RECEIVED

JUL 23 2004

PUBLIC SERVICE
COMMISSION

KENTUCKY-AMERICAN WATER COMPANY
STORAGE CAPACITY ANALYSIS
November 15, 2002

STATE OF KENTUCKY
LINDA
CAROL
BRIDWELL
17603
REGISTERED
PROFESSIONAL ENGINEER

KENTUCKY-AMERICAN WATER COMPANY
STORAGE CAPACITY ANALYSIS
November 15, 2002

A. INTRODUCTION

Kentucky-American Water Company (KAWC) provides water service and fire protection to Fayette County and portions of Bourbon, Harrison, Scott, Woodford, Jessamine, Clark, Owen, Grant and Gallatin Counties in central Kentucky. A total of 105,246 customers were served as of October 31, 2002 that represents an estimated total population of 300,000 people. This includes approximately 1,800 customers of the former Tri-Village Water District and Elk Lake Water System in Owen County that were acquired in 2001 and 2002 respectively. The storage related to these two Owen County systems has not been included in this analysis since these two systems currently have storage in excess of the average daily demand. The Clark County service area was acquired by KAWC in 1999 and integrated into KAWC's Lexington system in 2001. A small portion of Clark county service area (300 customers) is fed from the City of Winchester.

The KAWC service area utilizes two primary sources of supply: the Kentucky River and Jacobson Reservoir. In an emergency, a third source of supply, Lake Ellerslie, can also be utilized; however, it has a very low safe yield. The system also includes two treatment plants: the Kentucky River Station (KRS), which is rated for 40 MGD, and the Richmond Road Station (RRS), which is rated for 25 MGD. As of November 28, 2000 the KRS was granted a temporary re-rated capacity of 45 mgd during summer months by the Division of Water (DOW). Further, KAWC has demonstrated the capability of producing up to 50 mgd from KRS and 26 mgd from RRS while maintaining good finished water quality. The DOW has recognized temporary instances on any given day where a system must exceed the reliable plant capacity to meet system demands provided that health standards are met and proper disinfection is maintained. Water treated at KRS is derived only from the Kentucky River whereas RRS is piped to treat water from the Kentucky River, Jacobson Reservoir, or Lake Ellerslie.

The KAWC distribution system consists of approximately 1,526 miles of mains and 6,478 fire hydrants. The mains range in size from 2" to 36" with mains larger than 6" comprising 65% of the total footage. The system is divided into three pressure gradients known as Main Service, High Service, and Sadieville and includes a total of 12 storage tanks (both elevated and pumped storage) and 12 booster stations. A summary of the existing KAWC storage and pumping facilities is provided in Exhibit No. 1 on the following page.

STOLL | KEENON | & | PARK | LLP

300 WEST VINE STREET | SUITE 2100 | LEXINGTON, KENTUCKY 40507-1801
(859) 231-3000 PHONE | (859) 253-1093 FAX | WWW.SKP.COM

LINDSEY W. INGRAM, JR.
859-231-3033
ingramjr@skp.com

RECEIVED
JUL 08 2004
DIVISION OF ENGINEERING

July 8, 2004

Via Hand Delivery

Jason Brangers, Esq.
Public Service Commission
211 Sower Blvd.
Frankfort, Kentucky 40601

RECEIVED
JUL 23 2004
PUBLIC SERVICE COMMISSION

RE: Case No. 2004-00254

Dear Mr. Brangers:

In response to the Executive Director's letter of July 2, 2004, and your telephone conversation with Linda Bridwell, I enclose four copies each of Kentucky-American Water Company's Storage Capacity Analysis dated September 1993 and November 15, 2002, each bearing the original signature and seal of Linda Carol Bridwell, Registered Professional Engineer of the Commonwealth of Kentucky.

Very truly yours,

STOLL, KEENON & PARK, LLP

By Lindsey Ingram
Lindsey Ingram, Jr.

/sl
Encs.
cc w/o encs.: Linda C. Bridwell
312\C:\work\lwi\kawc\russell Cave\004 Brangers.doc

B. REGULATIONS/HISTORY

The Kentucky Public Service Commission Title 807, Chapter 5 - Utilities, Section 4 - Continuity of Service, paragraph (4) states "the minimum storage capacity for systems shall be equal to the average daily consumption." Section 4 is entitled "Continuity of Service" and generally deals with provisions to provide continuous supply to customers during various emergency situations. The "emergency" storage is generally required so that an adequate supply of water is available in the event of a scenario where water cannot be distributed from the system's source and treatment facilities. Reasons for not being able to supply water to the system could include an emergency in the source of supply (such as a spill), a power failure, or an upset or other treatment problem.

EXHIBIT NO. 1
Kentucky-American Water Company
Existing Storage and Pumping Facilities

Raw Water Pumps

Intake	No. of Pumps	Total Pumping Capacity (MGD)	* Reliable Pump Capacity (MGD)	** Standby Pump Capacity (MGD)
Kentucky River	6	74.4	62.0	0.0
Jacobson Reservoir	3	22.8	9.4	13.4
Lake Ellerslie	2	10.0	4.0	6.0
Total	**11**	**107.2**	**75.4**	**19.4**

Finished Water Storage at Treatment Plants

Plant	Clearwell Volume (MG)	No. of Pumps	Total Pumping Capacity (MGD)	* Reliable Pump Capacity (MGD)	** Standby Pump Capacity (MGD)
KRS	2.97	6	51.6	41.7	9.9
RRS	1.05	6	37.0	27.0	16.5
Total	**4.02**	**12**	**88.6**	**68.7**	**26.4**

Main Service Gradient Storage Facilities

Tank	Year Built	Volume (MG)	Elevated	Overflow Elevation	No. of Pumps	Total Pumping Capacity (MGD)	* Reliable Pump Capacity (MGD)	** Standby Pump Capacity (MGD)
Clays Mill	1995	3.00	No	1022.50	2	18.00	9.00	9.00
Tates Creek	1954	0.50	Yes	1185.25	0	N/A	N/A	N/A
Parkers Mill	1968	3.00	No	1025.00	1	9.00	0.00	9.00
York Street	1949	1.00	No	1000.25	1	2.50	0.00	0.00
Cox Street Ground	1948	1.00	No	1001.75	1	2.50	0.00	0.00
Cox Street Elevated	1955	1.00	Yes	1117.00	1	3.00	0.00	0.00
Mercer Road	1965	2.00	Yes	1107.00	1	5.00	0.00	0.00
Hume Road	1988	3.00	No	979.50	3	9.00	6.00	6.00
Total		**14.50**			**10**	**49.00**	**15.00**	**24.00**

High Service Gradient Pumping Facilities

Booster	No. of Pumps	Total Pumping Capacity (MGD)	* Reliable Pump Capacity (MGD)	** Standby Pump Capacity (MGD)
Briar Hill	2	4.00	2.00	0.00
Mt. Horeb	2	1.15	0.57	0.00
Newtown	3	7.70	4.70	7.70
Delaplain Road	1	0.85	0.00	0.00
Total	**8**	**13.70**	**7.27**	**7.70**

High Service Gradient Storage Facilities

Tank	Year Built	Volume (MG)	Elevated	Overflow Elevation	No. of Pumps	Total Pumping Capacity (MGD)	* Reliable Pump Capacity (MGD)	** Standby Pump Capacity (MGD)
Briar Hill	1998	0.75	Yes	1150.00	0	N/A	N/A	N/A
Muddy Ford	1989	0.75	Yes	1130.00	0	N/A	N/A	N/A
Hall	1962	0.21	No	1115.00	2	0.58	0.29	0.00
Total		**1.71**			**2**	**0.58**	**0.29**	**0.00**

Sadieville Gradient Storage Facilities

Tank	Year Built	Volume (MG)	Elevated	Overflow Elevation	No. of Pumps	Total Pumping Capacity (MGD)	* Reliable Pump Capacity (MGD)	** Standby Pump Capacity (MGD)
Sadieville	1975	0.38	Yes	992.00	0	N/A	N/A	N/A
Total		**0.38**			**0**	**N/A**	**N/A**	**N/A**

MG = Million Gallons
MGD = Million Gallons Per Day
*** Reliable Pumping Capacity = Station capacity with the largest pump out of service**
**** Standby Pumping Capacity = Station capacity during a power outage using an alternate power source (i.e. diesel fuel or natural gas)**

In 1993 the Public Service Commission granted KAWC a variance from this regulation and reduced the storage requirement in the Main Service gradient to 50% of an average day demand by giving credit for standby distributive pumping facilities at the treatment plants. This variance was granted based on the an engineering analysis developed by KAWC in September, 1993 entitled "Storage Capacity Analysis" which reflected KAWC's 1992 Least Cost/Comprehensive Planning Study. The variance was granted in an order dated December 20, 1993. This report updates the findings of the September, 1993 report.

C. PURPOSE OF FINISHED WATER STORAGE

Treated water storage in a water distribution system is provided for various purposes as quoted from the following sources:

1. Introduction to Water Distribution (Volume 3 of AWWA's Principles and Practices of Water Supply Operations)

   Chapter 8, Section 8-1, under the chapter heading "Purpose of Water Storage" states that "water storage in the distribution system is required for the following reasons:

   - Equalizing supply and demand
   - Increasing operating convenience
   - Leveling out pumping requirements
   - Providing water during source or pump failure
   - Providing water to meet fire demands
   - Providing surge relief
   - Increasing detention times
   - Blending water sources"

   Under the chapter heading "Capacity Requirements", it also states:

   "The capacity of distribution storage is based on the maximum water demands in different parts of the system. Capacity varies for different systems and can only be determined by qualified engineers after a careful analysis and study of a particular system. Storage capacity needed for fire protection should be based on the recommendation of fire underwriter's organizations. Because there are so many variables involved, operators should contact the Insurance Services Organization Office or the Fire Insurance Rating Office in their state to obtain any available information.

Additional storage capacity may be necessary to meet emergencies such as pump failure, source failure, or transmission-line break. The need for emergency storage should be based on the reliability of the supply and pumping equipment and the availability of backup equipment and standby power resources."

2. Recommended Standards for Water Works (Ten States Standards)

Chapter 7, Finished Water Storage, states the following in chapter 7.0.1 "Sizing":

"Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demand, and where fire protection is provided, fire flow demands.

a. Fire flow requirements established by the appropriate state Insurance Services Office should be satisfied where fire protection is provided.
b. The minimum storage capacity (or equivalent capacity) for systems not providing fire protection shall be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system."

In summary, the quantity of treated water storage in the distribution system should be the sum of equalization requirements, fire flow storage, and to meet emergency conditions depending on the reliability of the source and treatment facilities, system configuration, and the availability of standby power. The minimum storage capacity equal to the average daily consumption is appropriate where there is no reliability of supply and pumping equipment, and no standby power resources. Section F below describes the analysis of the KAWC system under these criteria.

D. SUMMARY OF PREVIOUS ANALYSIS

In 1993, KAWC submitted a storage capacity analysis to the PSC that recommended the appropriate water storage needs for its system through the year 2005. That analysis evaluated the need for storage based on equalization and fire flow requirements, as well as the need for storage based on the Public Service Commission's requirement of maintaining a supply equal to an average day demand (emergency storage). The results of that analysis, which was segregated for each of the three KAWC pressure gradients known as Main Service, High Service, and Sadieville, are summarized in Exhibit No. 2 on the following page.

If KAWC was to provide one day's emergency storage requirement in the year 2005, storage volume shortfalls of 26.55 MG and 1.44 MG are projected for the Main Service and High Service gradients respectively based on the current storage capacity. However, KAWC at that time requested a deviation from the one-day emergency storage requirement for the Main Service gradient. This was requested on the basis that adequate standby power existed at the company's two treatment plants. The Commission approved this request in their order dated December 20, 1993, and reduced the emergency storage requirement to 50% of the average day demand, or 18.61 MG for the KAWC Main Service gradient. This methodology reduced the storage deficit in the Main Service gradient from 26.55 MG to 7.95 MG.

The 1993 analysis recommended the construction of five storage tanks between 1994 and 2005 in order to eliminate the storage deficit. These included:

1. A 3 mg pumped storage tank to be located in the southwest area of the distribution system.

2. A second 3 mg pumped storage tank at the site of either the existing Hume Road 3 mg pumped storage tank or the Parkers Mill Road 3 mg pumped storage tank.

3. A second 3 mg pumped storage tank at the location of the pumped storage tank to be located in the southwest area of the distribution system

4. A 0.75 mg elevated tank northeast of the Avon Depot and booster station to serve the High service zone.

5. A 1.0 mg pumped storage facility on Russell Cave Road.

EXHIBIT NO. 2
Kentucky-American Water Company
1993 Storage Capacity Analysis

Year	Avg Day (MGD)	Max Day (MGD)	Existing Effective Storage (MG)	Equalization Storage Need (MG)	Equalization + Fire Flow Need (MG)	Equalization + Fire Flow Surplus/Deficit (MG)	Emergency Storage (100%) Requirement (MG)	Emergency Storage Surplus/Deficit (MG)
Main Service Gradient (15% equalization factor)								
1992	37.54	63.79	10.66	9.57	11.49	-0.83	37.54	-26.88
1996	37.67	64.90	10.66	9.74	11.66	-1.00	37.67	-27.01
2000	37.47	65.05	10.66	9.76	11.63	-0.97	37.47	- 26.81
2005	37.21	65.23	10.66	9.78	11.70	-1.04	37.21	-26.55
High Service Gradient (25% equalization factor)								
1992	1.44	1.82	0.95	0.46	1.09	-0.14	1.44	-0.49
1996	2.38	3.01	0.95	0.75	1.38	-0.43	2.38	-1.43
2000	2.39	3.02	0.95	0.76	1.39	-0.44	2.39	-1.44
2005	2.39	3.02	0.95	0.76	1.39	-0.44	2.39	-1.44
Sadieville Gradient (25% equalization factor)								
1992	0.07	0.12	0.25	0.03	0.21	0.04	0.07	0.18
1996	0.07	0.12	0.25	0.03	0.21	0.04	0.07	0.18
2000	0.08	0.12	0.25	0.03	0.21	0.04	0.08	0.17
2005	0.08	0.13	0.25	0.03	0.21	0.04	0.08	0.17

MG = Million Gallons
MGD = Million Gallons Per Day

E. STORAGE IMPROVEMENTS

Since 1993, KAWC has constructed and placed into service two storage facilities to address the emergency storage deficits identified in the 1993 analysis. The Clay's Mill storage tank and booster station was completed in 1996 at a total cost of $3,120,000, and includes 3.0 MG of pumped storage in the Main Service gradient. The Briar Hill elevated storage tank was completed in 1999, and provides 0.75 MG of elevated storage in the High Service gradient. A 4.0 MGD pumping facility was also constructed concurrently with the Briar Hill tank, to boost water into the tank from the Main Service gradient. The total cost of the Briar Hill facilities was $1,640,000.

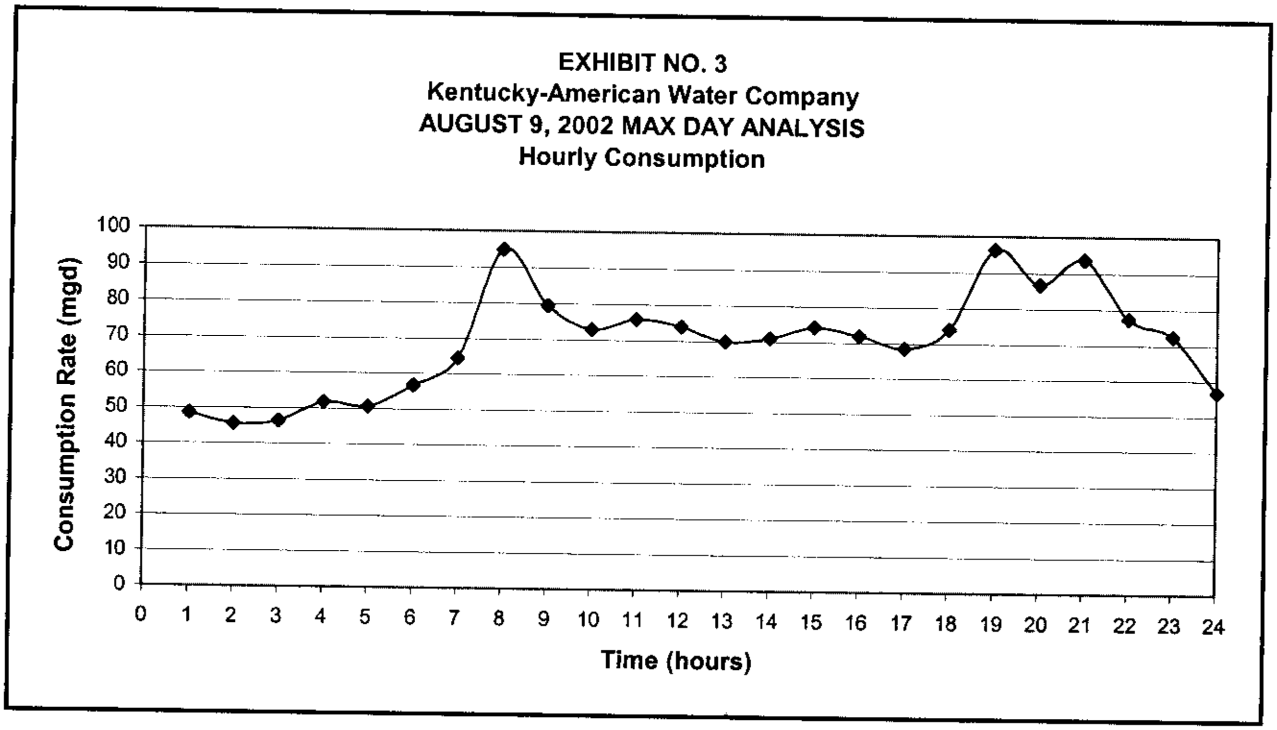
In addition to the above improvements, KAWC's telephone telemetry system was upgraded to a radio based system and completed in February, 2000 at a total cost of $530,000. During thunderstorms, the conventional telephone telemetry system would experience routine outages that prevented KAWC from being able to remotely monitor and control the distribution storage and pumping facilities. The installation of the radio-based system greatly reduced this problem, although loss of the radio system is still a small possibility.

The above storage improvements have reduced the projected deficits in the Main Service and High Service gradients from the 1993 analysis to 5.20 MG and 0.69 MGD respectively based on the emergency storage requirements of the Commission's 1993 Order. They have also eliminated all previously identified storage deficiencies from the 1993 analysis based on equalization and fire flow needs.

KAWC currently has two additional storage tanks under design, with construction scheduled for 2003-2004. A second 3 MG tank is to be constructed at the Clay's Mill site. Also, a 1 MG pumped storage tank referred to as the Russell Cave Road Tank is to be constructed in the High service gradient. The three (3) million gallon tank at Hume Road was projected to be designed in 2003 and constructed in 2004-2005. More details about these tanks are included in Section J.

F. CURRENT STORAGE CAPACITY ANALYSIS

American Water Works Service Co. (AWWSC) has updated the 1993 storage capacity analysis to include the new storage facilities, incorporate updated system demand projections and water usage patterns, and extend the analysis through a planning horizon to the year 2020. The updated study includes a determination of the equalization storage needs based on an hour-by-hour analysis of the plant production rates, incremental storage changes, and customer usage on a maximum demand day. A maximum day demand of system delivery, 71.82 mgd occurred on August 5, 2002. However, there were some unusual tank operations that day, and therefore August 9, 2002 was deemed to be a more representative day and more appropriate for analysis in this report. Total system demand on this day was 70.23 mgd. From this information, an hourly demand curve was developed which identifies the amount of equalization volume utilized on that day. The hourly demand curve for August 9, 2002 can be found in Exhibit No. 3 below.



The analysis of hourly demands shows that consumption reached a peak rate of 96.23 mgd during the period from 6 pm to 7 pm on August 9, 2002. The minimum consumption rate that day was 45.51 mgd during the 1 am to 2 am period. The amount of storage needed to equalize system production to a constant rate on that day was calculated to be 5.83 MG, or 8.3% of the maximum day demand. To be sure that the equalization analysis adequately identifies the amount of storage that might be needed under a range of demand patterns, higher equalization percentages were used in the calculations. Equalization factors selected for the Main Service and High Service gradients are 12% and 15%, respectively. The current factors are reasonable in comparison with values for similar sized systems. The equalization factor of 20% used in the Sadieville gradient was estimated due to lack of metering facilities; however, it also is reasonable based on results of other analyses performed for similar sized systems. Equalization factors generally decrease as the size of the system becomes larger.

The needed fire flow volumes (which have not changed from the 1993 analysis) were then added to the equalization storage needs to determine the appropriate amount of storage for proper operation of the system. The quantity of treated water storage needed for fire protection purposes is determined from the insurance rating surveys performed periodically by the Insurance Services Office (ISO). For the Main Service gradient, the fire flow need determined by the ISO is 8,000 gpm over a four (4) hour duration, which equals 1.92 MG. For the High Service gradient, a fire flow need of 3,500 gpm over a three (3) hour duration, which equals 0.63 MG, was estimated in the absence of current ISO information. This fire flow estimate conservatively reflects a significant fire demand for a large commercial or industrial customer.

For the Sadieville gradient, a fire flow need of 1,500 gpm over a two (2) hour duration, which equals 0.18 MG, was estimated in the absence of current ISO information. This generally reflects the fire flow needs for the customer makeup in this gradient.

The summation of equalization and fire flow needs was then compared to the existing usable storage in the system to determine if a surplus or deficit exists. The results of this analysis are summarized in Exhibit No. 4. The emergency storage requirement set by the Commission of one average day demand was also reviewed to identify if a surplus or deficit exists from that perspective. The results of this analysis are summarized in Exhibit No. 5.

EXHIBIT NO. 4
Kentucky-American Water Company
Storage Capacity Analysis
Equalization and Fire Flow Storage Need

Year	Avg Day (MGD)	Max Day (MGD)	* Existing Storage (MG)	Equalization Storage Need (MG)	Equalization + Fire Flow Need (MG)	Equalization + Fire Flow Surplus/(Deficit) (MG)
Main Service Gradient (12% equalization factor)						
2005	40.55	69.31	14.50	8.32	10.24	4.26
2010	42.57	72.52	14.50	8.70	10.62	3.88
2015	44.59	75.79	14.50	9.09	11.01	3.49
2020	46.88	79.25	14.50	9.51	11.43	3.07
High Service Gradient (15% equalization factor)						
2005	4.22	7.21	1.71	1.08	1.71	0.00
2010	4.43	7.54	1.71	1.13	1.76	(0.05)
2015	4.64	7.88	1.71	1.18	1.81	(0.10)
2020	4.87	8.24	1.71	1.24	1.87	(0.16)
Sadieville Gradient (20% equalization factor)						
2005	0.090	0.153	0.380	0.031	0.211	0.169
2010	0.094	0.160	0.380	0.032	0.212	0.168
2015	0.099	0.168	0.380	0.034	0.214	0.166
2020	0.104	0.175	0.380	0.035	0.215	0.165

MG = Million Gallons
MGD = Million Gallons Per Day
***For Equalization Purposes, Clearwell Storage at the Treatment Plants is not Included**

Based solely on equalization and fire flow needs, the analysis indicates that there are no storage deficiencies in the Main Service and Sadieville gradients, and only a very minor storage deficit in the High Service gradient, through the year 2020. This is primarily a result of the storage additions KAWC made in the Main Service and High Service gradients following the Commission's order after their review of the 1993 analysis. The minor deficiency in the High Service gradient is offset by the ability to reliably pump additional water from the Main Service gradient where adequate storage for solely equalization and fire flow exists.

EXHIBIT NO. 5
Kentucky-American Water Company
Storage Capacity Analysis
Emergency Storage Volume Calculation

Year	Avg Day (MGD)	Max Day (MGD)	* Existing Storage (MG)	Emergency Storage Requirement @ 50% for Main, 100% for HS & Sadieville (MG)	Emergency Storage Surplus/(Deficit) @ 50% for Main, 100% for HS & Sadieville (MG)	Emergency Storage Requirement @ 100% for all Gradients (MG)	Emergency Storage Surplus/(Deficit) @ 100% for all Gradients (MG)
Main Service Gradient							
2005	40.55	69.31	18.52	20.28	(1.76)	40.55	(22.03)
2010	42.57	72.52	18.52	21.28	(2.76)	42.57	(24.05)
2015	44.59	75.79	18.52	22.30	(3.78)	44.59	(26.07)
2020	46.88	79.25	18.52	23.44	(4.92)	46.88	(28.36)
High Service Gradient							
2005	4.22	7.21	1.71	4.22	(2.52)	4.22	(2.52)
2010	4.43	7.54	1.71	4.43	(2.73)	4.43	(2.73)
2015	4.64	7.88	1.71	4.64	(2.94)	4.64	(2.94)
2020	4.87	8.24	1.71	4.87	(3.17)	4.87	(3.17)
Sadieville Gradient							
2005	0.090	0.153	0.380	0.090	0.290	0.090	0.290
2010	0.094	0.160	0.380	0.094	0.286	0.094	0.286
2015	0.099	0.168	0.380	0.099	0.281	0.099	0.281
2020	0.104	0.175	0.380	0.104	0.276	0.104	0.276

MG = Million Gallons
MGD = Million Gallons Per Day
***For Calculation of Emergency Volume Purposes, Clearwell Storage at the Treatment Plants is Included**

The above analysis indicates that additional storage is needed in the Main Service and High Service gradients to meet the emergency storage requirements. However, the Emergency Storage Requirement shown is based solely on a percentage of projected average daily demand. This approach, while reasonable, is arbitrary when applied to a specific water system. For instance, as shown in Exhibit 5, when 50% of average day demand is considered to be the appropriate volume of emergency storage, KAWC has a 2020 deficit of 4.92 MG. However, when 100% of average day demand is considered to be the appropriate volume, the 2020 deficit increases substantially to 28.36 MG. In order to conduct a full and thorough analysis of the appropriate amount of storage, peak hour equalization needs, fire protection storage, water quality concerns, and an assessment of system vulnerability under a range of emergency scenarios should be reviewed. Each of these issues is discussed further below.

G. WATER QUALITY CONCERNS

From a system reliability point of view, for many components, it can be considered that "more is better". However, finished water storage can be an exception. Recommended Standards for Water Works (Ten State Standards) states that "excessive storage capacity should be avoided where water quality deterioration may occur." The specific water quality deterioration issues that can become a direct concern with additional storage in the KAWC system include maintenance of a disinfectant residual, increased disinfection by-product formation, and nitrification. Additionally, indirect water quality concerns may also arise due to the potential need to modify distributive pumping operations at the treatment plants.

KAWC currently employs the practice of chloramination (chlorine + ammonia to form chloramines) for final disinfection at its treatment plants prior to delivery to the distribution system. Although chloramines are not as strong a disinfectant as free chlorine, they provide the benefit of being able to persist longer, which reduces the potential need for rechlorination in the distribution system. Additionally, continued formation of disinfection by-products (trihalomethanes or THMs) in the distribution system, which is a function of time, is significantly decelerated. Although the use of chloramines in lieu of free chlorine lessens the potential for loss of a disinfectant residual or increased disinfection by-product formation, increased detention time due to additional storage increases the concern. The maximum contaminant level (MCL) for THMs is 80 ug/L per the Stage I Disinfectants/Disinfection By-Product (D/DBP) Rule. Haloacetic acids (HAAs) are also regulated with an MCL of 60 ug/L. The Stage II D/DBP Rule will require that the MCLs for THMs and HAAs be met at all times at points of maximum detention time in the system. Excess finished water storage could impact the ability to meet this future regulation.

The more immediate water quality concern with the use of chloramines and longer detention times is nitrification. Nitrification in a water system results when nitrifying bacteria (which are nonpathogenic) use ammonia-nitrogen as a food source and convert it to nitrite and ultimately nitrate. Nitrite can exert a significant and almost instantaneous chlorine demand and may accelerate the natural breakdown of a chloramine residual. Additionally, growth of nitrifying bacteria can stimulate the growth of other bacteria including coliforms that use growth by-products of the nitrifying bacteria. The growth of nitrifying bacteria is slow but is accelerated by a neutral to alkaline pH, excess nitrogen in the water, warm temperatures, and long detention times. When KAWC first began practicing chloramination, they experienced nitrification in warm temperatures but have been able to control it by closely monitoring the chlorine-ammonia ratio. In order to ensure that monochloramines are formed and not dichloramines or trichloramines (which are unstable), it is necessary to have excess ammonia in the water; however, too much free ammonia will promote nitrification. Even though KAWC has historically been able to adequately control nitrification, minimizing the detention time in the distribution system is a critical factor in continuing to prevent nitrification.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) lowered the finished water turbidity MCL from 0.5 NTU to 0.3 NTU in at least 95% of the measurements taken each month while at no time exceeding 1.0 NTU in any single sample. The ability to operate the treatment plants with minimal flow variations to avoid treatment upsets is critical in meeting this more stringent regulation. When finished water storage volume in excess of that needed for equalization is provided in the distribution system, variations in raw water flow can occur. These variations in the raw water flow can cause treatment upsets which may compromise the ability of the plants to meet the turbidity requirements of the IESWTR. Thus, maintaining storage in the distribution system that does not significantly exceed the equalization needs is preferred. The current analysis has shown that the existing storage capacity in all three pressure gradients meets this requirement.

H. RELIABILITY SCENARIO ANALYSIS

It is appropriate to conduct a reliability scenario analysis based on both accepted engineering standards, and also actual occurrences. This report will consider both. In particular, on July 31, 2002, a service disruption to a portion of the KAWC system occurred due to a power failure at the Kentucky River Station during a time of peak summer demand. This was a failure circumstance with details that varied from the assumptions in the 1993 analysis, but its ramifications will be considered in detail in this updated analysis.

July 31, 2002 Power Outage

A localized power interruption to the Kentucky River Station during a time of high system demand resulted in temporary disruption of service to some customers. The loss of pressure resulted in the precautionary issuance of a Boil Water Advisory to KAWC customers. Full service was restored to customers within approximately 30 minutes. A full review of this event has been made in another document, including an assessment of the cause and response, as well as a plan for improvements to reduce the chances of a recurrence of such an event. Therefore, this report will provide only a brief summary of the event and the recommended improvements.

The KAWC system had adequate capacity of emergency power, pumps, and storage to meet customer demands. However, the event revealed that improvements are needed to provide the capability to automate or otherwise streamline getting these facilities into emergency service within the first moments after the outage begins. The loss of pressure that some customers experienced happened within minutes of the beginning of the outage, before emergency power facilities could be turned on.

System improvements which will improve response to a future occurrence similar to the July 31, 2002 outage will be implemented beginning in 2002, and are described in Section J.

Failure Scenarios

In addition to consideration of the July 31, 2002 power outage, the adequacy of the KAWC system has been analyzed under a series of theoretical, but plausible, emergency scenarios. These scenarios represent accepted utility planning criteria. Obviously, it is recognized that more severe emergency scenarios can be considered possible, although highly unlikely. Designing the water system based on more extreme scenarios would be very costly, and would create operational difficulties, increased operation and maintenance costs, and water quality problems, with little likelihood of ever delivering benefit from the additional facilities. The following analysis evaluates the ability of the KAWC system to supply water in the event of a total failure of any single major component (source, treatment plant, or booster station).

The KAWC system utilizes two separate sources (the Kentucky River and Jacobson Reservoir), and includes two separate treatment plants known as the Kentucky River Station

(KRS) and the Richmond Road Station (RRS). Thus, the level of reliability is significantly greater than that of a single source/treatment system. It is assumed that only a single operational failure would occur at any one time since the two sources are not on the same water supply, and the treatment plants and booster stations are all serviced by separate electrical substations. This analysis is based on the need to provide 0.10 mgd into Sadieville, 4.87 mgd into High Service and 46.88 mgd into Main Service, which represents an average day's supply in each of those gradients in the year 2020. An additional analysis is also included which evaluates the reliability of the system in the event of a total power outage across the entire service area when system demands would be lower than average.

1. <u>Sadieville Gradient Reliability</u> - The Sadieville tank is filled from the High Service gradient by opening an electrically operated valve. Communication with the valve is via radio telemetry, which provides an added degree of reliability in a thunderstorm. The valve can be opened manually in an extreme emergency. Therefore, the Sadieville gradient is capable of providing an adequate supply of water in the event of an emergency. Additionally, the tank is elevated with a volume greater than an average day demand. Thus, the gradient could function adequately in an emergency even without the need to provide water from the High Service gradient.

2. <u>High Service Gradient Reliability</u> - The three tanks in the High Service gradient are filled by four separate booster stations with a total of eight separate pumping units. The four stations are known as Briar Hill, Mt. Horeb, Newtown, and Delaplain Road. These booster stations have a total pumping capacity of 13.7 mgd which includes 7.7 mgd of standby pumping power at the Newtown Booster as shown in Exhibit No. 1. Also, each booster station is serviced by a separate electrical substation.

   If there were a complete loss of the largest station (Newtown), it would still be possible to pump 6.0 mgd into the High Service gradient, which alone would satisfy the High Service demand of 4.87 mgd. Considering the number of booster stations, the number of pumping units, standby power, and individual electrical substations, the High Service gradient is fully capable of providing an adequate supply of water in the event of an emergency.

   Since 1.71 MG of the demand could be taken from existing storage, 3.16 mgd would need to be taken from the Main Service gradient. Thus, the Main Service analysis will address the ability to provide an additional 3.16 MG into the High Service gradient in addition to its own emergency supply.

2. <u>Main Service Gradient Reliability</u> - The Main Service Gradient is supplied directly from KAWC's two treatment plants, which can produce water at capacities of 50 mgd (KRS) and 30 mgd (RRS) if needed during an emergency. These facilities derive their source of supply from two independent sources: the Kentucky River and Jacobson Reservoir. An analysis of a complete loss of any one of these five major system components is provided below.

   a. *<u>Loss of Jacobson Reservoir</u>* - The intake on the Kentucky River has a reliable capacity (largest unit out of service) of 62.0 mgd of which 22.0 mgd can be directed to RRS. Thus, if raw water could not be derived from Jacobson Reservoir, 62.0 mgd could still be produced and distributed which is significantly above the average day demand in the Main Service gradient. Thus, the short-term loss of Jacobson Reservoir would not have a significant negative impact on the ability to provide an emergency supply of water to the Main Service gradient.

b. *Loss of the Kentucky River* - If the Kentucky River were lost due to some emergency, all source water would need to be derived from Jacobson Reservoir, and could be supplemented from Lake Ellerslie if necessary. The piping and pumping configuration at Jacobson Reservoir allows it to supply raw water to only RRS at a maximum rate of 22.8 mgd. There is an additional 1.05 MG of clearwell capacity at RRS. Up to 10.0 mgd of raw water could also be supplied to RRS from Lake Ellerslie. Additionally, even though the Kentucky River would be lost, KRS could continue to distribute finished water from its clearwells, which have an effective capacity of 2.97 MG.

The availability of 22.8 mgd of pumpage from Jacobson Reservoir, 1.05 MG of RRS clearwell storage, and 10.0 mgd of pumpage from Lake Ellerslie is limited to the 30 mgd treatment capacity of RRS. Adding this to the 2.97 MG of clearwell storage at KRS, 14.50 MG of storage in the Main Service Gradient, and deducting 3.16 mgd allocated for the High Service gradient equals 44.31 MG. This meets the total emergency storage need of 40.55 mgd in the year 2005, but is slightly below the 44.59 MG requirement in the year 2015. However, of this 44.31 MG, 30 mgd is a continuous supply from RRS as opposed to a finite supply from storage tanks. This is a significantly more desirable scenario for being able to provide an adequate supply of water. This small calculated future deficiency in total emergency storage will be remedied by the tanks proposed in Section J.

c. *Loss of the Richmond Road Station* - If RRS were lost, KRS could continue to deliver water at 50 mgd capacity. This continuous supply coupled with the 11.34 MG of storage (14.50 MG – 3.16 MG allocated for the High Service gradient) more than satisfies the calculated emergency storage requirement. Thus, loss of RRS would not compromise the ability to provide an emergency supply of water to the Main Service gradient.

d. *Loss of the Kentucky River Station* - If KRS were lost, RRS could deliver water at its 30 mgd capacity, since adequate source would still be available from both the Kentucky River, Jacobson Reservoir, and Lake Ellerslie. Similar to the analysis in "b" above, the sum of 30 mgd of pumpage from the RRS, 1.05 MG of RRS clearwell storage, 14.50 MG of storage in the Main Service Gradient, and deducting 3.16 mgd allocated for the High Service gradient equals 42.39 MG. This again is slightly below the total emergency storage need of 44.59 MG in the year 2020. However, of this 42.39 MG, 30 mgd is a continuous supply from RRS as opposed to a finite supply from storage tanks. Similar to the conclusion in "b" above, this is a significantly more desirable scenario for being able to provide an adequate supply of water. This calculated future deficiency in total emergency storage will be remedied by the tanks proposed in Section J.

e. *Loss of Storage Tanks* – Since the tanks are spread throughout the distribution system and are on separate power substations, a loss of all of the tanks would be the likely result of a systemwide power outage, which will be addressed in the next section. If the radio system were to fail, the tanks can still be operated manually until the system can be repaired. Although it would take time for personnel to access each tank, the combination of the treatment plants could handle even peak day demands until the tanks could be manually operated.

3. Power Outage Scenario - In the event of a total power outage across the entire service area, actual experience in existing large water systems has shown that usage is reduced to less than 50 percent of the normal average daily use since various water usages are curtailed (e.g. washing machines, dishwashers, many commercial activities, etc.). Thus, the system demands in the year 2020 that would need to be satisfied in this type of emergency are approximately 0.05 mgd in the Sadieville gradient, 2.43 mgd in the High Service gradient, and 23.44 mgd in the Main Service gradient. This analysis evaluates the ability of each system component to continuously supply water for a 24-hour period in a total power outage scenario.

a. *Sadieville Gradient* – The single 0.38 MG tank in this gradient is an elevated tank which is not dependent on power to meet the system demand. Since the demand is only 0.05 mgd, the system is adequate over a 24-hour period.

b. *High Service Gradient* - This gradient includes 0.21 MG of pumped storage with no standby power, and 1.5 MG of elevated storage. Since the demand is 2.43 mgd, an additional 0.93 mgd would need to be provided from standby pumpage into the gradient. The Newton Booster Station, which supplies water to this gradient, includes 7.7 mgd of standby pumping capacity. Assuming that adequate volume (0.93 mgd) is available from the Main Service gradient (verified below), the system is adequate over a 24-hour period. Also, the proposed Russell Cave Road Tank will further enhance reliability within the High Service gradient.

c. *Main Service Gradient* - The Main Service gradient includes 0.5 MG of elevated storage plus 14.0 MG of pumped storage. 3.0 MG of the pumped storage is stored in elevated tanks that can bypass the pumps in a system wide power outage. Standby pumpage, with a capacity at least equal to its respective tank volume over a 24-hour period, is available at three of the ground storage tanks. These three tanks have a total volume of 9.0 MG bringing the total amount of available storage to 12.5 MG in a power failure scenario. The total system demand is 24.37 mgd (23.44 mgd Main Service + 0.93 mgd High Service). Thus, an additional 11.87 mgd would need to be provided from standby pumpage at the treatment plants. The two treatment plants that supply this gradient include 26.4 mgd of standby pumping capacity. Adequate capability (11.87 MG needed) is available at the treatment plants during a power outage (verified below). Therefore, the system is adequate over a 24-hour period.

d. *Treatment Plants* - The two treatment plants have clearwell capacity of 4.02 MG. This volume alone would not be adequate to meet the 11.87 MG need identified above; however, adequate standby pumping capacity exists at the raw water facilities to continuously supply water to the treatment plants. Further, backup power is available to process the raw water to meet the needed deficit as evaluated below.

e. *Raw Water Facilities* - The total standby raw water pumping capacity from the sources of supply is 19.4 mgd. This standby capacity is located at Jacobson Reservoir and Lake Ellerslie, which can supply only RRS. A total of 16.5 mgd of standby pumping capacity is located at RRS. This source and treatment raw water pumping capacity is more than the needed 11.87 MG in the Main Service gradient. Thus, the existing storage and standby pumping facilities in the system could adequately satisfy the demand in the event of a power outage across the entire service area.

I. CONSIDERATION OF FUTURE ADDITIONAL SOURCE OF SUPPLY

KAWC is in need of additional water supply to meet current and future demands during a drought. Also, KAWC is in need of additional treatment capacity to meet future maximum day demands. These needs have been fully elaborated on in other documents and proceedings, and will not be elaborated on in detail here. However, regardless of which alternative is ultimately chosen and constructed in order to provide the additional supply and treatment capacity, the end result will be that the new facilities will provide further reliability to the KAWC system. If the new facilities consist of new Kentucky River intake and treatment plant facilities, this will provide additional intake capacity, raw water and finished water pumping capacity, emergency powered pumping capacity, and finished water storage (i.e., plant clearwells). If the new facilities consist of a finished water pipeline to deliver water from some other source, this will provide the reliability of a third, independent source of supply, which is delivered through independent intake, pumping, treatment, emergency power, and clearwell storage facilities. ***In either case, the future additional source of supply and treatment facilities will significantly increase the reliability of the KAWC system, beyond the calculations shown in this report.***

Having more storage than is needed for equalization, fire protection, and reasonable emergency scenarios is not likely to provide any benefit to KAWC customers (and in fact will be a detriment due to increased O & M and energy costs, and water quality degradation), and those facilities would become even less likely to ever be beneficial once the needed additional supply and treatment facilities are in place.

The additional supply and treatment capacity development project will come at a significant rate impact to KAWC customers. It is appropriate and prudent to consider the full benefits that project will bring, and take advantage of costs that can be avoided because of it. Avoiding the construction of extra storage volume beyond that with a documented need can result in an avoided cost benefit to KAWC's customers. These ancillary benefits of the new supply and treatment capacity project point out the value of moving forward with that project expeditiously, for reasons even beyond the documented supply and treatment capacity needs.

J. RECOMMENDED IMPROVEMENT PROJECTS

Electrical, Valving, and Pumping Improvements in Response to July 31, 2002 Power Outage

A series of system improvements which would allow immediate response and remediation in event of an outage during a high demand period, such as occurred on July 31, 2002, will be implemented. The improvements will enhance the performance of the KAWC system in the moments immediately after a power disruption. The improvements are fully detailed in a separate November 2002 report, and therefore are just briefly listed here. The total estimated cost for these improvements is $1,320,000.

- Improvements to ball valves at pumped storage tank sites to allow quick, remote opening of the valves during an emergency

- Modifications to the control logic within KAWC's Supervisory Control and Data Acquisition (SCADA) system to automatically turn on pumps at storage tanks in response to a drop in system pressure

- Modifications to the Tates Creek Elevated Tank to allow water to flow from this tank into the system by gravity in response to a drop in system pressure

- Installation of a second transformer at KRS and appropriate electrical improvement including a breaker at the transmission line to improve reliability of electrical service at that plant

- Installation of a sectionalizing breaker on the transmission lines by Kentucky Utilities to remotely switch the electrical feed to KRS to the second feed line serving the facility

Proposed Additional Storage Facilities

It is proposed that KAWC will construct four additional storage tanks. Two tanks are currently under design, with construction planned in 2003-2004. An elevated tank is proposed for design in 2003, with construction in 2004-2005. An additional ground storage tank is recommended for construction by 2010.

1. Second Three (3) MG Tank at existing Clay's Mill Three (3) MG Tank site

The Clays Mill pumped storage complex consists of a 3 mg ground storage tank with a reliable 9 mgd booster pump station. The basic mode of operation is typical pumped storage, which means that at night the tank is filled (during periods of low customer demand) from the distribution system pressures supplied by the treatment plants, and during the day the tank is emptied (during periods of high customer demand) by pumps withdrawing water from the tank and delivering it to the distribution system to help sustain system pressures. The complex is located in the southwest portion of the KAWC distribution system and is used to service this localized area.

The installation of a second 3 mg tank at Clays Mill will increase system storage in the Main Service Gradient. As part of the design of this second tank, with some minor piping changes KAWC will have the ability to operate these two tanks in either a pumped storage mode or in an in-line booster mode. In pumped storage mode, the addition of the second tank will allow 15-hour long pump run times, which means continuously pumping during the day into the distribution system from the morning peak to the evening peak without running out of water. In in-line booster mode, the pumps will be able to run 24 hours long without running out of water (assuming KRS is online). This project is currently at the end of the design phase, with the design scheduled to be completed this year.

Design of the tank is underway will be completed in 2002, with construction planned for 2003-2004. Estimated project cost is $1,500,000.

2. <u>Russell Cave Road Tank</u>

KAWC plans to construct a 1 mg ground storage tank and pump station along Russell Cave Road in the High Service gradient. The tank will provide stable and adequate pressures to high elevation areas in Scott, Bourbon and Harrison Counties, and will provide more reliability of service to the Toyota Manufacturing facility. It will provide the volume necessary to ensure adequate equalization and fire protection capabilities within the High Service gradient through 2020. It will also allow the Muddy Ford tank to be taken out of service for needed maintenance. This project includes a 1 MG ground storage tank, space for a second tank, a booster pump station with two 3 MGD booster pumps and space for a third, a diesel generator capable of running both pumps and a lagoon for any tank overflows.

Design of the tank is nearly complete, with construction planned for 2003-2004. Estimated project cost is $1,500,000.

3. <u>Two (2) MG Elevated Tank in Main Service gradient</u>

KAWC proposes to construct an elevated tank within the Main Service gradient. The tank will be constructed with an overflow elevation adequate to provide "floating" storage; that is, the water in the tank will be available to the Main Service gradient via gravity. In this way, the tank will instantly respond to any low pressure event in the area by delivering water via gravity to keep pressures stable.

The tank is still in the concept phase, so details are tentative. However, preliminary specifications are for a tank volume of 2 MG, overflow elevation of 1185 ft., and a location in the vicinity of Strader Drive, which is a high elevation area where low pressures have been experienced in the past.

Land acquisition, design, and permitting are proposed to begin in 2003, with construction of the tank to be completed by 2005. Estimated cost for the tank and booster is $3,000,000.

4. Second Tank at Parker's Mill or Hume Road

Similar to the second tank planned for Clay's Mill described above, KAWC proposes to construct a 3 MG "twin" ground storage tank at the site of either the Parker's Mill or Hume Road tank and pump station. The tank will provide additional emergency storage volume, and will share pumping facilities with the existing 3 MG tank. An additional 6 mgd pump will be added to the pump station which will increase the cost over the second Clays Mill Road tank construction.

This tank is proposed for construction by 2010. Decision on which site to put this tank would be made at the time of preliminary design, based a study of the system's demand patterns at that time. Estimated project cost is $1,800,000 (in 2002 dollars).

K. SUMMARY

This report has provided an analysis of the adequacy of Kentucky-American Water Company's finished water storage volume, and also an assessment of the reliability of the KAWC distribution system to meet potential emergency scenarios.

Section B of this report assesses the Kentucky regulation on storage volume (807 KAR 5:066 Section 4(4)), which is included under the topic of "Continuity of service" and deals with provisions to provide continuous service to customers during various emergency situations. In 1993, the Public Service Commission granted KAWC a variance from this regulation and reduced the storage requirement in the Main Service gradient to 50% of average day demand. KAWC currently provides 20.61 MG of finished water storage throughout its distribution system (including plant clearwell storage).

Section C describes the purpose of finished water storage, which is primarily to equalize treatment plant flows, provide water to meet fire events, and provide the capability to continue to meet customer demands during an emergency. A summary of KAWC's 1993 storage analysis is summarized in Section D. KAWC has completed two tanks since 1993, the 3 MG Clay's Mill pumped storage facility, and the Briar Hill elevated tank and pump station. These improvements have been constructed at a cost of $4,760,000 (Section E).

An updated analysis of equalization and fire protection needs within each of KAWC's three pressure gradients was conducted (Section F). System performance on the maximum demand day on August 9, 2002 was analyzed in detail. KAWC delivered 70.23 mgd on that day. The analysis concludes that existing storage facilities are adequate to meet current equalization and fire protection needs in all three gradients. A slight deficit occurs in the High Service gradient compared to equalization needs beyond 2005, but this deficit will be met by construction of a new tank which is currently under design and planned for construction in 2003-2004. With regard to emergency storage volume, current storage capacity is 50.4% of 2001 average day demand.

Having more storage than is needed for proper system operation can lead to water quality problems, as described in Section G. Formation of disinfection by-products, nitrification, and treatment plant upsets are among the potential problems.

A detailed assessment of the KAWC distribution system was conducted in Section H. Both the July 31, 2002 power outage as well as a series of theoretical emergency scenarios were analyzed. Although KAWC facilities were adequate to meet customer demands during the July 31, 2002 outage, rapid de-pressurization of the distribution system before pumps could be turned on resulted in the short-term disruption of service to certain customers. Electrical, valving, and pumping improvements are planned for 2003 to enhance the capability of KAWC's facilities to immediately and automatically respond to a pressure drop, and thereby avoid any service outage during a repeat of a similar event. These improvements will be implemented at a cost of approximately $1,320,000.

The emergency scenario analysis studied the effect of interruption of any component of the KAWC system, such as a source of supply, treatment plant, or pump. The KAWC distribution facilities, which consist of 12 storage tanks, 12 booster stations, dedicated electrical service at each station, 20 individual pumping units, and 7 individual pumping units with standby power, have a high degree of reliability and can adequately respond to any of these scenarios.

KAWC is in need of additional water supply to meet current and future demands during a drought. Also, KAWC is in need of additional treatment capacity to meet future maximum day demands. This is described in Section I. The future additional source of supply and treatment facilities will significantly increase the reliability of the KAWC system, beyond the calculations shown in this report. Having more storage than is needed for equalization, fire protection, and reasonable emergency scenarios is not likely to provide any additional benefit to KAWC customers while potentially creating operating concerns. Further, those facilities would become even less likely to ever be beneficial once the needed additional supply and treatment facilities are in place.

Section J presents the recommended improvement projects which KAWC proposes to undertake. In addition to the $1.32 million in electrical, valving, and pumping improvements discussed above, KAWC proposes to build four additional storage tanks, providing an additional 9 MG of finished water storage. The tanks are strategically located, and will provide additional emergency storage volume, "floating" storage which makes water available by gravity flow during a power outage, and additional capacity in the High Service gradient to meet equalization and fire protection needs. KAWC proposes to spend approximately $8.0 million by 2010 for these additional storage facilities. By 2010, KAWC would then have 29.61 MG of finished water storage, or 63% of average day demand at that time.

In conclusion, this report provides a thorough analysis of KAWC's equalization, fire protection needs, and emergency readiness. Improvements are proposed which will make KAWC fully capable of meeting all reasonable scenarios. At that time, it is felt that KAWC will have an optimum amount of finished water storage. Additional storage to meet a general standard of one-day storage volume would cost the ratepayers an additional $12 million. With the rate impact for additional water treatment and raw water facilities in the near future, KAWC needs to assure facility construction provides the appropriate benefits to the ratepayer. However, these facilities would provide little or no additional benefit, and in fact would be a detriment during daily operations due to increased O & M and energy costs, and water quality degradation. Many large water systems do not have one day finished water storage within the distribution system, and operate efficiently. It is recommended that the technical analysis of KAWC system operations and emergency scenarios as presented within this report be given precedence over a general standard for storage volume applied to all size systems. It is further recommended that KAWC's deviation from the one day storage requirement of 807 KAR 5:066 Section 4(4) be continued through 2005.

RECEIVED
JUL 23 2004
PUBLIC SERVICE
COMMISSION

RECEIVED
JUL 23 2004
PUBLIC SERVICE
COMMISSION

KENTUCKY-AMERICAN WATER COMPANY
STORAGE CAPACITY ANALYSIS

September 1993

STATE OF KENTUCKY
LINDA
CAROL
BRIDWELL
17603
REGISTERED
PROFESSIONAL ENGINEER

7/7/04

September 1993

KENTUCKY-AMERICAN WATER COMPANY
STORAGE CAPACITY ANALYSIS

A. Introduction

The Kentucky-American Water Company provides water service and fire protection to Fayette County and portions of Scott, Bourbon, Woodford and Harrison Counties in Central Kentucky. The Company's major source of supply is the Kentucky River, located 12 miles southeast of Lexington. The Company also utilizes Jacobson Reservoir and Lake Ellerslie (formerly Reservoirs No. 4 and No. 1) located on Richmond Road in Lexington.

The Company has two treatment facilities: the Kentucky River Station, which has a treatment capacity of 40 million gallons per day, and the Richmond Road Station, which has a treatment capacity of 25 million gallons per day. Supply for the Richmond Road Station can be obtained from the two reservoirs, Jacobson and Lake Ellerslie. Supply for the Kentucky River Station is obtained from the Kentucky River.

The Company's service area consists of three pressure zones: The Main Service zone which covers the majority of the service area, the North Counties High Service zone, and the Sadieville zone. The distribution system consists of more than 6,480,000, feet of mains ranging in size from 2" to 30". These mains are of various materials such as copper, gray cast-iron, ductile iron, asbestos cement and pre-stressed concrete. Mains 6" and larger comprise 88% of the total footage. The Company has approximately 4.0 million gallons of water storage in clearwells and approximately 12.84 million gallons stored in tanks throughout the system. The Company has 80,553 customers and there are 5,926 fire hydrants. Kentucky-American serves an estimated population of 240,000. A map of the Kentucky-American service area is included as Exhibit A at the end of this report.

The Kentucky Public Service Commission Order to Kentucky-American Water Company entered in Case No. 10237 on May 9, 1988 states that "Kentucky-American should perform the necessary hydraulic and economic analyses to determine the appropriate water storage requirements for its systems." In response to this Order, Kentucky-American prepared an analysis regarding storage in June 1991. This was originally prepared during the development of 1992 Least Cost/Comprehensive Planning Study and has been updated with the recommendations from the Planning Study and to address changes in the regulations that have occurred since the original analysis was prepared.

B. Purpose of Finished Water Distribution Storage

Treated water storage is provided in a water distribution system for various purposes. Volume 3, "Introduction to Water Distribution Principles and Practices of Water Supply Operations", AWWA 1986 lists a number of reasons why water storage is required in a distribution system: equalizing supply and demand, increasing operating convenience, leveling out pumping requirements, to offset pump failure, fire demands, surge relief, increasing detention times and blending water sources. Under the subheading of "Capacity Requirements" the above reference also states:

> "The capacity of distribution storage is based on the maximum water demands in the different parts of the system. Capacity varies for different systems and can only be determined by qualified engineers after a careful analysis and study of a particular system. Storage capacity needed for fire protection should be based on the recommendations of fire underwriters' organizations. Because there are so many variables involved, operators should contact the Insurance Services Organization Office or the Fire Insurance Rating Office in their state to obtain any available information.

Additional storage capacity may be necessary to meet emergencies such as pump failure, source failure, or transmission-line break. The need for emergency storage should be based on the reliability of the supply and pumping equipment and the availability of backup equipment and standby power sources."

The Ten States "Recommended Standard for Water Works" contains a subsection entitled "Sizing" under "Finished Water Storage" which states:

"Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands, and where fire protection is provided, fire flow demands.

a. Fire flow requirements established by the appropriate state Insurance Services Office should be satisfied where fire protection is provided.
b. The minimum storage capacity (or equivalent) for systems not providing fire protection shall be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system."

The New Jersey Department of Environmental Protection has taken a site-specific approach in its regulations mandating system storage requirements. The required amount of storage varies from 20 percent to 100 percent of average day demand depending on several factors:

1. single source vs. multiple source
2. auxiliary power provisions
3. interconnections with other water companies

A dual source without interconnections and with auxiliary power equal to at least 50 percent of the average day, has a storage capacity requirement equal to 50 percent of the average day demand under the NJDEP regulations.

In summary, the quantity of treated water storage in the distribution system should be the sum of equalization requirements and fire flow storage. Additional storage may be appropriate to meet emergency conditions, either finished water or raw water, depending on the reliability of the treatment facilities and the availability of standby power capacity.

C. Existing Kentucky-American Storage Facilities

The existing Kentucky-American Water Company storage facilities are listed in Table I.

Table 1
Kentucky-American Water Company
Existing Storage Facilities

Storage Tank	Year Built	Tank Capacity (MG)	Tank Diameter (Ft.)	Height Fdn to OF (Ft.)	Overflow Elevation (Ft.-USGS)
Cox Street Pumped Storage	1948	1.0	70	35	1001.75
York Street Pumped Storage	1949	1.0	70	35	1000.25
Tates Creek Elevated	1954	0.5	50	148	1185.25
Cox Street Elevated	1955	1.0	78	160	1117.00
Mercer Road Elevated	1965	2.0	105	125	1107.00
Parkers Mill Road Pumped Storage	1968	3.0	113	40	1025.00
Hume Road Pumped Storage	1988	3.0	120	36	979.50
Muddy Ford Elevated	1989	0.75	64	122	1130.00
Hall Standpipe	1962	0.21	20	90	1115.00
Sadieville Standpipe	1975	0.38	30	72	993.00

Total existing storage capacity equals 12.84 MG. Also, an additional 4.03 MG is provided by the clearwells at the Richmond Road and Kentucky River treatment plants.

D. **State of Kentucky Requirements**

The Kentucky Public Service Commission regulations 807 KAR 5:066 Water, under Section 5, Continuity of Service, contains a subsection entitled, "Storage". This regulation states "The minimum storage capacity for systems shall be equal to the average daily consumption." The intent of this regulation is clear; to require that a water utility have sufficient capability to deliver a one day's supply of water to its customers under emergency conditions.

Kentucky-American proposes to meet the one day emergency supply capability for its Main Service zone by providing usable distribution system storage of one-half the average day system delivery and providing a minimum of one-half the average day system delivery in the form of standby emergency power for production and pumping capacity from Jacobson Reservoir and Lake Ellerslie to the system via standby production and pumping facilities at Richmond Road Station and standby power facilities at the Kentucky River Station. The North Counties High Service zone and Sadieville Servize zone are too remote from the Richmond Road Station standby pumping to adequately utilize those facilities, thus Kentucky-American proposes to meet the one day emergency supply requirements in these two zones by providing usable distribution storage of at least one average day system delivery.

Storage adequacy is also to be evaluated based on the ability to provide maximum day equalization for that zone plus fire storage or one-half the average day for the Main Service zone and one average day for the other zones.

Kentucky-American proposes that the above combinations of finished water storage and raw water storage deliverable through emergency power capabilities be accepted by the Public Service Commission and approved "the minimum storage capacity".

The storage analysis presented in this report shows that one average day's finished water storage capacity is recommended in the Northern Counties High Service zone and in the Sadieville service zone and that a combination of storage and emergency powered production facilities will provide one average day's supply in the Main Service portion of the water system. The provision of raw water storage and emergency standby power to meet one-half of the average day demand is considered preferable to finished water storage because the standby powered production facilities can continue to furnish water beyond one day, whereas distribution storage would be depleted. In addition, the provision of one day's distribution storage would result in water quality deterioration and operating difficulties in trying to recirculate stored water. For example, if 100 percent of the average day was placed into distribution system storage, about 36 MG of storage would be required. To recirculate this water twice each week would require about 10 MG to be recirculated each day. Undesirable large variations in hourly plant production rates would routinely be necessary in order to avoid water quality degredation in the distribution system. This would clearly be an inefficient pattern of plant operation.

Reserve emergency storage would be duplication of the existing standby power facilities at Richmond Road Station and Jacobson Reservoir. Finished water storage would be less desirable than plant production capability because of the one time availability of stored water versus the consecutive daily production capacity provided by the standby power facilities.

Kentucky-American's proposal to meet one day's emergency demand with a combination of standby power capacity and distribution storage is a reasonable, operable plan which provides the full intent of the emergency supply regulation.

E. Equalization Storage

Equalization storage must be of sufficient capacity to furnish all system demands above the average rate on the maximum day. With this approach, treatment plant capacity is required to be no larger than the projected maximum day. These rules of design are standard engineering practice for water works design.

Limiting the plant capacity to the maximum day rate and providing equalizing storage for hourly peaking allows the water transmission pipelines from the treatment plant to be optimized at the maximum day capacity. The peak demands in excess of the maximum day rate are met from storage and the pipelines from the plant need to transmit only the average flow on the maximum day. At night when demands are less than the average demands on the maximum day, the transmission mains can carry this reduced system demand plus the water needed to refill the storage tanks.

Equalization storage requirements are obtained from an analysis of the hour by hour plant output, incremental storage changes and customer demand on the maximum demand day. A sample of the 1988 maximum day analysis for the Kentucky-American system is shown on Exhibit B. Page B-1 is the maximum day analysis for the two water treatment plants, page B-2 analyzes the storage tanks and page B-3 summarizes the data and derives the hourly customer demand. The last column on page B-3 represents the variation of customer demand above (or below) the 64.53 MG average demand for the day. The sum of hourly demands above the maximum day (shown in brackets) and this quantity of water, 6.827 MG, is the volume of water needed to equalize the hourly demands.

Equalization storage is normally converted to a percentage of the maximum day demand. Past maximum day analyses derived equalization storage percentages of 12 percent in 1980, 14 percent in 1986, and 10.6 percent in 1988. Actual design of equalization storage is taken as 15 percent of the projected maximum day at Kentucky-American to insure storage adequacy.

F. **Fire Protection Storage**

The quantity of treated water storage needed for fire protection purposes is determined from the insurance rating surveys performed periodically by the Insurance Services Office. The maximum fire flow requirement in the Main Service (urban) zone of Kentucky-American is 8000 gpm for a duration of four (4) hours or a total volume of 1.92 MG. The High Service zone in the northern counties of the Kentucky-American system is developing in response to stimulation by new industry. In the absence of current insurance rating surveys, fire flow requirements are estimated to approach 3500 gpm for three (3) hours duration or a volume of 0.63 MG. The Sadieville area, with its existing 0.38 MG standpipe, has a fire flow capability of 1000 to 1500 gpm for two (2) hours depending on the ground elevation at the fire location. The existing storage volume is adequate for the current Sadieville service zone.

G. **Emergency Standby Power**

Emergency standby power is available at the Jacobson Reservoir pumping station and at the Richmond Road Purification Plant. These standby facilities provide for raw water pumping at a rate of 16 mgd and delivery of the water into the distribution system at a rate of 21.5 mgd. Raw water is available from Jacobson Reservoir (526 MG) and Lake Ellerslie (70 MG) in emergency situations. This represents a 33 day supply at the 16 mgd standby water treatment rate. Even if Jacobson Reservoir was one-half depleted, there would be 263 MG remaining in storage or a 16 day supply at a 16 mgd rate.

In addition to the emergency power at Richmond Road Station there is a 10 mgd distributive pump at the Kentucky River Station with emergency power. The combined capacity of the clearwell storage facilities at the Kentucky River Station is 2.97 MG.

This amount of storage could be delivered on a one time basis by the standby power driven pump. The combined output from the Kentucky River Station and Richmond Road Station would be 18.97 mgd for any single day. This is within one percent of one half of the average daily demand to date and within five percent of one half of the average daily demand expected beyond the year 2000. Additionally, the 1992 LC/CPS recommends improvements to the standby power capacity at Richmond Road Station which will increase the raw water standby pump from 16 MGD to 20 MGD. This will provide excess of one-half average day system demand in standby pumping capability.

Actual experience in existing large water systems has shown that under area-wide power failure, customer use is reduced to less than 50 percent of the normal average day use because the area-wide electrical blackout curtails activities and appliance use that would normally result in water usages A factor of 50 percent of the average day demand is used throughout the American Water Works Company properties to size standby power facilities based on past experience in the system.

The existing standby power capacity at Kentucky-American is adequate to produce and distribute one-half of the projected average day demand through the year 2000.

H. <u>Total Storage Requirements</u>

A storage analysis is presented below for each of the three pressure zones in the water system. The Main Service system covers the larger portion of Fayette County including the urban area. The North Counties High Service zone covers parts of Fayette County plus the balance of the system in the counties north of Fayette, except for Sadieville. The Sadieville system is a small reduced pressure zone serving Sadieville. As described earlier, the North Counties High Service zone and the Sadieville zone are too remote to include standby pumping capabilities in the analysis.

Storage requirements for the Main Service zone were determined by the criteria established previously. Storage is recommended to be the larger of:

(1) Equalization of the maximum day pumpage plus fire storage.

(2) Fifty percent of the average day demand.

Standby power capability will be maintained at a minimum of 50 percent of the average day demand. Storage requirements consider only net usable storage. The clearwell and washwater storage at Richmond Road Station are not considered usable for distribution storage since these facilities are needed to enable Richmond Road Station to operate satisfactory under emergency standby power conditions. The clearwell capacity at the Kentucky River Station is not considered usable for equalization or fire protection because this storage is needed for normal plant operations. However, under emergency standby conditions the Kentucky River Station clearwell capacity would be available with the existing standby power in the high service pump array.

For the North Counties High Service zone and the Sadieville Service Zone, the storage requirements shall be the greater of:

1) Equalization of the maximum day pumpage plus fire storage.
2) One average day demand.

Tables II, III and IV summarize the results of the storage analysis over the next 15 years. These tables have been updated with the final demand projections from the 1992 LC/CPS.

Table II
Storage Evaluation
Main Service System

Year	Avg. Day (MG)	Max Day (MG)	Equalization Storage(1) (MG)	Equalization Plus Fire Storage (2) (MG)	Emergency Storage (50% x Avg. Day) (MG)
1992	37.54	63.79	9.57	11.49	18.77
1996	37.67	64.90	9.74	11.66	18.84
2000	37.47	65.05	9.76	11.63	18.74
2005	37.21	65.23	9.78	11.70	18.61

(1) 15% of Max Day
(2) Fire is 8000 below x 4 hrs. or 1.92 MG
(Table 6-2 of 1992 LC/CPS)

Table III
Storage Evaluation
North Counties High Service Zone

Year	Avg. Day (MG)	Max Day (MG)	Equalization Storage(1) (MG)	Equalization Plus Fire Storage (2) (MG)	Emergency Storage (Avg. Day) (MG)
1992	1.44	1.82	.46	1.09	1.44
1996	2.38	3.01	.75	1.38	2.38
2000	2.39	3.02	.76	1.39	2.39
2005	2.39	3.02	.76	1.39	2.39

(1) 25% of Max Day
(2) Fire is 3500 below x 3 hrs. or 0.63 MG
(Modified Table 6-3 of 1992 LC/CPS)

Table IV
Storage Evaluation
Sadieville Service Zone

Year	Avg. Day (MG)	Max Day (MG)	Equalization Storage(1) (MG)	Equalization Plus Fire Storage (2) (MG)	Emergency Storage (Avg. Day) (MG)
1992	.07	.12	.03	0.21	.07
1996	.07	.12	.03	0.21	.07
2000	.08	.12	.03	0.21	.08
2005	.08	.13	.03	0.21	.08

(1) 25% of Max Day
(2) Fire is 1500 below x 2 hrs. + 0.18 MG
(Modified Table 6-4 of 1992 LC/CPS)

The Main Service zone currently has seven tanks with a gross storage capacity of 11.5 MG and a net usable capacity of 10.66 MG. Table II reveals a year 2005 need for 11.70 MG of storage for equalization and fire protection. The emergency storage volume is larger at 18.84 MG by 1996 and 18.61 by 2005. Additional usable storage of at least 8.0 MG is therefore recommended between now and the year 2005.

In the North Counties High Service zone, equalization storage plus fire protection storage needs will be a 1.39 MG by the year 2005. Emergency storage needs of 2.39 MG are anticipated. The equalization storage was based on 25 percent of the Maximum Day for this service zone and for the Sadieville service zone. Metering facilities have not been in service long enough to establish actual equalization storage needs in these service zones. An equalization allowance of 25 percent has been used based on comparison with data from similar sized systems. The storage needs can be adjusted when additional metering data becomes available. This adjustment will not result in a sizable amount of change in storage needs.

The High Service zone contains existing storage with a total capacity of 0.96 MG and a net usable capacity of 0.95 MG. The year 2005 storage need is 1.39 MG for equalization and fire protection or 2.39 MG as emergency storage. New usable storage capacity of 0.44 MG is needed to meet the equalization and fire storage needs by 2005. A larger tank of 1.44 MG would provide 100 percent of the average day in storage through the year 2005. Actual metered data will be available to redefine the storage area and tank design at the time of design.

The Sadieville service zone contains one standpipe with a capacity of 0.38 MG and a usable capacity of 0.25 MG. The average day demand is about 0.08 MG. The equalization and fire protection requirement is 0.21 MG as shown in Table IV. The existing storage tank is adequate for either condition.

I. Conclusions and Recommendations

The provision of usable distribution storage sized to meet the equalization and fire protection requirement or one-half of the average day for emergencies in the Main Service system is a reasonable, operationally sound criteria in the case of Kentucky-American, where one-half of the average daily demand is available from standby powered source of supply and production facilities. These recommendations can be surpassed in special instances where localized conditions require additional storage for effective system operation.

The above conclusions establish a need based on the calculations for 7.95 MG in storage by the year 2005 for the Main Service portion of the system. A total of 9.00 MG has been recommended in the 1992 LC/CPS to fully accommodate this need. One project to construct 3.0 MG is already underway. In the High Service zone, new storage with a minimum capacity of 1.44 MG is recommended between the present and year 2005 based on the calculations to match the expected average day demand in this zone which is rather remote from the standby powered facilities at Richmond Road Station. The 1992 LC/CPS recommends two projects with a total of 1.75 MG capacity to maintain the pressure gradient.

The 1992 Least Cost/Comprehensive Planning Study contained distribution storage tank projects to meet the storage recommendations as presented in this storage analysis. The projects are:

Project A-12

3.0 MG PUMPED STORAGE TANK
CLAYS MILL ROAD

Design/Construction: 1993-1994

Project Cost: $2,060,000

Description:

Construct 3.0 MG pumped storage facility in southwestern portion of the distribution system located on a major transmission main. The distribution storage tank is designed to meet the peak hour and fire flow demands of the southwestern area. It will be the first increment of new storage to satisfy part of the 7.95 MG of additional usable storage capacity needed in the Main Service zone between now and year 2005. Completion of this facility will reduce the Main Service storage deficit by 3.0 MG from 7.95 MG to 4.95 MG.

Computer simulations have shown that the proposed storage tank can work effectively in this portion of the system where there currently is no storage. Two pipeline projects must be installed concurrently or before construction of this storage facility. Project A-9 for 49,000 feet of 24-inch transmission main must be completed by the time this 3.0 MG storage facility is completed in order to provide adequate connections between the tank and the existing distribution system. Project A-15 consists of 17,000 feet of 20-inch main which also must be installed in conjunction with this storage project. The scope of this storage tank project includes dechlorination facilities to dechlorinate any overflow from the tank or any water obtained from draining the tank for inspection or maintenance purposes.

Project A-24

3.0 MG PUMPED STORAGE TANK, HUME ROAD

Design/Construction: 1996

Project Cost: $1,220,000

Description:

Construct the second storage tank at the Hume Road site. This tank will add 3.0 MG of storage in the Main Service system bringing the total usable storage up to 16.66 MG, compared to the long term needs estimated at 18.61 MG. The Hume Road pumps will be upgraded or replaced to fully utilize the 6.0 MG of storage capacity at the site.

The scope of this project includes a retention basin or other suitable facilities to provide for draining the tank and disposing of the chlorinated water in a satisfactory manner.

Project B-6

0.75 MG ELEVATED TANK, AVON AND 23,000 FEET OF 12-INCH

Design/Construction: 1997-2005

Project Cost: $2,880,000

Description:

Construct a 0.75 MG elevated tank on Ironworks Road in the general vicinity northeast of the Avon Depot. An alternate site would be on Briar Hill Road in the Clintonville vicinity. This tank would provide elevated storage for the new eastern portion of the High Service system created by pipeline projects A-22 plus the booster station and pipelines of project A-13. The tank would increase High Service storage to 1.70 MG of usable storage. The site for the tank could be revised as necessary to avoid the Avon Landing Field, as long as adequate pipeline connections are provided for the tank. The site should be the highest suitable ground elevation. The tank location should be researched thoroughly to insure that the ground elevation is suitable and that sufficient land is obtained to provide dechlorination facilities for the potential overflow of water from the tank, or for draining the tank for any reason.

Project B-8

1.0 MG PUMPED STORAGE FACILITY, RUSSELL CAVE

Design/Construction: 1997-2005 Project Cost: $1,150,000

Description:

This storage tank will meet peaking needs in the center of the High Service pressure zone. It will provide the additional storage needed to meet the one average day's storage recommended for the High Service system. This tank was changed from elevated storage in the 1986 LC/CPS to pumped storage because a greater need for elevated storage exists in the Avon area. The pumped storage facility will provide supplemental flows for peaking and fire protection in the central portion of the High Service zone. The tank capacity will be finalized at design time after accumulation of metering data on High Service system consumption, and confirmation of the equalization storage, fire storage and emergency one average day storage quantities needed to fulfill the storage needs in the High Service system.

The scope of this project includes dechlorination facilities to dechlorinate any overflow from the tank or any water obtained from draining the tank for inspection or maintenance purposes.

Project B-13

3.0 MG PUMPED STORAGE FACILITY

Design/Construction: 1997-2005 Project Cost: $1,280,000

Description:

Construct the second storage tank at the southwestern pumped storage facility located on Clays Mill Road. This tank will add 3.0 MG of storage in the Main Service system bringing the total to 19.66 which will more than satisfy the 18.61 MG goal of equalling one half of the 2005 average day. An additional pump will be added to fully utilize the 6.0 MG of storage capacity at the site.

The need for storage will be reviewed prior to construction to take into consideration any changes in the demand projections or other factors which affect distribution storage requirements.

Project B-14

EMERGENCY POWER IMPROVEMENTS

Design/Construction: 1997-2005 Project Cost: $300,000

Description:

In order to increase the standby production capabilities for the Kentucky-American system to a rate equal to half of the average day system demand, it will be necessary to replace one of the pumping units at Jacobson Reservoir, and one of the distributive pumping units in the plant with direct drive diesel pumping units. Presently, there is only 16.0 mgd of raw water standby pumping capacity at Jacobson Reservoir when operating one unit only, and 21.5 mgd of finished water distributive standby pumping capacity at the Richmond Road Station. The desired rate for delivery is approximately 20 mgd. The existing diesel generators at the Richmond Road Station which power the chemical feed systems and sedimentation equipment are adequate for 20 mgd rates.

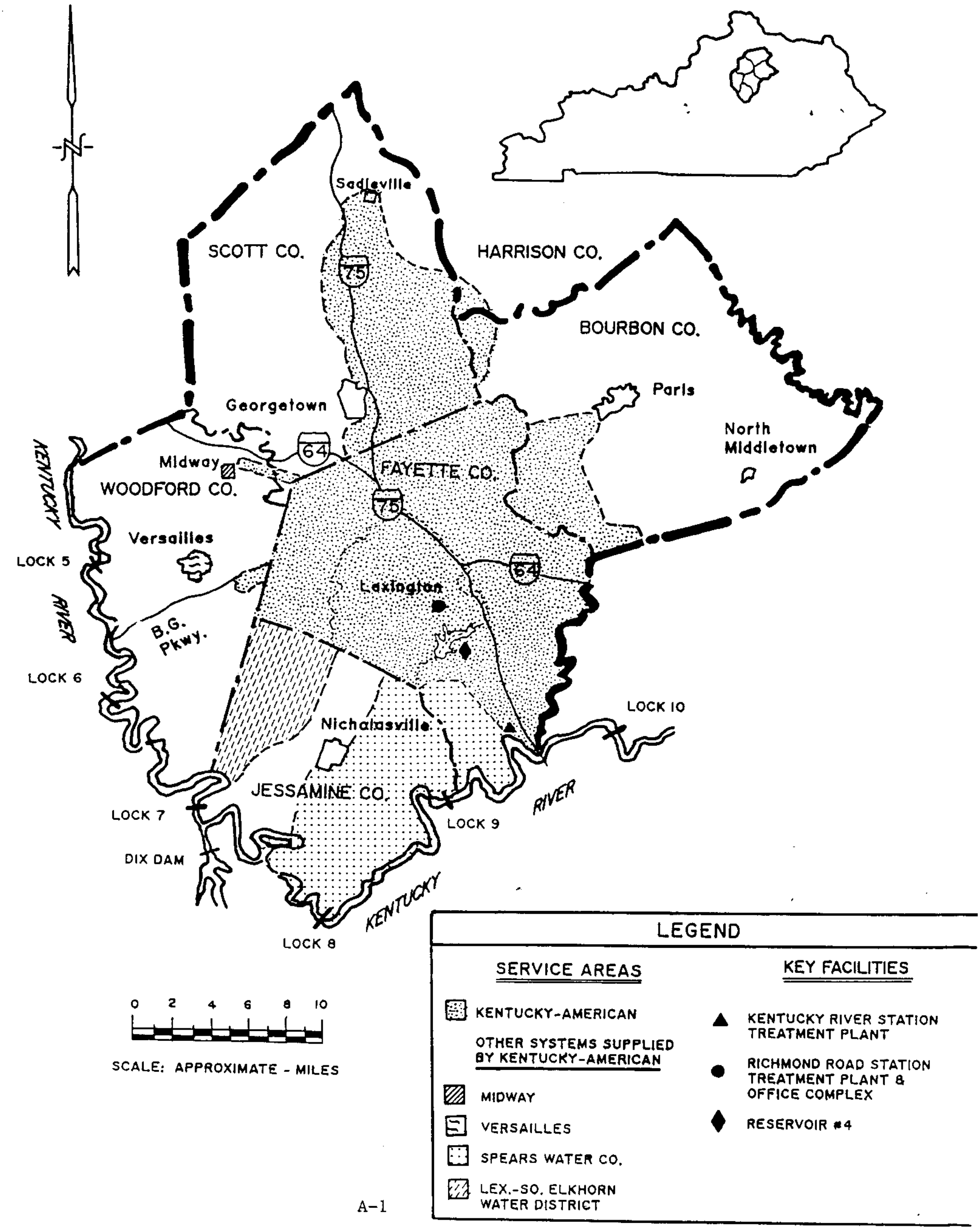
H. Cost Implications of Additional Storage

The storage recommendations described above are estimated to cost $8,890,000 (1992 dollars, including companion pumping facilities where necessary). The actual cost estimate will vary depending on the specific sizes, locations and timing for the storage facilities.

Providing one full average day supply in finished water storage would cost an estimated $17,000,000 to $20,000,000. The additional expenditure of $8,000,000 to $11,000,000 to provide one average day's storage is not recommended, as this amount of storage does not improve normal system operation (in fact, it could lead to water quality problems during low demand periods), and it only marginally improves overall system reliability.

As described above, a combination of finished water storage and raw water storage with emergency power for treatment and delivery is considered an appropriate goal for Kentucky-American Water Company system, considering its size, sources, treatment facilities, and system configuration. Construction of the proposed reliability storage should be phased throughout the 15-year planning horizon.

EXHIBIT A



SCOTT CO.
HARRISON CO.
BOURBON CO.
Sadieville
Georgetown
Paris
North Middletown
Midway
WOODFORD CO.
FAYETTE CO.
Versailles
Lexington
B.G. Pkwy.
Nicholasville
JESSAMINE CO.
KENTUCKY RIVER
LOCK 5
LOCK 6
LOCK 7
DIX DAM
LOCK 8
LOCK 9
LOCK 10
75
64
0 2 4 6 8 10
SCALE: APPROXIMATE - MILES
LEGEND
SERVICE AREAS
KENTUCKY-AMERICAN
OTHER SYSTEMS SUPPLIED BY KENTUCKY-AMERICAN
MIDWAY
VERSAILLES
SPEARS WATER CO.
LEX.-SO. ELKHORN WATER DISTRICT
KEY FACILITIES
KENTUCKY RIVER STATION TREATMENT PLANT
RICHMOND ROAD STATION TREATMENT PLANT & OFFICE COMPLEX
RESERVOIR #4

EXHIBIT B

KENTUCKY-AMERICAN WATER COMPANY
JUNE 08,1988 SYSTEM FLOW ANALYSIS
TREATMENT PLANTS

RICHMOND ROAD STATION

HOUR	CHART 24 UNIT 17 (MGD)	CHART 23 UNIT 18 (MGD)	CHART 17 UNIT 16 (MGD)	DIESEL UNIT 5 (MGD)	DIESEL UNIT 19 (MGD)	DIESEL UNIT 14 (MGD)	RRS TOTAL (MGD)
MID-1	9.55	3.45	6.96	0.00	2.62	0.00	22.58
1-2	9.05	3.27	6.57	0.00	3.28	0.00	22.17
2-3	8.70	3.14	6.32	0.00	3.14	0.00	21.30
3-4	9.18	3.32	6.67	0.00	3.31	0.00	22.48
4-5	8.24	2.96	5.99	0.00	2.96	3.30	23.45
5-6	7.84	2.83	5.74	0.00	1.89	5.70	24.00
6-7	7.86	2.84	5.72	0.00	0.90	5.72	23.04
7-8	8.74	3.16	6.48	2.19	3.18	6.35	30.10
8-9	7.07	2.56	5.14	3.54	2.56	5.14	26.01
9-10	7.58	2.75	6.21	0.96	0.92	4.52	22.94
10-11	8.70	3.14	6.32	0.00	0.00	6.32	24.48
11-NOON	8.86	3.20	6.44	0.00	0.00	6.44	24.94
NOON-1	8.87	3.20	6.44	0.00	0.00	6.44	24.95
1-2	8.89	3.21	6.51	0.00	2.14	6.46	27.21
2-3	9.27	3.35	6.73	0.00	3.35	6.73	29.43
3-4	9.14	3.30	6.64	0.00	3.30	6.64	29.02
4-5	8.21	3.25	6.06	0.00	1.28	5.37	24.17
5-6	10.32	3.73	7.50	0.00	0.00	0.00	21.55
6-7	10.30	3.70	7.52	4.29	3.10	0.00	28.91
7-8	9.68	3.50	7.03	4.85	3.50	0.00	28.56
8-9	9.64	3.48	7.00	4.83	3.49	0.00	28.44
9-10	9.88	3.57	7.18	4.95	3.57	0.00	29.15
10-11	9.64	3.79	7.19	0.79	0.56	0.00	21.97
11-MID	9.70	3.51	7.05	0.00	0.00	0.00	20.26
TOTAL	214.91	78.21	157.41	26.40	49.05	75.13	601.11
TOTAL/24	8.95	3.26	6.56	1.10	2.04	3.13	25.05

RICHMOND RD STATION (905)

HOUR	FGN # 291 gage el. 987.00 (psi)	AVG PSI	HGL(FT)
MID	NA	NA	NA
1	NA	NA	NA
2	NA	NA	NA
3	NA	NA	NA
4	NA	NA	NA
5	NA	NA	NA
6	NA	NA	NA
7	NA	NA	NA
8	NA	NA	NA
9	NA	NA	NA
10	NA	NA	NA
11	NA	NA	NA
NOON	NA	NA	NA
1	NA	NA	NA
2	NA	NA	NA
3	NA	NA	NA
4	76.0	76.0	1162.6
5	76.0	76.0	1162.6
6	76.0	75.0	1160.3
7	74.0	72.0	1153.3
8	70.0	68.0	1144.1
9	66.0	72.0	1153.3
10	78.0	75.0	1160.3
11	72.0	75.5	1161.4
MID	79.0		

KENTUCKY RIVER STATION

HOUR	CHART 26 NORTH 30" (MGD)	CHART 37 SOUTH 30" (MGD)	CHART 42 UNTS 22&25 (MGD)	KRS TOTAL (MGD)
MID-1	9.00	9.00	19.50	37.50
1-2	9.00	8.90	19.20	37.10
2-3	9.00	9.10	19.50	37.60
3-4	9.00	8.00	19.50	36.50
4-5	9.00	8.00	19.40	36.40
5-6	9.00	8.00	19.50	36.50
6-7	9.00	9.30	19.60	37.90
7-8	9.00	9.40	19.90	38.30
8-9	9.00	9.60	20.00	38.60
9-10	9.25	10.10	20.80	40.15
10-11	9.25	10.20	20.90	40.35
11-NOON	9.25	10.20	20.70	40.15
NOON-1	9.00	10.00	20.50	39.50
1-2	9.00	10.00	20.80	39.80
2-3	9.25	10.10	20.90	40.25
3-4	9.25	10.35	21.00	40.60
4-5	9.20	10.20	21.00	40.40
5-6	9.51	10.50	21.00	41.01
6-7	9.00	10.42	21.10	40.52
7-8	9.40	10.50	21.30	41.20
8-9	9.80	10.70	21.50	42.00
9-10	9.50	10.20	20.60	40.30
10-11	8.90	10.00	20.20	39.10
11-MID	8.80	9.30	20.00	38.10

KENTUCKY RIVER STA (907)

HOUR	FGN # 1 gage el. 903.00 (psi)	AVG PSI	HGL(FT)
MID	165.0	166.5	1287.6
1	168.0	169.0	1293.4
2	170.0	172.0	1300.3
3	174.0	175.5	1308.4
4	177.0	177.5	1313.0
5	178.0	178.0	1314.2
6	178.0	178.5	1315.3
7	179.0	179.0	1316.5
8	179.0	178.5	1315.3
9	178.0	175.0	1307.3
10	172.0	171.0	1298.0
11	170.0	170.0	1295.7
NOON	170.0	170.0	1295.7
1	170.0	170.0	1295.7
2	170.0	169.0	1293.4
3	168.0	166.5	1287.6
4	165.0	163.0	1279.5
5	161.0	160.5	1273.8
6	160.0	159.0	1270.3
7	158.0	156.5	1264.5
8	155.0	153.5	1257.6
9	152.0	154.5	1259.9
10	157.0	158.5	1269.1
11	160.0	162.5	1278.4
MID	165.0		

HOUR	TREATMENT PLANT TOTAL (MGD)
MID-1	60.08
1-2	59.27
2-3	58.90
3-4	58.98
4-5	59.85
5-6	60.50
6-7	60.94
7-8	68.40
8-9	64.61
9-10	63.09
10-11	64.83
11-NOON	65.09
NOON-1	64.45
1-2	67.01
2-3	69.68
3-4	69.62
4-5	64.57
5-6	62.56
6-7	69.43
7-8	69.76
8-9	70.44
9-10	69.45
10-11	61.07
11-MID	58.36

KENTUCKY-AMERICAN WATER COMPANY
JUNE 08,1988 SYSTEM FLOW ANALYSIS
STORAGE TANKS

HOUR	TATES CREEK FT.CHG.	TATES CREEK (MGD)	COX ST.ELEV. FT.CHG.	COX ST.ELEV. (MGD)	COX ST.GRND. FT.CHG.	COX ST.GRND. (MGD)	YORK STREET FT.CHG.	YORK STREET (MGD)	MERCER ROAD FT.CHG.	MERCER ROAD (MGD)	PARKERS MILL FT.CHG.	PARKERS MILL (MGD)	HALL TANK FT.CHG.	HALL TANK (MGD)	HUME RD TANK FT.CHG.	HUME RD TANK (MGD)	TOTAL STORAGE CONTRIBUTION (MGD)
MID-1	-2.0	-0.64	-5.5	-4.40	0.0	0.00	-11.8	-8.09	0.0	0.00	-3.0	-5.40	-5.2	-0.29	0.0	0.00	-18.82
1-2	-6.2	-1.98	-4.5	-3.60	0.0	0.00	-6.2	-4.25	-6.0	-8.29	-3.4	-6.12	-5.0	-0.28	-1.5	-2.70	-27.22
2-3	-4.7	-1.50	-3.9	-3.12	0.0	0.00	-1.8	-1.23	-4.9	-6.77	-3.0	-5.40	-7.0	-0.39	-2.1	-3.78	-22.20
3-4	-0.2	-0.06	-2.1	-1.68	0.0	0.00	-0.2	-0.14	-4.1	-5.66	-1.9	-3.42	-3.5	-0.20	-2.9	-5.22	-16.38
4-5	-0.1	-0.03	-2.8	-2.24	-2.7	-1.85	0.0	0.00	-3.2	-4.42	-4.2	-7.56	-4.5	-0.25	-3.3	-5.94	-22.30
5-6	3.7	1.18	0.6	0.48	-6.5	-4.45	0.0	0.00	-3.3	-4.56	-2.5	-4.50	-2.5	-0.14	-1.0	-1.80	-13.79
6-7	4.5	1.44	0.2	0.16	-4.0	-2.74	0.0	0.00	0.0	0.00	0.0	0.00	0.7	0.04	-2.2	-3.96	-5.06
7-8	5.0	1.60	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	-0.2	-0.01	0.0	0.00	1.59
8-9	0.0	0.00	0.2	0.16	-0.1	-0.07	0.0	0.00	0.0	0.00	0.0	0.00	2.2	0.12	0.0	0.00	0.21
9-10	0.0	0.00	2.0	1.60	-0.1	-0.07	0.0	0.00	0.6	0.83	0.0	0.00	7.2	0.40	0.0	0.00	2.77
10-11	0.0	0.00	7.3	5.84	-0.1	-0.07	0.0	0.00	2.1	2.90	0.0	0.00	8.6	0.48	0.0	0.00	9.16
11-NOON	0.0	0.00	-4.5	-3.60	7.2	4.93	0.0	0.00	0.8	1.11	0.0	0.00	4.0	0.22	0.0	0.00	2.66
NOON-1	0.0	0.00	1.0	0.80	-1.0	-0.69	0.0	0.00	0.0	0.00	2.6	4.68	-8.7	-0.49	0.0	0.00	4.31
1-2	0.0	0.00	1.1	0.88	-0.1	-0.07	0.0	0.00	0.1	0.14	1.1	1.98	10.7	0.60	0.0	0.00	3.53
2-3	0.0	0.00	1.4	1.12	-0.1	-0.07	0.0	0.00	-0.2	-0.28	0.0	0.00	6.0	0.34	0.0	0.00	1.11
3-4	0.0	0.00	1.5	1.20	-0.1	-0.07	0.0	0.00	2.2	3.04	0.3	0.54	6.4	0.36	0.0	0.00	5.07
4-5	0.0	0.00	2.5	2.00	4.4	3.01	5.3	3.63	2.4	3.32	0.0	0.00	0.2	0.01	0.0	0.00	11.98
5-6	0.0	0.00	4.4	3.52	4.0	2.74	4.5	3.09	3.3	4.56	1.5	2.70	3.6	0.20	0.0	0.00	16.81
6-7	0.0	0.00	3.1	2.48	3.5	2.40	4.2	2.88	0.0	0.00	4.2	7.56	8.2	0.46	0.0	0.00	15.78
7-8	0.0	0.00	0.0	0.00	2.0	1.37	0.0	0.00	1.2	1.66	4.0	7.20	5.6	0.31	4.0	7.20	17.74
8-9	0.0	0.00	0.0	0.00	0.0	0.00	6.2	4.25	0.1	0.14	4.8	8.64	4.3	0.24	1.9	3.42	16.69
9-10	0.0	0.00	0.0	0.00	0.0	0.00	-0.2	-0.14	4.2	5.80	0.2	0.36	4.2	0.24	3.6	6.48	12.74
10-11	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	3.2	4.42	0.0	0.00	-4.2	-0.24	3.3	5.94	10.12
11-MID	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	1.5	2.07	-0.4	-0.72	-7.5	-0.42	0.2	0.36	1.29
TOTAL		0.00		1.60		4.32		0.00		0.00		0.54		1.32		0.00	7.78
TOTAL/24		0.00		0.07		0.18		0.00		0.00		0.02		0.06		0.00	0.32

NOTE: A negative change in elevation indicates tank is refilling.

KENTUCKY-AMERICAN WATER COMPANY
JUNE 08, 1988 SYSTEM FLOW ANALYSIS
SUMMARY

HOUR	TREATMENT PLANTS (MGD)	STORAGE TANKS (MGD)	CONSUMPTN RATE (MGD)	VAR.FROM AVG RATE (MGD)
M-1	60.08	-18.82	41.26	(23.27)
1-2	59.27	-27.22	32.05	(32.48)
2-3	58.90	-22.20	36.70	(27.83)
3-4	58.98	-16.38	42.60	(21.93)
4-5	59.85	-22.30	37.55	(26.98)
5-6	60.50	-13.79	46.71	(17.82)
6-7	60.94	-5.06	55.88	(8.65)
7-8	68.40	1.59	69.99	5.46
8-9	64.61	0.21	64.82	0.29
9-10	63.09	2.77	65.86	1.33
10-11	64.83	9.16	73.99	9.46
11-N	65.09	2.66	67.75	3.22
N-1	64.45	4.31	68.76	4.23
1-2	67.01	3.53	70.54	6.01
2-3	69.68	1.11	70.79	6.26
3-4	69.62	5.07	74.69	10.16
4-5	64.57	11.98	76.55	12.02
5-6	62.56	16.81	79.37	14.84
6-7	69.43	15.78	85.21	20.68
7-8	69.76	17.74	87.50	22.97
8-9	70.44	16.69	87.13	22.60
9-10	69.45	12.74	82.19	17.66
10-11	61.07	10.12	71.19	6.66
11-M	58.36	1.29	59.65	(4.88)
TOTAL	1540.94	7.78	1548.72	(163.86) 163.86
TOTAL/24	64.21	0.32	64.53	(6.827) 6.827

EQUALIZATION STORAGE

$$\frac{6.827}{64.530} = 10.6\% \text{ of Maximum Day}$$