RECREATIONAL IMPACT OF MULTI-PURPOSE RESERVOIRS

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BY

W. L. GRECCO

JOINT HIGHWAY RESEARCH PROJECT
PURDUE UNIVERSITY AND INDIANA STATE HIGHWAY COMMISSION
Final Summary Report

RECREATIONAL IMPACT OF MULTI-PURPOSE RESERVOIRS

TO: J. F. McLaughlin, Director
Joint Highway Research Project

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

December 13, 1973
Project: C-36-54KK
File: 3-3-37

Attached is the Final Summary Report for the HPR Part II Research Study titled "Recreational Impact of Multi-Purpose Reservoirs". The Report has been prepared by Professor W. L. Grecco formerly of the JHRP Staff and principal investigator on this Study.

The Report is a summary of the research previously reported to the Board in two Interim Reports and outlines the application of the New Reservoirs Model developed in the Study to future reservoirs in the state. Considerable information on the purpose of trips for those attracted to reservoir recreational areas is also included and will be of value to the Department of Natural Resources.

The Study was terminated on June 30, 1971 and the delay in preparing this Final Report resulted from time constraints on the principal investigator while at Purdue in 1971-72 and on even greater constraints after terminating his tenure at Purdue in August 1972. Comments made in the review of the second Interim Report in October 1970 by the FHWA reviewer have also been considered in preparing this Final Summary Report. In particular no inclusion of the motorboat fuel tax research performed under this Study has been included as it is not pertinent to the major objectives of the research, development of a predictive model for recreational travel.

The Report is submitted for acceptance as adequate fulfillment of the objectives of the Study and as the final activity on this Study.

Respectfully submitted,

Harold L. Michael
Associate Director

HLM:ms

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Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Research Study titled "Recreational Impact of Federal Multi-Purpose Reservoirs".

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Final Summary Report

RECREATIONAL IMPACT OF MULTI-PURPOSE RESERVOIRS

by

William L. Grecco
Research Engineer

Joint Highway Research Project
Project No.: C-36-54KK
File No.: 3-3-37

Prepared as Part of an Investigation
Conducted by
Joint Highway Research Project
Engineering Experiment Station
Purdue University
in cooperation with the
Indiana State Highway Commission
and the
U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Purdue University
West Lafayette, Indiana
December 13, 1973
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ABSTRACT

The principal objectives of this study were to develop recreational demand models and to determine their stability. Models were of the form \( Y = A e^{-Bx} \) and utilized easily obtainable and predictable variables. A technique was developed illustrating how the model can be used to predict future attendance and traffic volumes. Three parks on reservoirs in Indiana were used in the study. Data were collected by interviewing 25 percent of arriving trips at the park entrances. About 13,000 interviews were conducted in 1965 and 1966 and an additional 12,000 over the period 1967 through 1969.

Models were developed by non-linear regression analysis utilizing distance, population and the influence of other similar facilities. Two equations constituted the prediction model, one for the condition when there is no other similar facility closer to a county than the reservoir under study, and one for the condition when there is another such facility closer to the county than the reservoir under study. A comparison was made between the characteristics of the model as developed in the two phases of the study. It was found that while parameter \( B \) remained fairly constant over time, there was an increase in parameter \( A \).
INTRODUCTION

Need for Study

There are several factors which point to the need for a procedure for predicting travel to recreational areas. Typically in large urban areas, the links in the transportation network most frequently stressed to capacity and over are those carrying the work trips. In many of these same areas, the top thirty of the highest traffic volumes are often greatly affected by recreational traffic. The effects on rural highways in the vicinity of recreational facilities or along the minimum path between population centers and recreational facilities are even more significant. Design volumes, in many instances, will prove deficient if proper consideration is not given to the estimation of recreational travel.

Increased recreational travel because it is highly peaked causes the peak hour to be an even higher percentage of the ADT. Typically, the urban road designer can expect that the peak hour will be about ten percent of the ADT. The percentage for rural highways is higher; but when these rural locations are affected by recreational travel, the percentage may reach twenty percent. This figure can go only one way; higher, due to the growth in outdoor recreation. There are many reasons to expect increased recreational travel such as increased population, increased leisure time, increased disposal income and improved road accessibility.
The above four factors make modeling of demand difficult, but transportation planners have learned to model where population increases and increased mobility are important dependent variables. The effects due to increased income and increased leisure time cause the users to increase their demand for recreation. Models built with present attitudes, therefore, may predict recreational demands somewhat low. Until a stable level is reached, however, such interim models, even though they forecast low values, are desirable for wise planning, especially if the user recognizes their probable conservative nature.

Indiana's Recreational Development

The control and use of water resources is and will continue to be of major importance to the economic life of the United States. Flood control, irrigation, and hydro-electric power were originally the three purposes considered in the cost analysis for justification of the construction of dams and their resulting reservoirs. However, not until recent years have the recreational benefits been generally included in the economic analysis or even recognized as an economic factor.

Recreation is now recognized as big business in this country. A substantial portion of the Gross National Product is devoted to recreational pursuits in all areas of the nation, and Indiana is no exception.

Indiana has a State Park System which was established in 1916. The State had as its first parks certain areas selected on the basis of their outstanding scenic, geological, historical,
or ecological features. In recent years, however, some areas were acquired for the purpose of providing recreational facilities - such as swimming, fishing, boating, and similar activities - more than for the purpose of acquiring an outstanding landscape of great historical or geological significance. Whereas some areas in a state park system may be considered "primitive" areas, others have been established for the primary purpose of providing recreational facilities for relatively large concentrations of populations.

Water is a recreational magnet and will attract large numbers of people for recreational purposes. The multi-purpose dams and their reservoirs are therefore natural recreational attractions and consequently traffic generators. The recreational potential of a reservoir, however, cannot be fully utilized unless transportation planning coincides with reservoir development plans so that an adequate transportation system is available as the recreational demand grows. The agencies responsible for planning must have some means of determining demand prior to construction so that the best use can be made of the available resources of land and money. At the present time, little factual information is available that can be used by planners to estimate the recreational demand. Many reservoir sites are located in areas with poor existing transportation facilities. Usually existing roads were designed for rural traffic of low volumes, and as such these roads cannot begin to accommodate the traffic generated by a reservoir and its attendant recreational facilities.
Corps of Engineers Reservoirs constructed in Indiana have been a relatively recent attempt by man to alter the effects of natural forces. While their primary purpose is flood control, the creation of large bodies of water present new opportunities that effect growth and development in the area. Therefore, it is extremely important to visualize what may happen so that appropriate measures can be taken to facilitate an orderly expansion.

The area of water available for recreational purposes within the State of Indiana is in the process of being substantially increased under flood control programs of the U.S. Army Corps of Engineers. Six multi-purpose reservoirs have been completed to date; eight more are authorized and many more are planned (see Figure 1). The six completed reservoirs have added a total of over 20,000 acres of water at summer levels.

For multi-purpose recreation reservoirs, Federal funds are available for 100 percent of the flood control cost allocation and 50 percent of the additional costs for recreation and wildlife purposes, including land and minimum basic facilities. In Indiana, the State Department of Natural Resources is responsible for the development and operation of recreational facilities at such reservoirs.

**PURPOSE AND SCOPE**

In recognition of the necessity of planning proper highway facilities, the Indiana Department of Natural Resources early in 1965 asked the Joint Highway Research Project (JHRP) at
FIGURE 1

MAJOR RESERVOIRS IN INDIANA
Purdue University to conduct research that would develop information that could be used for planning recreational developments at future reservoir sites. Three reservoirs were suggested for study; two had been in operation for several years and the third was in the process of being opened for public use although few facilities were available. The two developed parks were Lieber State Park on Cagles Mill Reservoir and Raccoon State Recreation Area on Mansfield Reservoir. The developing third park was located on Monroe Reservoir.

Funding for the project was provided by the Bureau of Public Roads of the U.S. Department of Transportation and the Indiana State Highway Commission through the Joint Highway Research Project. The purpose of the proposed research was to provide necessary data which would assist the Indiana State Highway Commission and the Department of Natural Resources in planning for future highway requirements due to recreational travel to the multi-purpose reservoirs in the State.

The project was conducted in two phases. Phase I included a physical inventory of existing facilities, data on the facility users and land value data. Data were collected on a designed sampling basis throughout the year.

For the reservoirs, the research examined:

a. the numbers and characteristics of the users (family size, adults, minors, returnees),

b. the sphere of influence of the facility (distances that users traveled, direction, effect of competing facilities),

c. the characteristic of the traffic generated by the facility (how many vehicles, from where and when),
d. the effect on land use and values.

Phase II was a continuation of the project on a reduced sampling basis in order to verify the stability of the models.

DATA COLLECTION

In order to acquire sufficient data for the study, collection was made over a period extending from June, 1965 until October, 1966 at all three parks for Phase I. Data collection for Phase II of the study was carried out between June, 1967 and August, 1969 at the same parks.

The primary source of data was a 25 percent interview of vehicular trips arriving at the parks. The 25 percent sample was considered adequate for analytical purposes and did not create a disruption in traffic flow. Over 13,000 interviews were conducted in Phase I.

With the exception of 1968, when reduced sampling was performed, interviewers were stationed both at gatehouses and boat ramps. At the gatehouses, the interviews were performed while arriving vehicles were stopped, either to pay fees or show a season pass. Each interview took approximately 20 seconds. At the boat ramps the interviews were performed while the boats were being readied for launching.

Over the three year period of Phase II, over 12,000 interviews were performed at the following locations within each park:

Mansfield: Main gate, Dam and Hollandsburg boat ramps
Cagles Mill: Main gate, Cunot Dock boat ramp
Monroe: Paynetown, Fairfax, and Hardin Ridge gatehouses, Cutright, Dam, and Moores Creek boat ramps.
It should be noted that Hardin Ridge (Monroe) has been developed by, and is under the administration of, the U.S. Forest Service. It is, nevertheless, a part of the recreational facilities offered at Monroe Reservoir and is, for this reason, included in the study.

The structure of the interviews was unchanged from Phase I through Phase II. It was decided that the interviewer should ask the driver from which county the trip had originated, as well as recording the license number, the prefix of which (on Indiana passenger cars) is a code number relating to the county in which the car was licensed. This was good training for the interviewers, since thereafter they did not fail to obtain the county of origin of vehicles for which the license plates had no such county code prefix (campers, buses, trucks, out of state vehicles).

The driver was asked the purpose of the visit. The number of adults and children (persons under 12 years of age) was determined. The number of adults and children was of greater importance prior to 1967, since the fee charged was dependent on the number of adults in each car. However, in 1967 the state introduced a fixed rate for each vehicle, and in 1968, and optional season pass was available.

The interviewers made note of any equipment carried, such as a boat, house trailer or camping trailer. The time of day, the date, park, interview location (main gate, or boat ramp) were also recorded.
The majority of the interviews were conducted over the weekend periods, from Friday afternoon to Sunday afternoon during the summer months. Weekends were selected randomly. During 1965, the parks were visited every two weeks beginning early in June and continuing through August. Mansfield was visited one weekend and Cagles Mill and Monroe the next weekend throughout the summer. Periodic visits were made during the fall and winter and also during the spring of 1966, in order to determine the yearly distribution of trips. During the 1966 summer season visits were made to each park every third weekend. Weekday visits were made in June and August only.

During 1965 and 1966 under Phase I of the research, insufficient data were collected at Monroe Reservoir (which was then in the process of being developed) to be incorporated in the prediction model. However, by the end of Phase II of the research, all of the facilities shown in Figures 2, 3, and 4 were in operation at the three reservoirs.

All the interviews in 1967, 1968 and 1969 were conducted over the weekend periods, from Friday afternoon to Sunday afternoon during the months of June, July and August. Weekends were assigned at random. In 1967, each park was visited on 3 weekends. In 1968, Mansfield and Cagles Mill were each visited on 3 weekends and Monroe on 4 weekends. In 1969, each park was visited on 4 weekends.
FIGURE 2
MANSFIELD RESERVOIR
FIGURE 3
CAGLES MILL RESERVOIR

CAGLES MILL FLOOD CONTROL RESERVOIR
STATE FOREST — RECREATION AREA

SCALE IN MILES
1/2 0
FIGURE 4
MONROE RESERVOIR
The general procedure for weekends was to begin at 2:00 p.m. on Friday and interview until 9:00 or 10:00 p.m. On Saturdays, interviewing would begin at 9:00 a.m. and continue until 8:00 p.m. On Sundays, interviewing would begin at 9:00 a.m. and continue until 4:00 p.m. The hours were selected on the basis of observations made at Mansfield. After about 9:00 p.m. on Fridays, few arrivals were noted, and few arrived before 9:00 a.m. on any day of the week. The parks were open 24 hours a day during the summer, but interviews were conducted only during the stated hours. The park records on attendance showed that on weekends the arrivals during the interview period usually accounted for about 90 percent of the total visitors on Saturdays and Sundays and about 75 percent on Fridays. Weekday interviews were conducted in essentially the same manner as were the weekend interviews.

In order to standardize the trip rate from any particular county, a unit of measure was selected as trips per 1000 population. There was a large variation among county populations. Marion County contained 785,000 people, while Union County contained 6000. Obviously the total number of trips from the two counties would vary even if the distances to a park were the same. The use of a trip rate tended to normalize the disparity of population differences.

The official attendance (vehicles) for each year at Mansfield and Cagles Mill was obtained from attendance records maintained by the Department of Natural Resources; Monroe attendance figures were obtained from the Park Superintendent,
Monroe Reservoir and the U. S. Department of Agriculture Forest Service. The estimated total attendance (vehicles) at each reservoir for each year is shown in Table 1. The observed trips from a county were divided by the appropriate County Trip Expansion Factor, which is the proportion of the estimated total trips to a park that were sampled in a year. County Trip Expansion Factors are listed in Table 2.

The Indiana county population estimates for the years 1965 to 1969 were linear interpolations of projections developed by the Indiana University, Graduate School of Business (1)*. The Illinois county population estimates were linear projections of 1960 census data and U. S. Bureau of Census estimates 1966 (2). The distance figures were developed from the population centroid of each county to the center of each reservoir. Road miles were measured using the primary highway system.

It became apparent, when comparing Illinois and Indiana county trip rates for equivalent distances from a reservoir, that Illinois county trip rates were significantly lower. Analysis of this fact resulted in assessment of a stateline penalty of an additional 30 miles for each Illinois county to equalize trip rates. This also had the effect of including in the analysis only those Illinois counties within 95 miles of a reservoir.
### TABLE 1
**ESTIMATED TOTAL ATTENDANCE (VEHICLES)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Facility</th>
<th>Cagles Mills</th>
<th>Mills</th>
<th>Mansfield</th>
<th>Monroe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td></td>
<td>30,695</td>
<td>57,146</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>1966</td>
<td></td>
<td>41,322</td>
<td>--</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>1967</td>
<td></td>
<td>42,713</td>
<td>60,486</td>
<td>39,269</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td></td>
<td>50,570</td>
<td>63,592</td>
<td>77,758</td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td></td>
<td>43,149</td>
<td>41,477</td>
<td>108,646</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 2
**COUNTY TRIP EXPANSION FACTORS**

<table>
<thead>
<tr>
<th>Year</th>
<th>Facility</th>
<th>Cagles Mills</th>
<th>Mansfield</th>
<th>Monroe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td></td>
<td>0.210</td>
<td>0.287</td>
<td>0.200</td>
</tr>
<tr>
<td>1966</td>
<td></td>
<td>0.200</td>
<td>0.342</td>
<td>0.212</td>
</tr>
<tr>
<td>1967</td>
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<td>0.015</td>
<td>0.018</td>
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<td>1968</td>
<td></td>
<td>0.012</td>
<td>0.014</td>
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<td>1969</td>
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<td>0.022</td>
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<td>0.013</td>
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DATA ANALYSIS

Model Form

Several model forms were reviewed before selecting the one to be used. Consideration was given to the multiple regression modeling used by Schulman in his study of weekend trips to Indiana's twenty state parks (3). His work identified ten variables which contributed to the attraction of trips to a recreational area. The model produced the trips attracted at the park as a function of its characteristics. A gravity-type distribution model was used which utilized road distances to represent the friction of space. It was assumed that trips produced at the counties were only a function of the population resident in each county. Unger's work proposed the use of an activity index made up of population characteristics generally available from the census. Although his index values may be more significantly related to recreational trip production than mere population, the difficulty of predicting future values precluded their use (4).

The proposed model developed in this study is for multi-purpose reservoir recreational areas which by design would have similar park characteristics and differences would be primarily in size of the reservoir. Previous models failed to consider the effects of competition on recreational trip attractions. The proposed model attempted

*Numbers in parentheses refer to entries in the List of References.*
to overcome this deficiency. In addition and for simplicity, the friction of space is represented by the road distance from the park to the county seat. A statistical test was made of Indiana counties to check if the county seat would adequately represent the population centroid. Of the ninety-two counties, thirteen were eliminated because there existed in each a city whose population exceeded that of the county seat. For the remainder, the average deviation of the centroid was about 1 1/2 miles and only two counties exceeded five miles. The center of the county seat was used as the population centroid for these counties.

Model Development: Phase I

A normal plot of the trip rates versus distance of the various counties from a reservoir produced a curved line. A plot of the same data on a semi-logarithmic graph produced a straight line, indicating that an exponential type of function should describe the trip rates in terms of distance. This result was expected since the relationship between trip length and distance has been shown to be exponential (5). The relationship is based on the premise that a trip desires to be as short as possible; a person making a trip for any purpose will usually go no further than is necessary to satisfy the purpose for which the trip is being made.

For determining the trip rate, the function used was:

\[ Y = A e^{-Bx} \]

where

- \( Y \) = trips per 1000 population from county to reservoir
- \( A \) = \( Y \) intercept of non-linear regression curve
\[ e = \text{base of natural logarithms} \]
\[ B = \text{rate of change of non-linear regression curve} \]
\[ x = \text{distance in tens of miles from a county to a reservoir.} \]

Two regression curves were developed; one curve (CLOSEST) is to be used for counties that are closest to the specified park and the other curve (INTERVENING) is for trips to a park that is not the closest. The collected data recorded trips from a particular county to more than one park. The characteristics or the parameters of the model might be different for each of the two cases. Case one is the condition where one or more parks are closer to the county than the park under consideration. See Figure 5. Case two is the condition where there is no park closer to a county than the park under consideration. See Figure 6.

**Trip-Making Characteristics**

**Trips by Purpose.** In order to determine what percentage of the total trips each trip purpose produces, two tables were developed. The first, Table 3, shows the percentage of total trips contributed by each single purpose; no multi-purpose trips are included. The second, Table 4, is considered to be more useful in explaining the trip purposes because it contains the multi-purpose trips as well as the single purpose trips for each purpose (6).

One conclusion is that swimming is the most preferred activity; followed in order by boating, picnicking, and camping. See also Table 5.
Uppercase confidence band
Lowercase confidence band

$y = 129 - 0.488x$

**Figure 5**
Total trips with intervening park
Figure 6
Total trips to closest park

The graph shows the relationship between trips per OOC population and distance (miles) with upper and lower confidence bands. The trend line is given by the equation $y = 33.8e^{-0.579x}$.
### TABLE 3

**SINGLE PURPOSE TRIPS IN PERCENT OF TOTAL ANNUAL TRIPS**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Mansfield 1965</th>
<th>Cagles Mill 1965</th>
<th>Cagles Mill 1966</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boating</td>
<td>11.1</td>
<td>9.6</td>
<td>18.2</td>
<td>13.0</td>
</tr>
<tr>
<td>Camping</td>
<td>3.2</td>
<td>4.8</td>
<td>5.1</td>
<td>4.4</td>
</tr>
<tr>
<td>Picnicking</td>
<td>6.5</td>
<td>5.7</td>
<td>6.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Swimming</td>
<td>12.3</td>
<td>12.4</td>
<td>15.2</td>
<td>13.3</td>
</tr>
</tbody>
</table>

### TABLE 4

**MULTI-PURPOSE TRIPS IN PERCENT OF TOTAL ANNUAL TRIPS**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Mansfield 1965</th>
<th>Cagles Mill 1965</th>
<th>Cagles Mill 1966</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boating</td>
<td>36.9</td>
<td>37.6</td>
<td>47.1</td>
<td>40.5</td>
</tr>
<tr>
<td>Camping</td>
<td>18.4</td>
<td>25.7</td>
<td>13.4</td>
<td>19.2</td>
</tr>
<tr>
<td>Picnicking</td>
<td>32.3</td>
<td>36.4</td>
<td>21.6</td>
<td>30.1</td>
</tr>
<tr>
<td>Swimming</td>
<td>38.1</td>
<td>55.6</td>
<td>31.9</td>
<td>41.9</td>
</tr>
</tbody>
</table>

### TABLE 5

**AVERAGE TRIP PURPOSE IN PERCENT FOR SUMMER MONTHS (JUNE, JULY, AUGUST)**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Mansfield 1965</th>
<th>Cagles Mill 1965</th>
<th>Cagles Mill 1966</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boating</td>
<td>36.0</td>
<td>36.0</td>
<td>33.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Camping</td>
<td>18.6</td>
<td>21.0</td>
<td>16.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Picnicking</td>
<td>32.0</td>
<td>33.3</td>
<td>25.5</td>
<td>30.3</td>
</tr>
<tr>
<td>Swimming</td>
<td>42.0</td>
<td>55.1</td>
<td>45.5</td>
<td>47.5</td>
</tr>
</tbody>
</table>
Arrival distributions were plotted in order to determine the arrival patterns both for total trips and for each trip purpose. Considerable variations exist among the days of the weekend - Friday, Saturday, and Sunday - and are shown in Figures 7, 8 and 9. The only major difference between parks noted was in the magnitude of trips per hour. This effect, as already explained, was due to the population distribution around the parks.

The values for the arrival distributions were obtained by averaging the summer weekend observations for the months of June, July and August. From Figure 10, it can be seen that less than 30 percent of the total annual trips to a park are made prior to June. By the end of August, more than 90 percent of the total annual trips have been made. The arrival rates for the months other than June, July, and August will be much less than those plotted in Figures 7, 8 and 9. These Figures record the average arrival rates and daily distributions for the summer months for the parks involved.

Figure 11 shows trip rates by purpose. The values were determined in the same manner as were the values for total trips. The plots show the relative attractiveness of each activity.

Of interest is the relationship of the curves to each other in terms of distance. For distances of less than 30 miles, swimming as a trip producer is ahead of all the others; beyond that point, boating is the most attractive. Beyond 70 miles, picnicking and camping are more attractive than
Figure 7
Total trip arrivals to Mansfield in 1965
FIGURE 8
TOTAL TRIP ARRIVALS TO CAGLES MILL IN 1965
Figure 9

Total Trip Arrivals to Cagles Mill in 1966
CUMULATIVE TRIPS

MONTHS

MANSFIELD
CAGLES MILL
MONROE

FIGURE 10
CUMULATIVE TRIPS
FIGURE II
TRIP RATES BY PURPOSE FOR CLOSEST PARK - 1965
swimming. The curves for boating, picnicking, and camping tend to converge with an increase in distance and swimming decreases.

**Persons Per Trip.** The average number of persons per trip is shown in Table 6. The values were obtained by dividing the total number of people sampled who visited a park in a year by the total number of trips sampled in that same year. There is no significant difference among the values, the average value being 3.69 persons per trip.

**Maximum Volume.** It is not enough for the planner to know how many trips will be made to a particular reservoir in any year. The additional information that he requires is the distribution of these trips over the year, the week, and the day, so that he can provide for adequate park facilities, the seasonal hiring of park staff, and easy and adequate access. Since the planner is interested in the maximum volumes, it is in terms of these that the analysis was performed.

Approximately 95 percent of all trips to a reservoir are made between the beginning of April and the end of September. The maximum volume week was determined for each reservoir for each year from official attendance figures, and the average ratio of maximum volume week to total annual trips was calculated to be approximately 10 percent.

In Phase I, it was found that, on the average, 25 percent of all weekly trips arrived at the reservoir during the period Monday through Friday a.m., assuming similar weather conditions. This means that, on the maximum volume weekend, 75 percent of 10 percent of the total annual trips to the reservoir can be expected, which amounts to 7.5 percent.
TABLE 6
AVERAGE NUMBER OF PERSONS PER TRIP

<table>
<thead>
<tr>
<th></th>
<th>1965</th>
<th>1966</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mansfield</td>
<td>3.72</td>
<td>3.40</td>
</tr>
<tr>
<td>Cagles Mill</td>
<td>3.84</td>
<td>3.63</td>
</tr>
<tr>
<td>Monroe</td>
<td>3.80</td>
<td>3.63</td>
</tr>
</tbody>
</table>
Approximately 50 percent of all weekend trips arrived on Sunday. It therefore was concluded that on the maximum volume weekend, reservoir attendance would amount to 7.5 percent of the total annual trips, and that the highest daily volume would be 3.75 percent of the total annual trips on a Sunday.

**Return Visitors.** The percentage of visitors who visit the parks more than once in a year was determined by the letter interviews conducted during the fall and winter of 1965. Eighty-three percent of those who sent back the questionnaires indicated that they had visited the parks more than once. Forty percent of the questionnaires distributed at the park were returned. The average number of visits to that park per person interviewed was 8.5. The high percentage of multiple visits is probably a good measure of user satisfaction. Comments on the questionnaire indicated little dissatisfaction with the type of facilities available or with the manner in which the parks were operated.

**Model Development: Phase II**

The model developed in Phase I used trips per 1000 population; this was also used in this phase. The official attendance figures (vehicles) for each year at Mansfield and Cagles Mill were obtained from attendance records maintained by the Department of Natural Resources; Monroe attendance figures were obtained from the Park Superintendent, Monroe Reservoir and the U. S. Department of Agriculture Forest Service.
For each reservoir, a plot of the county trip rates (calculated from 1967, 1968, and 1969 data) versus distance from the reservoir again indicated an exponential relationship. This supported the Phase I choice of an exponential model to describe the 1965 and 1966 data.

The Phase I model consisted of two regression equations. One equation was to be used for counties that are closest to a specified reservoir, and the other for counties that are closer to one or more other reservoirs than to the specified reservoir. The decision was made to arrange the data into nine subgroups. Six of the data subgroups were for a combination of Cagles Mill and Mansfield (one for each of the three years of data for each of the CLOSEST and INTERVENING reservoir conditions); the last three were for Monroe (each of the three years of data but not separated by CLOSEST and INTERVENING reservoir conditions). There are two reasons for isolating Monroe data; firstly, it was apparent from the total attendance figures that Monroe was still in its initial growth period (in contrast to Cagles Mill and Mansfield which were older reservoirs); secondly, Monroe is a much larger reservoir than the other two (10,750 acres compared to Cagles Mill's 1,400 and Mansfield's 2,100), and is, in a sense, unique, since it will remain the largest single body of water in the state for many years. The latter is essentially why CLOSEST and INTERVENING were not considered significant conditions for Monroe. It was felt that Monroe
is such a large trip attractor that intervening opportunities were not really applicable. It was also reasoned that most of the reservoirs planned in the state will be more nearly the size of Cagles Mill and Mansfield; therefore, for predictive purposes, a model based on data from these two reservoirs should be more reliable than one which either includes Monroe data, or is based on Monroe data alone.

**Monroe Model.** One idea underlying the analysis for the Monroe model was that if it could be shown that the parameter \( B_1 \) (for \( i = 1 \) to 3) did not vary significantly between the three years, it might be possible to derive a prediction equation (with a pooled estimate of parameter \( B \)) by extrapolating the parameter \( A \) to the design year.

The first step in the analysis therefore, was to test for homogeneity of variances of the trip rate data over the three year period. This assumes that the regression equations were reasonable predictors of the data (which they were). Under these conditions, testing for homogeneity of variances in the data is approximately equivalent to testing for homogeneity of the error estimates of the regression equations. Homogeneity of the error estimates of the regression equations is necessary in order to test the significance of \( B_1 \).

Two tests were applied to the data: firstly, Bartlett's Test (7), in which a chi-square statistic is computed (assuming normal populations); and secondly, the Foster-Burr Test (8), in which a Q statistic is computed which is a monotone function
of the coefficient of variation of the sample variances. The fact that the populations were not normal reduces the inferences possible from Bartlett's Test; however, less research has been directed towards non-normal populations than to normal populations, so the test was applied bearing the limitations in mind.

It was decided to delete from the data those counties with low trip rates (less than 1.0) as homogeneous variances then would be more likely to result. This reduced the sample sizes from 64 for each year to 52, 46, and 51 for 1967, 1968, and 1969 respectively. Bartlett's Test and the Foster-Burr Test were applied to these data; the chi-square statistic from Bartlett's Test was 0.393, and the Q statistic from the Foster-Burr Test was 0.335, both of which are insignificant at an $\alpha$-level of 0.01. The hypothesis of homogeneity of variances in this case could not be rejected.

It was then possible to test the hypothesis that the parameters, $B_i$, for each of the three data years were equal. The procedure, explained in Ostle (9), is to first test the hypothesis that all the observations can be described by one regression equation. If the F-statistic computed is significant (leading to the rejection of the hypothesis), the hypothesis of equal parameters $B_i$ can be tested by another F-test. F-values of 8.63 and 0.496 respectively were obtained from the two tests; thus, the hypothesis that all the observations could be described by one regression equation was rejected, but the hypothesis of equal parameters $B_i$ could not be rejected.
The pooled estimate of the parameter B for inclusion in the equation for each year was established by running the non-linear regression program for 1967, 1968, and 1969 data combined. The value of B was calculated to be 0.558. As a last step, the non-linear regression program was rerun for each year, forcing a regression line with parameter $B = 0.558$ through the data, and obtaining the parameter A in the equation:

$$Y = A e^{-0.558X}$$

The three equations that resulted were:

1967: $Y = 217 e^{-0.558X}$
1968: $Y = 355 e^{-0.558X}$
1969: $Y = 634 e^{-0.558X}$

Figure 12 shows how the parameter A varies from 1967 to 1969. The sharp increase that has occurred is a combination of the growth of Monroe in terms of facilities, reputation and popularity, and of an increase in recreational trip-making, in general. The latter, however, is probably a small component.

From the above explanation, an extrapolation of the present trend of the parameter A (line A in Figure 12) is likely to overestimate the design year value of parameter A. What is more likely to happen is a leveling off as indicated by lines B, C, and D. Without more facts however, there is no basis for choosing any one line over the others. It was therefore decided to recommend the value of parameter A as obtained from
FIGURE 12

MONROE - CHANGE IN PARAMETER "A" WITH TIME
the 1969 data and to acknowledge that it is a conservative estimator of the total annual trips to Monroe for any future year.

The choice of the 1969 equation as the prediction equation was not based on the fact that no significant differences were found between the parameters $B_i$. However, the equation recommended as the Monroe Model,

$$Y = 634 \ e^{-0.558X}$$

does include a contribution from the data of each year (in the pooled estimate of $B$), and so that analysis was not ignored. The Monroe Model is shown in Figure 13.

**New Reservoirs Model.** The New Reservoirs Model consists of two equations (one from each of the CLOSEST and INTERVENING conditions) that are considered to be the best for prediction purposes.

Exactly the same procedure that was employed in the development of the Monroe Model was employed to develop the equations for the New Reservoirs Model. Once again, the variances of each year's data were homogeneous after counties with low trip rates (less than 1.0) were excluded from the analysis. The results form Bartlett's Test and the Foster-Burr Test for these data were such that the hypothesis of equal variances could again not be rejected.

The hypothesis of equal parameters $B_i$ for each year for CLOSEST and INTERVENING was tested next, and in both cases it was found that the hypothesis could not be rejected. The data
$Y = 634 \, e^{-0.558X}$

**Figure 13**

Annual Trips to Monroe
for each year were combined within CLOSEST and INTERVENING, and the non-linear regression program was rerun to find a pooled estimate of parameter B for each group. The pooled estimates of B were 0.573 and 0.407 for CLOSEST and INTERVening respectively. The result of forcing these B values through the data for each year gave the following equations:

**CLOSEST**

1967: \[ Y = 520 \, e^{-0.573X} \]
1968: \[ Y = 465 \, e^{-0.573X} \]
1969: \[ Y = 398 \, e^{-0.573X} \]

**INTERVening**

1967: \[ Y = 212 \, e^{-0.407X} \]
1968: \[ Y = 151 \, e^{-0.407X} \]
1969: \[ Y = 136 \, e^{-0.407X} \]

It is immediately apparent that the parameter A is decreasing in both cases (while in the case of Monroe, the parameter A was increasing yearly). To understand why this resulted, the location of Mansfield and Cagles Mill with respect to Monroe should be considered. All three reservoirs are within 60 miles of each other; because of this, it would be naive to believe that the attendance at Mansfield and Cagles Mill would remain unaffected during the growth period of Monroe. It was considered likely that this downward trend in parameter A was a transient response to the appearance of Monroe, and that it will not continue for more than a few years. For this reason, and because most future recreational reservoirs in Indiana (for which the New Reservoirs Model is intended)
will not be close to such a large facility as Monroe, it was decided to recommend the equations that were developed from the 1967 data for CLOSEST and INTERVENING.

The actual equations thus adopted as the New Reservoirs Model are:

CLOSEST: \[ Y = 520 e^{-0.573X} \]
INTERVENING: \[ Y = 212 e^{-0.407X} \]

Note that both these equations, which are shown in Figures 14 and 15 respectively, use the pooled estimate of the parameter \( B \).

**Land Value Changes**

In order to investigate land value increases in the vicinity of a reservoir and to measure this effect, land value information was obtained from the deeds on file in the respective county courthouses. Two groups of land values were determined for each reservoir. One group was designated the control group and consisted of randomly selected parcels of land that were five miles or further from the reservoir. The second group was composed of land parcels within one mile of the reservoir.

Land value was determined from the Federal Revenue Stamps required on deeds. These stamps are placed on the deed and give a measure of the stated purchase price. Previous work by Hensen, Michael and Matthias showed this method to be effective (10).
$Y = 520 e^{-0.573X}$

**Figure 14**

Annual Trips to Closest Park
ANNUAL TRIPS WITH INTERVENING PARK
Only unimproved parcels were considered since more than deed information would have been necessary to separate the cost of improvements from the cost of the land. Parcels that were transferred between related persons were also ignored as the cost of land in such transactions may not represent the true value of the land. Land bought by the Government was also not included in the sample as a truly willing buyer-willing seller relationship may not have existed.

In order to make comparisons, the average cost of an acre was determined for both groups of land for each park for two year periods. Two year periods were used in order to have enough samples for a meaningful average. The results are shown in Figures 16, 17, and 18. The curves were fitted by linear regression techniques. It is clear that there is a difference in the value of land near a reservoir in comparison to similar land that is not near the same reservoir. It is also clear that there is a substantial variation among the reservoirs as to cost differential and as to time effects. The first value plotted for each curve is for the two year period when the Government began buying land for the reservoir. Additional research in this area is recommended.

The data indicates further that the value of land near a reservoir is greater than similar land distant from the reservoir and could be useful in combatting claims, such as that made by Parke County Officials that the Mansfield
Figure 16
Land Values for Mansfield
FIGURE 17
LAND VALUES FOR CAGLES MILL
FIGURE 18

LAND VALUES FOR MONROE
reservoir took four sections of taxable land (assessed at $250,000) off the tax roles. The increased value of land near a reservoir if properly valued in subsequent reassessments should over a rather short period of time recoup such losses. In addition, development near the reservoir to service the new activities will result in additional assessable value rather quickly.

SUMMARY

The primary objective of this study was to develop a simplified procedure for estimating the number of annual vehicular trips to recreational areas associated with multipurpose reservoirs; then, further to examine the stability of the developed model for making long range forecasts of attendance. Several factors influenced the approach taken. Based upon information provided by the Division of State Parks, Department of Natural Resources, it was concluded that with the exception of size the recreational park characteristics of future reservoirs would be approximately the same. Multiple linear regression models of earlier research at Purdue (3) had utilized a large number of park characteristics because of the variability of the State Parks in the State. The researchers on the study summarized in this report noted that the complexity of that earlier model limited its use for forecasting.

Their choice of an exponential model, \( Y = A e^{-Bx} \), to relate trip rates and distances was established in Phase I and substantiated by data collected during the second phase;
three equations of the same form were developed. Of these three equations, two (developed from data collected at Mansfield and Cagles Mill Reservoirs) constitute the New Reservoirs Model. The third equation (the Monroe Model) is recommended for prediction of annual trips to Monroe Reservoir only or to other reservoirs with similar characteristics to those of Monroe. The main reason for developing a separate model for Monroe was its uniqueness.

The two equations developed in the initial phase for the CLOSEST and INTERVENING categories were $Y = 338 e^{-0.579X}$ and $Y = 129 e^{-0.488X}$ respectively. Comparing the equations from both phases, it was found that while an increase in the value of the parameter $A$ (by factors of 1.54 and 1.64 for the CLOSEST and INTERVENING categories respectively) occurred over time, there was little change in the value of parameter $B$ (almost none for the CLOSEST category). This is an important result, since it implies that a growth in the trip rates (which was investigated in Phase II) is best measured by changes in the value of parameter $A$. Furthermore, if continued study indicated changing trip rates, only the parameter $A$ in each of the two equations need be adjusted. It is not known from this or other research how much or in what manner the $A$ parameters of the two equations are likely to change over a period of one or two decades. The data collected in this recreational study indicated that any prediction of the future behavior of $A$ would be unwise; only the fact that $A$ did increase over time was observed.
There are many factors which could influence the value of parameter A. Although not a part of this research, one might expect that increased popularity of boating and waterskiing could affect the value of A. This increase might be caused by significant reductions in the price of boats due to improved technology in the plastics industry. Shortages of gasoline might have just the opposite effect. Increased sales volumes, lower prices and a wider range of choices on recreational vehicles will probably affect the value of A. It should be noted, however, that the researchers do not suggest that the model would be better if factors such as noted above were included in the model. The model should include enough causative parameters to give confidence in its results but not so many as to discourage its use.

The single equation that constitutes the Monroe Model is $Y = 634 \, e^{-0.558X}$. There is no way of comparing this equation with those of the New Reservoirs Model, because it was developed using all counties within 125 miles of Monroe in one category. No Monroe data were used in the initial phase (because Monroe was not yet developed sufficiently), so there is no way of making a comparison for this model between the two phases of the study. It should be noted that the recommended equation is a conservative estimator for the total annual trips to Monroe, since Monroe was still in its initial growth period.
It is concluded that the New Reservoirs Model, which is based on easily understood and readily obtainable variables (distance, population, and the influence of similar facilities) should be capable of predicting future attendance (and from whence they came) at new reservoirs with a reasonable though conservative estimate. In contrast to other previously developed models, which utilize many socio-economic and park characteristic variables (often difficult to measure and evaluate and extremely difficult to project), the New Reservoirs Model is much simpler to use and probably as accurate. The New Reservoirs Model should be adequate for advanced planning purposes and can be used to predict recreational reservoir attendance, traffic volume estimates and origins of that traffic. It is evident, however, from this research that the demand function is subject to change and that the developed model will need to be under constant surveillance for changing values of parameter A.

APPLICATION PLAN

The objectives of Phase II of the research also included the development of a simplified procedure that could be easily implemented by the highway department. The simplified prediction procedure for new reservoirs can be summarized as follows:

1. Determine the location of the reservoir.
2. Locate other similar recreational facilities.
3. Determine the road distance (miles) to the reservoir from counties within 125 miles
4. Obtain county population predictions for the design year.
5. Determine which of the counties are closest to the reservoir under study than to any other similar facility.

6. Determine the trip rates for each county closest to the reservoir from Figure 14.

7. Determine the trip rates for the remaining counties from Figure 15.

8. For each county, calculate the total annual trips for the design year by multiplying the trip rate by the population prediction.

9. Sum the total annual trips for all counties. Divide by 0.9 to account for trips originating further than 125 miles away. The final figure is the estimated total annual trips for the design year.

The first and second Interim Reports (6), (11) of this study provided application examples of the models developed. In the first Report, a forecast of traffic to be attracted to the proposed Wildcat Reservoir during 1975 if it were then in use was made to demonstrate the simplicity of the technique. The second Interim Report forecasted 1975 trips to the Mississinewa Reservoir, then under development.

Since the submission of the above reports, further computations have been made on Mississinewa to predict attractions to the reservoir for 1970 and 1971. Using the New Reservoirs Model, the forecasted attendance for 1971 was 357,000. As noted in this report, the models should provide forecasts that are inherently conservative. An Indiana Department of Natural Resources estimate of the total attendance at Mississinewa for 1971 is 665,200 people. The extent by which the New Reservoirs model underforecast this travel is considerable and gives support to a continued program of research which would monitor
the trends affecting parameter A in the model. The values for parameter A in the New Reservoirs model are for 1967 demand conditions. These conditions may have been much changed for 1971 and may be even further changed by 1975.
LIST OF REFERENCES


6. Matthias, J. S., Recreational Impact of Multi-Purpose Reservoirs, Joint Highway Research Project, Purdue University, No. 20, August, 1967.


