp Branch and Big Creek, the geographical features indicated favorable conditions for a site location. The watershed area lying above the structure site constituted 40,394 acres. Runoff from the area would necessitate a flood pool with an estimated capacity of 39,014 acre feet, elevation 826 at full pool level. A permanent pool of 1,683 acre feet capacity, at elevation level 794, inundating approximately 275 surface acres would be formed.

After tentatively outlining the boundaries of the permanent pools on topographic maps and visually inspecting the proposed inundated areas, it became apparent that construction of neither impoundment "9" nor "10" could be justified economically under present conditions. Considerable portions of three major railroads would have been inundated. Structure "9" would have flooded portions of the Missouri, Kansas, and Texas Railway, and the Chicago, Rock Island, and Pacific Railway along Big Creek, Dam number "10" would have flooded a sizeable length of the St. Louis-San Francisco Railway which runs parallel to Camp Branch for some distance. The excessive costs of relocating tracks or raising railroad beds would have increased the total costs of the two projects beyond the proportions of the benefits foreseen. Therefore, the analysis for the two sites was terminated.

Measures Not Included in Benefit-Cost Analysis

Four measures were not analyzed in determining the feasibility of upstream impoundment structures. These were land treatment, stream channel improvements, fish and wildlife conservation, and recreation. The limited resources available for research were devoted to an analysis of those more basic factors affecting the feasibility of upstream impoundments. These four aspects were considered and their need and values recognized but were omitted from the benefit-cost estimates concerning the retarding structures and the corresponding impoundment areas.

Land Treatment. Soil and water conservation practices on the individual farm are primary elements in watershed protection. Such measures generally increase farm income by

Figure 2. Map of Big Creek Watershed Illustrating Big Creek and its Major Tributaries

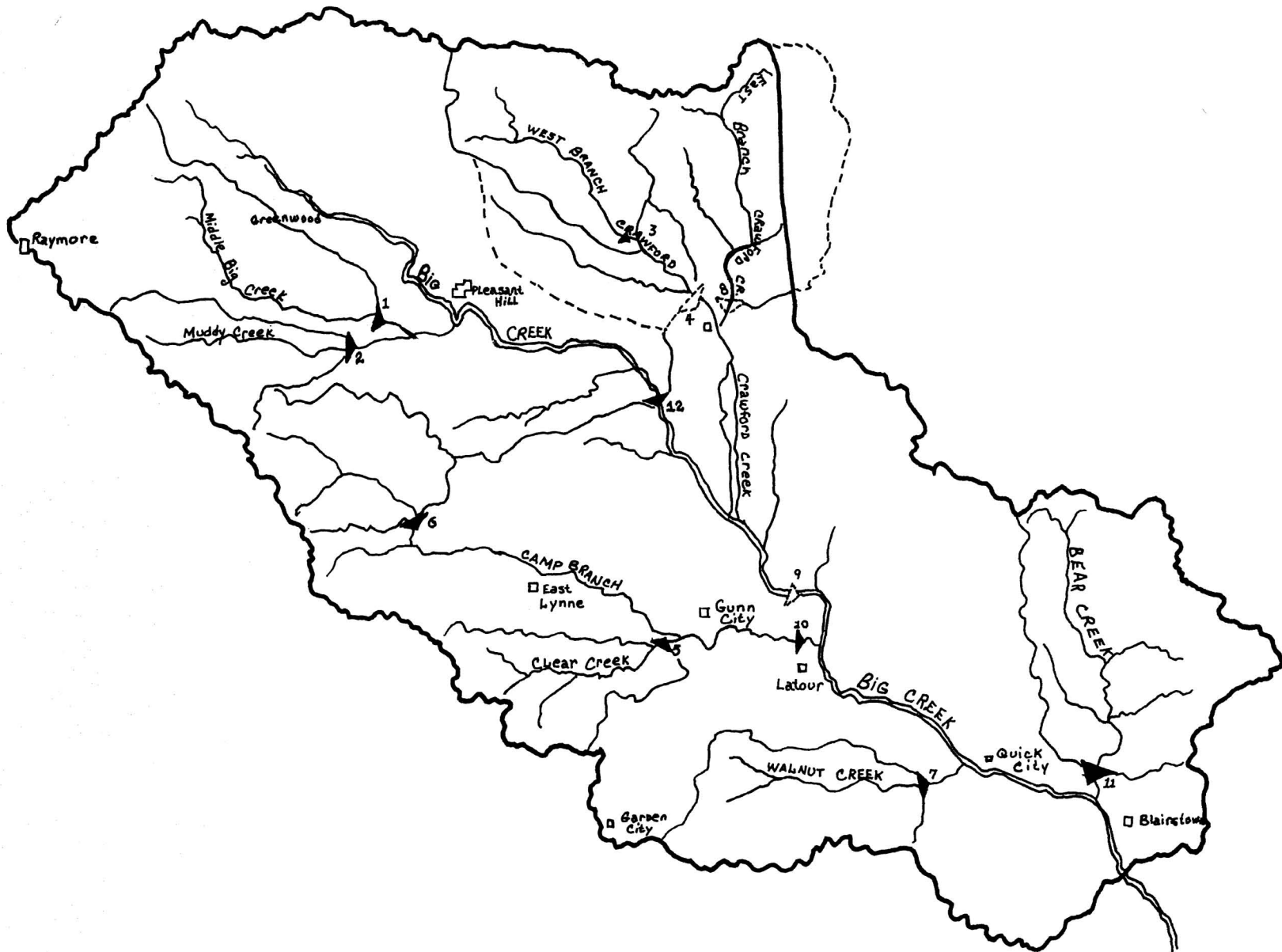
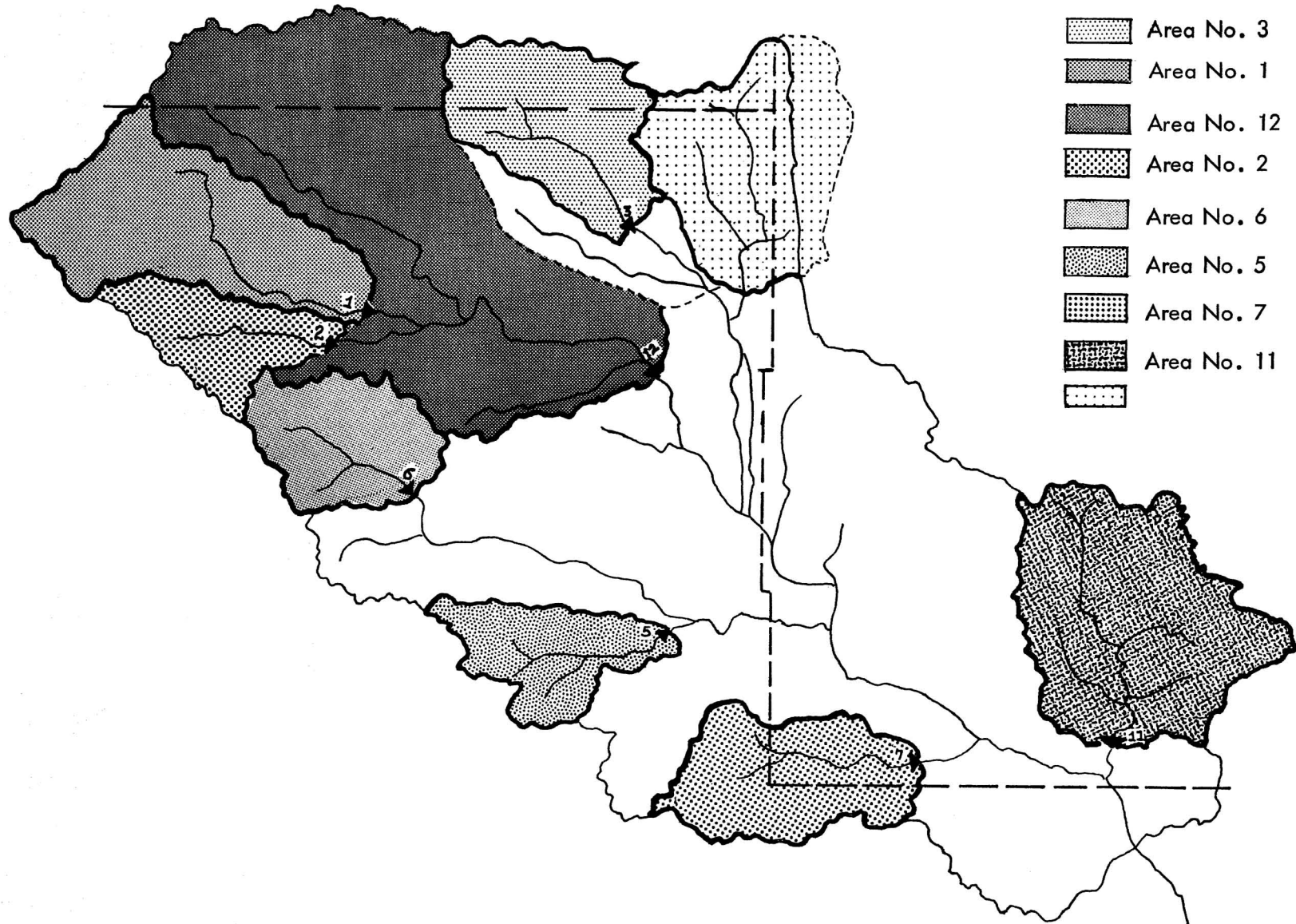


Figure 3. Big Creek Watershed, Sub-watershed Divisions, and suggested Floodwater Retarding Structure Locations



increasing crop yields and efficiency of machinery and labor, thus generally leading to cheaper production and increased trade volume in an area. Land treatment measures also affect peak runoff and thereby have beneficial effects on a given floodplain by reducing flooding.

Benefits from land treatment were recognized but not included in the study. It is estimated, however, that a general land treatment program throughout the watershed area would reduce floodwater damage by 8 to 12 percent. This estimate is based on the "South Fork of the Blackwater River Watershed" which lies adjacent to Big Creek Watershed.⁵

Channel Improvements. Some channel improvement is believed desirable and necessary if floodwater damages are to be held at a minimum in the watershed. Evidence points to some badly eroded channel sections in the area. Also, several sections of channels are clogged with brush and trees, thus causing heavy silting, improper drainage, and reducing the full carrying capacity of the channels. No attempt was made to determine the cost of channel improvement or benefits which might be expected from a channel improvement program; however, observations were made during the course of the study to determine the extent of needed channel improvements. With the activation of a watershed protection and flood prevention program in the area, it is recommended that channel improvement be considered.

Game and Fish Conservation. Benefits to be derived from possible fish and wildlife sources were not considered in the economic analysis of the suggested impoundment structures. There are several locations within the region which appear to have excellent conditions for such purposes and would likely add substantial value in a watershed conservation program.

Recreation. It is widely acknowledged that recreation is a valuable asset to a community or region. The associated facilities that accompany establishment of recreational areas have a substantial economic impact on the communities and their surrounding territories. The water orientation of a large proportion of outdoor recreation suggests the feasibility of the eight suggested impoundments for recreational development.

The recreational potentials of the Big Creek watershed were recognized but, since recreation possibilities were not one of the primary objectives of the research, no analysis was made. Information presently available is insufficient to make definite projections as to the recreational potentials of the Big Creek watershed. Therefore, no monetary values from recreation were assigned to the benefit-cost ratios derived in the study.

Recreation is believed to be of sufficient importance in its influence on social and economic structures to warrant analysis of its potentiality as part of an overall watershed development program.

REACH IV

Structure "1"

Location. Individual analysis of the sub-watershed areas within the Big Creek watershed and of the flood water retarding structures begins with structures "1" and "2." The locations of these potential structures are near the headwaters of Big Creek in Cass County and are positioned to partially protect Reach IV from flooding.

Site number "1" is located in Sec. 25, Twp. 46 N, Range 31 W on Middle Big Creek, approximately one mile south and west of Pleasant Hill, and about 1.5 miles above the confluence of Middle Big Creek and Big Creek.

Sub-watershed. The gently rolling to steeply sloping drainage area of Middle Big Creek comprises approximately 18,980 acres. Its maximum length is nine miles extending in a westerly direction from structure site with an average width of about 4.5 miles. Its elevation ranges from 850 feet at structure site to 1,080 feet m. s. l. at its western extremity. (Figure 4)

⁵ Work Plan for Watershed Protection and Flood Prevention; South Fork of Blackwater River Watershed, Johnson County, Missouri. 1961 (Unpublished)

Figure 4. Big Creek Sub-Watersheds 1 and 2

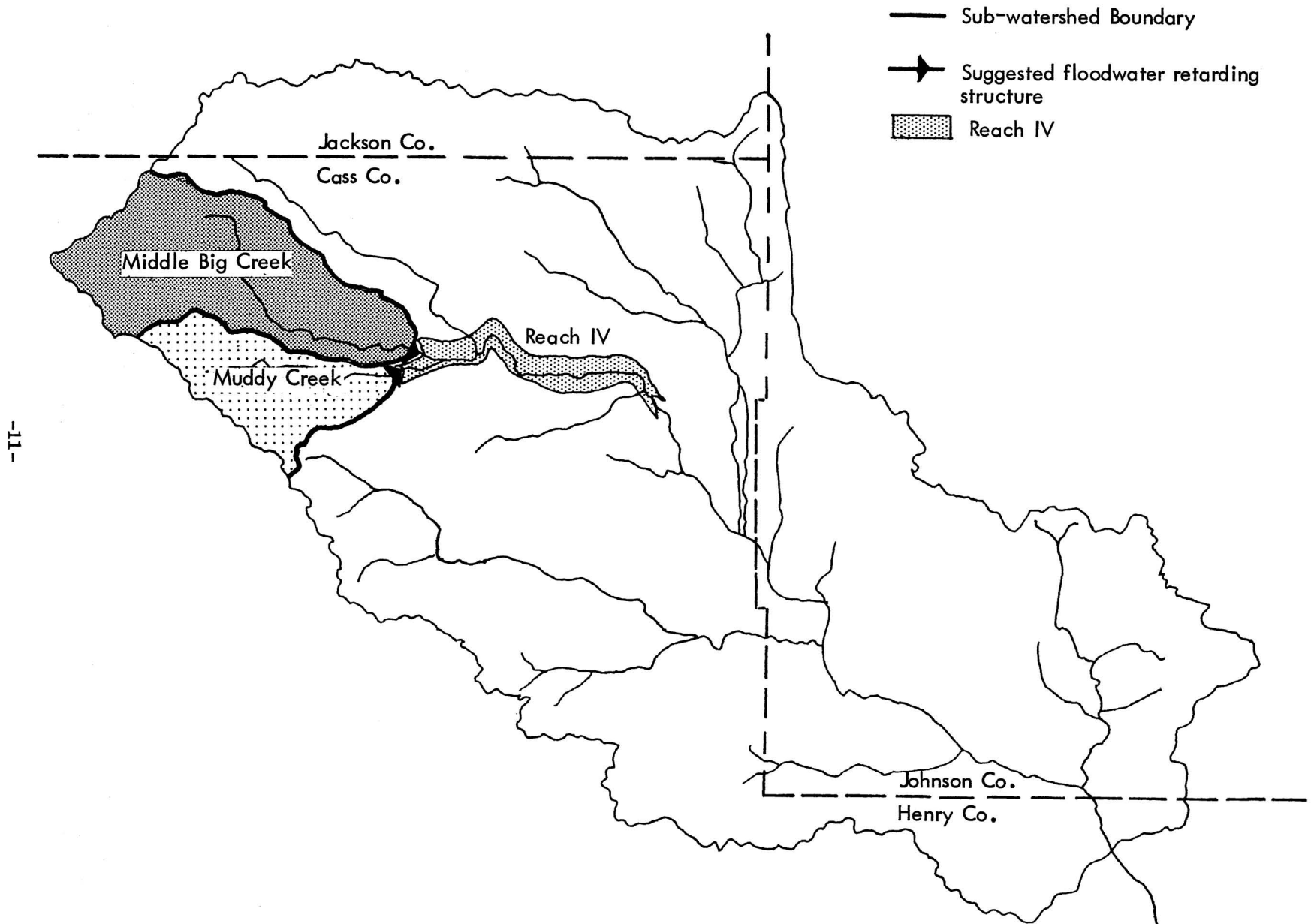


TABLE 2 - ESTIMATED ANNUAL BENEFITS RESULTING FROM A 70, 60, AND 50 PERCENT REDUCTION OF FLOOD DAMAGES, REACH IV.⁸

Estimated Percent Of Damage Reduction	Annual Benefits To Crops and Pasture with Project (Dollars)	Annual Benefits From More Intensive Use Of Cropland (Dollars)	Annual Benefits From Changed Use of Pasture And Timber (Dollars)	Total Annual Benefits (Dollars)
70%	17,721.00	4,485.00	5,984.00	28,190.00
60%	14,814.00	3,839.00	5,151.00	23,809.00
50%	12,653.00	3,202.00	4,289.00	20,144.00

⁸ Based on projected long term prices as per U. S. Department of Agriculture, Agricultural Research Service, Agricultural Price and Cost Projections for Use in Making Benefit and Cost Analyses of Land and Water Resource Projects. Washington, (U. S. Department of Agriculture) 1957. (Plus supplements and corrections as issued by the Department).

Reach. The floodplain which retarding structure number "1" would partially protect extends downstream for about 7.8 miles. Within the floodplain there are an estimated 3,402 acres, of which 2,426 are generally cropped. There are 16 farm dwellings and 7.5 miles of road in the proposed protected reach.

Structure "1".

Class "b"⁶
 Length 1,523 feet
 Height 42 feet
 Total cost \$365,636
 Annual amortized cost \$13,875
 Annual maintenance cost \$710
 Total average annual cost . . \$14,586

Permanent Pool.

Height (m. s. l.) 858 feet
 Capacity 791 acre feet
 Surface area 180 acres
 Shoreline length 6.3 miles

Flood Pool.

Height (m. s. l.) 889 feet
 Capacity 18,330 acre feet
 Maximum surface area . . 1,235 acres

Damages. Annual flood damages occur varying in severity with location along the floodplain. The estimated average acreage devoted

⁶ Class "b" structures are designed for a 50 year frequency storm having a six hour intensity of 14 inches of rainfall. The structure freeboard for class "b" structures are designed so that a 11.5 inch runoff would not overtop the fill. (See Appendix A)

to crop production in the reach is 2,426 acres, leaving about one-third of total acreage in other uses. The principal crops grown are corn, soybeans, wheat, oats, and hay. Crop yields in the reach range slightly higher than state averages. Annual average flood damages to crops and pasture were estimated at \$19,609.00. A moderate estimate of other agricultural damages, erosion, and indirect damages would add an additional \$5,692.00, giving a total flood damage of \$25,302.00 annually for Reach IV.

Benefits. Estimated average annual benefits derived for structure "1" were \$19,733.00. Benefits from crops and pastures contributed nearly 49 percent of the total benefits derived; change in land use, 37 percent; indirect benefits, 6 percent; erosion, 7 percent; and the remainder is attributed to residual benefits. The analysis indicated a benefit-cost ratio of 1.35:⁷

Structure "2"

Location. Structure number "2" is located approximately two miles southwest of Pleasant Hill, on Muddy Creek, two miles above its confluence with Middle Big Creek; Sec. 25 and 26, Twp. 46 N, R 31 W.

Sub-watershed. The watershed is made up of gently rolling terrain of a prairie nature characteristic of the county. The drainage area of Muddy Creek, lying above the suggested struc-

⁷ Maximum benefits derived for any reach did not exceed 70 percent reduction in floodwater damages. However, 60 and 50 percent reductions were also used to compute benefit-cost ratios. (See Appendix B)

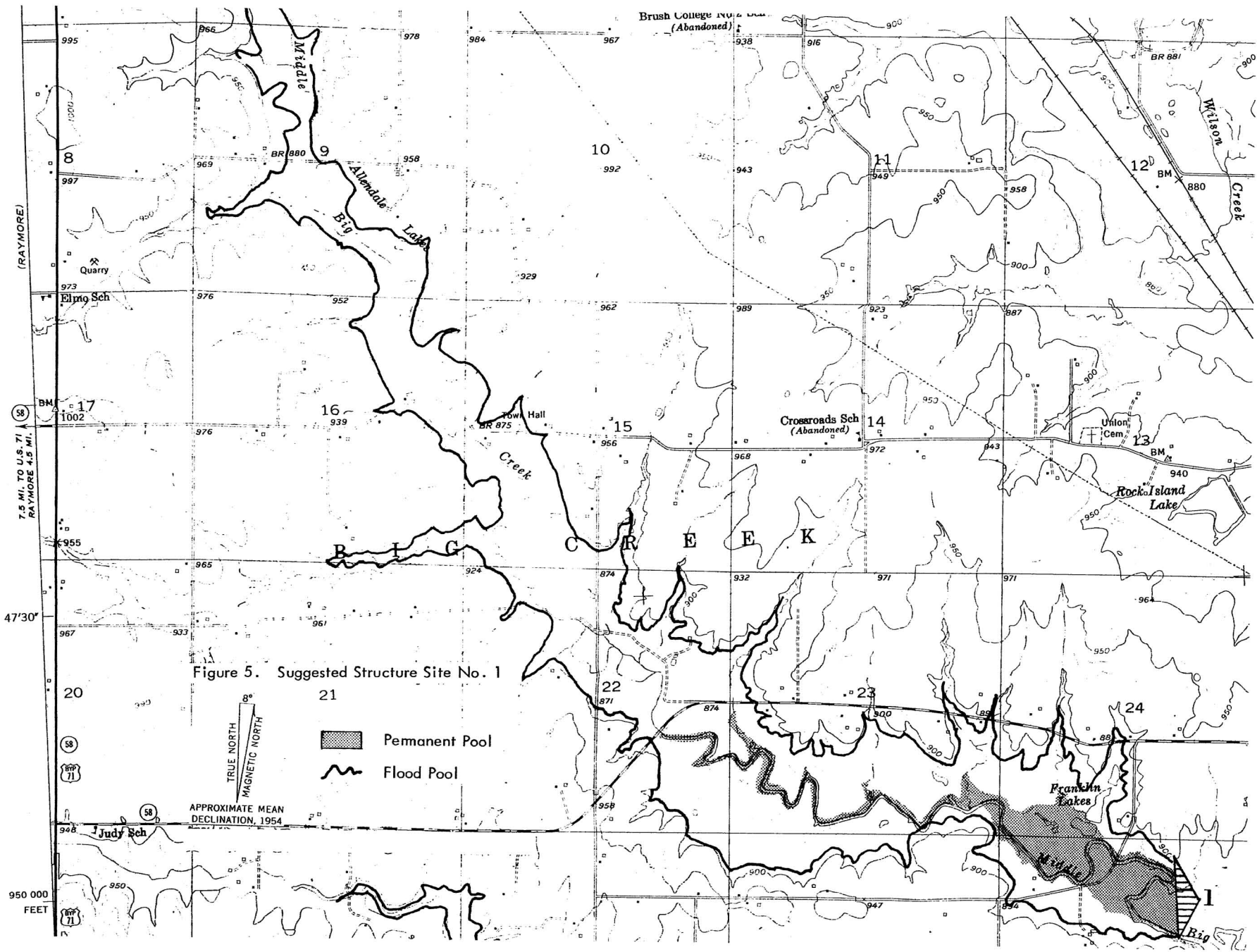
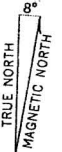


Figure 5. Suggested Structure Site No. 1

- Permanent Pool
- Flood Pool



APPROXIMATE MEAN DECLINATION, 1954

(RAYMORE)

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ture site, is composed of approximately 9,206 acres, extending 6.2 miles upstream from site location. (See Figure 4).

Reach. The floodplain which retarding structure number "2" protects is comprised of about 1.7 miles of valley floor along Muddy Creek, and extends down Big Creek nearly 7.6 miles. There are no additional farm dwellings or roads other than those given in the discussion of structure number "1".

Structure "2".

Class "b"
 Length 1,777 feet
 Height 43 feet
 Total cost \$164,209
 Annual amortized cost . . . \$6,232
 Annual maintenance cost . . . \$311
 Total average annual cost . . . \$6,542

Permanent Pool.

Height (m. s. l.) 859 feet
 Capacity 371 acre feet
 Surface area 65 acres
 Shoreline length 3 miles

Flood Pool.

Height (m. s. l.) 890 feet
 Capacity 8,890 acre feet
 Maximum surface area . . . 630 acres

Damages. The structure protects the same floodplain as structure "1" with the exception of 1.7 miles immediately below the site on Muddy Creek; therefore, the estimated flood damages are given under this section in the discussion of structure "1."

Benefits. Annual benefits estimated for structure "2" were \$8,457.00. Over 85 percent of the benefits derived as a result of the structure were attributed to crop and pasture protection. The remaining 15 percent of the benefits were accredited to changes in land use and miscellaneous indirect benefits. A derived estimate of benefit-cost ratio was 1.29:1.

The combined benefit-cost ratio for structures "1" and "2" at an estimated 70 percent reduction of flood damage in the reach was 1.33:1, and at 60 percent reduction 1.13:1. (See Appendix Tables VIII, IX, and X).

REACH III

Structure "12"

Location. Suggested structure site "12" is located about 9.8 miles downstream from site "1." This site is the only structure located on Big Creek and is about 2.3 miles south of Strasburg.

Sub-watershed. The drainage area lying above site "12" is the largest sub-watershed delineated in the Big Creek area. It comprises

approximately 47,180 acres which extend north-westwardly from the structure site for about 15.3 miles. The maximum elevation in its upper reaches approximates 1,040 feet m. s. l. There is a drop of 235 feet in elevation from the furthest point to dam site. (Figure 7).

Reach. The reach extends along both Big Creek and Crawford Creek, the floodplain being roughly in a "Y" shape. The reach is approx-

TABLE 3 - ESTIMATED ANNUAL BENEFITS RESULTING FROM A 70, 60, AND 50 PERCENT REDUCTION OF FLOOD DAMAGES, REACH III.⁹

Estimated Percent Of Damage Reduction	Annual Benefits To Crops and Pasture with Project (Dollars)	Annual Benefits From More Intensive Use Of Cropland (Dollars)	Annual Benefits From Changed Use of Pasture And Timber (Dollars)	Total Annual Benefits (Dollars)
70%	26,014.00	6,583.00	8,805.00	41,402.00
60%	22,297.00	5,648.00	7,565.00	35,510.00
50%	18,579.00	4,694.00	6,286.00	29,559.00

⁹ Ibid.

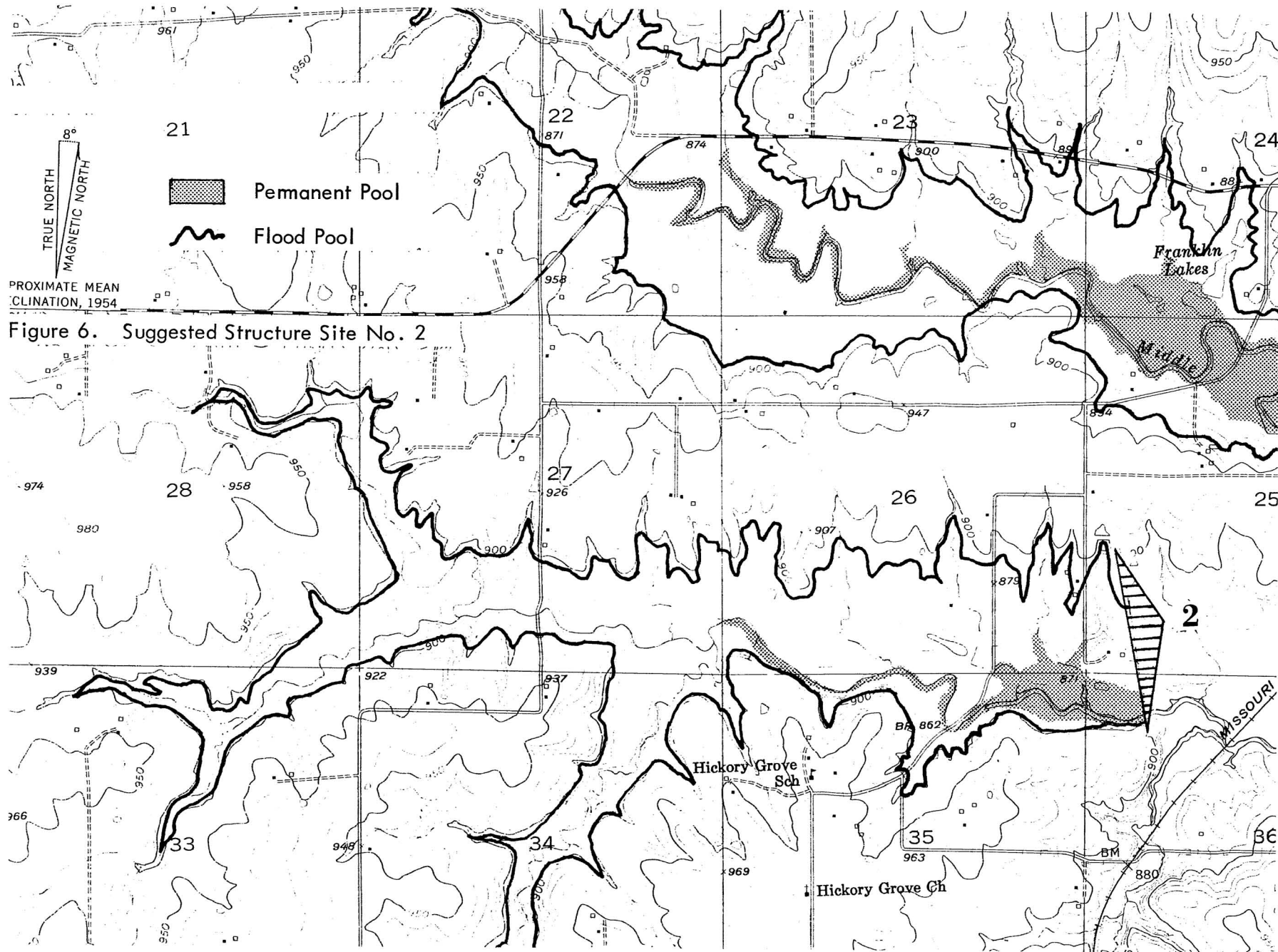
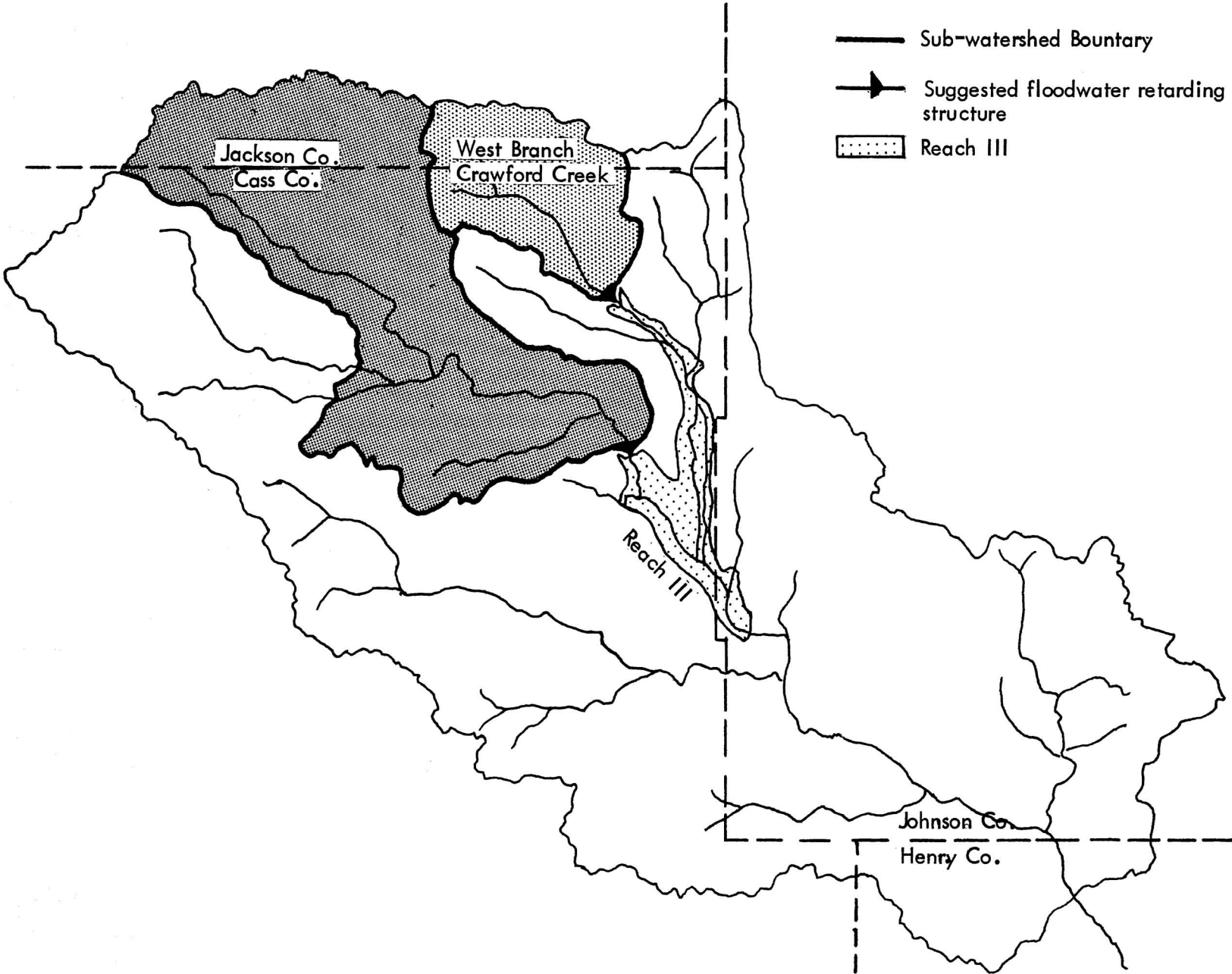


Figure 7. Big Creek Sub-Watersheds 3 and 12



imately 11 miles in length and comprises about 4,995 acres. Nearly 70 percent, or 3,560 acres, of the total area is classed as cropland. The major crop produced is corn, with soybeans and wheat being of lesser significance. The land in the reach is regarded as moderately to highly productive. A considerable part of it is in marginal crop use and a sizeable acreage cannot be used at present to full potential for either crops or pasture because of poor drainage. Crop yields within the reach are generally above average in those years when flood damages are moderate. At least one damaging flood occurs each year.

Since a relatively large part of the floodplain rises in elevation only ten feet along both Big Creek and Crawford Creek, selected structures sites "12" and "3" were not analyzed individually. In the study relative to flood damage reduction and benefits they were analyzed in conjunction with one another.

Structure "12".

Class "a"
 Length 4,555 feet
 Height 20 feet
 Total cost \$233,992
 Annual amortized cost \$13,318
 Annual maintenance cost \$319
 Total average annual cost . . \$13,637

Permanent Pool.

Height (m. s. l.) 817 feet
 Capacity 1,966 acre feet
 Surface area 435 acres
 Shoreline length 4.6 miles

Flood Pool.

Height (m. s. l.) 826 feet
 Capacity 11,757 acre feet
 Maximum surface area . . 1,415 acres

Damages. See "Structure '3'."

Benefits. See "Structure '3'."

Structure "3"

Location. Site "3" is located on the West Branch of Crawford Creek, about three miles above Strasburg. The suggested retarding structure site is in Cass County and in the north one-half of the Big Creek watershed.

Sub-watershed. Structure "3" is in a position to retain runoff from an estimated 13,938-acre drainage area. The general characteristics of the terrain over the watershed area are of gently rolling features; however, the area is interspersed with low and boggy areas. Rise in elevation from structure site to upper extremity of watershed is about 196 feet.

Reach. The anticipated limits of the reach extend south and east of the structure about 3.2 miles before spreading out and combining with the Big Creek floodplain. (See Figure 7). The Floodplain immediately below structure "3" is relatively narrow at points and begins to spread just below the confluence of West Branch of Crawford Creek and Crawford Creek. A more detailed discussion of the reach is given under "Structure '12'."

Structure "3".

Class "b"
 Length 4,213 feet
 Height 40 feet
 Total cost \$548,969
 Annual amortized cost . . . \$20,833
 Annual maintenance cost . . . \$1,208
 Total average annual cost . . \$22,041

Permanent Pool.

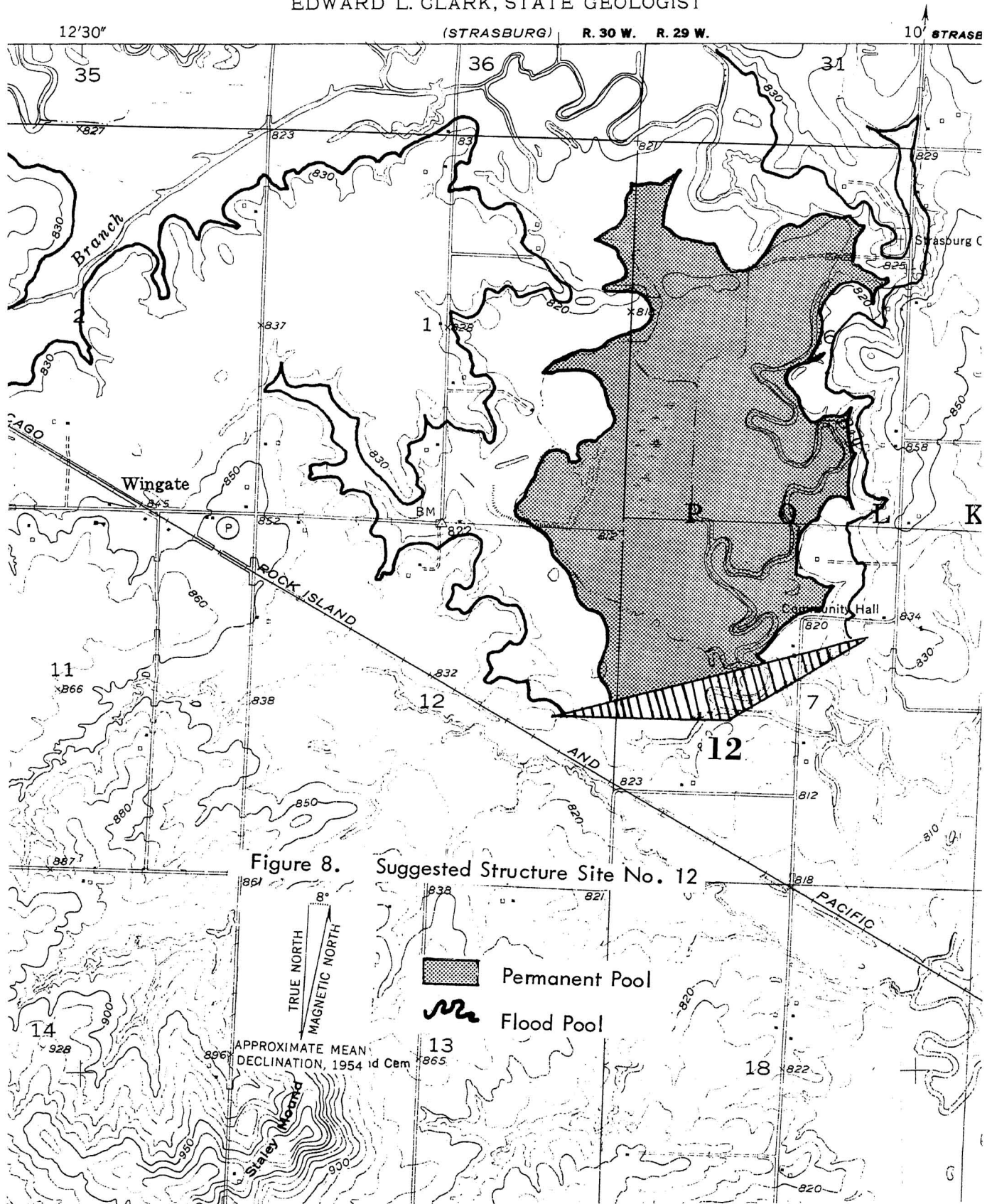
Height (m. s. l.) 867 feet
 Capacity 581 acre feet
 Surface area 135 acres
 Shoreline length 3.5 miles

Flood Pool.

Height (m. s. l.) 894 feet
 Capacity 13,462 acre feet
 Maximum surface area . . 1,009 acres

Damages. A derived monetary value for crops damaged by flooding was estimated on an annual basis. A flood damage value by composite acre at a depth of 0 to 2 feet and 2 feet and over of flooding was determined for the protected reach. The total damages to crops and pastures in the combined reach were estimated at \$28,784.00 annually. Other damages occurring were estimated at \$8,356.00 giving a total annual damage in the floodplain area of \$37,140.00.

STATE OF MISSOURI
 GEOLOGICAL SURVEY AND WATER RESOURCES
 EDWARD L. CLARK, STATE GEOLOGIST



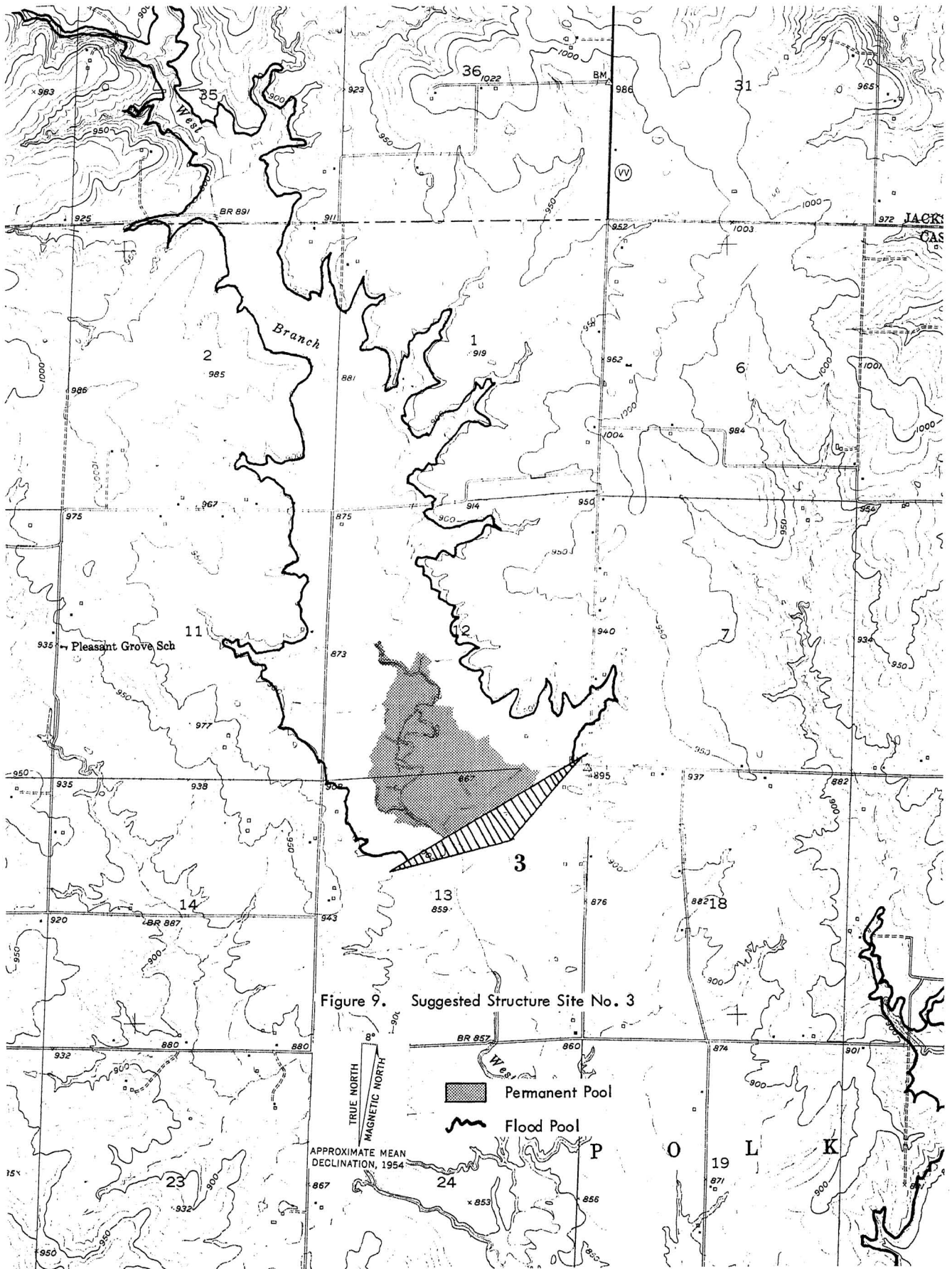




Figure 9. Suggested Structure Site No. 3

 Permanent Pool
 Flood Pool

TRUE NORTH
 MAGNETIC NORTH
 8°
 APPROXIMATE MEAN
 DECLINATION, 1954

Benefits. Benefits derived as a direct result of suggested flood retarding structures "12" and "3" were estimated at \$41,402, based on an estimated 70 percent flood reduction figure (Table 3). The benefits were primarily

attributed to flood protection of agricultural land, crops and farm property. A benefit-cost ratio for the two structures combined was approximated at 1.16:1.

REACH II

Structure "5"

Location. Structure "5" is situated on Clear Creek about 0.5 mile from its confluence with Camp Branch in Cass County, 2 miles southwest of Gunn City.

Sub-watershed. The terrain of the area has the general characteristics of eastern Cass County, with gently rolling features, intermittently cut with small branches and localized boggy spots. The sub-watershed consists of approximately 9,122 acres, with its furthestmost boundry extending 4.4 miles to the west of the selected dam site. The total rise in elevation of the sub-watershed is 118 feet, ranging from 802 feet elevation at site to 920 feet m. s. l. at its furthestmost point.

Reach. Camp Branch floodplain extends from the confluence of Camp Branch with Big Creek in Johnson County in a westwardly direction for 10.7 miles. (Figure 10) Over 90 percent of the reach area lies in Cass County. The floodplain along Camp Branch Creek ranges in width from 2,000 feet to nearly one mile. Within the floodplain reach there are 12 dwellings and 6.5 miles of road. There is an estimated 3,024 acres of land; 67 percent, or 2,156 acres, was devoted to crop production. The remaining acreage, excluding farm lots and road rights-of-way, consisted of timber and non-crop marginal land. A substantial part of the land in the reach is inadequately drained and in its present condition is generally unsuited for cultivation.

Structure "5".

Class	"b"
Length	2,026 feet
Height	40 feet
Total cost	\$297,450
Annual amortized cost . . .	\$11,288
Annual maintenance cost . . .	\$601
Total average annual cost . .	\$11,889

Permanent Pool.

Height (m. s. l.)	816
Capacity	380 acre feet
Surface area	100 acres
Shoreline length	4.8 miles

Flood Pool.

Height (m. s. l.)	844 feet
Capacity	8,810 acre feet
Maximum surface area . . .	890 acres

Damages. The intensity of annual flooding along Reach II varies with location. Productivity of the cropland ranges from fair to good with average yields of the major crops, corn, wheat, soybeans, oats, and hay, usually running slightly above the state averages when flood damages do not occur. The estimated average acreage in crop production in the reach is 2,156 acres, this being about 70 percent of the total land in the floodplain. The average annual flood damage occurring to crops and pasture was estimated at \$17,428.00. Other agricultural damages, erosion, and indirect damages were estimated at \$5,059.00, giving a sum of \$22,487.00 total annual flood damages in the reach.

Benefits. Estimated annual benefits from the structure are \$10,072.00. The benefits are primarily from flood protection of agricultural land and crops. A benefit-cost ratio for the structure was approximated at 0.85 to 1.

Structure "6"

Location. Structure "6" is located on Camp Branch about 10.7 miles upstream from the confluence of Camp Branch with Big Creek. Its position is near the headwaters of Camp Branch, approximately 6.5 miles directly south of Pleasant Hill in Cass County (See Appendix Table III for legal description.)

Sub-watershed. The drainage area which structure "6" is associated with comprises ap-

Figure 10. Big Creek Sub-Watersheds 5 and 6

- Sub-watershed boundary
- ▶ Suggested floodwater retarding structure
- ▨ Reach II

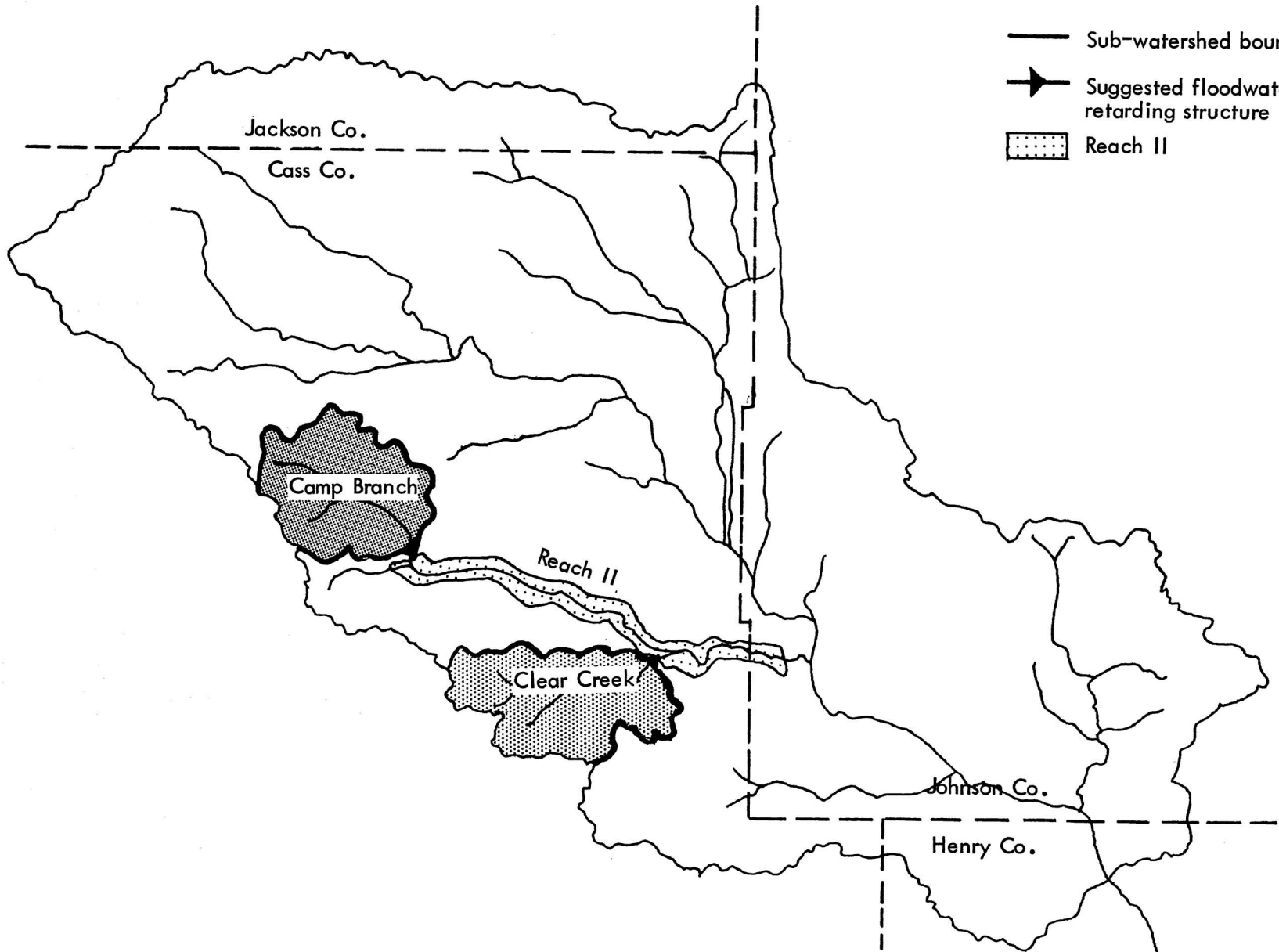


TABLE 4 - ESTIMATED ANNUAL BENEFITS FROM 70, 60, AND 50 PERCENT
REDUCTION OF FLOOD DAMAGES, REACH II¹⁰

Estimated Percent Of Damage Reduction	Annual Benefits To Crops and Pasture with Project (Dollars)	Annual Benefits From More Intensive Use Of Cropland (Dollars)	Annual Benefits From Changed Use of Pasture And Timber (Dollars)	Total Annual Benefits (Dollars)
70%	15,759.00	4,077.00	5,344.00	25,180.00
60%	13,501.00	3,421.00	4,590.00	21,512.00
50%	11,244.00	2,844.00	3,840.00	17,928.00

10

Ibid.

proximately 9,405 acres of land. The watershed is circular in shape, having a rise in elevation of about 154 feet from the site of the retarding structure to the furthest point of the watershed, a distance of nearly 5 miles (Figure 10 and Appendix Table IV).

Reach. The reach consists of more than 3,000 acres of land and is discussed under "Structure '5'." Retarding structure "6" is one of the two suggested for the protection of Reach II.

Structure "6"

Class "b"
 Length 3,385 feet
 Height 40 feet
 Total cost \$328,525
 Annual amortized cost \$12,468
 Annual maintenance cost . . . \$704
 Total average annual cost . . \$13,172

Permanent Pool.

Height (m. s. l.)862 feet

Capacity 392 acre feet
 Surface area 75 acres
 Shoreline length 4.4 miles

Flood Pool.

Height (m. s. l.)887 feet
 Capacity 9,084 acre feet
 Maximum surface area . . .740 acres

Damages. Extensive flooding occurs along Camp Branch creating damages in the thousands of dollars annually. The estimated 2,156 acres of crops planted in the reach incur damages estimated at approximately \$22,487.00. See Damages under Structure "5" for a more detailed discussion.

Benefits. Average annual benefits occurring from structure "6" are estimated at \$15,108.00. The benefit-cost ratio is approximated at 1.2 to 1. See Appendix Table VIII for combined benefit-cost ratio, Reach II.

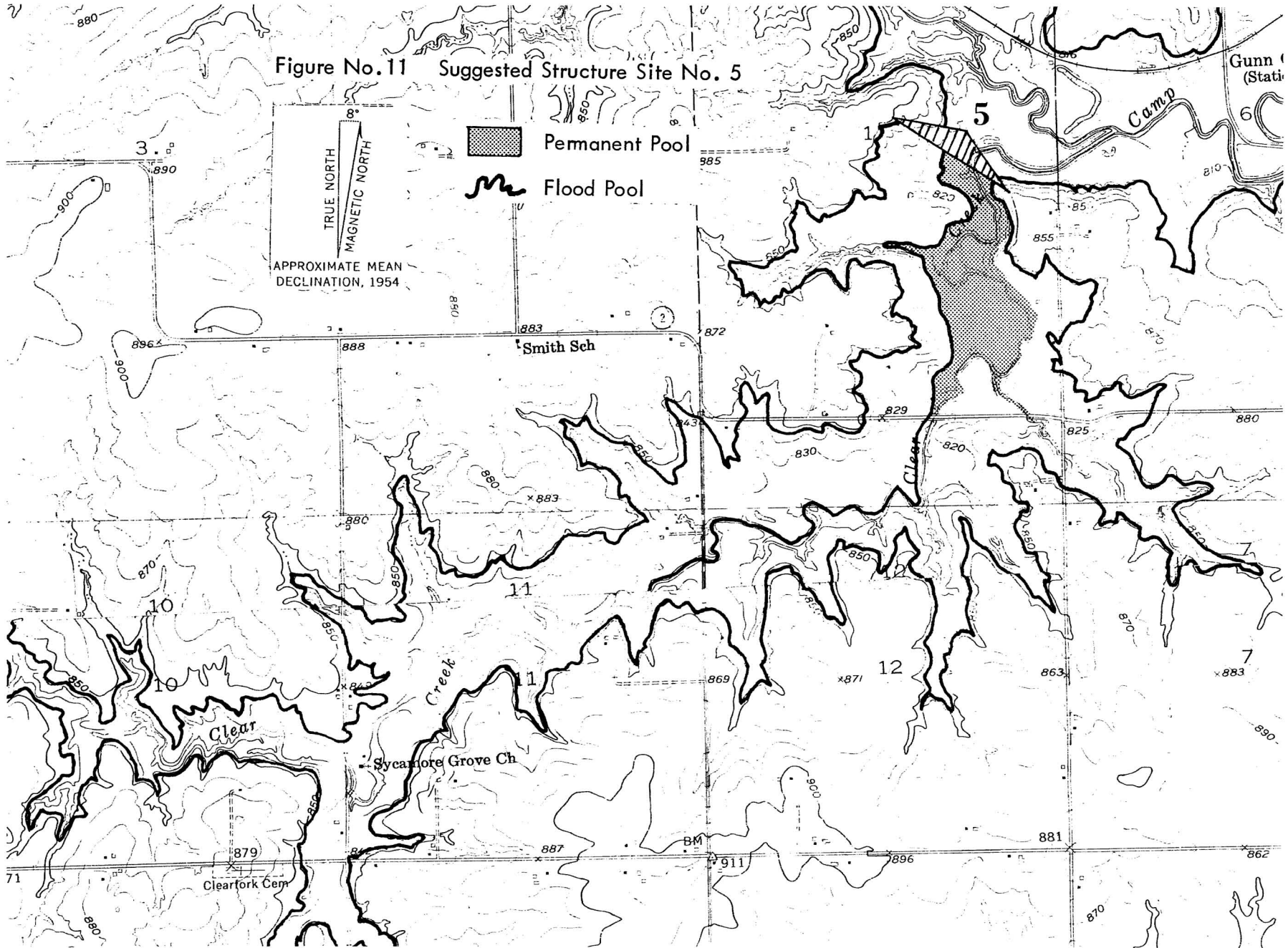


Figure No. 11 Suggested Structure Site No. 5

Permanent Pool
Flood Pool

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1954

Smith Sch

Sycamore Grove Ch

Clearfork Cem

Gunn (Station)

Camp

Clear Creek

Clear

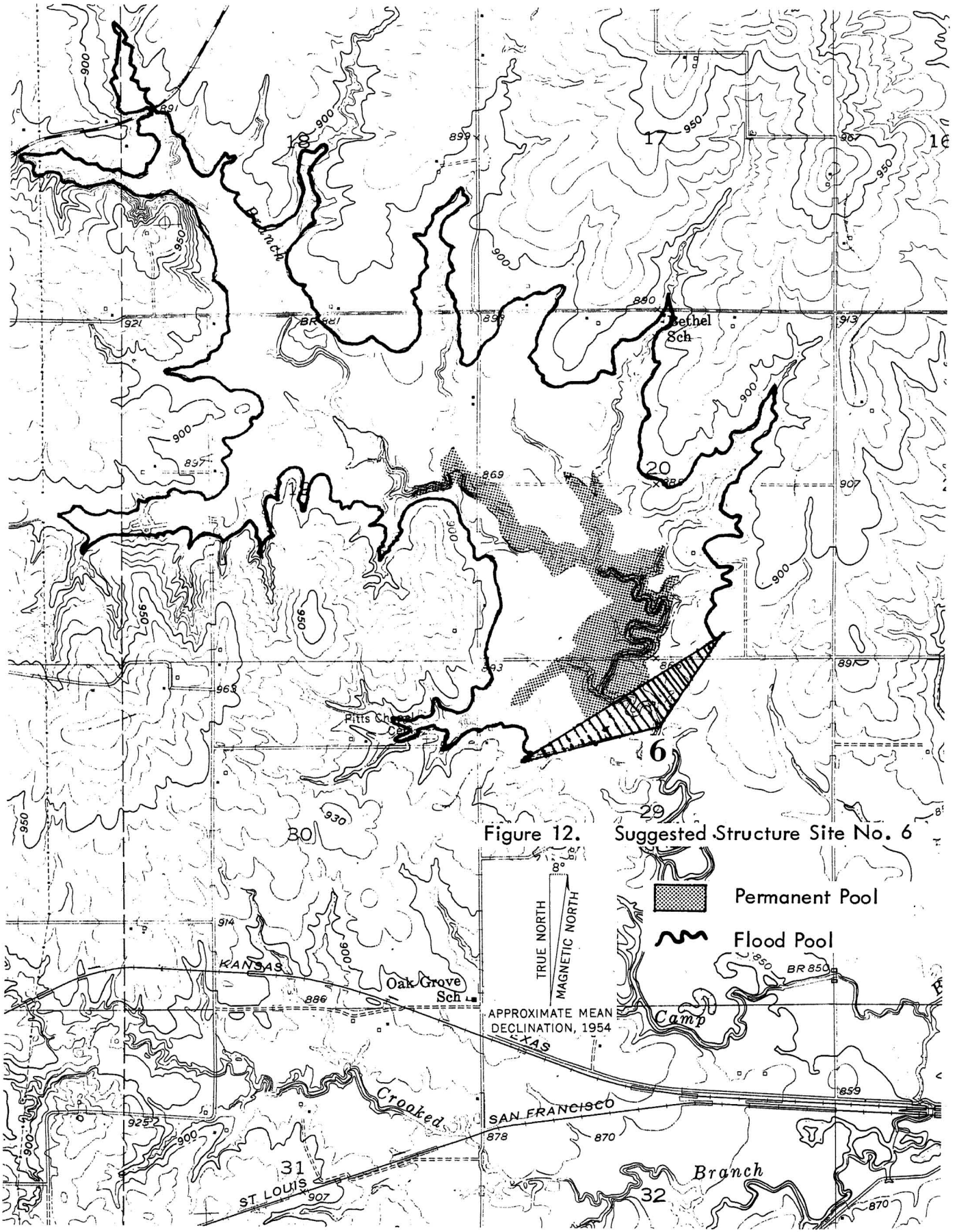

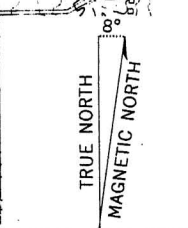


Figure 12. Suggested Structure Site No. 6

-  Permanent Pool
-  Flood Pool



APPROXIMATE MEAN DECLINATION, 1954

REACH I

Reach I-b

Structure "7"

Location. This possible structure site is located in southeast Johnson County, near the Henry County line and on Walnut Creek about 3 miles up from its point of confluence with Big Creek.

Sub-watershed. The sub-watershed to which Structure "7" is adjacent is one of the smaller drainage areas of the Big Creek watershed, comprising approximately 9,466 acres. The sub-watershed is about 2.6 miles wide and 6.3 miles in length, with a maximum elevation of 950 feet m. s. l.

Reach. The reach below the structure site along Walnut Creek is part of the Big Creek floodplain. The area usually experiences annual flooding with moderate to severe damage to crops and agricultural property. (Figure 13)

Structure "7"

Class	"b"
Length	2,870 feet
Height	33 feet
Total cost	\$265,777
Annual Amortized Cost . . .	\$10,085
Annual maintenance cost . . .	\$542
Total average annual cost . .	\$10,628

Permanent Pool.

Height (m. s. l.)	775
Capacity	394 acre feet
Surface area89 acres
Shoreline length	2.8 miles

Flood Pool.

Height (m. s. l.)	799
Capacity	9,143 acre feet
Maximum surface area759 acres

Damages. Estimated total damage resulting from flooding along Walnut Creek was \$27,093.00. Structure "7" is situated to reduce floodwater damages in the upper portion of the reach, particularly the excess flooding at the confluence of Walnut Creek with Big Creek.

Benefits. The allocation of estimated total benefits between structure "7" and "11" derived for the reach gives a 1.01 to 1 benefit-cost ratio for structure "7."

Structure "11"

Location. Structure site "11" is located on Bear Creek approximately 0.8 mile above its confluence with Big Creek, about 1.4 miles north of Blairstown in Johnson County.

Sub-watershed. The structure would control runoff from a sub-watershed of 17,715 acres. The drainage area extends north from structure site about 8.8 miles with an average width of 4.5 miles. The topography is of a rolling nature rising in elevation about 150 feet, at an average rate of 17 feet per linear mile.

Reach. The proposed protected reach immediately below the suggested structure site is part of the lower Big Creek floodplain. The lower Big Creek reach is susceptible to frequent flooding causing heavy crop damages. Much of the reach area is cultivated, with corn, wheat, and soybeans being the principal crops.

Structure "11"

Class	"b"
Length	2,700 feet
Height	40 feet
Total cost	\$390,642
Annual amortized cost	\$14,825
Annual maintenance cost	\$746
Total average annual cost . .	\$15,571

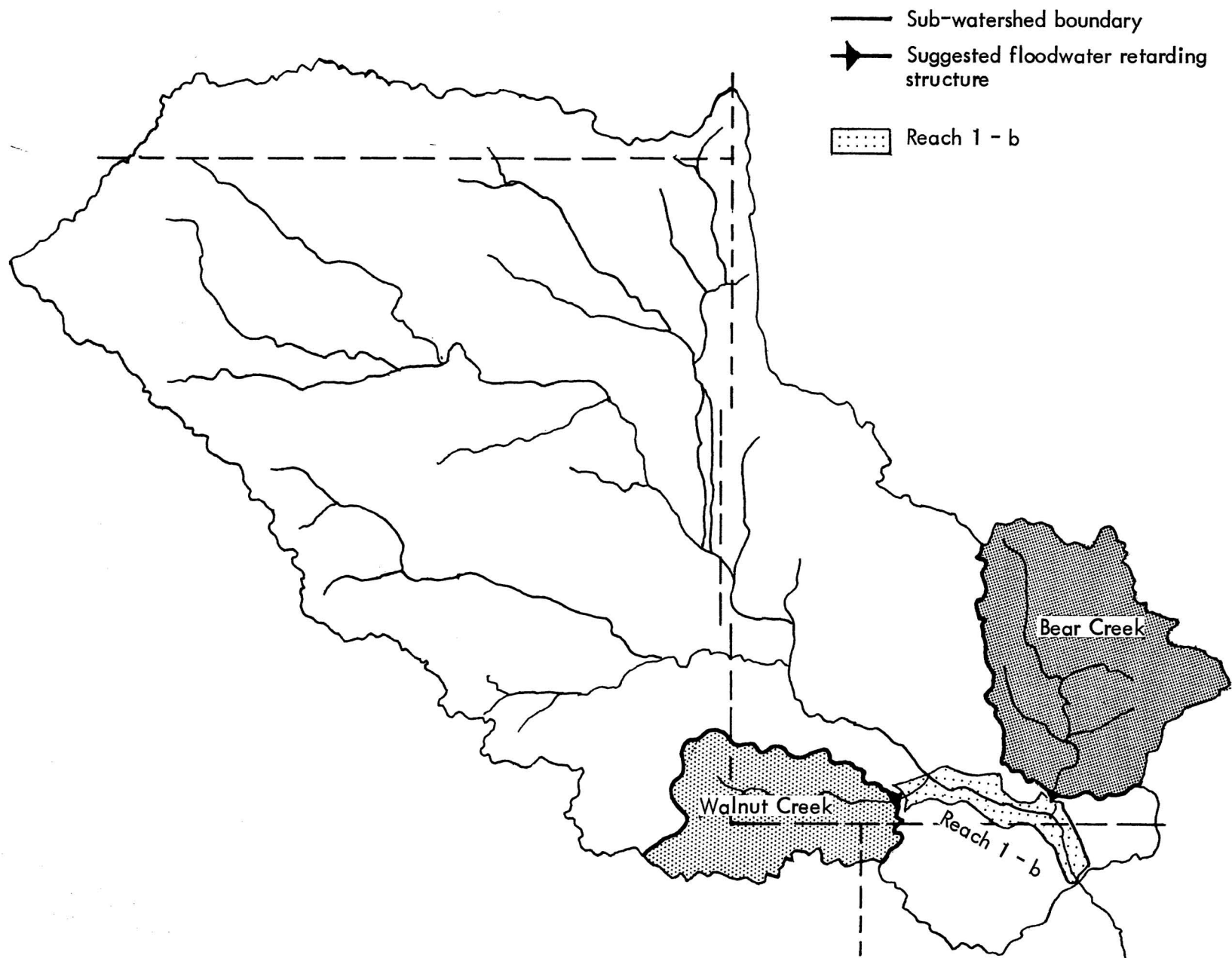
Permanent Pool.

Height (m. s. l.)761
Capacity	738 acre feet
Surface area	133 acres
Shoreline length	14.1 miles

Flood Pool.

Height (m. s. l.)	785
Capacity	17,109 acre feet
Maximum surface area1,469 acres

Figure 13. Big Creek Sub-Watersheds 7 and 11



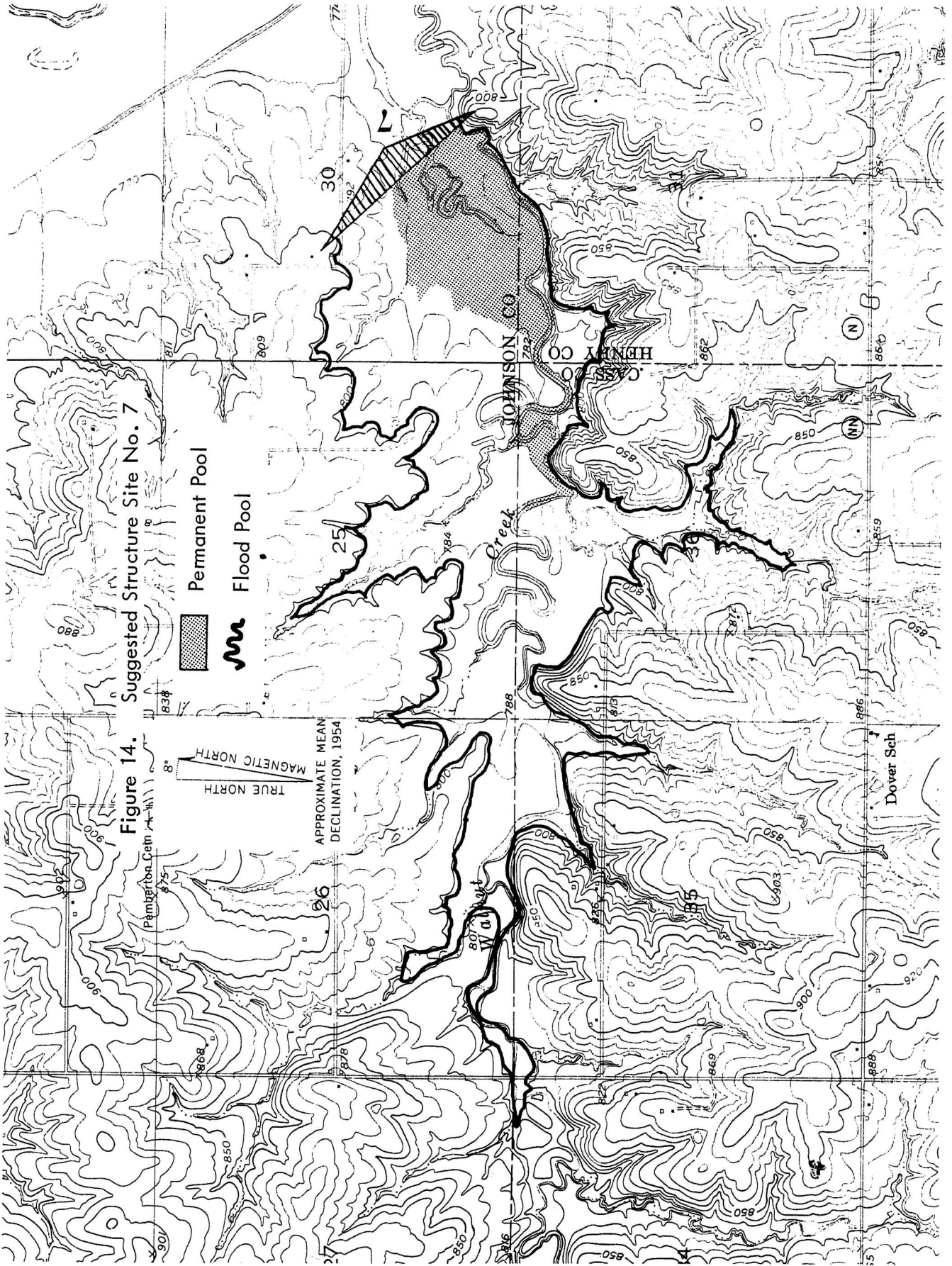


Figure 14. Suggested Structure Site No. 7

Permanent Pool
 Flood Pool

TRUE NORTH
 MAGNETIC NORTH

APPROXIMATE MEAN DECLINATION, 1954

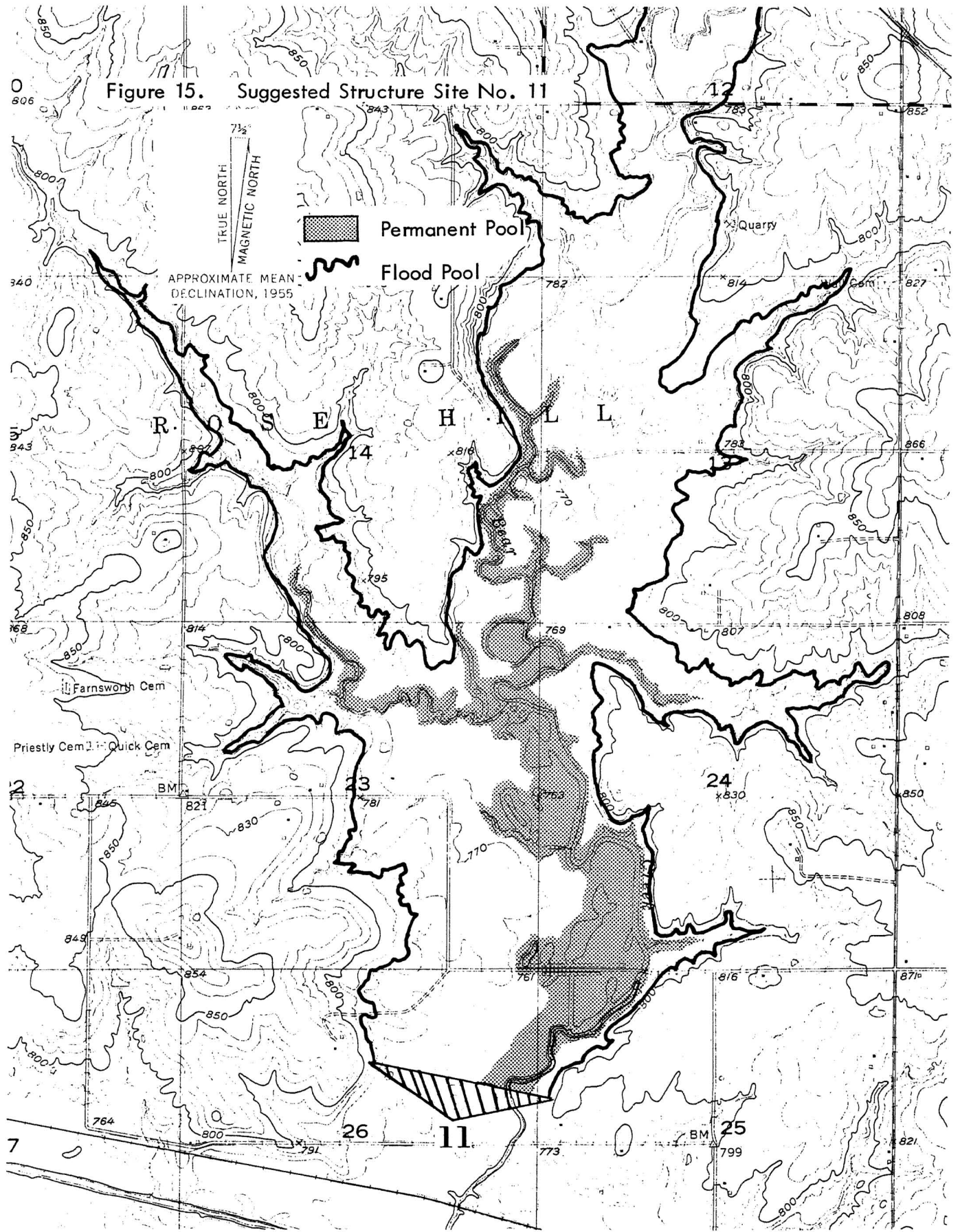
Pamgritba Cem

Dover Sch

Creek

JOHNSON CO
 HENRY CO

Figure 15. Suggested Structure Site No. 11



TRUE NORTH
MAGNETIC NORTH
7 1/2°

Permanent Pool
Flood Pool

APPROXIMATE MEAN DECLINATION, 1955

R. E. HILL

Farnsworth Cem

Priestly Cem Quick Cem

Quarry

7

0
806

340

943

768

12

849

764

827

814

827

854

800

843

800

830

791

783

816

778

773

14

23

11

800

770

770

773

12

807

816

799

783

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830

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808

850

821

827

866

871

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808

850

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BM

D

799

821

821

821

Damages. The lower Big Creek reach consists of approximately 3,645 acres. Structures "7" and "11" are in position to partly protect the area of the lower reach. Damages as a result of flooding are quite extensive, estimated at \$27,093.00.

Benefits. The benefits allocated to structure "11" resulting from its influence on flood reduction gave a benefit-cost ratio of 1.24 to 1. Figuring structures "7" and "11" as a unit gave a benefit-cost ratio of 1.15 to 1.

TABLE 5 - ESTIMATED ANNUAL BENEFITS RESULTING FROM A 70, 60, AND 50 PERCENT REDUCTION OF FLOOD DAMAGES, REACH I-b¹¹

Estimated Percent Of Damage Reduction	Annual Benefits To Crops and Pasture with Project (Dollars)	Annual Benefits From More Intensive Use Of Cropland (Dollars)	Annual Benefits From Changed Use of Pasture And Timber (Dollars)	Total Annual Benefits (Dollars)
70%	18,960.00	4,803.00	6,442.00	30,205.00
60%	16,249.00	4,117.00	5,532.00	25,898.00
50%	13,556.00	3,430.00	4,590.00	21,576.00

¹¹ Ibid.

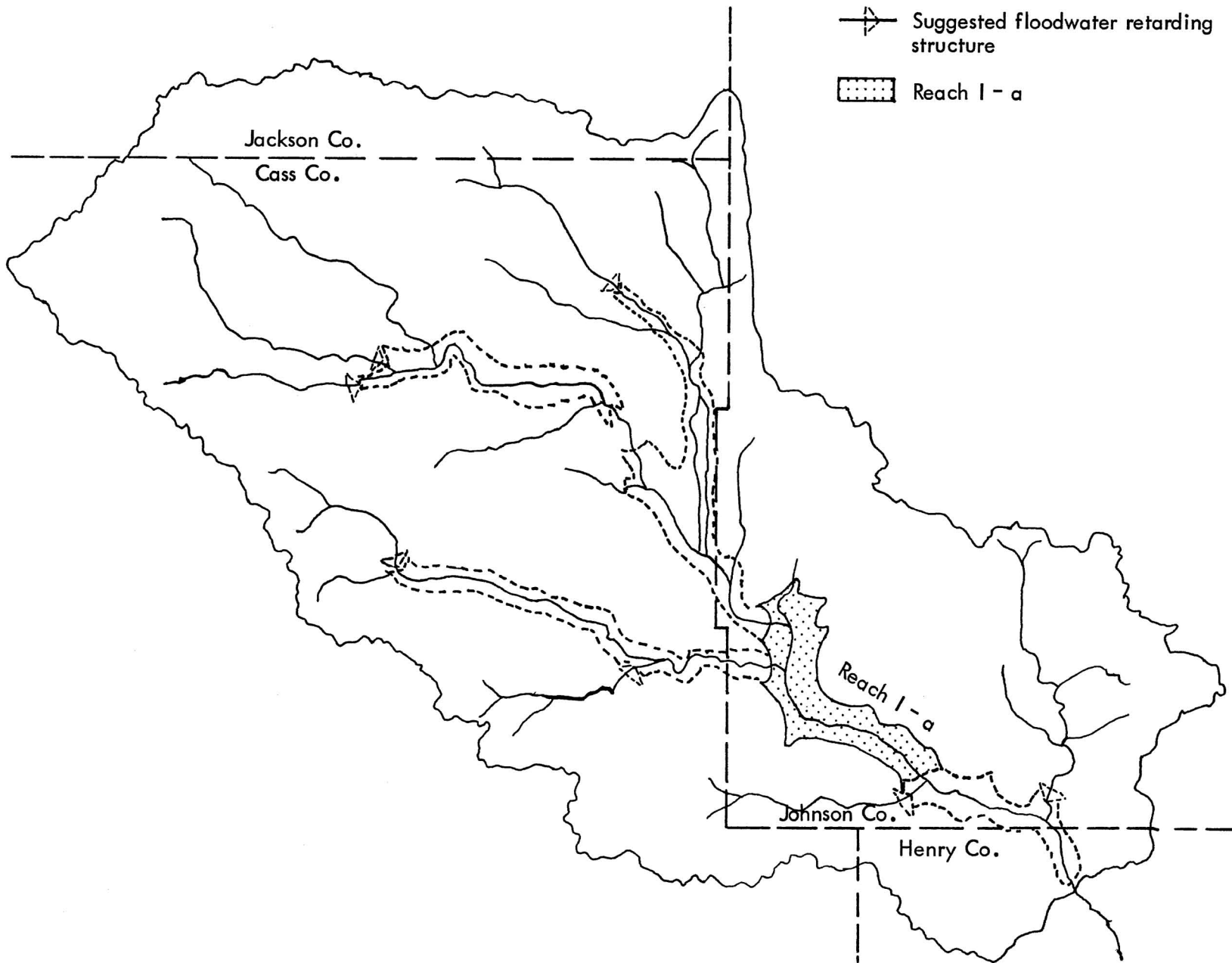
Reach I-a

The reach consists of the upper Big Creek floodplain, extending from a point about one mile east of the Johnson and Cass County line down the Big Creek valley to the confluence of Walnut Creek with Big Creek. (Figure 16). Reach 1-a comprises approximately 6,660 acres, of which about 4,750 acres are classified as crop and pasture land. A large part of the crop land is planted in corn, wheat, and soybeans. Severe annual flooding is experienced throughout the reach. In the floodplains of the combined reaches, 1-a and 1-b, there are three towns, 20 rural residences, 8 miles of road, and 11 miles of railroad track. The benefit accruing to reach 1-a as a result of reduction of floodwater damage and change in land use was estimated at \$55,272.00. It was assumed that all suggested flood retarding structures, with the exception of structures "7" and "11," would have an influence on the frequency and severity of flooding in this primary flood-

plain of the watershed. Therefore, these benefits could be allocated on a proportionate basis to all retarding structures upstream from the reach increasing their benefit-cost ratios favorably. The allocation to each would be in direct proportion to the size of watershed and in indirect proportion to distance from the protected reach.

The study has been primarily concerned with the Big Creek watershed as a unit. Attention has not been directed to any single retarding structure or sub-watershed but, rather, to the entire watershed. Therefore, the estimated benefits accruing from Reach 1-a were not proportioned out to individual structures but were used in determining an over-all benefit-cost ratio for the entire project. The benefit-cost ratio yield through summation of total costs and benefits for the watershed unit was 1.67 to 1.

Figure 16. Big Creek Sub-Watershed Reach I - a



APPENDIX A

1. Structures. The floodwater retarding structures are classified as: Class "a", Class "b", and Class "c." These structure classifications are based on a number of specific characteristics and requirements such as materials, size, locations, and the expected life of the structure. The class "b" structure is generally designed for a 50-year period and located in such a position that loss of life and property would be at minimum if the structure should break.
2. Cost. Through the cooperation of the Missouri Soil Conservation Service a composite cost figure of \$1.35 per cubic yard of fill was determined and used in computing estimated costs of the floodwater retarding structures discussed in this report.
3. In computing benefits in the analysis of the various reaches, an estimated 70 percent reduction of floodwater damages was assumed as a basis. Sixty and 50 percent reductions in flood damages were also used and are given in Appendix tables.
4. "Permanent Pool" as used in the report refers only to the sediment pool capacity and does not include storage for municipal water supplies or recreational uses. To provide for such storage the estimated acre feet for the purpose would be added to the sediment pool storage.

APPENDIX B

APPENDIX TABLE I LAND USE BY CROP CLASSIFICATION;
COUNTY ACREAGE AND ESTIMATED WATERSHED ACREAGE

Classification	Cass County (acres)	Johnson County (acres)	Big Creek Watershed (acres)
Crops:			
Corn	61,743	58,839	55,092
Wheat	24,142	24,458	11,749
Soybeans	17,011	18,469	21,932
Oats	17,171	21,850	6,527
Other Crops	22,679	24,951	18,799
Meadow	30,217	38,395	19,361
Cropland in Pasture			
or not in use	42,823	68,460	20,687
Total Cropland	215,786	255,422	154,147
Pasture	125,116	135,168	32,020
Timber	34,392	38,487	20,365
Other	71,426	99,563	54,570
TOTAL	446,720	528,640	261,102*

* The discrepancy in total watershed acreage, 269,999 and 261,102 acres, results from excluding that part of the watershed below the confluence of Bushy Creek with Big Creek in the extreme lower reach.

APPENDIX TABLE II. ACREAGE AND LAND USE, BY REACH

Reach	Total Acres	Row	Cropland	Pasture Acres	Meadow Acres	Other	Timber Acres	Waste Acres
		Crop Acres	Not In Crop			Crop Acres		
I-a	6,662	2,431	526	1,146	693	480	520	866
I-b	3,645	1,330	288	627	379	263	284	474
II	3,024	1,104	239	520	314	218	236	393
III	4,995	1,824	395	859	519	360	390	648
IV	3,402	1,242	268	585	354	245	265	443
Totals	21,728	7,931	1,716	3,737	2,259	1,566	1,695	2,824

APPENDIX TABLE III. LOCATION OF THE POTENTIAL FLOODWATER
RETARDING STRUCTURES IN THE BIG CREEK WATERSHED.

Structure Number	Section Number	Township	Range	Quadrangle Map (7.5 Minute)
1	25	T-46-N	R-31-W	Pleasant Hill
2	25 & 36	T-46-N	R-31-W	Pleasant Hill
3	12 & 13	T-46-N	R-30-W	Strasburg
4	19, 25 & 30	T-46-N	R-30-W, R-29-W	Strasburg
5	1	T-44-N	R-30-W	East Lynne
6	20 & 29	T-45-N	R-30-W	Harrisonville
7	30	T-44-N	R-28-W	Quick City
8	28 & 29	T-46-N	R-29-W	Strasburg
9	26 & 35	T-45-N	R-29-W	Kingsville
10	3	T-44-N	R-29-W	Kingsville
11	25 & 26	T-44-N	R-28-W	Blairstown
12	7 & 12	T-45-N	R-30W, R-29-W	East Lynne

APPENDIX TABLE IV. SUB-WATERSHED AREAS, AND WATER STORAGE CAPACITY OF SEDIMENT AND FLOOD POOLS FOR THE POTENTIAL FLOODWATER RETARDING STRUCTURES WITHIN THE BIG CREEK WATERSHED

Structure Number	Sub-Watershed Area In Acres	Est. Storage Capacity of the Sediment Pool In Acre-Feet	Est. Storage Capacity of the Flood Pool In Acre-Feet
1	18,980	791	18,331
2	9,206	371	8,891
3	13,938	581	13,462
4	18,832	784	18,188
5	9,122	380	8,810
6	9,405	392	9,084
7	9,466	394	9,143
8	9,896	412	9,958
9	130,763	5,448	126,295
10	40,394	1,683	39,014
11	17,715	738	17,109
12	47,186	1,966	11,757
Totals	334,903	13,940	290,042

APPENDIX TABLE V. ESTIMATED CONSTRUCTION AND MAINTENANCE COSTS FOR THE POTENTIAL FLOODWATER RETARDING STRUCTURES WITHIN THE BIG CREEK WATERSHED

Structure Number	Est. Total Cost of Construction ¹ (Dollars)	Est. Annual Cost of Construction (Dollars)	Est. Annual Maintenance Cost (Dollars)	Est. Total Annual Cost (Dollars)
1	365,636	13,875	710	14,586
2	164,209	6,231	310	6,542
3	548,969	20,833	1,207	22,041
4	*	*	*	*
5	297,450	11,288	601	11,889
6	328,525	12,467	704	13,171
7	265,756	10,085	542	10,628
8	*	*	*	*
9	*	*	*	*
10	*	*	*	*
11	390,642	14,824	746	15,571
12	233,992	13,318	319	13,637
Totals	2,595,179	102,921	5,139	108,065

¹ Includes estimated cost of land.

* Omitted from analysis

APPENDIX TABLE VI. ESTIMATED SURFACE AREA OF FLOOD AND
SEDIMENT POOLS, AND MILES OF SHORELINE

Structure Number	Surface Area In Acres		Sediment Pool Shoreline In Miles
	Flood Pool (acres)	Sediment Pool (acres)	
1	1,235	180	6.33
2	630	65	2.92
3	1,009	135	3.79
4	1,482	190	6.10
5	890	100	4.81
6	740	75	4.36
7	759	89	2.76
8	1,030	140	*
9	14,000	950	*
10	3,000	275	*
11	1,469	133	14.13
12	1,415	435	4.58
Totals	27,659	2,767	49.78

* Shoreline was not computed for these structures.

APPENDIX TABLE VII. ESTIMATED FLOODWATER DAMAGES
BY CLASSIFICATION FOR REACHES*

Reach Number	Damages To Crops and Pastures (Dollars)	Other Agricultural Damages (Dollars)	Erosion Damages (Dollars)	Indirect Damages (Dollars)	Total Damage (Dollars)
I-a	38,376.48	767.53	5,871.60	4,501.56	49,517.17
I-b	20,997.69	419.95	3,212.64	2,463.02	27,093.30
II	17,427.78	348.56	2,666.45	2,044.27	22,487.06
III	28,784.04	575.68	4,403.96	3,376.36	37,140.04
IV	19,609.35	392.19	3,000.23	2,300.17	25,301.94
Totals	125,195.34	2,503.91	19,154.88	14,685.38	161,539.51

* Based on projected long-term prices.

APPENDIX TABLE VIII. BENEFIT-COST ANALYSIS BY REACH FOR THE BIG CREEK WATERSHED, WITH AN ESTIMATED 70 PERCENT REDUCTION OF FLOODING.^{1/2}

Reach	Estimated Average Annual Benefits From Flood Reduction						Average Annual Cost (Dollars)	Benefit-Cost Ratio
	Crops & Pasture	Other Agri-cultural	Erosion	Indirect	Changed Land Use	Total Benefits		
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)		
I-a	26,873	537	4,112	3,152	20,598	55,272	*	*
I-b	14,694	294	2,248	1,724	11,245	30,205	26,199	1.15 to 1
II	12,213	244	1,869	1,433	9,421	25,180	25,061	1.01 to 1
III	20,161	403	3,085	2,365	15,388	41,402	35,679	1.16 to 1
IV	13,734	275	2,101	1,611	10,469	28,190	21,129	1.33 to 1
Totals	87,675	1,753	13,415	10,285	67,121	180,249	108,068	1.67 to 1

* Not analyzed separately

¹ Based on projected long-term prices.

² The position of Reach 1-a receives floodwater protection from all retarding structures except numbers "7" and "11", therefore no additional cost above those estimated costs already included were used. However, benefits derived from this as a result of flood protection were not included in computing individual structure benefit-cost ratios but are considered in the over-all benefit-cost analysis.

APPENDIX TABLE IX. BENEFIT-COST ANALYSIS BY REACH FOR THE BIG CREEK WATERSHED, WITH AN ESTIMATED 60 PERCENT REDUCTION OF FLOODING.¹

Reach	Estimated Average Annual Benefits From Flood Reduction						Average Annual Cost (Dollars)	Benefit-Cost Ratio
	Crops & Pasture	Other Agri-cultural	Erosion	Indirect	Changed Land Use	Total Benefits		
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)		
I-a	23,022	460	3,522	2,700	17,530	47,234	*	*
I-b	12,593	252	1,927	1,477	9,649	25,898	26,199	0.99 to 1
II	10,464	209	1,601	1,227	8,011	21,512	25,061	0.86 to 1
III	17,280	346	2,644	2,027	13,214	35,511	35,679	0.99 to 1
IV	11,481	230	1,757	1,347	8,995	23,810	21,129	1.13 to 1
Totals	74,840	1,497	11,451	8,778	57,399	153,965	108,068	1.43 to 1

* Omitted from Analyses.

¹ Based on projected long-term prices.

APPENDIX TABLE X. BENEFIT-COST ANALYSIS BY REACH FOR THE
BIG CREEK WATERSHED, WITH AN ESTIMATED 50 PERCENT REDUCTION OF FLOODING.¹

Reach	Estimated Average Annual Benefits From Flood Reduction						Average Annual Cost (Dollars)	Benefit- Cost Ratio
	Crops & Pasture (Dollars)	Other Agri- cultural (Dollars)	Erosion (Dollars)	Indirect (Dollars)	Changed Land Use (Dollars)	Total Benefits (Dollars)		
I-a	19,188	384	2,936	2,251	14,705	39,464	*	*
I-b	10,506	210	1,607	1,232	8,021	21,576	26,199	0.82 to 1
II	8,714	174	1,333	1,022	6,684	17,927	25,061	0.71 to 1
III	14,399	288	2,203	1,689	10,979	29,558	35,679	0.82 to 1
IV	9,806	196	1,500	1,150	7,491	20,143	21,129	0.95 to 1
Totals	62,613	1,252	9,579	7,344	47,880	128,668	108,068	1.19 to 1

* Omitted from Analyses

¹ Based on projected long-term prices.

TABLE XI. ESTIMATED ANNUAL COSTS
BIG CREEK WATERSHED

Retarding Structure	Amortization of Install- tion Cost (Dollars)	Operation & Maintenance Costs (Dollars)	Total Cost (Dollars)
1	13,875.89	710.68	14,586
2	6,231.75	310.62	6,542
3	20,833.38	1,207.97	22,041
4	*	*	*
5	11,288.23	601.31	11,889
6	12,467.56	704.16	13,171
7	10,085.00	542.49	10,628
8	*	*	*
9	*	*	*
10	*	*	*
11	14,824.86	746.32	15,571
12	13,318.84	319.04	13,637
Total	102,714.80	5,128.68	108,065

* These structures were omitted from the analysis and are not included in total annual cost.

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