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Water Management Services, LLC

ENGINEERING • PLANNING • OPERATIONS • RATE STUDIES

August 14, 2004

Mr. James Rice
Kentucky Public Service Commission
P. O. Box 615
211 Sower Boulevard
Frankfort, Kentucky 40602-0615

Re: Green River Valley Water District
Rural Development Grant & Loan Project
Water System Additions & Improvements

Dear Mr. Rice:

In a transmittal dated August 13, 2004, three (3) copies of the requested Preliminary Engineering Report were sent to you. Today, on Saturday there is some question in my mind as whether or not those reports were sealed. To be sure, I have enclosed three original sealed and signed cover sheets for that report.

If necessary, please insert the attached with the report.

Should you have any questions or comments about this submittal, please contact me.

Sincerely,

Sam McIlwain, P.E.

cc: Mr. William W. Davis
Mr. David Paige, GRVWD

Preliminary Engineering Report

ADDITIONS AND IMPROVEMENTS TO WATER TREATMENT AND TRANSMISSION FACILITIES

GREEN RIVER VALLEY WATER DISTRICT

AUGUST 25, 2003

Prepared By:

WATER MANAGEMENT SERVICES, LLC

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Preliminary Engineering Report

ADDITIONS AND IMPROVEMENTS TO WATER TREATMENT AND TRANSMISSION FACILITIES

GREEN RIVER VALLEY WATER DISTRICT

STATE OF KENTUCKY
SAM L. McILLWAIN
12473
LICENSED
PROFESSIONAL ENGINEER

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AUGUST 25, 2003

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2004-285

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Water Management Services, LLC

ENGINEERING • PLANNING • OPERATIONS • RATE STUDIES

August 13, 2004

RECEIVED

AUG 16 2004

PUBLIC SERVICE
COMMISSION

Mr. James Rice
Kentucky Public Service Commission
P. O. Box 615
211 Sower Boulevard
Frankfort, Kentucky 40602-0615

Re: Green River Valley Water District
Rural Development Grant & Loan Project
Water System Additions & Improvements

Dear Mr. Rice:

In accordance with your request to Mr. William Davis of Ogden, Newell & Welch, transmitted herewith are three (3) copies of the engineering reported *Preliminary Engineering Report – Additions and Improvements to Water Treatment and Transmission Facilities – Green River Valley Water District – dated August 25, 2003.* This is the document referred to in the previously submitted USDA – Rural Development's Kentucky Guide 7 (Preliminary Engineering Report).

Should you have any questions or comments about this submittal, please contact me.

Sincerely,

Sam McIlwain, P.E.

cc: Mr. William W. Davis
Mr. David Paige, GRVWD

Preliminary Engineering Report

ADDITIONS AND IMPROVEMENTS
TO
WATER TREATMENT AND TRANSMISSION FACILITIES

GREEN RIVER VALLEY WATER DISTRICT

AUGUST 25, 2003

Prepared By:
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I INTRODUCTION

A. Background Information

The Green River Valley Water District (GRVWD) was created in 1959 under the provisions of Chapter 74 of the Kentucky Revised Statutes. Initially, the GRVWD was formed to service substantial areas of Hart County. In 1960, the County Court of Barren County granted permission to the GRVWD to annex areas of Barren County into GRVWD's service area. Subsequent to those events, GRVWD has annexed areas of Green County, Larue County and Metcalfe County into its service area. **Map No. 1** enclosed in the appendix of this Report indicates the present service area or boundaries of the GRVWD.

Under KRS 74.120(2), GRVWD is granted authorization to contract for water service to municipalities and other water districts. Under this provision of law, GRVWD provides water service to the cities of Munfordville and Bonnieville, which each operate their own water systems and purchase wholesale water from the GRVWD for resale. GRVWD also provides water services to the cities of Cave City and Horse Cave, which each own their own water systems and purchase water for resale. However, these two cities contract with GRVWD to operate their water systems.

Other smaller municipal entities within the service area of GRVWD do not own or operate a water system and, therefore, are within the service area of the GRVWD. These other smaller municipal entities and remaining rural areas of GRVWD's service area depend on GRVWD for water service. In addition to serving the water needs within GRVWD's boundaries, GRVWD also sells water to Larue County Water District No. 1 and Green -Taylor Water District.

The catalysts for the formation of the GRVWD was perennial shortage of water and often poor quality of water afforded by wells used for both public and private water sources. For the most part, the geology within the GRVWD service area is Karst having numerous sink holes. Because of this geology setting, ground water supplies from wells are unreliable relative to a source of dependable quantity and quality of water.

The GRVWD operates under the regulations of the Kentucky Public Service Commission (PSC). Of the many regulations imposed by the PSC, one of the more important is that PSC must approve all rate increases for water service.

Management of GRVWD is vested, by law, in five (5) commissioners, three (3) from Hart County and two (2) from Barren County. Each commissioner is appointed by the respective county judge executive of the county in which the commissioner resides. Also, the Cities of Horse Cave and Cave City have water boards that, in addition to their responsibilities to their cities, serve an advisory role to the GRVWD Board.

The GRVWD received a grant of $350,000 from the US Environmental Protection Agency for additions and improvements to the GRVWD's water system. This grant, which is to be administrated by the Kentucky Division of Water, was authorized by a 1999 Special Appropriation to the US Environmental Protection Agency. To qualify for this grant, the GRVWD was required to complete certain planning requirements consistent with the provisions of 401 KAR 5:006.

Subsequent to obtaining the EPA grant, GRVWD also obtained a grant and loan from the USDA – Rural Development for construction of water additions and improvements recommended in the regional plan, which was developed in compliance with 401 KAR 5:006.

For this Report, portions of that completed and approved Regional Facility Plan is included for information purposes. Included is a listing of some of the information contained herein.

1) Map showing the planning area (Appendix);
2) A description of the existing regional facilities (Section III);
3) A description of the planning area characteristics (Section III);
4) A discussion of the need for the project (Sections V and VI);
5) A discussion of the current and projected population in the planning area including existing population in the current service area, twenty (20) year projected population, and existing population without public water service (Section IV);
6) An evaluation of alternatives, including a "no action" plan (Section I);
7) Intended sources of funding shall be addressed along with estimated user fees (Sections I and IX); and
8) In addition to the cost for the current project(s) being proposed, cost estimates shall be given for the entire 20 year planning period (Section I).

B. Other Applicable Studies

In 1995, the Barren River Area Development District (BRADD) completed separate documents entitled _Water Supply Plan_ for the three (3) counties (Hart, Barren and

Metcalfe Counties) that are served, in part, by the GRVWD. In addition, similar plans were prepared by the Lincoln Trail Area Development District (LTADD) for Larue County and by Lake Cumberland Area Development District (LCADD) for Green County. The stated goals and objectives of those water supply plans are as follows:

- Meet the requirements of 401 KAR 4:220;
- Provide cities, counties, special districts and other public water suppliers with a twenty year forecast of water consumption and water supply requirements;
- Provide a locally accessible base of demographic, geographic and hydrologic information and projections to guide water system expansion and renovation;
- Provide up-to-date and locally accessible, water supply, water distribution and water storage information and mapping services;
- Provide information on potential water supply contamination sources and a basis for water supply contamination response planning;
- Provide a basis for specific recommendations for water system expansion, renovation and, if appropriate, consolidation;
- Provide water source adequacy data and specific information to provide a basis for alternate water source recommendations; and
- Provide, in tables and maps, an inventory of populations served with an adequate supply of clean and uncontaminated drinking water and also inventories of unserved population.

Many of the items required of this Report were addressed in the Water Supply Plans that were prepared for the counties served by the GRVWD. Where appropriate, this Report and GRVWD's Facilities Plan refer to the Water Supply Plans that were prepared by BRADD, LTADD and LCADD.

C. Purpose of the Report

A comment contained in January 2, 2002 letter from the Kentucky State Clearinghouse states that the Kentucky Division of Water requires a preliminary engineering report be submitted and approved before final plan and specifications are submitted. While the previous regional facility plan report was approved, the purpose of this Report is to comply with the January 2, 2002 comment from the Kentucky Division of Water.

In addition to this Report, the submittal to the Division of Water shall also include preliminary construction drawings showing details of the water treatment and transmission facilities that are to be added using the funds from the USDA – Rural Development.

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II PLANNING AREA INFORMATION)

A. General Background

Effective May 14, 1997, 401 KAR 5:006 states in part " *...no average daily design capacity of an existing regional facility shall be expanded by more than thirty percent, ...without the regional planning agency submitting a regional facility plan and the cabinet approving the plan".* Since 401 KAR 5:006 is intended to refer to wastewater facilities, its applicability may be more a conceptual than a regulatory requirement. Because of water sales to other water districts, GRVWD's water treatment plant (WTP) can be considered a regional water treatment facility. Consequently, for the purposes of water supply matters, GRVWD can be considered a regional planning agency.

Section 4 - Contents of Plan of 401 KAR 5:006 states that " *...the regional facility plan shall include the necessary information to allow for an environmental assessment and to assure that the most cost-effective and environmental sound means of achieving the established water quality goals are implemented".* Items included in Section 4 of 401 KAR 5:006 that are addressed in this **Section III - Planning Area Information** are as follows:

- At least one original 7-½ minute USGS topographic map shall be submitted showing the planning area.
- A description of the planning area characteristics, including the location of wetlands, delineation of the 100 year floodplain area, topography, groundwater, surface streams, geology, soils with specific mention of suitability or unsuitability of soils, and topography for on-site sewage disposal systems.

Relative to the issue of a planning area map, a 7-½ minute topographic map showing the planning area, entitled **Map No. 1**, was submitted as part of the Regional Facilities Plan that was previously submitted and approved by the Kentucky Division of Water. The size of the service area of the GRVWD is quite large requiring parts or all of fourteen (14) USGS topographic maps with a scale of 1 inch equaling 2,000 feet. Therefore, the previous submittal was in the form of a computer CD containing the AutoCAD Release-14 file with attached TIF files.

In addition to standard information shown on a USGS topography map, certain other information has been added to **Map No. 1**. A discussion of this added information is as follows:

- **Present Boundary of the GRVWD**

The present boundary of the GRVWD has been established by the laws of the Commonwealth of Kentucky. While it is possible, it is not expected that there will be a change in these existing boundaries.

While the municipalities of Cave City, Horse Cave, Munfordville, and Bonnieville are surrounded by the GRVWD, it is to be noted that these municipalities are not part of the GRVWD. However, all of these entities purchase water from the GRVWD and, in the case of Horse Cave and Cave City, the GRVWD operates the water system for these two cities. The most likely change in service area boundaries would be for GRVWD to assume the water system for one or more of these municipalities.

- **Projected 10 Year and 20 Year Planning Area**

As evidenced by **Map No. 1**, GRVWD has water mains extending through the entire service area. However, as addressed in Section IV of this Report, there remains an estimated 1,370 persons residing in GRVWD's service area that are not served by a public water system. That unserved population represents about 11 percent of the total estimated population currently residing inside the service area of the GRVWD.

For the most part, this unserved population is located on roads where water mains are yet to be extended. Based on recent progress in extending water mains and on current plans to extend water mains into unserved areas, it is to be anticipated that most of the estimated 1,370 persons currently unserved will be served in the next ten years.

Because of the inadequacy of private water sources, it is anticipated that population growth within the service area of the GRVWD will occur in locations where public water from GRVWD is available.

- **Location of the 100 Year Flood Plain within the GRVWD Service Area**

A majority of the service area of the GRVWD has a geological setting that is highly Karst. Many areas of the service area have no surface streams. Areas that do have a surface stream are, for the most part, relatively small and do not have a defined 100-year flood plain.

However, the Green River, which splits the service area of the GRVWD, drains a major portion of the mid section of Kentucky and, consequently, does have a 100-year flood plain. For the most part, the Green River flood plains are relatively narrow. This topography feature of the Green River serves to contain the flooding of Green River to a narrow band. For the Green River service area, development pressures have been such that a limited number of structures are at risk of flooding from the Green River. A majority of these structures are located in the Munfordville Area, which is located adjacent to the Green River.

The water treatment facilities are located above the 100-year flood elevation of the Green River. Except for the raw water intake, all pumping stations of the GRVWD are located in areas that are not subject to flooding. In the case of the raw water intake, these facilities by their very nature must be located within the flood plain. However, the pumps utilized for the Green River water intake are submersible units that are designed to withstand flooding. Electric controls for the operation of these pumps are located above the 100-year flood elevation.

B. General Nature of the Planning Area

In the last several years, water supply plans have been prepared by the Barren River Area Development District (BRADD) for Hart, Barren and Metcalfe Counties; for Green County by Lake Cumberland Area Development District (LADD) and for Larue and Nelson Counties prepared by Lincoln Trail Area Development District (LTADD). Items addressed in these plans include many of the issues of Section 4 of 401 KAR 5:006.

These water supply documents contain extensive discussions of basic hydrological, geological, and geographic considerations. Reference to these water supply plans is recommended for questions and concerns about these considerations. Copies of these documents are available for review at the offices of the area development districts named above. Also, copies are available at the office of the GRVWD as well as the other water distributors that are served by the GRVWD. Presumably, copies are also available at the regional and Frankfort Offices of the Kentucky Division of Water.

For the most part, the service area of the GRVWD is located above a Karst geological setting. Each of the water supply plans addresses the hydrogeologic sensitivity of the service area where hydrogeologic sensitivity is defined as an appraisal of the maximum possible groundwater recharge potential, flow rates and flow directions as dictated by the local geology.

The "bottom line" of this sensitivity appraisal for the service area can best be summarized in the findings of a 1993 study by J. A. Ray and P. W. O'Dell entitled

"*DIVERSITY: A new method for evaluating sensitivity of groundwater to contamination*". In that study, much of the GRVWD service area was given a score of 5, which is characterized by high potential for the ease, and speed of vertical infiltration (recharge) of liquids to penetrate through the soil. As is common knowledge in the Karst area of GRVWD, this characteristic results in an inherent high potential for contamination of the area's uppermost aquifer.

Given the number of "sink holes" in the GRVWD's service area, this finding is logical and is quite well understood by local citizens of the GRVWD service area. For that reason, most private ground water supplies are not adequate and can easily be contaminated with either or both toxic and biological waste. Also, most private ground water supplies are easily exhausted during periods of drought and are, again, considered an inadequate supply of water.

Surface Waters

Surface waters will include surface water drainage such as creeks and streams, floodplains, wild and scenic Rivers, and wetlands for the planning area. Because of the highly Karst nature of the GRVWD's service area, surface water for the GRVWD is limited primarily to the Green River. Since Green River is not classified by formal definition as a wild or scenic river, the proposed projects will not impact a wild or scenic river.

However, the Green River is a very scenic river that is a venue of float and canoe trips and, therefore, is deserving against activities that would detract from those and similar events. In any case, the proposed projects also do not appear to impact any outstanding aesthetic water areas including the Green River.

Wetlands

The U.S. Department of Interior, Fish and Wildlife Services maintains maps showing potential area of wetlands. Because of the Karst nature of the area, undoubtedly such a map would be replete with potential wetlands showing a majority of the sinkholes in the area. For the most part, projects proposed in this Report are water main extensions along existing roads, where no wetlands are expected to be encountered.

Topography

The topography of the area is shown on **Map No. 1** of this Report.

Geology and Soil Types

A detailed description of geology and soil types are contained in the water supply plans prepared by the Barren River Area Development District (BRADD) for Hart, Barren and Metcalfe Counties; for Green County by Lake Cumberland Area Development District (LADD) and for Larue and Nelson Counties prepared by Lincoln Trail Area Development District (LTADD).

Land Use

There is currently no planning and zoning organization for the service area of the GRVWD and, therefore, no land use map is included.

Zoning Map

As with land use, there is not a planning and zoning organization within the service area of GRVWD.

Well Contamination

Well contamination is common in the service area of the GRVWD. Because of the Karst nature of the area and of the network of underground streams, contamination can easily occur and can be long lasting and wide spread. Generally, wells in a heavily Karst area such as the service area of the GRVWD are deemed to be inadequate as sources of water, particularly in areas of heavy commercial and residential development.

Endangered Species and Archaeological and Historical

Planning house comments have been requested and received regarding the presence of endangered species, archaeological and historical sites within the service area of the GRVWD from the Kentucky Clearinghouse. The comments received will be fully complied in the construction of planned water facilities.

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III EVALUATION OF WATER DEMANDS

A. Existing Water System

1. Existing Water Demand

Information concerning historical daily quantities of water treated was obtained from records maintained by the Green River Valley Water District (GRVWD) at their water treatment plant located adjacent to Highway 31E and immediately south of Green River and at their main office located adjacent to Les Turner Road in Cave City. Information so obtained included 26 months of daily flow records beginning in August of 1997 and going through the end of September of 1999.

In addition to the water treated by GRVWD's water treatment plant, GRVWD occasionally purchases water from the Glasgow Water System. The occasions when water is purchased is during periods of peak demands in the Cave City area of the District's water service area. Since the completion of a 12-inch water transmission main between Horse Cave and Cave City, GRVWD has not had a need to purchase water from Glasgow Water System.

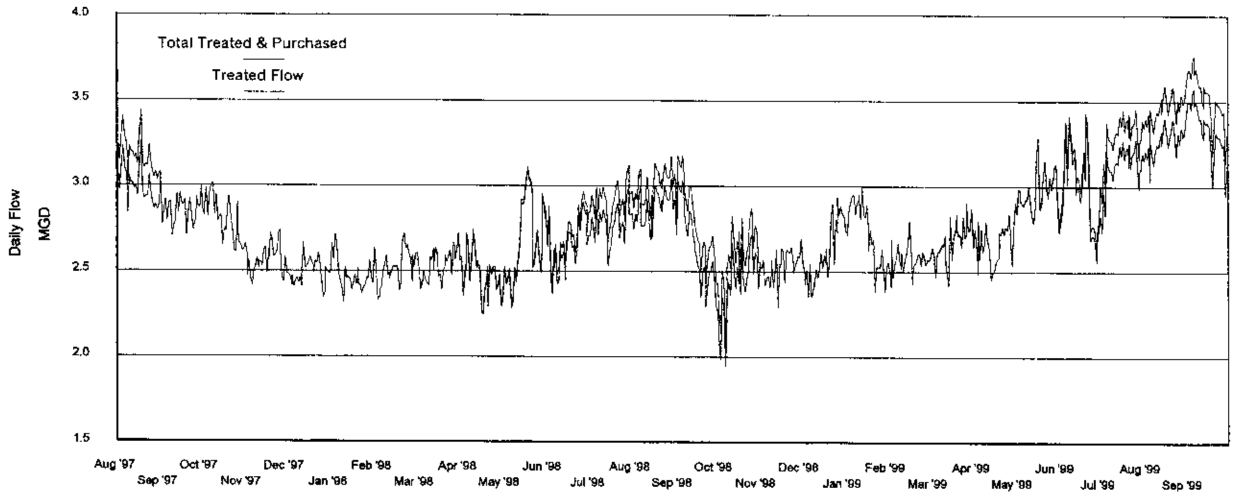
Because of the nature of the metering facilities, records of the purchased quantities of water are only available on a monthly basis. For the purposes of this Report, it is assumed that the monthly quantity of water purchased from the Glasgow Water System was used evenly throughout the month. Therefore, the average daily quantities of water purchased from Glasgow, as presented in **Figure III-1** below, are calculated daily averages based on the monthly quantity of water purchased.

During the 26-month review period, the average daily flow treated by the GRVWD water treatment plant was found to be about 2.8 million gallons per day (MGD). For the 26-month period under review, the average month was September 1998 when the average daily flow was 2.8 MGD.

Relative to water treated by GRVWD's treatment plant, the maximum month was found to be September 1999 when an average daily flow of 3.3 MGD was treated. This 3.3 MGD does not include the quantity of water purchased from the Glasgow Water System. Including the quantity of purchased water during September 1999, the average daily flow increases to about 3.5 MGD. The maximum day during the maximum month was September 7, 1999 when the total amount of treated and purchased water was 3.76 million gallons.

Figure III-1 below is a graphic presentation of GRVWD's daily flow. The blue line represents the daily amount of water treated by GRVWD's treatment plant. The red line shows the total amount of water treated plus the calculated daily average of water purchased from the Glasgow Water System. As demonstrated below, significant quantities of water are typically purchased from the Glasgow Water System during the summer months to meet peak demands.

Figure III-1
Green River Valley Water District
Daily Flow



Relative to the fluctuations in actual flows, published data on typical fluctuations in water use is reported below in **Table III-1**. As would be expected, maximum use usually occurs during two seasons: 1) in summer months, when water is in demand for garden and lawn irrigation, and 2) in winter months, when large quantities of water is wasted to prevent freezing pipes and fixtures.

Table III-1
Typical Fluctuations in Water Use [1]

	Percentage of Average for Year	
Design Conditions	**Range**	**Typical**
Average Day - Average Month	110 - 140	120
Average Day - Maximum Month	120 - 170	140
Maximum Day - Maximum Month	160 - 220	180
Maximum Hour	225 - 320	270

1 [1]Metcalf & Eddy, Inc., Water and Wastewater Engineering, Third Edition, McGraw-Hill, Inc., New York, 1991.

A comparison of actual peak flows experienced by GRVWD versus peak flows calculated using the above typical peaking factors is shown below in **Table No. III-2**.

Table III-2
Summary of Water Demands
(Million Gallons per Day)

	Avg. Day Avg. Month	Avg. Day Max. Month	Max. Day Max. Month
Actual	2.8	3.5	3.8
Theoretical	2.8	3.9	5.0

An essential design consideration in the design of water treatment facilities is the need to provide facilities that will meet maximum day - maximum month water demands. While storage reservoirs are provided to meet peak hourly and peak day demands, such facilities do not have the capability to singularly meet peak demands substantially longer than 24 hours. Also, supplemental connections used to meet peak demand, such as the Glasgow connection, may not always be available. Therefore, water treatment facilities must have the capability to meet maximum day demands.

During the 26-month review period, the maximum day demand on the GRVWD system was found to be 1.35 times the average demand. The current design capacity of the water treatment plant is 4.0 MGD. The current water treatment plant has the capability of meeting a peak demand of 1.4.

Because of the 1.35 factor actually experienced by the GRVWD system, the 1.8 factor suggested in **Table III-1** appears excessive. However, severe drought conditions or extremely cold weather conditions could result in a peaking factor greater than the recorded 1.35. When estimating peak water demands for the expansion of the GRVWD water treatment plant, consideration should be given to water demands greater than the calculated 1.35 peaking factor.

2. Existing Population Served

a. General

The service area of the GRVWD is shown on **Map 1** included in the Appendix of this Report. As noted, the GRVWD includes portions of Hart, Barren, Green, Larue and Metcalfe Counties. Because of this situation, population data which is obtainable from the University of Louisville's Kentucky Population Research Center and US Census Bureau must be disaggregated to estimate the population served by the GRVWD.

However, population data for the cities of Horse Cave, Cave City, Munfordville, and Bonnieville which are served by GRVWD is available. The cities of Munfordville and Bonnieville operate their own water systems and purchase wholesale water from the GRVWD for resale. The cities of Cave City and Horse Cave own their own water systems and purchase water for resale. However, these two cities contract with GRVWD to operate their water systems.

Other smaller municipal entities within the service area of GRVWD do not own or operate a water system. These other municipal entities and rural areas depend on GRVWD for water service. As addressed in later sections of this Report, some rural areas within the service area of GRVWD are not provided water service. These unserved areas of the GRVWD service area are awaiting funding so that water mains may be extended to their locations.

In addition to serving the water needs within GRVWD's boundaries, GRVWD also sells water to Larue County Water District No. 1 and Green-Taylor Water District.

Based on the District's service area shown in **Map 1**, the total acreage of these counties, the acreage and the percent served by the GRVWD are listed in **Table III-3.**

Table III-3
Acreage Served by the GRVWD

	Total Estimated Acreage	Estimated Acreage Served by GRVWD	Estimated Percent Served by GRVWD
Barren County	314,240	42,240	13.4%
Green County	184,960	20,480	11.1%
Hart County	266,240	188,160	70.7%
Larue County	168,320	16,640	9.9%
Metcalfe County	186,240	48,000	25.8%
Total	1,120,000	315,520	

b. Existing Population Estimates

In estimating the existing population served by the GRVWD, a review of historical population estimates for the five counties and the cities within the District was made. For the years 1990 through 1998, this information was obtained from the University of Louisville's Kentucky Population Research website and is summarized in **Table III-4.** Except for 1990, these population figures are for non-census years.

Table III-4
University of Louisville Population Figures

Location	1990	1991	1992	1993	1994	1995	1996	1997	1998
Barren County	34,00	34,292	34,433	34,870	35,073	35,745	36,24	36,730	36,979
Cave City	1,95	1,963	1,96	1,986	1,989	2,018	2,04	2,065	2,075
Green County	10,37	10,359	10,400	10,382	10,361	10,486	10,55	10,567	10,650
Hart County	14,89	15,205	15,501	15,671	15,951	16,191	16,33	16,549	16,738
Bonnieville	300	307	312	315	32	322	325	329	332
Horse Cave	2,284	2,327	2,368	2,387	2,41	2,447	2,456	2,478	2,494
Munfordville	1,556	1,556	1,576	1,597	1,60	1,621	1,631	1,629	1,640
Larue County	11,67	11,784	11,964	12,221	12,371	12,559	12,74	12,877	13,058
Metcalfe County	8,96	8,984	8,992	9,190	9,189	9,300	9,35	9,491	9,561

c. Existing Water Usage

For a 26-month period beginning August 1997 through September 1999, a review of the number of customers served by the GRVWD and the amount of water sold to those customers was made. Information for this review was obtained from records maintained by GRVWD. For that 26-month review period, the number of customers served and the average month and peak month water sales to those customers are summarized in **Table III-5**.

Table No. III-5
GRVWD Customers and Water Sales

Water Customers	Number of Customers	Average Day Average Month Water Demand (Gals per Day)	Average Day Peak Month Water Demand (Gals per Day)
GRVWD			
Residential	5,284	1,048,000	1,350,000
Commercial & Others	186	111,400	182,100
Cave City			
Residential	750	138,600	185,700
Commercial & Others	320	132,800	228,100
Horse Cave			
Residential	880	115,600	133,100
Commercial & Others	64	142,100	182,900
Munfordville / Bonnieville		300,000	372,000
Mammoth Cave National Park		30,200	58,700
Larue County W. D. No. 1		257,600	300,300
Green-Taylor W. D.		128,000	175,000
Total	7,484	2,404,300	3,167,900

It is important to note that the above water sales total does not equate to water treated by the GRVWD water treatment plant. Some of the water sold by GRVWD includes wholesale water purchased from Glasgow Water System. Also, the above water sales figures do not include an allowance for unaccounted water nor water used in the water treatment process or miscellaneous uses.

To project water needs of the service area served by the GRVWD, it is necessary to estimate the population currently served by the GRVWD. With those population estimates, estimates of water needs to serve future population as well as existing unserved population can be made.

The water sales figures listed above in **Table III-5** can be used to estimate existing populations served by the GRVWD. In general, per capita usage of water for residential population ranges between 30 gallons to 100 gallons. A summary of typical per capita water consumption are summarized in **Table III-6**.

TABLE III-6
Typical Water Unit Flow Rates

Source	Unit	Flow, gallons per unit Range	Typical
Residences			
Typical Home	Person	45 - 90	70
Better Home	Person	60 - 100	80
Older Home	Person	30 - 60	45
Apartment	Person	50 - 80	65
Industrial (sanitary only)	Employee	8 - 25	13
Office	Employee	7 - 16	13
Restaurant	Seat	20 - 50	12
Shopping Center	1,000 sq. ft.	10 - 20	12
Laundry	Machine	450 -650	550
Hospital	Bed	125 -240	165
Rest Home	Resident	50 -120	85
Schools			
Cafeteria only	Student	10 - 20	11
With Gym & Showers	Student	15 - 30	15

It is a reasonable assumption that all of the population of the cities of Cave City and Horse Cave are served by the GRVWD. Since there is population data for these cities, estimates of per capita water consumption for these cities can be made. From **Table III-4** the 1998 population for Horse Cave and Cave City was shown to be 2,494 and 2,075 respectfully. From **Table III-5**, the average residential water demand for Horse Cave and Cave City was shown to be 115,600 gallons per day and 138,600 respectfully. Based on this information, **Table III-7** lists the calculated average persons per residential customer and the calculated average usage per person.

Table III-7
Average Water Usage per Person

Location	Average Residential Demand (GPD)	1998 Population	Number of Customers	Persons per Customer	Usage Per Person (GPD)
Cave City	138,600	2,075	750	2.8	67
Horse Cave	115,600	2,494	880	2.8	46

As stated in **Table III-7**, the average water use per person in Cave City and Horse Cave ranges between 46 to 67 gallons per day. Reasonably, it can be assumed that rural residential water customers are involved in more water consumption activities such as animal water and garden irrigation than are residential water customers located inside municipalities.

Therefore, for the purpose of this Report, a higher per capita water consumption figure was used to estimate the population of the rural customers served by the GRVWD. Applying a 75 gallons per day per capita figure to the average residential rural water demand (1,048,000 gallons per day) contained in **Table III-5** yields a population of 13,973 for the rural area of the GRVWD service area.

This population does not include the population within the municipalities of Horse Cave, Cave City, Munfordville, and Bonnieville. However, the 13,973 figure does include an allowance for other smaller municipalities served by GRVWD.

Therefore, including the 1998 population figures for Horse Cave, Cave City, Munfordville and Bonnieville, the estimated total population served by the GRVWD is summarized below in **Table III-8**.

Table III-8
Existing Population Served by GRVWD

Location	Population
Bonnieville	332
Cave City	2,075
Horse Cave	2,494
Munfordville	1,640
Remaining in District	13,973
Total	20,514

While the above tabulation gives an estimate of the current population served by the GRVWD, it does not present an estimate of the number of existing population within the service area of GRVWD that is not currently served public water. To estimate that number of unserved population, a review of 1990 US Census data was made. Part of the information gathered during that 1990 census listed the number of households that were served by wells or sources of water other than a public water supply.

It is an assumption of this Report that all of that population residing inside the municipalities are served by public water system. Therefore, the portion of the population that does not have public water resides in the rural areas of the five counties.

Table III-9 tabulates the 1990 rural population for the five counties, portions of which are served by the GRVWD. These tabulated population figures exclude the portion of the population residing inside municipalities located in these five counties. Also listed is the percent of each county included in the service area of GRVWD.

Based on the percent of area served by GRVWD, an allocation of the total population within the GRVWD was made. Based on this allocation, the rural population within the GRVWD service area is estimated to have been about 13,797. However, not all of these 13,797 were connected to the GRVWD water system.

Table III-9
Estimate of the 1990 Rural Population within the GRVWD Service Area

Location	1990 Population of Counties	Percent of Counties within the GRVWD Service Area	Estimated 1990 Population within GRVWD Service Area
Barren County	18,502	13.4%	2,479
Green County	8,381	11.1%	930
Hart County	10,750	70.7%	7,600
Larue County	8,645	9.9%	856
Metcalfe County	7,486	25.8%	1,931
Total	53,764		13,797

Table III-10 tabulates the 1990 population reported by the US Census Bureau to have a private water supply and was not connected to a public water source. Based on the approach used for **Table III-9**, an allocation of this unserved population within the GRVWD service area was made. Based on the totals in **Table III-9** and **Table III-10**, it is estimated that the 1990 rural population served by the GRVWD was 13,797 less 2,661 or 11,136.

Table III-10
Estimate of the 1990 Rural Population within the GRVWD Service Area Not Served by GRVWD

Location	1990 Population of Counties Not Served by Public Water System	Percent of Counties within the GRVWD Service Area	Estimated 1990 Non Served Population within GRVWD Service Area
Barren County	1,734	13.4%	232
Green County	1,656	11.1%	184
Hart County	2,051	70.7%	1,450
Larue County	2,252	9.9%	223
Metcalfe County	2,218	25.8%	572
Total	9,911		2,661

In **Table III-11**, a similar allocation of 1998 rural population as estimated by the University of Louisville was made. The allocation in **Table III-11** was again made based on the percent of area within each county served by the GRVWD.

Table No. III-11

Estimate of the 1998 Rural Population within the GRVWD Service Area

Location	1998 Population of Counties	Percent of Counties within the GRVWD Service Area	Estimated 1998 Population within GRVWD Service Area
Barren County	20,056	13.4%	2,688
Green County	8,611	11.1%	956
Hart County	12,272	70.7%	8,676
Larue County	9,713	9.9%	962
Metcalfe County	8,002	25.8%	2,065
Total	58,654		15,346

The 15,346 population figure listed above in **Table III-11** compared to the estimated 13,973 figure shown in **Table III-8** suggests that there are some 1,370 persons located within the GRVWD's service area that are currently not connected to the public water system. Since 1990, GRVWD has undertaken several water extension projects to serve the existing population.

The above 1,370 population figure suggests that the 1990 unserved population of 2,661 (see **Table III-10**) has been reduced by about 1,290 persons. This reduction is consistent with the water customers added by recent water extension projects.

B. Future Water Demands

1. Population Projections

Evaluation of needs for the GRVWD water system must include projections for future population and for existing population not presently served as presented above. Considerations of a number of issues are involved in evaluating these future water needs and demands; the main one being an estimate of future population served.

Projection of population growth is a complex undertaking involving many considerations. Any number of local, state and national events can occur that could increase or decrease the rate of population growth within the GRVWD.

The website of University of Louisville's Kentucky Population Research Center provides population projections through the year 2020 for all Kentucky counties. The projections for the five counties within the District are presented in **Table III-12**.

While the Kentucky Population Research Center does not specifically list population projections for the cities located within these counties, the projected growth of these cities is included in the county projections.

Table III-12
Summary of Population Projections for the Five County Area
Year 2000 through Year 2020

	2000	Annual Increase from 1998	2010	Annual Increase from 2000	2020	Annual Increase from 2010
Barren County	38,147	1.57%	41,054	0.74%	42,796	0.42%
Green County	10,655	N/A	10,691	N/A	10,529	N/A
Hart County	17,204	1.38%	18,630	0.80%	19,495	0.45%
Larue County	13,351	1.10%	14,307	0.69%	14,856	0.38%
Metcalfe County	9,690	0.67%	10,141	0.46%	10,342	0.20%

An allocation of the above projected population was made to the GRVWD based on the percentage of the county served by the GRVWD. This procedure is similar to that used to allocate existing population within the GRVWD's service area. The year 2000 population has been adjusted down to account for the existing population that is currently not served by the GRVWD. However, it is assumed that by the year 2010, the vast majority of that existing population will be served by GRVWD and, therefore, no adjustments were made to the projected population figures for the years 2010 and 2020. A summary of the allocation is presented in **Table III-13**.

Table III-13
Summary of Population Allocation to the GRVWD Service Area
Year 2000 through Year 2020

		2000	2010	2020
Barren County		4,995	5,501	5,735
Green County		1,091	1,187	1,169
Hart County		11,431	13,171	13,783
Larue County		1,210	1,416	1,471
Metcalfe County		2,185	2,616	2,668
	Total	20,911	23,892	24,825

2. Evaluation of Future Water Demands

a. Projections of Water Needs

The average daily quantity of water treated and purchased is 2.8 MGD. Excluding the wholesale water supplied to Larue County Water District No. 1, Green-Taylor Water District and the Mammoth Cave National Park, the average daily quantity of water used by the GRVWD is about 2.4 MGD which equates to about 117 gallons per day per person. As reported earlier in this Report, the average water consumption by residential water customers ranges between about 50 to 75 gallons per person per day.

Therefore, water consumption by residential customers accounts for about half of the average 117 gallons per day per person treated and purchased by GRVWD. This is typical of what is experienced by most municipal water systems. The remaining portion of the 117 gallons per day per person figure is water used internally by the water treatment process or consumed by institutional, commercial, and industrial customers. Also included in the 117 gallon figure is water used in fire protection, hydrant flushing, and other similar services. Finally, every water system has some unaccounted for water, some of which is non-detectable water main leaks. This unaccounted for water is included in this 117 gallons per day per person figure.

Therefore, the projection of future water needs used in this Report assumes that the quantity of average water treated by GRVWD will continue to average 117 gallons per day per person. Consequently, this approach allows for water demands by future institutional, commercial and industrial customers. For projecting the water demands on the GRVWD water treatment plant, this approach is adjudged to be appropriate. However, for evaluation of water needs within a specific area of the water system, this approach would not be appropriate.

Relative to the issue of peak demands, the existing GRVWD system was found to have experienced a peak 1.35 times greater than the average daily water demand. Currently, the existing GRVWD water treatment plant has the capability to meet a peak demand of 1.4 times the average water demand. Based on a review of records of the GRVWD water system, the capability of meeting a maximum day water demand 1.35 times greater than the average flow may be adjudged to be minimally adequate. For planning purposes, a peaking factor of 1.5 is recommended, which is somewhat less than that suggested in **Table III-1**.

b. Allowance for Reserve Capacity

In addition to water demands resulting from the above population projections, consideration should be given to large water uses by new or existing industrial customers. Normally the addition of a new industry with a large water demand is an infrequent occurrence, but such additions when they do occur can meet or exceed the reserve capacity of the water system. There is not practical means to project such events; therefore, the normal procedure is to include in the design capacity a reserve allowance of 5 to 10 percent of the average daily water demand.

In future reviews of capacity needs for the GRVWD water treatment plant, it is suggested that a reserve capacity of about 0.25 MGD be maintained and a peaking factor of 1.5 be applied to the annual average of daily water production. Using that criteria, the water treatment plant's present water needs amount to about 4.38 MGD which is the sum of 2.4 MGD (current average water production less wholesales) times a peaking factor of 1.5 plus a 0.25 MGD reserve and a peak of 0.53 MGD sold to wholesale customers. Based on these figures, it is the finding of this Report that the GRVWD water treatment plant is in need of an expansion.

C. Recommendations

However, with continued growth of water demands on the GRVWD water system and the loss of the Glasgow connection, not expanding the existing GRVWD water treatment plant would reduce the available peak factor of 1.35 to a level where peak water demands could not be met.

As indicated previously, projections of future increases in average daily demand of the GRVWD system were made. These projected water needs are listed in **Table III-14**. It is assumed that all of the projected demands will be met by the GRVWD water treatment plant since the existing Glasgow connection may not be available.

Therefore, one of the findings of this Report is that GRVWD's water treatment plant is in need of an expansion. As listed below, the WTP potentially could receive peak flow demand in excess of its design capacity of 4.0 MGD since water treatment facilities are required to have capacity to meet peak day water demands. In a more traditional sense, recommendations regarding expansion of water treatment facilities have historically been triggered when the average water demand reaches 80 percent of the design capacity of the treatment facilitates. GRVWD's WTP has reached that "rule to thumb" level at 3.2 MGD.

Table III-14
Projected Water Needs for GRVWD

	1998	2000	2010	2020
Average Day, MGD				
Average Daily Flow, MGD				
GRVWD Customers	2.40	2.45	2.80	2.90
Wholesale Customers	0.53	0.53	0.53	0.53
Reserve Capacity	0.25	0.25	0.25	0.25
Total	3.18	3.23	3.58	3.68
Peak Day, MGD				
GRVWD Customers	3.60	3.67	4.19	4.36
Wholesale Customers	0.53	0.53	0.53	0.53
Reserve Capacity	0.25	0.25	0.25	0.25
Total	4.38	4.45	4.97	5.14

4

IV RAW AND FINISHED WATER CONSIDERATIONS

A. General

As indicated previously, the Barren River Area Development District (BRADD) completed a Water Supply Plan that had the following stated goals and objectives:

- Provide information on potential water supply contamination sources and a basis for water supply contamination response planning; and
- Provide water source adequacy data and specific information to provide a basis for alternate water source recommendations.

Where appropriate, this Section of the Report will refer to the Water Supply Plans prepared by BRADD for the five (5) counties served by the GRVWD.

B. Quantity of Water Supply

GRVWD's water treatment plant is located adjacent to and about a 1,000 feet south of the Green River near the point US Highway 31E crosses the Green River. Sources of raw water for the water treatment plant is, of course, the Green River as well as the Rio Verde Spring which is located north of Green River, which is side of Green River from the water treatment plant.

The Water Supply Plan prepared by BRADD contains information on water use, water use forecast and water supplier source assessment and supply adequacy assessment. A summary of that information is as follows:

1. Water Use

For the year 1990, BRADD's Water Supply Plan contains the following tabulation on page 9 of Section I - Phase One Document.

Water Usage by Supplier (gallons)

Water Supplier	1985	1990	1992
Green River Valley *	777,499,000	783,916,000	766,748,000

* - Includes water sold to Cave City, Munfordville Water Company, Bonnieville Water Company, Larue County Water District and Green - Taylor Water District. Green River Valley Water District also distributes water to Horse Cave, rural Barren, Edmonson, Hart, Larue and Metcalfe Counties.

It is to be noted that GRVWD supply of water to Edmonson County is limited mainly to the wholesale of water to the Mammoth Cave National Park. Also, GRVWD distributes to Green County and to Cave City.

BRADD's water supply plan also disaggregated the water use by the two sources of water used by the GRVWD's water treatment plant. A tabulation of BRADD's disaggregation is listed below. Presumably this disaggregation represents the average daily flow treated by the GRVWD's water treatment plant during the year 1990.

DISAGGREGATED WATER USE BY SOURCE
(gallons per day)
Year 1990

Type of Use	Green River	Rio Verde Spring	Total
Residential	1,247,860	203,140	1,451,000
Commercial	292,400	47,600	340,000
Industrial	106,640	17,360	124,000
Public/Unaccounted	421,400	68,600	490,000
Total	2,068,300	336,700	2,405,000

2. Water Use Forecast

For the years 2005, 2010 and 2020, BRADD's Water Supply Plan contains the following tabulations on pages 15 through 17 of the Section I - Phase One Document. The water listed under "other permitted" is water pumped from the Green River from other water suppliers, namely Butler and Edmonson County water suppliers.

BRADD's water supply plan did not specify whether or not the flows were average or peak. Presumably the flows are average daily flow rates. In **Table No. IV-14** in the previous section of this Report, the average flow for 2010 was estimated to be 3.58 MGD being treated or pumped from the Green River. This compares to 3.3 MGD listed below. For the year 2020, **Table No. IV-14** lists a flow of 3.68 as compared to 3.8 MGD listed below for the year 2020.

DISAGGREGATED WATER USE BY SOURCE
(gallons per day)
YEAR 2005

Type of Use	Gallons Used	Other Permitted *	Agricultural	Permit Exempt	Total
GREEN RIVER SOURCE					
Residential	1,806,000	1,398,300			3,204,300
Commercial	393,020	139,500			532,520
Industrial	100,620	119,200			219,820
Public/Unaccounted	423,120	388,300			811,420
Subtotal	2,722,760	2,045,300			4,768,060
RIO VERDE SOURCE					
Residential	294,000				294,000
Commercial	63,980	1,000,000			1,063,980
Industrial	16,380				16,380
Public/Unaccounted	68,880				68,880
Subtotal	443,240	1,000,000			1,443,240
Total	3,166,000	3,045,300			6,211,300

DISAGGREGATED WATER USE BY SOURCE
(gallons per day)
YEAR 2010

Type of Use	Gallons Used	Other Permitted *	Agricultural	Permit Exempt	Total
GREEN RIVER SOURCE					
Residential	1,982,300	1,473,900			3,456,200
Commercial	412,800	166,300			579,100
Industrial	101,480	129,300			230,780
Public/Unaccounted	423,120	405,500			828,620
Subtotal	2,919,700	2,175,000			5,094,700
RIO VERDE SOURCE					
Residential	230,580				230,580
Commercial	55,580	1,000,000			1,055,580
Industrial	17,360				17,360
Public/Unaccounted	68,600				68,600
Subtotal	372,120	1,000,000			1,372,120
Total	3,291,820	3,175,000			6,466,820

DISAGGREGATED WATER USE BY SOURCE
(gallons per day)
YEAR 2020

Type of Use	Gallons Used	Other Permitted *	Agricultural	Permit Exempt	Total
GREEN RIVER SOURCE					
Residential	2,407,140	1,589,600			3,996,740
Commercial	469,560	198,000			667,560
Industrial	100,620	116,700			217,320
Public/Unaccounted	410,220	325,100			735,320
Subtotal	3,387,540	2,229,400			5,616,940
RIO VERDE SOURCE					
Residential	269,360				269,360
Commercial	60,900	1,000,000			1,060,900
Industrial	17,780				17,780
Public/Unaccounted	68,740				68,740
Subtotal	416,780	1,000,000			1,416,780
Total	3,804,320	3,229,400			7,033,720

3. Water Supply Adequacy Assessment

On page 22 of the Section I - Phase One Document, BRADD presents the following source assessment for the GRVWD.

SOURCE ASSESSMENT

Public Water Supplier	Source	Type	Normal (Gals/Day)	Min. Flow	Drought Volume
GRVWD	Green River	Stream	485,000,000	64,900,000	N/A
	Rio Verde Spg.	Spring	2,500,000	N/A	N/A

Based on the procedure used in the BRADD document, a water source is deemed to be adequate if the average projected water withdrawal does not exceed 85 percent of the available water by the year 2020. As reported in the BRADD's Water Supply Plan, the calculated low flow of the Green River at the water intake for GRVWD is 485,000,000 gallons per day. Permitting guidelines of the Kentucky Division of Water allow for water available to any one user be limited to 10 percent of the average flow.

Therefore, 10 percent of the average flow at GRVWD's water intake is 48,500,000 gallons per day. As reported by BRADD, if the average rate of water use is no more than 85 percent of the 10 percent figure, a water supply is deemed to be adequate. Eighty-five (85) percent of the 48,500,000 figure is about 41,225,000 gallons per day. GRVWD's projected water withdrawals are currently less than ten (10) percent of that figure. While GRVWD's withdrawal rates are expected to increase, withdrawals are never expected to approach the 41,225,000 figure.

In addition to the Green River source, the GRVWD also has the Rio Verde Spring as a source of water. According to BRADD, the available water from the Rio Verde Spring is 2,500,000 gallons per day. Eighty-five (85) percent of that flow is about 2,125,000 gallons per day. This requirement is consistent with the GRVWD's withdrawal permit for withdrawal from the Rio Verde Spring where GRVWD is required to maintain a minimum 2.0 cubic feet per second flow for downstream agricultural purposes. However, since Rio Verde Spring discharges so close to Green River, its adequacy is tied closely to the parameters of the Green River.

In any case, the Green River is deemed to be an adequate water source for GRVWD that is in full compliance with the permitting standards of the Kentucky Division of Water. While the Rio Verde Spring is not adequate to supply the entire water needs of the GRVWD, it is extremely valuable to have a water treatment plant with two separate sources of water.

C. Quality of Raw Water

The GRVWD water treatment plant uses the Green River and Rio Verde Spring as sources of water supply. Information regarding the water quality of the water entering the GRVWD water treatment plant for a twelve-month period was obtained from the records of the GRVWD. This data has been summarized in **Table IV-1**.

Table IV-1
Monthly Averages of Raw Water Quality Data
October 1998 - September 1999

Month	pH	Total Alkalinity	Total Hardness	Turbidity
Oct. 1998	7.1	109	116	2
Nov. 1998	7.1	98	2	2
Dec. 1998	7.2	102	112	5
Jan. 1999	7.4	119	127	16
Feb. 1999	7.4	126	132	5
Mar. 1999	7.3	110	120	8
Apr. 1999	7.4	119	136	4
May 1999	7.1	105	121	9
Jun. 1999	7.1	107	126	8
Jul. 1999	7.2	101	118	10
Aug. 1999	7.1	93	111	9
Sep. 1999	6.3	84	101	9
Average	7.2	106	110	7

A comparison of average, maximum and minimum levels for the parameters listed above is as follows:

Table IV-2
Comparison of Average, Maximum and Minimum
October 1998 - September 1999

Parameters	Average	Maximum	Minimum
pH	7.2	7.9	5.5
Total Alkalinity	106	158	72
Total Hardness	110	154	88
Turbidity	7	183	1

The data in **Table IV-1** and **Table IV-2** suggest the raw water source to the GRVWD water treatment plant is consistent. However, during winter months when the river level is low and heavy rainfall and storm water conditions are experienced, turbidity and other parameters can increase significantly. During these periods, the water treatment facilities experience operational difficulties due to the relatively sudden increase in raw water turbidity.

D. Quality of Finished Water

1. General

The output of finished water from water treatment plants is regulated by various drinking water regulations issued by state and federal regulatory agencies. The more prominent of these regulations are those imposed by EPA under the authorization of the federal Safe Drinking Water Act (SDWA). The most recent of these regulations includes a group of rules to control disinfection byproducts and microbial pathogens referred to as the microbial / disinfection byproducts (M-DBP) rules.

The first phase of these recent regulations includes the *Interim Enhanced Surface Water Treatment Rule* (IESWTR) and the *Stage 1 - Disinfectants / Disinfection By-products Rule* (D/DBPR) both of which were promulgated on December 16, 1998. The second phase of these regulations is projected to be issued in several years.

For water systems that use a surface water source, the IESWTR and D/DBPR rules contain numerous requirements, many of which have to do with the operating and reporting functions of water treatment systems. While these operating and reporting functions are beyond the scope of this Report, there are a number of these requirements that either directly or indirectly affect the design and sizing of water treatment facilities.

Relative to the issue of design of water treatment facilities, the purpose of the Stage 1 D/DBPR is to require the reduction of disinfection byproducts (DBPs) by limiting the allowable concentration of DBPs such as total trihalomethanes (TTHMs) and Halocetic Acids (HAAs) and by the removal of materials in raw water that combine with chlorine to form DBPs. Primary among these materials or precursors is total organic carbon (TOC).

Similarly, the purposes of the IESWTR are to improve control of microbial pathogens in drinking water, particularly for the protozoan *Cryptosporidium,* and to guard against significant increase in microbial risk that might otherwise occur when water systems implement the Stage 1 D/DBPR. Generally, the IESWTR places more stringent controls on the performance of filters and added emphasis on the disinfectant contact time to effect the kill of *Cyrptosporidium* and other microbial organisms.

Some of the more important of these standards resulting from the first phase of the M-DBP rules are summarized below:

- Lower maximum contaminant level (MCL) of TTHM from 0.10 mg/L to 0.080 mg/L;
- Establish MCL of 0.060 mg/L for HAAs;
- Establish a maximum residual disinfectant level (MRDL) of 4.0 mg/L for chlorine;
- Require enhanced coagulation to reduce DBP precursors;
- Require a 2.0 log removal of *Cryptosporidium*;
- Strengthen turbidity performance requirements for filter effluent;
- Require individual filter units to have continuous turbidity monitoring equipment.

2. Total Organic Carbon (TOC)

The treatment technique required by the Stage 1 D/DBPR to reduce DBP precursors is Enhanced Coagulation which involves a two-step process. Step 1 requires the removal of a specific percentage of TOC during treatment. Required TOC removal percentages are based on raw water TOC and alkalinity and are listed in **Table IV-3**.

Table IV-3
Required Removal of TOC by Enhanced Coagulation

Source Water TOC (mg/L)	**Source Water Alkalinity (mg/L as $CaCO_3$)**		
	0 to 60	> 60 to 120	> 120
> 2.0 - 4.0	35.0%	25.0%	15.0%
> 4.0 - 8.0	45.0%	35.0%	25.0%
> 8.0	50.0%	40.0%	30.0%

If a system meets the above removal percentages or at least one of the conditions listed in §141.135(a)(2)(i)-(vi) of the D/DBPR regulations, the system shall be adjudged to be in compliance with the TOC removal requirements. The alternative criteria found in §141.135(a)(2)(i)-(vi) are as follows:

- The source water contains TOC of less than 2.0 mg/L, calculated as a quarterly running annual average (QRAA);
- Treated water containing TOC less than 2.0 mg/L, calculated as a QRAA;
- The treated water contains TOC of less than 4.0 mg/L, the raw water has an alkalinity greater than 60 mg/L, TTHMs tested in the water system are less than 0.040 mg/L, HAAs tested in the water system are 0.030 mg/L;
- Tests in the water distribution system determine that TTHMs are equal to or less than 0.040 mg/L and HAAs are equal to or less than 0.030 mg/L when only chlorine is used as the disinfectant; or
- Prior to the effective date for compliance, the water system has made a clear and irrevocable financial commitment to use technologies that will limit TTHMs to equal to or less than 0.040 mg/L and HAAs to equal to or less than 0.030 mg/L using any approved disinfectant;

TOC removal compliance is based on a running annual average, computed quarterly. If after the first year of monitoring, a running annual average removal ratio of less than 1.0 (actual TOC removal to required TOC removal) is achieved, the system is out of compliance. Systems that cannot meet the Step 1 removal percentages or the alternative compliance criteria must move on to Step 2 of the Enhanced Coagulation technique. Step 2 requires jar or bench scale testing to establish an alternative TOC removal percentage.

To date, GRVWD has completed 5 months of TOC sampling. The results of these samples along with the calculated removal ratio are listed below in **Table IV-4**.

Table IV-4
TOC Removal Compliance Calculations

Sample Date	Source Water Alkalinity (mg/L)	Source Water TOC (mg/L)	Treated Water TOC	Actual % TOC Removal	Required % TOC Removal	Removal Ratio	Quarterly Average Ratio
5/25/99	117	1.5	1.3	13%	N/A	1.00	-
6/08/99	109	1.8	1.8	0%	N/A	1.00	-
8/10/99	95	2.3	2.1	9%	25%	0.35	0.78
9/14/99	87	2.3	1.9	17%	25%	0.70	-

3. Disinfection By-Products (TTHM and HAA)

Relative to TTHM and HAA, the most recent four (4) quarters of concurrent TTHM and HAA results are listed below in **Table IV-5**.

Table IV-5
Concurrent Sampling Results for TTHM and HAA (mg/L)

Parameter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
TTHM	0.053	0.047	0.061	0.056
HAA	0.057	0.045	0.045	0.059

As indicated in **Table IV-6**, compliance with MCL level of TTHM and HAA is required starting December 16, 2001. At that time, the Stage 1 DBP rule requires that the annual average of TTHM be 0.080 mg/L or less and the annual average of HAA be 0.060 mg/L or less. Based on the above results and past records of TTHM sampling GRVWD should be in compliance with the TTHM and HAA MCL.

4. Interim Enhanced Surface Water Treatment (IESWTR)

As published in EPA documents, the primary purposes of the IESWTR are ".. (1) to improve control of microbial pathogens in drinking water, particularly for the protozoan *Cryptosporidium*, and (2) to guard against significant increases in microbial risk that might otherwise occur when systems implement the Stage 1 - Disinfectants / Disinfection Byproducts Rule".

Under the IESWTR, conventional filtration facilities such as those used at GRVWD's water treatment plant are required to achieve at least 99 percent (2-log) removal of *Cryptoporidium.* EPA data indicates that rapid granular filtration systems (such as used at the GRVWD facility) will achieve 99 percent removal of *Cryptoporidium*. This removal is conditioned on the fact that the filters are operated under appropriate coagulation conditions and the filters are optimized to meet the turbidity performance standards of the IESWTR. The IESWTR requires the combined filter effluent turbidity to be less than 0.3 NTU (nephelometric turbidity units) in at least 95 percent of the measurements taken each month. For compliance with this rule, turbidity samples shall be taken at four (4) hour intervals. In addition to the above, each individual filter shall be provided with continuous turbidity monitoring equipment.

EPA's schedule for compliance with the IESWTR and Stage 1 D/DBPR is generally three (3) years from the effective date of the rule. For GRVWD's water treatment plant, important milestones for compliance are summarized below in **Table IV-6**.

Table IV-6
Compliance Schedule

ACTION	MILESTONE
Initiate HAA monitoring	March 16, 1999
Submit TTHM & HAA monitoring data based on last 4 quarters	December 16, 1999
Notice of Intent to prepare disinfection profile and benchmarking	December 16, 1999
Initiate disinfection profiling data collection	March 16, 2000
Compliant with IESWTR turbidity requirements	December 16, 2001[1]
Compliant with Stage 1 Disinfectant / Disinfection By-product Rule	December 16, 2001[1]
Initiate TOC monitoring	January 2002[2]
Calculate first Running Annual Average for TOC removal compliance	January 2003

[1] States may grant two additional years for compliance if capital improvements are necessary.

[2] EPA recommends beginning at least one year earlier to determine whether compliance can be achieved.

5

V. EVALUATION OF WATER TRANSMISSION SYSTEM

A. General

Since beginning operation nearly 40 years ago, GRVWD has experienced a sustained annual increase in the number of water customers. Some of this increase is attributed to population growth within the GRVWD's service area. Other portions of the increase are due to GRVWD's efforts to provide or extend water to the existing population located within its service area.

Still other reasons for growth in water sales involve the growth in sales to other water distributors that purchase wholesale water from the GRVWD. The net effect of these increases has been to place an ever-increasing demand for water on the GRVWD's water transmission and distribution system and water treatment facilities.

Relative to the issue of the water transmission and distribution system, **Map 2** contained in the Appendix of this Report shows the location of water mains within GRVWD's service area. Generally, this map indicates the water mains existing as of 1998. Since 1998, water distribution mains have been added but are not shown. Also, **Map 2** does not include all water distribution mains within the cooperate limits of Horse Cave, Cave City, Munfordville and Bonnieville since these water mains are not owned by the GRVWD. However, all transmission mains that are the subject of this Section of the Report are shown on **Map 2** regardless of the ownership.

For the propose of this Report, the GRVWD's water transmission system is considered to be water mains that are eight (8) inches and larger as well as smaller water mains that serve water booster stations and water storage reservoirs.

Because of the barrier formed by the Green River, the GRVWD water system is divided into north and south systems. This division is most pronounced with the high service pumps at the water treatment plant where separate pumps serve the north and south portions of GRVWD's water service area. A general description of these existing water systems is as follows:

B. Existing Water System

1. North System

The North System's two (2) high service pumps are located atop the clearwell at the water treatment plant. From that point, flow is pumped and metered into an existing eight (8) inch water transmission main routed along US Highway 31E to the Linwood Water Booster Station and thence to the Magnolia Water Storage Tank.

The rated capacity of the high service pumps is about 420 gpm when discharging against a pump head of 540 feet. The distance between the high service pumps and the Magnolia Tank is about 40,000 feet. Without the Linwood Station, the high service pumps delivering water to the North System are limited to about 320 gpm to the Magnolia Tank.

The Linwood Booster Station is located some three (3) miles north of the water treatment plant and can be removed from service depending on the water demand in the northern portions of the GRVWD. The Linwood Water Booster Pump Station has a rated capacity of 520 gpm when discharging against a head of 118 feet.

From the WTP's high service pump and Linwood Booster Station water is directed along US Highway 31E to the Magnolia Water Storage Tank, which has an overflow elevation of 955. From the Magnolia Tank water is directed into the northern areas of the GRVWD as well as to the Larue County Water District No. 1. Master meters, which feed directly off the Magnolia Tank to Larue County Water District No. 1, are located on Highways 357, 470 and 31E.

There are two (2) water booster stations located on the north side of the Magnolia Tank. The largest of these stations is the Magnolia Water Booster Station, which directs water to the extreme northeast section of GRVWD's service area by way of the Mt. Sherman Water Storage Tank, which has an overflow elevation of 1,065. The capacity of the Magnolia Station is about 152 gpm when discharging against a head of 205 feet. A master meter directing wholesale water to Larue County Water District No. 1 is fed from the Mt. Sherman Tank.

The second pump located north of the Magnolia Tank is the Highway 1079 Water Booster Pump Station, which pumps water south along Highway 1079 from the Magnolia Community. The capacity of this Station is 50 gpm when discharging against a head of 80 feet. Along with the high service pumps, this Station directs water toward the Hudgins Water Storage Tank.

Another water booster station in the North System includes the Friendship Church Water Booster Pump Station located north of Highway 569. This station has a rated capacity of 70 gpm when pumping against a head of 115 feet.

Also located north of Green River is the Munfordville Water Booster Station located inside the City of Munfordville adjacent to Highway 31W. This Station, which has a rated capacity of 180 gpm when discharging against a pump head of 198 feet, directs water to the Pine Ridge Water Tank and to the Bonnieville Water Tank. The overflow elevation of the Pine Ridge Tank, which serves portions of Munfordville, has an overflow elevation of 929. The overflow of the Bonnieville Tank is reported to be also at elevation 929.

A summary of the water storage reservoirs located in the North System is listed below in **Table V-1**.

Table V-1
Listing of Water Storage Tanks
North System

Name		Volume (Gallons)	Overflow Elevation	Year of Construction
Magnolia Tank		500,000	955	1977
Pine Ridge Tank		150,000	929	1985
Mt. Sherman Tank		125,000	1,065	1988
Hudgins Tank		25,000	920	1988
Bonnieville Tank		25,000	929	1993
	Total	825,000		

2. South System

The South System is served by five (5) high service pumps located atop a high service pump chamber and one of the clearwell at the water treatment plant. One of these pumps is a 100 Horsepower (H.P.) constant speed electric motors, three (3) others are 200 H.P. constant speed motor and one (1) is a variable speed 200 H.P. motor. The rated capacity of the 100 H.P. high service pumps is about 525 gpm when discharging against a pump head of 450 feet. The rated capacities of the larger 200 H.P. pumps are about 1,500 gpm each when operating against a pump head of 500 feet. The maximum rated capacity of the single variable speed pump is about 1,300 gpm when discharging against a head of 500 feet.

From these high service pumps, flow is pumped and metered into two (2) existing twelve (12) inch water transmission mains routed south along the general route of US Highway 31E to the Canmer Community. From that point, an existing ten (10) inch water main continues south along Highway 31E to the Bunnell Crossing Water Booster Pump Station which is similar to the Linwood Station in that it can be removed from service depending on the water demand in the southern portions of the GRVWD. The Bunnell Crossing Station has a rated capacity of 590 gpm.

Also, from the Canmer Community, a twelve (12) inch and ten (10) inch water main extends west along Highway 1854 to the intersection with J. McQuire Road. At this point, the ten (10 inch) water main continues along Highways 1854, 88, and 31W to the Rowletts Community. At the point Highway 88 intersects Highway 31W, this ten (10) inch main connects to an eight (8) water main that is the main feed into the Munfordville and Bonnieville areas.

The twelve (12) water main extends along a series of roads including J. McQuire Road, Caldwell Road, Shady Lane, Highway 571, Red Book Road to Highway 31W where it connects to the Horse Cave water system and to the Horse Cave Water Storage Tank. As such, this water main serves as the main feed to the City of Horse Cave.

To serve the Horse Cave interchange with I-65, an eight (8) inch water main extends along Highways 335 and 218 from the terminal point of the above described ten (10) inch transmission main in the Rowletts Community to the Horse Cave Storage Tank. Feeding from this eight (8) inch water main are water mains serving the I-65 interchange and the Northtown Area. As indicated on **Map 2**, the Northtown area is served by the Northtown Water Booster Station, which has a rated capacity of 50 gpm when discharging against a pump head of 230 feet. Water from the Northtown Station is directed to the Northtown Water Storage Tank with an overflow elevation of about 961.

From the Bunnell Crossing Water Booster Station, water continues in a ten (10) inch transmission main south along Highway 31E to its intersection with Highway 218 (Wigwam Village). At this point, the ten (10) inch water main connects to an eight (8) inch water main routed west along Highway 218 to Horse Cave; to a six (6) inch water main running east along Highway 36 to the Le Grande Community; and to an eight (8) inch main directed south along Highway 685 to the Highway 685 Water Storage Tank, which has an overflow elevation of 822.0.

From the Highway 685 Tank water flows via a twelve (12) inch water main to Les Turner Road and thence to Highway 31E where it connects to an eight (8) inch water main in the Cave City water system. Also, the twelve (12) inch water main from the Highway 685 Tank connects to an eight (8) inch main that continues along Highway 685 to its intersection with Highway 70 at which point it connects to an eight (8) inch main that is in the Cave City water system.

As shown on **Map 2**, the Cave City water system is served by the Yogi Bear Water Storage Tank which is located adjacent to Highway 70 on the west side of I-65. The overflow elevation of the Yogi Bear Tank is 815.0.

From the Yogi Bear Tank, the Cave City Water Booster Station delivers water to the Toohey Ridge Water Storage Tank, which has an overflow elevation of about 1,038. The Toohey Ridge Tank feeds water westward to residential and commercial development along Highway 70 and to the Mammoth Cave National Park. Also served as part of this subsystem is the Eudora Community and portions of Park Ridge Road. Currently, the Toohey Ridge subsystem does not interconnect with other water mains of the GRVWD, but plans are underway to connect this system to the Northtown water system.

The above description of the South System generally describes the water system serving areas of GRVWD's service area west of Highway 31E including Horse Cave and Cave City. Areas east of Highway 31E are served by an interconnection of various subsystems served by several water booster stations and water storage tanks.

The first of these water booster stations is the Canmer Water Booster Pump Station, which is located east of the Canmer Community on Highway 677. This station, which is served by parallel six (6) and four (4) inch water mains, has two pumps, one rated for a capacity of 300 gpm when discharging against a head of 64 feet and one rated for a capacity of 230 gpm when discharging against a head of 80 feet. Water from the Canmer Station is directed to the Monroe Water Storage Tank located in the Monroe Community. The Monroe Tank has an overflow elevation of about 871. Water from this tank feeds through a six (6) inch main to a meter where Green - Taylor Water District purchases wholesale water from GRVWD.

The second of these water booster stations is the Bear Wallow Water Booster Station. As shown of **Map No. 2**, this Station, which is located near the intersection of Highways 31E and 685 has a rated capacity of 190 gpm when pumping against a pump head of 195 feet. From this Bear Wallow Station, water flows south along Highway 31E through a six (6) inch main to the Griderville Community and continues east along Highway 70 to the City of Hiseville. From Hiseville, water flows to the Hiseville Water Storage Tank located north of Hiseville as shown on **Map 2**. The overflow elevation of the Hiseville Water Storage Tank is about 870.0.

From the Hiseville tank, a series of water mains extends northeasterly along Highways 740 and 677 to the Three Spring Community and connecting to the Monroe Storage Tank. At Three Spring Community, the Three Spring Water Booster Station directs water to the Knob Lick Water Storage Tank located in Metcalfe County near the intersection of Highways 1243 and 640 and to the Crail Hope Water Booster Station located in the Crail Hope Community. The Three Spring Station, which is also fed by a water main from the Le Grande Community, has a rated capacity of 164 gpm when discharging against a pump head of 127 feet.

The overflow elevation of the Knob Lick Storage Tank is about 921. From this tank, water feeds to the Wisdom (Knob Lick) Water Booster Station which feeds water to the Echo Water Storage Tank located in the extreme southern portion of the GRVWD's service area. The rated capacity of the Wisdom Station is 70 gpm when discharging against a pump head of 192 feet. The overflow elevation of the Echo Tank is about 1,028.

As indicated above, water from the Three Springs Pump Station flows to the Crail Hope Station. The rated capacity of the Crail Hope Station is 30 gpm when discharging against a head of 111 feet. Flow from the Crail Hope Station is directed to the Crail Hope Water Storage Tank, which has an overflow elevation of about 962.0.

Listed below in **Table V-2** is a summary of the water storage reservoirs located in the South System.

Table V-2
Listing of Water Storage Tanks
South System

Name		Volume (Gallons)	Overflow Elevation	Year Construction
685 Tank		500,000	822	1962
Yogi Bear Tank		500,000	815	1976
Horse Cave Tank		500,000	842	1976
Toohey Ridge Tank		250,000	1,038	1977
Knob Lick Tank		150,000	921	1983
Hiseville Tank		250,000	870	1983
Monroe Tank		250,000	871	1985
Crail Hope Tank		25,000	962	1988
Echo Tank		25,000	1,028	1993
Northtown Tank		38,000	961	1997
	Total	2,488,000		

C. Identification of Water Supply Difficulties

For a water system that is large and has a great amount of elevation differences, the GRVWD water system has relatively few water supply problems. This is reflective of a well-operated and designed water system. However, regardless of how well a system is designed or operated, growth in water demands will ultimately result in transmission and water pressure problems. This is particularly true of a water system as large and spread out as the GRVWD.

From interviews and discussions with GRVWD operating personnel, the following conditions where reported as water pressure difficulties due to limitations in water transmission capacities. A brief discussion of these several conditions is a follows:

- **CAVE CITY AREA** - The GRVWD water transmission system is inadequate to maintain adequate water pressures in the Cave City during peak periods of water consumption. In recent years, periods of peak usage required water to be purchased from the Glasgow Water System to supplement water supplied to the Cave City area from the GRVWD water system. Due to increasing water demand on their water transmission system, the Glasgow Water Company can not continue to provide water to the level that it has in the past years. Therefore, additions and improvements are needed to the GRVWD water system in order to maintain adequate water pressure in the Cave City Area.

  Recently, the installation of a 12-inch transmission water main between Horse Cave and Cave City provided relief to water pressure problem. This water transmission addition was conceived as part of a larger project that includes the installation of a large water storage tank between Cave City and Horse Cave.

- **SOUTH SYSTEM TRANSMISSION MAINS** - The GRVWD WTP's high service pumps serving the South System currently experience discharge pressures in excess of 220 psi (510 feet). This is an indicator that the existing South Side transmission mains are approaching their maximum capacity. Additional transmission capacity is needed to transport present and future water demands into the southern portions of GRVWD's service area.
- **KNOB LICK AREA** - Along with the Cave City area, the southeast portions of GRVWD's service area have experienced water pressure difficulties during periods of peak water demands. Currently these portions of the GRVWD system benefit from high discharge pressures on the WTP's high service pumps. However, with the reduction of these discharge pressures needed to resolve transmission problems to the Cave City area, additional water pressure difficulties can be expected for this portion of the GRVWD water system. Therefore, additions and improvements are needed to maintain adequate water pressures for this portion of the GRVWD.
- **LOCUST GROVE ROAD** - Currently, the Locust Grove Road area east of Bonnieville experiences water pressure problems during periods of peak demand. This problem is due primarily to the elevation of this area and the location of this area on the end of a long dead end line. Additions to the GRVWD are needed to minimize pressure problems in this area.

- NORTH SYSTEM TRANSMISSION MAIN - The North System currently is maintaining adequate supply and pressure of water to the customers. However, similar to the South System, the WTP's high service pumps serving the North System are experiencing discharge pressures that indicate the existing eight (8) inch water transmission main is approaching its maximum capacity. While the Linwood Water Booster Station has extended the maximum capacity of this eight (8) inch water main, there is nevertheless a limit as to the amount of flow that can be accommodated by this size of water main. Continued growth within the North System will require additional capacity for the transmission main serving the Highway 31E corridor.
- **LARUE COUNTY WATER DISTRICT NO. 1** - Related to the above item, one of these customers is the Larue County Water District No. 1, which purchases water at four (4) master meter points. Currently, Larue Water District No. 1 has a need for additional water. Projections by Larue County Water District No. 1 indicate that they have water needs of more than double their current GRVWD's contract amount of 8,000,000 gallons per month. While GRVWD has no contractual obligations to supply additional water to Larue County, this situation is nevertheless identified as a point of water supply difficulties.

D. Hydraulic Computer Model

In consideration of the above water supply difficulties, a hydraulic computer model of the GRVWD water system was compiled as part of this Report and previous studies. The primary purpose of this hydraulic model was to review the capability of various portions of the water system to accommodate current and projected future peak water demands and to evaluate the effect of alternatives for additions and improvements.

In establishing the hydraulic model, the water system was divided into a network of pipes connected by nodes. For pipe sections, information relative to pipe size, length, and roughness are entered into the software program. For nodes, information on water demands and ground elevations is entered into the program. From that and additional information, the software program calculates the quantity of flow in each pipe, the head loss incurred by that flow and the resulting water pressure at the downstream node.

From this information, a comparison with actual field information was made and adjustments made to calibrate the model to replicate actual conditions. With the computer model properly calibrated, evaluations of the water system to meet various peak demands can be accurately performed. With the hydraulic model calibrated, various water demands such as average day, average day - maximum month, maximum day - maximum month and maximum hour can be analyzed for all or portions of the GRVWD water system.

The findings of the hydraulic analyses for each of the water supply difficulties are summarized below.

- CAVE CITY AREA AND SOUTH SYSTEM TRANSMISSION MAINS

  For this area of the GRVWD, the goals of this review are to:

- Reduce the pump discharge heads on the existing high service pumps serving the South System resulting in reduced electrical pumping costs and greater ability to deliver more water using the existing pumps;
- Improve and maintain the water supply to the Cave City area considering that the existing connection to Glasgow's water system is to be discontinued.

In consideration of these goals, a hydraulic review of the existing transmission system serving the southern portion of the GRVWD was performed. As shown on **Map 3** the existing transmission mains involved with this review are the following:

- A 12-inch main from the WTP routed cross-country to Canmer, then along Highway 1854 to McGuire Road and to Highway 31-W in the Horse Cave area. From Horse Cave, an 8-inch main follows Highway 31-W to Cave City.
- A 12-inch main from the WTP along Highway 31-E to Canmer where it reduces to a 10-inch and continues along Highway 31-E to Highway 218 where it reduces to an 8-inch main and follows Highway 685 to the Cave City area.
- A 10-inch main from Canmer that follows Highway 1854 to Highway 88 where it continues to the Munfordville/Rowletts area.

Reduction of Discharge Head on the Existing High Service Pumps

To reduce the pump discharge head on the high service pumps, the installation of a new transmission main from the WTP was reviewed. For the purpose of this Report, a 16-inch main, as shown on **Map 3**, would follow Highway 31-E to Hardyville where it would reduce to a 10-inch main and then follow Highway 88 to connect to the existing 12-inch transmission main at the intersection of Highway 88 and McGuire Road.

Maintenance of Water Supply to the Cave City Area

To increase the water supply to Cave City, the installation of a 12-inch main from Horse Cave to Cave City was reviewed. As shown on **Map 3**, this proposed main would follow along the railroad tracks and connect to the existing 8-inch main along Highway 31-W just before the existing Cave City meter. At that point, this proposed 12-inch water line would also connect to the existing 12-inch water main that is routed from the Highway 685 Water Tank along Les Turner Road to Highway 31E. As indicated earlier, this water transmission main has been installed.

These above described water mains would constitute recommended Phase I water transmission mains for the Cave City area. With continued growth in the southwestern area of the GRVWD, (Cave City and Horse Cave Areas), there will be a need for additional transmission and storage facilities.

For this future need when and if it occurs, Phase II facilities are preliminarily recommended that would entail the continuation of the Phase I transmission main along Highway 31E with a 12-inch main to the Bunnell Crossing water booster station and continuing to parallel the existing 10-inch and later 8-inch water transmission mains and connect to the existing 12-inch main located at the Highway 685 Water Tank.

In addition, the Phase II facilities would involve the installation of a large diameter ground storage tank on the high ground between Cave City and Horse Cave. The overflow elevation of this future tank would be 842.0, the same as the overflow elevation of the Horse Cave Water Tank. With the Phase I water main, this future tank would serve both Cave City and Horse Cave as well as other areas of GRVWD's service area.

Hydraulic Analyses

For this hydraulic review, several nodes or locations that represent critical areas of the system were chosen to demonstrate the capabilities of the water system. These nodes, which are shown on **Map 3,** are also listed below along with a brief description.

Table V-3
Description of Key Nodes
Cave City Hydraulic Analysis

Node	Location
25	Knob Lick Storage Tank, Overflow Elevation 921.5
54	Intersection of Hwy 677 and Hwy 218, Elevation 731
63	Intersection of Hwy 436 and Hwy 218, Elevation 659
99	Intersection of Hwy 1846 and Hwy 685, Elevation 740
101	Hwy 685 Storage Tank, Overflow Elevation 822
103	Intersection of Hwy 70 and Hwy 685, Elevation 710
106	Cave City Meter on Hwy 31-W, Location of Connection for proposed Horse Cave - Cave City Main, Elevation 640
116	Intersection of Hwy 31-W and Hwy 70 in Cave City, Elevation 635
131	Near Hwy 70 Railroad Crossing in Cave City, Elevation 650
138	Yogi Bear Storage Tank, Overflow Elevation 815
161	Near Intersection of Hwy 335 and Hwy 218 in Horse Cave, Location of Connection for proposed Horse Cave - Cave City Main, Elevation 685
164	Horse Cave Storage Tank, Overflow Elevation 842
184	Monroe Storage Tank, Overflow Elevation 871.25
198	Intersection of Hwy 677 and Hamilton Cemetery Rd, Elevation 679
210	Discharge Side of High Service Pumps

A summary of the computer runs used to evaluate the installation of the proposed transmission mains is presented below.

Table V-4
Description of Computer Runs
Cave City Hydraulic Analysis

Computer Model Run	Flow Conditions
1	Existing system with maximum day demand of 3.4 MGD
2	System without Glasgow connection and maximum day demand of 3.4 MGD
3	System without Glasgow connection and with proposed 16-inch main along Hwy 31-E and 10-inch main along Hwy 88 under maximum day demand of 3.4 MGD
4	System without Glasgow connection and with proposed 12-inch main from Horse Cave to Cave City under maximum day demand of 3.4 MGD
5	System without Glasgow connection and with both proposed mains under maximum day demand of 3.4 MGD

The results of the computer runs are summarized below in terms of pressure at the key nodes and hydraulic elevation at the storage tanks.

Table V-5
Summary of Computer Analyses Results
Cave City Hydraulic Analysis

Node	Run 1	Run 2	Run 3	Run 4	Run 5
25	910 '	914 '	914 '	907 '	906 '
54	66 psi	69 psi	68 psi	64 psi	63 psi
63	107 psi	109 psi	109 psi	105 psi	105 psi
99	46 psi	48 psi	49 psi	47 psi	47 psi
101	841 '	845 '	846 '	844 '	845 '
103	52 psi	53 psi	53 psi	53 psi	53 psi
106	88 psi	87 psi	87 psi	88 psi	88 psi
116	84 psi	84 psi	84 psi	84 psi	84 psi
131	76 psi	76 psi	76 psi	76 psi	76 psi
138	815 '	815 '	815 '	815 '	815 '
161	79 psi	83 psi	82 psi	70 psi	70 psi
164	867 '	876 '	874 '	847 '	847 '
184	916 '	924 '	919 '	908 '	903 '
198	116 psi	122 psi	112 psi	111 psi	103 psi
210	236 psi	244 psi	217 psi	231 psi	206 psi

As indicated by Run 1, the discharge pressure currently experienced by the high service pumps is approximately 236 psi (Node 210). With the addition of the proposed Highway 31-E transmission main in Run 3, the pressure drops 19 psi. In Run 5 with both the proposed Highway 31-E and Horse Cave - Cave City water mains, the pressure drops to 206 psi or a total of 30 psi.

E. RECOMMENDATION – SOUTH TRANSMISSION SYSTEM

Based on this hydraulic review, it is recommended that the 16-inch transmission main along Highway 31-E and the 10-inch transmission main along Highway 88 be installed to alleviate the discharge heads on the high service pumps and that the 12-inch Horse Cave-Cave City main be installed to provide greater reliability of water service to the Cave City Area.

F. NORTH SYSTEM TRANSMISSION FACILITIES

1. General Information

As indicated earlier, Larue County Water District No. 1 (LCWD), which does not have a water treatment plant, purchases much of its water from GRVWD. As with most water utilities, LCWD is extending water to existing population that does not have availability to a public water system. LCWD water purchase agreement with GRVWD is for a total of 8,000,000 gallons per month.

Under periods of peak demand, LCWD monthly water purchases exceed the 8,000,000 gallon per month limit. To provide additional water to serve to meet future water demands, LCWD anticipates the need to purchase of additional water from GRVWD.

Listed in **Table V-6** is a comparison of requested water purchases by LCWD to projections by Lincoln Trail Area Development District (LTADD) for future LCWD water demands. Average monthly flows have been adjusted by a factor of 1.6 to estimate the *maximum day - maximum month flow.*

Table V-6
Projections of LCWD's Peak Water Demands
From GRVWD (Gallons per Minute)

Year	LCWD	LTADD
2000	202	356
2005	326	449
2010	525	528
2015	N/A	607
2200	N/A	N/A

Currently, LCWD's maximum month usage rate is about 9.1 million gallons, which is well above their contracted limit of 8.0 million gallons per month. As indicated above, LCWD's projected year 2000 peak water demand is about 350 gpm or some 15.3 million gallons per month. If LTADD projections are used, LCWD's peak water demand from GRVWD could grow to over 26.3 million gallons per month by the year 2015.

GRVWD's existing water treatment plant and water transmission main facilities do not have the capability to meet these projected levels of water demand. Concerning that issue, **Section VII** of this Report discusses the needs for GRVWD's water treatment plant (WTP). In that section of the Report, it is recommended that the WTP be expanded to provide a capacity of 6.0 million gallons per day (MGD) or 2.0 MGD more than the WTP's current design capacity of 4.0 MGD.

Summarized in **Table III-14** of **Section III** of this Report are estimates of water demands on the GRVWD water system. In that tabulation, projections of wholesale water demands where assumed to remain constant at the current level of 0.53 MGD. Of that 0.53 MGD, 0.30 MGD or 9.1 million gallons per month is allocated for LCWD. If LCWD's water allocation was increased to 26.3 million gallons per month as suggested above, the 0.53 MGD allocated for all wholesale customers will increase by 0.57 MGD resulting in a total water demand of 1.1 MGD from wholesale customers.

GRVWD's projected year 2020 peak day flow would increase from 5.14 MGD to about 5.71 MGD with an additional 0.57 MGD of water being allocated to LCWD. Consequently, the recommendation contained in **Section VI** of the Report calling for a 6.0 MGD expansion of the WTP would remain unchanged.

G. RECOMMENDATION – NORTH TRANSMISSION SYSTEM

The existing north water transmission system between the WTP and connection points to the LCWD's water system will have to be increased in capacity to meet water demands on the GRVWD water system and the anticipated demands of the LCWD. Currently, the existing water transmission system consists of an 8-inch water main. Hydraulic calculations indicate that a minimum 10-inch parallel transmission main will be required.

The existing Magnolia water storage tank does not contain sufficient usable storage capacity to accommodate projected flow demands. Therefore, in addition to parallel transmission mains, GRVWD will need, at some point in the future, to add a second storage capability at the site of the existing Magnolia water storage tank.

The additional water transmission mains and water storage tank needed to accommodate the above indicated water demands from LCWD are shown on **Map 3**.

6

VI EVALUATION OF THE WATER TREATMENT PLANT

A. General

The original GRVWD water treatment plant was constructed in the early 1960's. Major treatment components that made up that original treatment plant consisted of a raw water pump and intake arrangement, Rio Verde Spring intake and water transmission main, rapid mixing chamber, flocculation basin, sedimentation basin, gravity filters, clearwell and high service pumps. The reported design capacity of the original water plant was about 1.0 million gallons per day (MGD).

Since that initial construction, several projects have been implemented during the ensuing years to expand and to enhance the capacity and performance of the water treatment plant. With the completion of these previous projects, the capacity of the water treatment plant currently is reported to be 4.0 MGD.

Major components added during previous additions and improvement projects included the following:

- Water intake and pumping modifications;
- Additional Rio Verde Spring Transmission facilities;
- Expansion of the flocculation basin;
- Additional sedimentation basins;
- Additional filters; and
- Additional high service pumps and clearwells.

B. Evaluation of the Water Treatment Plant

1. General

The present design capacity of the existing GRVWD WTP is reported to be 4.0 MGD. While this 4.0 MGD figure represents the design capacity of the overall WTP, the capacity rating of any water treatment facility is actually a composite of the capacities of the several treatment components that make up the water treatment facility.

One of the findings of this Report as contained in **Section III** indicates a need for additional water treatment capacity. Based on the unit capacities of the sedimentation basins and filters, it appears that an expansion of the water treatment plant to 6.0 MGD is appropriate for the estimated 20-year needs of GRVWD.

A discussion of the unit components of the water treatment plant is herein summarized. The capacity of each of these components was evaluated to determine if the proposed design flow of 6.0 MGD can be met by these existing facilities and to what extent these treatment components will need to be expanded to accommodate the proposed 6.0 MGD design flow. This evaluation takes into consideration new EPA regulations, state criteria, treatment efficiencies, and the need to replace or rehabilitate existing equipment and structures.

2. Raw Water Intake Facilities

a. Intake Screen and Pump Chambers

The existing intake facilities for the water treatment plant involve two separate water sources, namely, the Green River and the Rio Verde Spring. A discussion of these two water sources is as follows:

Rio Verde Spring Source

The initial water treatment plant was designed to receive, as its primary source of water, raw water from the Rio Verde Spring. As originally designed, water flows by gravity from the Rio Verde Spring to the water treatment plant. The elevation difference between the Rio Verde Spring and the water treatment plant is three to four feet. An eighteen (18) inch and twelve (12) inch raw water transmission mains are installed between the Rio Verde Spring and the WTP to accommodate flow from the Rio Verde Spring. At a point about 1,400 feet from the WTP, the 18-inch transmission main from the Spring connects to a 12-inch raw water transmission main from the raw water pump station. From this junction point, a combination of a 12-inch and 20-inch main feeds into the water treatment plant.

As noted earlier in **Section III** of the Report, the *Water Supply Plan* prepared for the GRVWD's water treatment plant by Barren River Area Development District (BRADD) estimates the maximum available capacity of the Rio Verde Spring to be about 2,000,000 gallons per day or a rate of about 1,400 gpm. A hydraulic review of the Spring's existing raw water transmission mains indicates a capacity to accommodate a flow rate of 1,400 gpm. However, this review indicates that the mains connecting to the Rio Verde Spring are severely limited in capacity when operated in conjunction with the Green River raw water pumps.

It is a finding of this Report that the quantity of water withdrawn from the Rio Verde Spring is controlled by the discharge pressures developed by the Green River raw water pumps. There are severe disadvantages associated with this situation. The characteristics of the Green River water and Rio Verde water are somewhat different and, therefore, have different chemical and flocculation needs. Because of this difference, it is desired that a consistent proportion or ratio of river water to spring water be maintained. The current flow limitation imposed of the spring operation does not afford the opportunity to establish such a consistent ratio.

In additional, the configuration of the new treatment facilities requires the additional of a new flash mixing basin. This new flash mixing basin combined with a need to better balance the hydraulic flow to the various flocculation and settling basins requires elevation of the flash mixing basin to be raised above the elevation of the existing mixing basin. To accommodate this increase in elevation, two (2) raw water pumps will be added at the proposed flash mixing chamber to elevate water from the Rio Verde Spring into the proposed flash mixing basin.

Each of these pumps will be rate for 2.0 MGD, which is the estimated output of the Rio Verde Spring. Each pump will be equipped with a variable frequency controls that will allow the output of the pumps to be controlled. In combination with a separate raw water flow meter and separate transmission main for the spring water, this variable pumping capability will enable the proportion of spring water to the river water to be set by the plant operator.

Green River Raw Water Intake Source

The existing Green River intake arrangement involves two (2) separate pump stations that withdraw water from the Green River. At a discharge head of 70 feet, one of these stations, containing dual Wemco pumps, is rated for a capacity of about 1,400 gpm or 2.0 MGD. The other station, which contains a single Flygt pump, is rated for a capacity of about 1,200 gpm when also discharging against a head of 70 feet. Both of these pump stations contain non-clog pumps capable of operating pumping unscreened water.

The Wemco pumps connected to screened intakes sited at two locations in the Green River. Because of siltation problems and possibly a screen capacity problems, the Wemco Station cannot operate both pumps due to a lack of intake capacity. Because of this limitation, the combined capacity of both pump stations is less than the WTP's design capacity of 4.0 MGD. In addition, there are field observations that suggest no flow from the Spring can reach the WTP when both river pumps are operating at their maximum pumping rate.

In summary, there are supporting hydraulic calculations and field observations suggesting that the existing raw water transmission facilities can not deliver the WTP's design capacity of 4.0 MGD. To meet existing and future water demand, new raw water intake, pump, and transmission facilities are required.

A brief listing of the recommended additions and improvements is a follows:

- As stated above, raw pumps will be installed on the discharge end of the raw water transmission mains serving the Rio Verde Spring. The proposed raw water pumping system will be equipped with a water meter to indicate and record the quantity of water being used from the Rio Verde Spring. The primary purpose of these pumps would be to eliminate current restraints placed on the use of spring water by the Green River pump stations, Such a hydraulic separation will enable the maximum use of the Rio Verde Spring. The installation of raw water metering facilities will enable set point proportioning of spring water to the river water which should facilitate plant operations and performance.
- Field surveys of the stream profile do not indicate any relatively deep pool in the river where screens could be safely located that would be protected from flood debris nor situated to avoid problems with siltation.
- Because of this situation, a new raw water intake and pumping station is proposed. This facilities will be located near the river's edge to allow water to low into a two (2) cell screening chamber. Each cell will be equipped with drum screens sized to accommodate a minimum of 4.0 MGD. The screen openings will 0.25 inches or less.
- For maintenance, the drum screens will be connected to an air tank that will allow the screens to be cleaned with an air burst. Also, each screen will be connected to the raw water line to allow back flushing. Finally, each screen cell will be equipped with a mechanically operated stop gate. This will allow each screening cell to be dewatered and cleaned, if necessary.
- Two pump chambers will be provided each equipped with two submersible non-clog pumps that will be similar to the existing raw water pumps. As with the existing pumps, the electrical controls will be located above flood level. The four (4) proposed raw water pumps will have the following capacities when pumping from a normal pool elevation in the Green River.

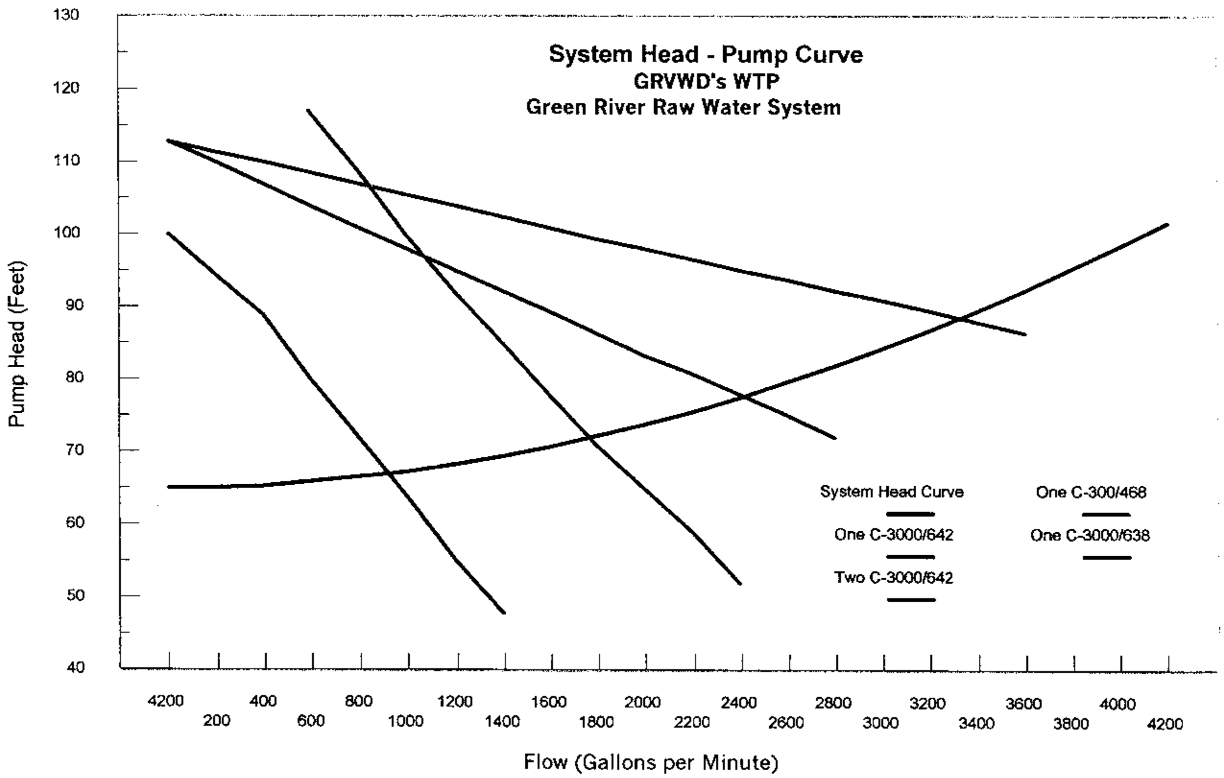
  One small pump with a capacity of 1.3 MGD

  One medium pump with a capacity of 2.5 MGD

  Two large pumps each with a capacity of 3.4 MGD

- In combination with a variable pumping rate of up to 2.0 MGD from the Rio Verde Spring, the above capacities will provide considerable flexibility in raw water feed rates to the water treatment facilities.

- To accommodate these proposed raw water pumps, a proposed 16-inch raw water transmission main will be installed connecting to the proposed flash mixing basin.
- For standby purposes, the existing raw water pumps and existing 12-inch raw water transmission main will remain in service.
- Raw water from the Green River raw water pumps will be metered to enable set point proportioning of spring water to the river water.
- Based on a preliminary selection of Flygt pumps, a graphic presentation of the system head curve versus pump curves is as follows:



3. Flash Mixing Facility

a. General Consideration for Coagulation and Flocculation

The coagulation and flocculation process is essential to properly condition raw water for effective particle removal through sedimentation and filtration. Coagulation is generally understood to begin at the point that the coagulating chemical is added. Coagulation is initiated by rapidly dispersing coagulates such as alum in the raw water under high energy mixing conditions to cause the destabilization and initial contact of small particles. This process is the purpose of the rapid or flash mixing facilities.

Following the coagulation process, the combination of particles and coagulants go to the flocculation basins where a gentle mixing occurs to improve the contact of the particles and to encourage the destabilized particles to form larger and denser solids that are more easily removed during the sedimentation and filtration process. The size and quality of the larger floc particles formed in the final stage of flocculation are indicators of the overall effectiveness of the coagulation and flocculation process.

b. Existing Conditions

Raw water enters the existing flash mixing chamber through sections of 16-inch and 12-inch lines. After the addition of chemicals, these 12-inch and 16-inch lines discharge water into the flash-mixing chamber. The existing flash or rapid mix chamber, which is equipped with a 1.0 HP mechanical mixer, has internal dimensions of 5.5 feet square by 9.0 feet deep. Since the flow is downward in the existing flash mixer, the location of the influent pipe determines the detention time in the flash mixer. Based on a review of the existing construction plans, the effective volume of the chamber is about 181 cubic feet or about 1,350 gallons.

The purpose of the flash mixing basin is to provide a thorough and complete mixing of the raw water and coagulant chemicals. One of the most important issues in the design of flash mixing basins is to provide enough energy to completely mix the coagulant chemicals with the particulate matter in the raw water.

One on the most accepted means of estimating the mixing energy in the flash mixing chamber is to calculate the velocity gradient, G. The velocity gradient is a function of the energy used (water horsepower) and the volume of the basin. The formula for G (velocity gradient) is the square root of power (P) added to the water in foot-pound per second divided by the sum of the volume (V) of the chamber times the viscosity (v) of water in pound-second per square feet or $[P / (V \times v)]^{0.5}$.

Typical requirements for detention time in flash mixing chamber range between 15 and 60 seconds. Most publications and design parameters recommend a velocity gradient between 700 to 1,000 feet per second per foot.

The existing flash chamber, which is equipped with a 1.0 horsepower mixer, has a calculated G value of about 300. At 4.0 MGD, the detention time is calculated to be 29 seconds. At 6.0 MGD, the detention time in the existing flash mixing chamber is about 19 seconds.

Therefore, at the current design flow of 4.0 MGD, the existing flash mixer is deemed to be within accepted design standards. At 6.0 MGD, the detention time becomes marginal. In addition to the detention time deficiency, a more critical deficiency with the existing flash mixing chamber is the hydraulic capacity of the influent piping and the control elevation of downstream processes.

Therefore, it is the finding of this Report that a new flash-mixing chamber is required to accommodate a flow of 6.0 MGD.

c. Proposed Flash Mixing Chamber

Based on generally recommended engineering practices, there should be at least two rapid mixing units if the design flow of the water treatment plant is greater than 3.0 MGD. With two or more units, one unit can be removed from service for maintenance and the plant can continue in operation. Recommendations concerning the need for two mixing units are contained in the Ten State Standards of 1997 and in recent guidance manuals published by EPA.

In consideration of these publications, it is the recommendation of this Report that two mixing units be installed in a flash mixing facility containing separate chambers. It is recommended that each chamber have a volume to provide a minimum detention time of 15 seconds at the design flow of 6.0 MGD. With both chambers in operation, the combined detention time would be 30 seconds, which is about mid range of the recommended detention time. This will require that each chamber contain about 144 cubic feet. In general, terms this will require each chamber to have a liquid depth of about 6 feet and a surface area of about 24.0 square feet. These chambers may be located either in parallel or in series.

For a mixing chamber size of 144 cubic feet, it is recommended that each chamber be equipped with a five horsepower mixer. This size of mixer will provide a G value of slightly less than 750, which is in the range of 700 to 1,000 recommended.

The installation of the enlarged flash mixing facilities creates problems concerning chemical addition. Currently lime, flocculation agent, and chlorine are fed to the flash mixing facilities. The relocation of the flashing mixing facilities presents some problems that requires the relocation of the chemical feed facilities.

Since the location of the flash mixing facilities is closely tied to the flocculation basins, discussion of the location of the flash mixing facilities is discussed in the following section on flocculation basins.

To facilitate the addition of chemical, a building is proposed that will provide space for lime storage and lime feed equipment. The location of the lime feeder will allow gravity feed to the proposed flash mixing basins.

The building will also house an alum day tank. The existing buried alum tank will be abandoned and two (2) new alum tank will be installed in the new filter building. Each of the new alum tanks will accommodate about 4,400 gallons, which will allow a truck load of alum to be off-loaded. An alum transfer pump will pump alum to the day tank on an "as needed" basis.

Facilities will be included in the proposed building to add chlorine at the flash mixing basin. Also, provisions will also be included to add chlorine on top of the tube settlers in the sedimentation basin as well as in the effluent channel from the sedimentation basins.

Finally, room space will be provided for the addition of activated carbon. This proposed room will be separate from other facilities and electrical facilities inside the room will in compliance with electrical code for spaces containing activated carbon.

4. Flocculation Basins

a. Existing Conditions

From the existing flash mixing chamber, water enters an existing four (4) cell basin. The volume of the existing flocculation basin is about 11,650 cubic feet or about 87,250 gallons. At the current design flow rate of 4.0 MGD, the volume of the basin results in a detention time of 31 minutes.

Design criteria of the Kentucky Division of Water require a minimum detention time of 30 minutes. According to design publications, water with a low raw water turbidity requires longer flocculation detention time than water with a high turbidity. Turbidity becomes quite low during some flow conditions in the Green River and does certainly the water from the Rio Verde Spring. For example, a raw water turbidity of about 2 was reported during the fall months of 1998. Also with snow melt, the temperature of the raw water can be quite low. Some design publications, recommend an increased detention time for cold weather conditions. Accordingly, this Report recommends that a 1.35 factor be applied to account for cold water that is sometimes experienced during the winter months. This factor increases the required detention time to 41 minutes.

However, according to a 1990 publication by AWWA entitled _Water Treatment Plant Design - Second Edition_, it is reported that most modern plants provide approximately 20 minutes of flocculation time (at 20 degree C) under peak plant flows. Applying the 1.35 factor to 20 minutes yields a detention time of about 30 minutes.

Each of the existing compartments is equipped with "vertical turbine" type flocculation units with 2.5 HP drives. Similar to the flash mixing equipment, one on the most accepted design parameters for a flocculation basin is the value G as defined above for flash mixers. According to the AWWA treatment plant design publication, the recommended value for G for the flocculation process should range from between 20 and 70 feet per second per foot. Based on the existing drives and basin volume, the existing basin provides a G value of about 70.

A second design parameter often used in flocculation design is the GT value which is the product of G (velocity gradient) times T (detention time in seconds). For each existing basin, the resulting maximum GT value at 4.0 MGD is 130,000. Recommended GT values range between 30,000 and 120,000.

b. Proposed Improvement to the Flocculation Basins

As indicated the combined volume of the existing flocculation basins is 87,250 gallons. At a proposed design flow of 6.0 MGD, the detention time in the existing basins is 21 minutes or less than the Kentucky Division of Water or Ten States Standard's design criteria of 30 minutes. However, because of the configuration of the existing basins, flocculation basin number one is not useable when a new flash-mixing basin is added. Further, the entrance and exist location of flow from flocculation basin 4 raises concerns about the effectiveness of this basin when operated with the other existing basins.

Therefore, with the abandonment of basin number one and the possible non-use of flocculation basin number four, the available volume of the existing flocculation basins two and three is about 43,500 gallons. Assuming 2 MGD of the expanded plant capacity is received by existing flocculation basins two and three, the detention time in the existing basins will be 31 minutes at their design capacity of 2.0 MGD. This is slightly more than the goal of about 30 minutes. With these modifications, the flow from these existing flocculation basins will be directed to sedimentation basins 1 and 2.

Further, it is proposed that a flocculation basin, similar in capacity and design to the existing, will be added to operate in conjunction with basin four. This combination of existing and proposed will serve existing sedimentation basins three and four. The detention time in this combination of existing and proposed will be 31 minutes.

New flocculation basins will be provided for proposed sedimentation basins 5 and 6. These proposed flocculation basins will be sized similar to the existing flocculation basins and will provide a 30-minute detention time for a 2.0 MGD design flow to sedimentation basins 5 and 6. These flocculation basins will be design using vertical shaft type and will have a length to width ration of 2 to 1.

When the water treatment plant is expanded to 6.0 MGD and to comply with requirements of the Kentucky Division of Water and with the *Ten States Standards*, additional flocculation basins are required. Each of the existing and proposed basins will be equipped with a minimum of 2.5 HP drives providing a G of about 70.

There is the concern of uneven or unbalanced flow distribution between flocculation basins and the sedimentation basins. Since a new flash mixing facility is needed, it is proposed that controlled flow be directed to each of the existing and proposed flocculating basins from the proposed flash mixing facilities. Briefly, this will entail separate feed pipes for each pair of flocculation basins from the proposed flash mixing facilities. The flow to each of these feed points will be controlled so that is a balance of flow to each of the flocculation basins and sedimentation basins.

5. Sedimentation Basin

a. Existing Conditions

Sedimentation basins have traditionally been divided into four zones, each with a specific function. These four zones and their individual functions are as follows:

1. The *inlet zone* provides a smooth transition from the influent flow to the uniform steady flow desired in the sedimentation zone.
2. The *sedimentation zone* provides volume and surface area for sedimentation.
3. The *sludge zone* receives the settled floc particles.
4. The *outlet zone* provides a smooth transition to the effluent flow.

While there are any number of types and configuration of clarifiers, the long rectangular sedimentation basin has long been one of the most popular types of unit used in water treatment design. This is, of course, the type of sedimentation basin used at the GRVWD water treatment plant. A discussion of this existing unit in conjunction with the four (4) zones described above is presented in the following paragraphs.

1. Influent Control

Following the flocculation basins, water flows to the four sedimentation basins by a concrete rectangular channel. This channel has a width of 18 inches and a liquid depth of about 18 inches resulting in a total wetted area of about 4.5 square feet. At the existing design flow of 4.0 MGD, the maximum velocity of this channel is about 2.0 feet per second. To prevent breakage of floc, the AWWA water treatment plant design publication recommends distribution velocities between the flocculation basins and sedimentation basins not exceed 1.5 feet per second.

From the influent channel, flow enters the sedimentation basins through two 12-inch gates and pipe arrangement. Following the 12-inch pipe is a masonry baffle that distributes the flow across the head of the sedimentation basin.

2. Sedimentation and Sludge Volume

The sedimentation volume is considered as the total volume of the basin, which includes the area of the basins times the sidewater depth of 8.0 feet. The total volume of the sedimentation basins is about 44,600 cubic feet or about 333,600 gallons. At the design flow of 4.0 MGD, the resulting detention time of the basins is about 2.0 hours.

The basins are equipped with solids removal equipment, which were retro-fitted into basins that were not designed for sludge removal equipment. The existing sludge removal equipment is ineffective; primarily because of the leaves and heavy solids received from the Green River raw water intake.

Currently, solids removal from the existing basins is accomplished by draining the basins. This is time consuming and can only be accomplished during extended period of low-water demands. As the WTP becomes more heavily loaded, the time available to drain and clean the sedimentation basins will become less and less. The installation of fine screening facilities should resolve the problems with the existing sludge removal equipment and the existing sludge collectors will be placed back into operation.

3. Effluent Conditions

Each existing sedimentation basin is equipped with about 360 square feet of tube settlers. At the existing design flow of 4.0 MGD, the loading rate on the tube settlers is about 1.9 gallons per minute per square foot. According to design criteria of the Kentucky Division of Water (Ten States Standards), the loading rate for tube settlers should not exceed 2.0 gallons per minute per square foot.

The sedimentation basins are equipped with horizontal drawoff troughs. The length of the troughs result in a weir loading rate of about 20,000 gallons per day per foot of weir length. The drawoff troughs are frequently flooded and, therefore, are not effective in providing a uniform drawoff of water across the surface of the tube settlers.

b. Proposed Sedimentation Basin

The existing sedimentation basins do not have sufficient capacity to accommodate a proposed design flow of 6.0 MGD. Therefore, two sedimentation basins of similar configuration to the existing basins should be added. At the proposed design flow of 6.0 MGD, the detention time provided by the existing and proposed sedimentation basins would be about 2.0 hours.

At the proposed design flow of 6.0 MGD, the loading rate for the combined surface area of the tube settlers for the existing and proposed sedimentation basins is 1.9 gallons per minute per square foot. This rate is less than the state's maximum allowed rate of 2.0 gallons per minute per square foot.

Each of the existing sedimentation basins is equipped with longitudinal weir troughs. These weir troughs play an important role in the "take-off" of flow upward though the tube settlers and to balance flow through each of the sedimentation basins. However, due to piping configuration between the filters and the effluent weirs, the weirs are often flooded. When this occurs, a uniform withdrawal of water from atop the sedimentation basins is not possible. To eliminate this problem, it is recommended that the existing weir troughs be replaced with orifice pipes and that the proposed sedimentation basins also be equipped with orifice pipes. With the orifice pipes, the withdrawal of water will be uniform regardless of the level of water inside the sedimentation basins.

Currently, the effluent channels on the end of each sedimentation basin are not hydraulically connected. With the proposed additions to the water treatment plant, the partitions that separate the sedimentation tanks will be removed. This removal will allow better balance of flows to the sedimentation basins and to the gravity filters. Under the current arrangement, interruption in filter operation such as backwashing causes increased and alteration in flows to the sedimentation basins. For more uniform operation, the partitions will be removed and the effluent channel from the proposed sedimentation basins will be connected to the existing effluent channels.

6. Gravity Filters

a. Existing Conditions

Filtration systems can be divided into two general categories - gravity and pressure system. The filters at the GRVWD facilities are gravity filters. Gravity filters are the most common filtration system used. Filter media are usually identified according to the number of media layers used and are referred to as single, dual, and multiple media. The filter media is typically installed on a support gravel that in turn rests on a manufactured filter bottom. The purpose of the combined filter media, support gravel and filter bottom configuration is to draw water down evenly through the filter bed trapping solids within the filter media. During cleaning or backwash operations, the combined filter configuration operates in reverse where flow is directed evenly up through the filter bed to effectively clean and remove accumulated solids.

The filter media at the GRVWD facilities is dual media using sand and anthracite supported by gravel located above a filter bottom. Currently, there are four (4) dual media gravity filters at the GRVWD water treatment plant.

The existing four (4) filters each have a width of 10 feet and length of about 18 feet resulting in a surface area of 180 square feet and a combined surface area of 720 square feet. Based on the existing design flow of 4.0 MGD, the resulting loading rate on the four (4) filters is 3.89 gallons per minute per square foot. This loading rate is slightly less than the maximum 4.0 gallons per minute per square foot allowed by the design criteria published by the Kentucky Division of Water.

b. Proposed Gravity Filter Additions

At the proposed design flow of 6.0 MGD, the loading rate on the existing 4 filter units would increase to 5.8 gallons per minute per square foot. With the new requirements of the EPA's Interim Enhanced Surface Water Treatment Rule (IESWTR), such a high loading rate is not recommended. Therefore, some modifications, additions, or improvements are needed in order to accommodate a design flow of 6.0 MGD.

It is recommended that two additional filters be added of similar size and configuration as the existing four (4) filters. The addition of two filters similar in size and design with the existing filters, would result in a design capacity of 6.17 MGD based on a loading rate of 4.0 gallons per minute per square foot.

7. Clearwell Improvements

From the filters, water flows to the four circular clearwells that have a combined volume of 900,000 gallons. A reported requirement of the Kentucky Division of Water is that clearwell capacity be at least 15 percent of the design capacity of the water treatment plant. For the existing design of 4.0 MGD, the total clearwell capacity needed to comply with this requirement is about 600,000 gallons. The capacities of the existing clearwell comply with that requirement.

For the proposed 6.0 MGD design, a total of 900,000 gallons of clearwell capacity would be required to comply with the 15 percent requirement. However, the sizing of clearwells is also governed by the contact time needed to meet disinfectant requirements of state and federal regulations. The Surface Water Treatment Rule (SWTR) requires that a minimum inactivation ratio of 1.0 be met at all times and under all conditions at water treatment plants. The inactivation ratio is calculated by dividing the CT (calculated) for a worst case condition by the CT (required), which is provided in publications issued by EPA.

Based on the existing design flow of 4.0 MGD and on the existing clearwell configuration (poor baffling), the CT calculation yields a disinfectant inactivation ratio of greater than 1.0. This calculation assumes the clearwells are 80 percent full and does not consider the effect of chlorine added before the filters. While that does not represent current operating procedures, it may reflect future conditions needed to meet chlorine byproduct requirements.

When Phase II of the Enhanced Surface Water Treatment Rule and Stage 2 of the Disinfectant / Disinfection By-product Rule are promulgated by the US - EPA, GRVWD and other water treatment entities may be required to use other disinfectants such as chlorine dioxide, chloramines, or other approved disinfectants. Should that be necessary, then greater contact time may be needed. Under those conditions, additional clearwell capacity may be needed.

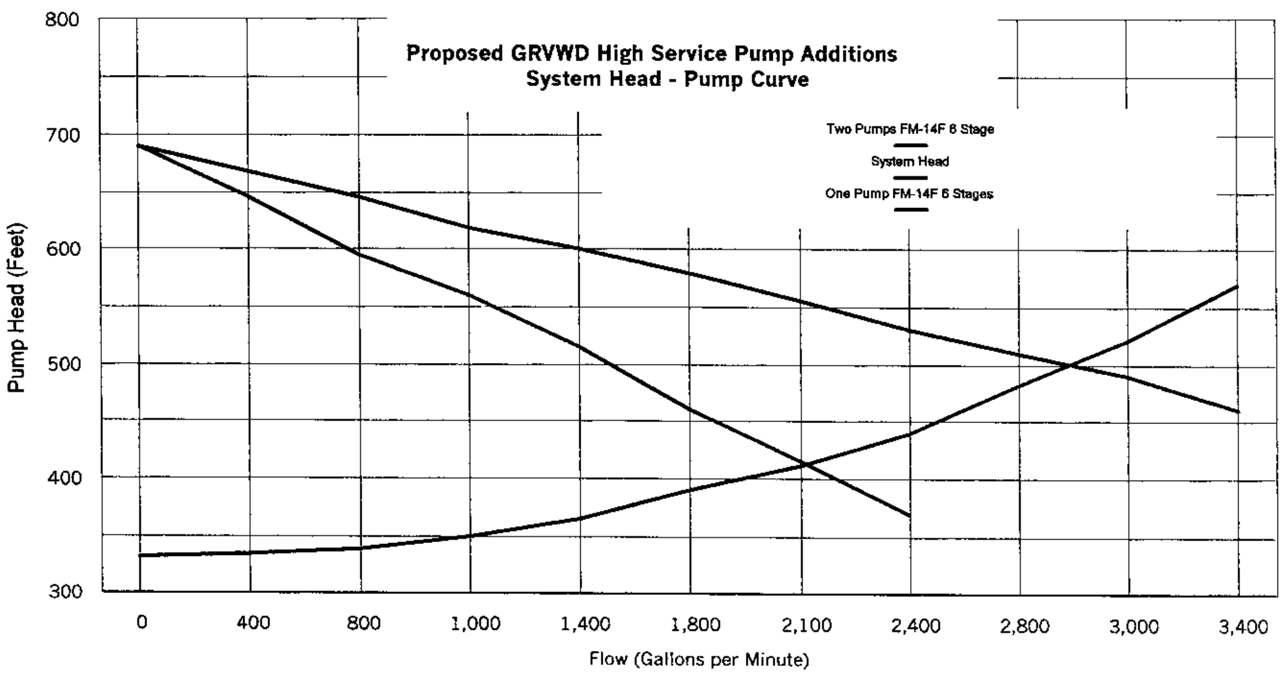
In addition, greater demand on the water treatment process places greater demand on the clearwell facilities to provide adequate backwash capacity as well as capacity for the high service pumps. Considering these needs and more stringent limits being placed on disinfectant and inactivation of disease causing organisms, it is the finding of this Report that an additional 200,000 gallon clearwell is needed.

8. High Service Pump Additions and Improvements

To serve GRVWD's south water system, the water treatment plant has five (5) existing high service pumps located atop a high service pump chamber and one pump located on one of the clearwells. To serve the north water system, two (2) existing high service pumps are located on one of the clearwells.

The five pump serving the south system consist of one 100 horsepower (H.P.) constant speed pump, three (3) others are 200 H.P. constant speed pump and one (1) is a variable speed 200 H.P. pump. The rated capacity of the 100 H.P. high service pump is about 525 gpm when discharging against a pump head of 450 feet. The rated capacities of the larger 200 H.P. pumps are about 1,500 gpm each when operating against a pump head of 500 feet. The maximum rated capacity of the single variable speed pump is about 1,300 gpm when discharging against a head of 500 feet.

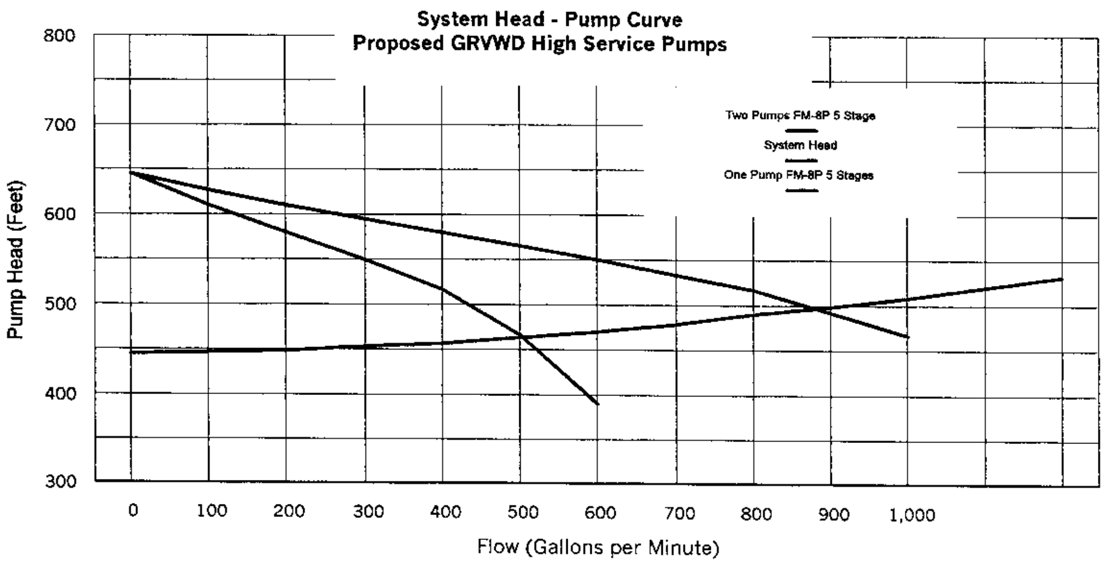
These south system high service pumps deliver water to two (2) existing twelve (12) inch water transmission mains routed south along the general route of US Highway 31E to the Canmer Community. To reduce excessively high discharge pressures on the high service transmission facilities and to have the capability to pump additional water into the south water system, an additional 16-inch water main is being installed for the south water system. Also, two additional high service pumps are being installed. One of these proposed high service pumps will be equipped with variable frequency controls that will allow a variable pumping rate to the south system.



Based on a preliminary selection of Fairbanks Morse, a graphic presentation of the system head curve versus pump curves for the high service pump additions serving the north water system is shown above. As indicated, these pumps will be capable of pumping 3.0 MGD when operating alone and about 4.14 MGD when operating together. The existing high service pumps will continue in operation.

Similar to the south water system, an additional 10-inch water main will be installed to serve the north water system. This additional main will reduce high discharge pressures on the high service transmission facilities and provide capacity to pump additional water into the north water system. Also, two additional high service pumps are being installed. One of these proposed high service pumps will be equipped with variable frequency controls that will allow a variable pumping rate to the south system.

Based on a preliminary selection of Fairbanks Morse, a graphic presentation of the system head curve versus pump curves for the high service pump additions serving the north water system is as follows:



As indicated above, these pumps will be capable of pumping about 0.7 MGD when operating alone and about 1.25 MGD when operating together. The existing high service pumps will continue in operation.

APPENDIX A