AVAILABLE WATER SUPPLY AND FUTURE DEVELOPMENT

A theoretical maximum water supply potential for the basin may be estimated using monthly discharges to derive average long-term total runoff. These figures give a general idea of the amount of precipitation which falls on the basin and is not used consumptively on a long-term basis.

The runoff volumes in the second column of table 26 were generated for the Indiana portion of the Whitewater River Basin, a total drainage area of 1329 sq. mi. The values are based on the 10 years of monthly discharge data collected at the gaging station on Whitewater River at Brookville for the post-reservoir period 1975-84.

As discussed previously in this report, the impoundment of Brookville Lake has changed the within-year distribution of flows. It was also shown that the average discharge is estimated to have been reduced by 2.5 percent as a result of the impoundment.

Because the monthly and yearly averages based on only 10 years of post-reservoir data have very limited value for planning purposes, an estimate of the long-term (62-year) average discharge for the existing (post-reservoir) condition was made by reducing the long-term pre-reservoir average basin runoff by 2.5 percent and then adding the post reservoir data to the adjusted series. The total yearly long-term average basin runoff of 319.9 billion gallons thus found was then distributed into monthly values according to observed monthly distribution of the post-reservoir data. These values are given in the third column of table 26.

The underlying assumption for derivation of long-term post-reservoir estimates is that the effect of Brookville Lake operation on downstream flows could be assumed to remain almost the same for wetter or dryer periods as compared to the 1975-84 period. It should be emphasized that the listed potential monthly supplies represent long-term average values. During dry years, when consumptive demands are at high levels, the available water supplies can be significantly less than average.

Water in the basin may be used and reused many times before it is lost to evaporation or as outflow from the basin. As long as the water is not used consumptively and the quality of the resource is not altered to the point that it becomes unsuitable for some purposes, there are very few limitations on total water use. However, constraints on water use in a particular location may result from its competing value for the maintenance of reservoir levels, for recreation, for support of aquatic life, for the availability of supply for downstream domestic and industrial water users, and for the provision of assimilative capacity for thermal loadings and wastewater treatment plant effluents.

Table 26. Mean monthly runoff volumes for Whitewater River at Brookville

{All values in billion gallons.}

Month	Runoff volume	
	10-year average[1]	62-year average[2]
April	39.3	36.6
May	37.0	34.5
June	19.9	18.5
July	17.8	16.6
August	19.7	18.3
September	8.0	7.4
October	14.8	13.8
November	23.6	22.0
December	34.4	32.0
January	33.1	30.8
February	41.0	38.1
March	55.1	51.3
Total yearly	343.7	319.9

[1]1975-84

[2]1916-17, 1924-73, 1975-84

It is important to note that future developments which cause increased consumptive use would not only reduce the total yearly long-term average value in table 26, but also would usually modify the hourly, daily, monthly, and even yearly distribution of the remaining theoretical upper limit of available supplies, depending on the nature of the project.

SURFACE-WATER AVAILABILITY

Significant Surface-Water Sites

An important aspect of water resource management is the identification of sites where there will be growth in demand for surface water or where surface water supply may be developed. Also important is the identification of sites where shortages may occur.

A significant surface-water site is a location where there is one or more of the following conditions: 1) a relatively large supply; 2) a relatively large demand; or 3) an insufficient water supply.

Four sites have been selected in the Whitewater River Basin (see fig. 33). Middle Fork Reservoir (site 16) has been selected as a significant site because it supplies Richmond, Indiana, the largest city in the Whitewater Basin, with about 60 percent of its water. The reservoir with its large supply and demand was thus investigated to determine its safe yield.

Although the West Fork of the East Fork Whitewater River (site 17) has not been developed as a supply for Richmond, it could be developed for that purpose and therefore was investigated as a significant site.

Brookville Lake, the third significant site (site 25) is the largest reservoir in the Whitewater Basin and is significant because of its large water supply. Prior to construction of the reservoir, the State of Indiana entered into an agreement with the U.S. Government to purchase the 89,300 acre-feet of water stored between elevations 713 feet m.s.l. and 740 feet m.s.l. for sale to any interested party. Contracts and rates charged are negotiated and administered by the Indiana Department of Natural Resources.

The fourth significant site is Salt Creek near Oldenburg (site 13) which is in an area of the Whitewater Basin that has little ground water. Salt Creek was investigated as a source of water supply because of its proximity to Batesville, which lies just beyond the basin divide and which has water treatment facilities.

Safe Yield

Reservoirs

To plan for the future use of surface water, the dependability of the supply must be known. The yield of a water supply is the amount of water that is available for use during some period of time, such as a day, a month, or a year. The safe yield of a reservoir has been defined as the minimum yield during the life of the reservoir (Linsley and others, 1982). Typically, safe yield is determined as the minimum yield during the worst dry period of record.

The concept of safe yield is misleading, however, because there is some probability that a period drier than the worst of record will occur. Even if a reservoir could be built large enough to always supply a guaranteed minimum yield, its cost might be unacceptably high.

A better approach to specifying the dependability of a water supply is to specify the probability of supplying the required demand during the life of the reservoir. The dependability of a reservoir of a given capacity will decrease as the level of demand increases. For a specified level of dependability, the storage required increases as the level of demand increases.

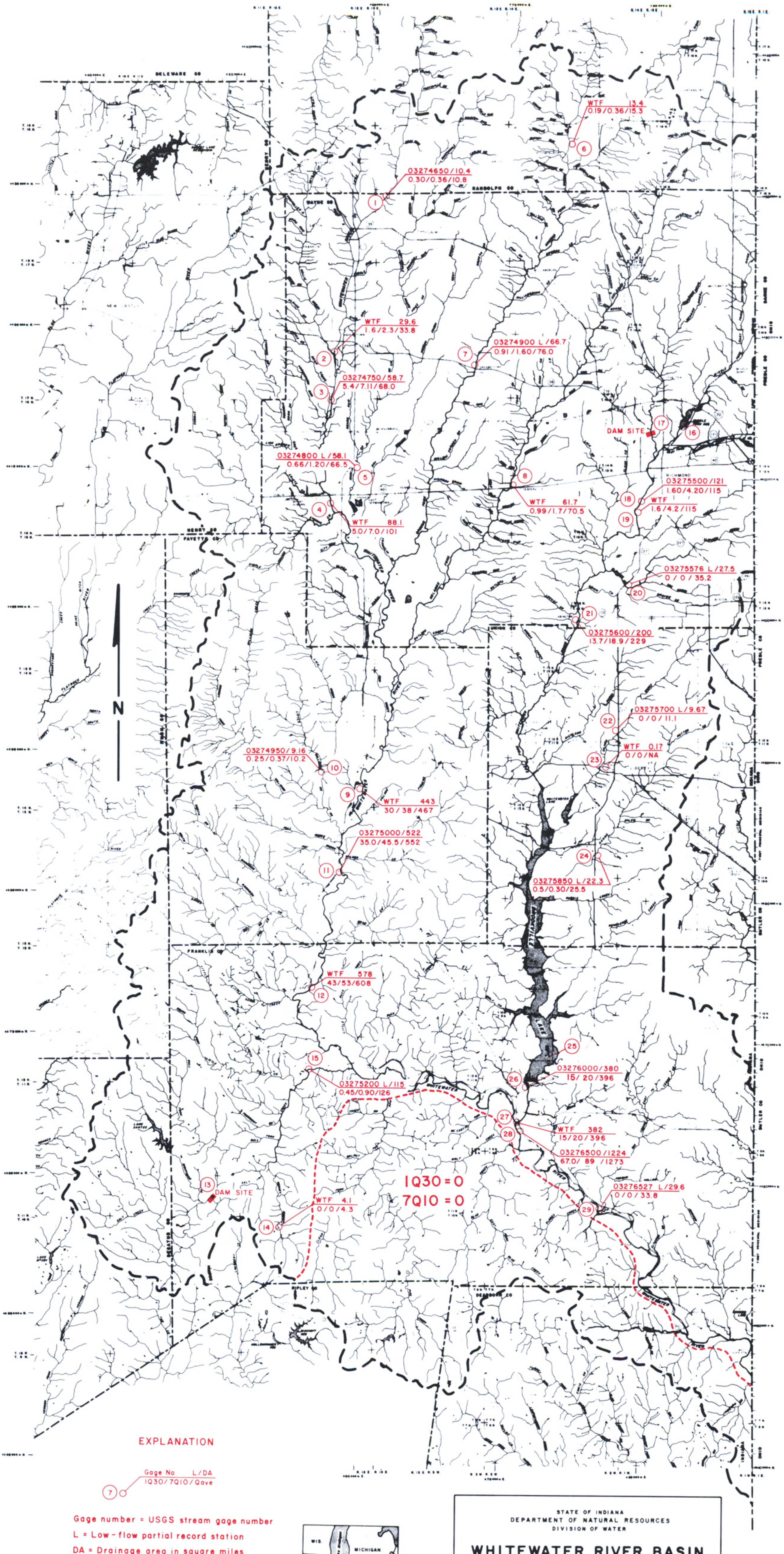
The storage required to meet a specified demand depends on the average stream flow, stream-flow variability, the magnitude of the demand, and the degree of dependability desired (see McMahon and Mein, 1986). The higher the desired level of dependability, the larger the reservoir needs to be. Dependability is defined and discussed in app. 13.

Selection of a storage capacity which will satisfy water demands of all users with the highest degree of dependability is not usually warranted. For irrigation requirements, the degree of dependability is usually recommended to be in the range of 75 to 85 percent, while for domestic and industrial water supply the desired dependability is usually in the range of 95 to 98 percent. Considering the envisaged purposes of water resources development in the Whitewater Basin, the dependability level of 98 percent has been adopted in the storage-yield analyses performed in this study. This level of dependability corresponds to allowing no deficits within a 50-year period of reservoir operation.

One way of determining the storage required is from a mass curve or Rippl diagram. The mass curve is a graph of the cumulative volume of inflow to the reservoir versus time and is derived from historical streamflow data. The worst dry period of record is usually used to determine the storage required but the entire period of record may also be used. The procedure is to select a range of anticipated drafts (levels of demand) and to determine the storage required for each draft. The results can be plotted as a curve which relates storage required to draft.

A computer program by Beik (1986) entitled YIELD performs mass-curve analysis for the period of data record at a given site. This program will determine the storage required to meet a given level of demand throughout a given period of record without allowing any deficits. If desired, the program will also determine the storage required if one, two, or more years of supply cut-backs during the life of the project can be tolerated by some users. The YIELD program was used to analyze the storage required for various drafts for three sites in the Whitewater Basin.

Middle Fork Reservoir, (fig. 33, site 16, Qave = 32.2 mgd, DA = 47.2 sq. mi.) supplies about 60 percent of Richmond's water. The average water use dur-



EXPLANATION

Gage No. L/DA
1Q30/7Q10/Qave

Gage number = USGS stream gage number

L = Low-flow partial record station

DA = Drainage area in square miles

1Q30 = 1-day, 30-year low flow in cfs

7Q10 = 7-day, 10-year low flow in cfs

Qave = Average flow in cfs

WTF = Wastewater Treatment Facilities

(7) Map location number

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

WHITEWATER RIVER BASIN

Compiled by: Richard F. Geekie

Drafted by: Burton C. Daniels, Supv.
Donald L. Spilmon
Connie K. Williams
Abbie G. George

SCALE AS SHOWN

Figure 33. Surface-water availability

ing 1985 from Middle Fork was 3.8 mgd (5.9 cfs).

The original plan for Middle Fork Reservoir was to build it in two phases. Phase One had a principal ogee spillway with a crest elevation of 971 feet m.s.l. Phase Two was a plan to add Tainter gates which would raise the maximum elevation to 985 feet m.s.l. Phase Two had not occurred as of 1986 and there is presently no plan to install the Tainter gates.

The Surveying Section of the Division of Water completed a hydrographic survey of Middle Fork Reservoir in 1986. The soundings taken were used to develop the depth curves of fig. 34. Information from this survey was used to estimate the amount of sedimentation that had occurred since the reservoir was first put into operation in 1961. The original storage at elevation 971 feet m.s.l. was 1010 million gallons (3095 acre-feet). The storage at this elevation in 1986 was 881.1 million gallons (2704 acre-feet). This means that 129 million gallons (391 acre-feet) have been lost to sedimentation in 25 years of operation.

A series of monthly discharges for a period of 55 years was generated for the reservoir site based on the records available for the Alpine stream gaging station from 1929-84. Reservoir evaporation was assumed to be about 3.13 feet per year based on data available for Brookville Lake and different gages in the general area. A dead storage volume of 255 mg (782 acre-feet) was set aside for sediment accumulation in the next 50 years of life of the reservoir. This value was based on the average sedimentation rate of 5.16 mg/year (15.64 acre-feet/year) as observed in the past 25 years of operation of Middle Fork Reservoir.

To find the capabilities of the existing Middle Fork Reservoir and also evaluate the effects of adding the Tainter gates to increase the usable reservoir storage, a draft-storage relationship was calculated by running the computer program YIELD successively for different assumed values of demand. The resulting values given in the table 27 are the total storage values required at the site to meet the given level of demand (draft) with no deficits allowed. These values include active storage needed to regulate the supply, dead storage needed for sediment accumulation, and storage to account for evaporation losses.

Fig. 35 shows the above relationship in graphical form. The so-called "draft-storage curve" enables one to estimate the storage required at the site to maintain a known demand with a predetermined dependability (in this case, 98 percent dependability). Conversely, the curve also enables one to estimate the expected dependable yield of a reservoir with an assumed or known storage capacity.

Table 27. Draft-storage: Middle Fork Reservoir

Draft		Storage	
cfs	mgd	ac-ft	mg
5	3.2	980	319
7	4.5	2038	664
8	5.2	2609	850
8.2	5.3	2704	881
10	6.5	3771	1229
12	7.8	5199	1694
12.8	8.3	5800	1890

As fig. 35 and table 27 show, the existing total storage capacity of 881 mg (2,704 acre-feet) in Middle Fork Reservoir can supply a dependable draft of approximately 5.3 mgd (8.2 cfs) during the next 50 years of life of the project. Installation of the proposed Tainter gates would increase the total storage to 1,890 mg (5,800 acre-feet) and increase the capability to about 8.3 mgd (12.8 cfs).

The projected total water demand for the Richmond area in the year 2000 is about 6.37 mgd. It is assumed that 60 percent or 3.8 mgd will come from Middle Fork Reservoir. The dependable yield of Middle Fork Reservoir (5.3 mgd) exceeds this projected surface-water demand of 3.8 mgd for the year 2000.

The draft-storage analyses of the **West Fork** dam site (fig. 33, site 17, Qave = 14.1 mgd, DA = 20.7 sq. mi.) was similar to the analysis of the Middle Fork Reservoir. A series of monthly discharges for a period of 55 years was generated for the site based on records available for the Alpine Station from 1929 to 1984. Reservoir evaporation was assumed to be about 3.13 feet per year. A dead storage volume of 112 mg (343 acre-feet) was set aside for sediment accumulation in the next 50 years of life of the reservoir. This value was based on an average sedimentation rate of 0.11 mg/sq. mi./year (0.33 acre-feet/sq. mi./year) as observed in the past 25 years of operation of Middle Fork Reservoir.

Table 28 presents the storage capacities required for various drafts. The storage capacities include storage for evaporation and sediment. Fig. 35 shows the draft-storage relationship in graphical form. Installation of Tainter gates would be a less costly way of increasing supply to Richmond than constructing a new dam on the West Fork.