Verdigris Basin Priority Issue
2010 Update
Water Supply Management and Conservation
September 2010

ISSUE

Reservoirs, community lakes, and streams in the Verdigris basin provide water for municipal and industrial water supply, irrigation, recreation and aquatic life. There is a need for a comprehensive management and conservation strategy by communities within the basin to make efficient use of the water resource.

DESCRIPTION

The rural nature of the Verdigris basin led to many small communities developing their own water supplies, either from direct intakes on the major rivers and streams or from construction of individual community lakes. Over time, as communities have grown and in many cases gotten smaller, water demands have changed. As treatment requirements have increased and become more expensive, numerous communities have faced challenges in meeting water supply needs, especially during drought conditions. Federal reservoirs have been built, which also provide water supply, and efforts are underway to operate them most efficiently for this purpose.

When this section of the Verdigris Basin Plan was adopted in January 2009, the following recommendations were made for this basin priority issue.

1. Develop a basin model of the hydrologic system with location specific supply and demand information.

2. Identify options for supply and demand management: reservoir pool raise, pool reallocation, dredging, new supplies, modification of reservoir operations, and conservation measures.

3. Refine models to reflect possible outcomes of identified options.

4. Based on results from model scenarios, implement the most beneficial and cost-effective options.

5. Compare the benefits of development of a water assurance district or an improved river/reservoir water management system to ensure sufficient supplies for all water users served by Fall River, Toronto and Elk City reservoirs.

6. Begin incorporation of demand management into water utility plans. Demand management should also include education of and interaction with the development community and include existing local authorities.

Since 2009, extensive work to address the above recommendations has been accomplished. This update provides additional information related to the recommendations based on evaluation using the OASIS model (Operational Analysis and Simulation of Integrated Systems).

Recommendation. Develop a basin model of the hydrologic system with location specific supply and demand information.

All of the streams in this basin are restricted so that no new appropriation rights are available for the time period July to September (typically the irrigation season) unless there is an alternate source of water shown to be available. There are four federal reservoirs in the basin: Fall River, Toronto, Elk City and Big Hill along with numerous multipurpose or city-owned small lakes, and natural stream flows available for water supply.

In 2007 the Kansas Water Office (KWO) completed a preliminary water supply and demand analysis in the Verdigris basin and in four other basins in the eastern part of the state. In all counties included in the Verdigris basin study, population and demand for water is projected to decrease in the future. That projection could change should a major industry locate in the basin. Even so, the supplies available are decreasing and the needs of an albeit decreasing population must still be met.

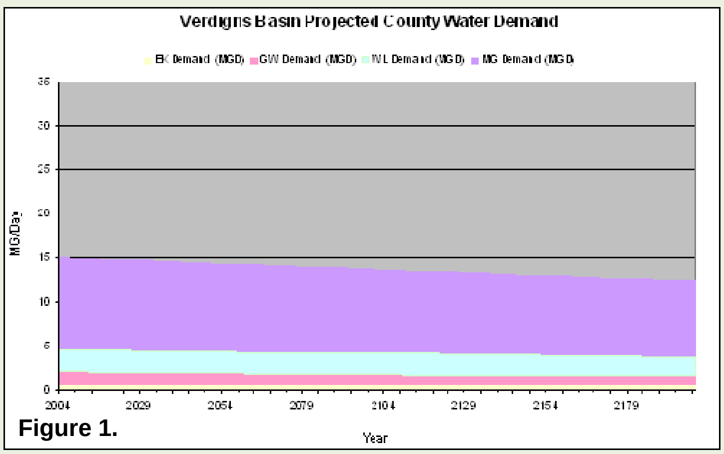

Figure 1.

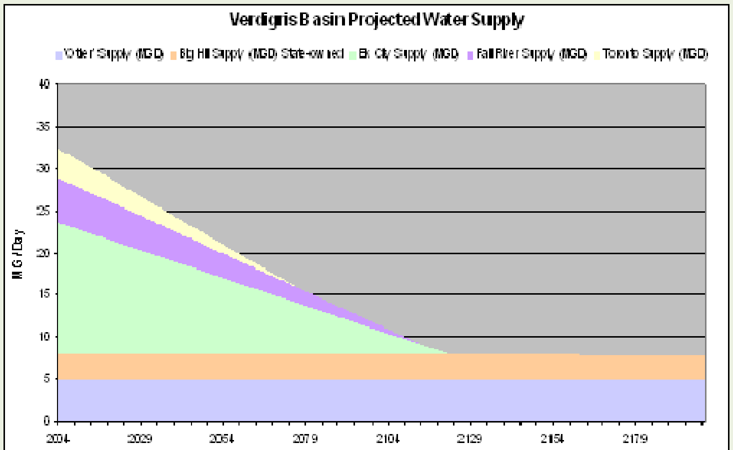

Figure 2.

Reservoirs are used, in part, to provide dependable water supplies in streams with highly variable flow. Fall River and Toronto reservoirs, among the oldest reservoirs in the state, were constructed with water supply storage capacity built in, before the federal law requiring state or local financial participation for water supply storage was enacted. The State may ask for municipal and industrial releases from these reservoirs without having to pay for the storage. In the other two basin reservoirs, Elk City and Big Hill, built after the local cost share requirement, the state does own water marketing storage and is required to pay for that storage capacity along with annual operation and maintenance payments. All four of these reservoirs are used to satisfy water supply demand in various parts of the basin.

This 2007 water supply assessment in the Verdigris basin concluded that a more complex model was needed to further refine projections and situations where projected demand may exceed supply on a more local scale, temporally and spatially, within each sub-basin.

To address the recommended actions, KWO selected the OASIS model. The OASIS model is a basin model of the hydrologic system which has the ability to simulate the interaction of multiple reservoirs and rivers in a system; simulate system management issues; identify areas of concern in a system; and evaluate alternative improvements to the system.

Supply and Demand

KWO analysis of the results from the OASIS model focuses on reservoir surface water elevation and storage, stream flows at gages with target flows, and shortages water users may experience during the model run. KWO is using the OASIS model to simulate the Verdigris basin under reservoir conditions in 2010 and 2050, after 40 years of sedimentation.

Reservoir Elevation

In addition to indicating the availability of water supply and water quality for downstream water users, reservoir elevations are important for in-reservoir recreation. As the reservoir elevation decreases, boat ramps become unusable, structures normally covered with water become boat hazards and access to the water's edge is limited. The following figures illustrate the percentage of time during the OASIS model drought simulation each reservoir exceeds a given elevation.

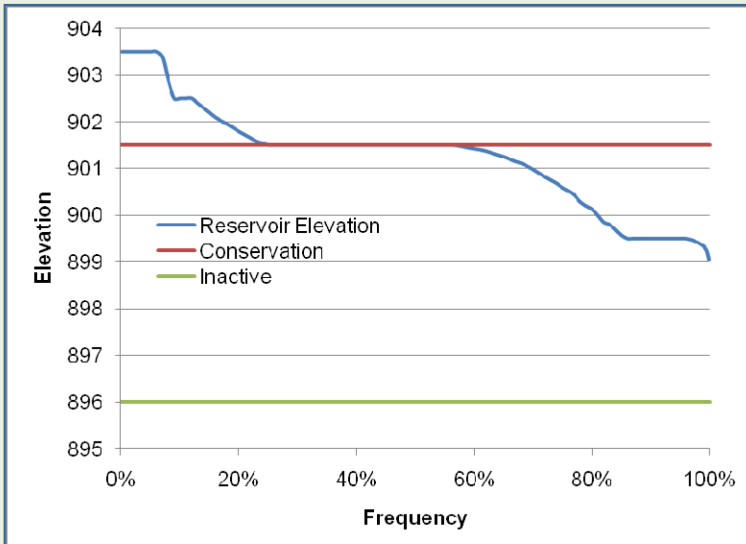

Figure 3. Toronto Reservoir Elevation Frequency

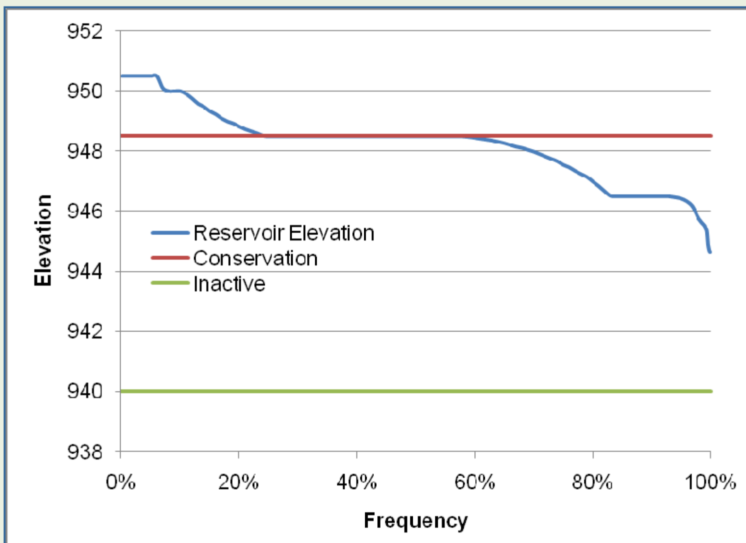

Figure 4. Fall River Reservoir Elevation Frequency

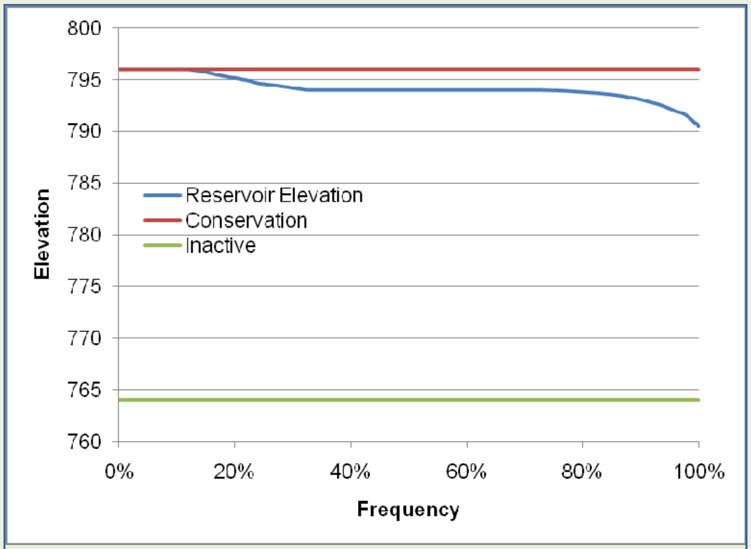

Figure 5. Elk City Reservoir Elevation Frequency

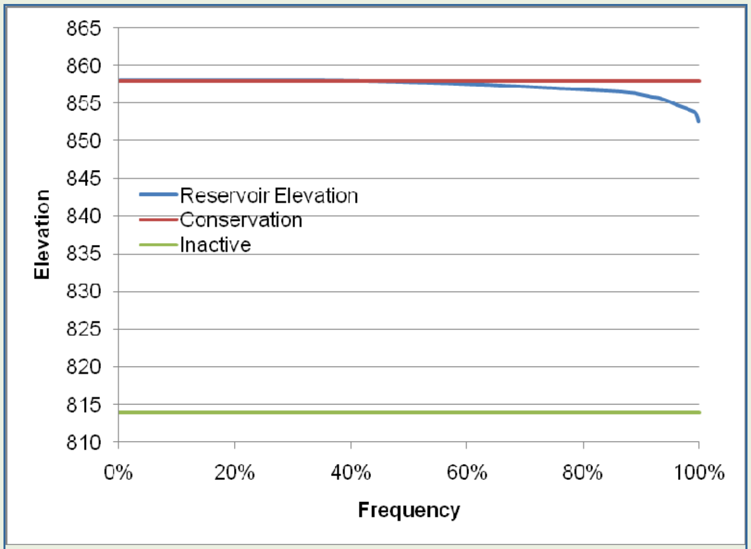

Figure 6. Big Hill Reservoir Elevation Frequency

The upper limit of each reservoir's elevation corresponds to the conservation pool elevation or the highest elevation reached in the lake level management plan (LLMP). The OASIS model does not store inflows above the LLMP because KWO's interest is the effect of drought conditions on water supply. The stair-stepped elevation at Toronto, Fall River and Elk City reservoirs also correspond to the LLMP at each reservoir.

Reservoir Storage

KWO has a Memorandum of Agreement (MOA) with the Division of Water Resources (DWR) to manage and protect releases from storage in the federal reservoirs in the basin. Protection of releases refers to ensuring that the water is available for the intended downstream use and is not diverted before reaching the intended place of use.

In the drought contingency section, the MOA states that "municipal and industrial water right owners who benefit from releases identified in this agreement shall adopt and implement a water conservation plan with drought contingency triggers that are based upon reservoir levels as described below." For Fall River and Toronto reservoirs a water watch is implemented when the conservation pool reaches one-half of maximum storage; a water warning is implemented when the conservation pool reaches one-third of maximum storage; and a water emergency is implemented when the conservation pool reaches one-tenth of maximum storage. The following figures illustrate the percentage of time during the OASIS model drought simulation each reservoir exceeds a given storage, and compares the storage with the storage remaining when a watch, warning and emergency are triggered.

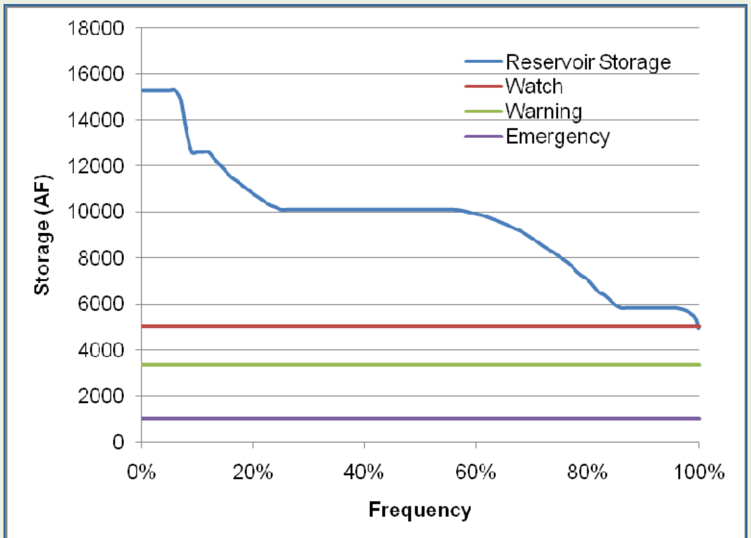

Figure 7. Toronto Reservoir Storage Frequency

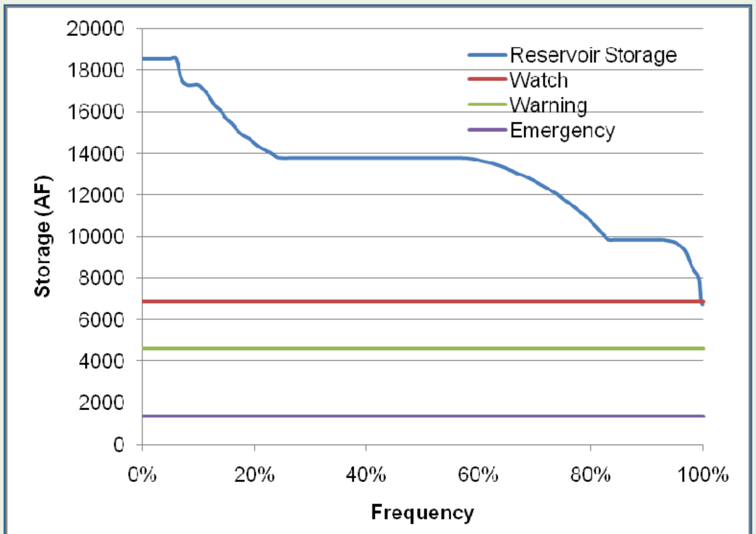

Figure 8. Fall River Reservoir Storage Frequency

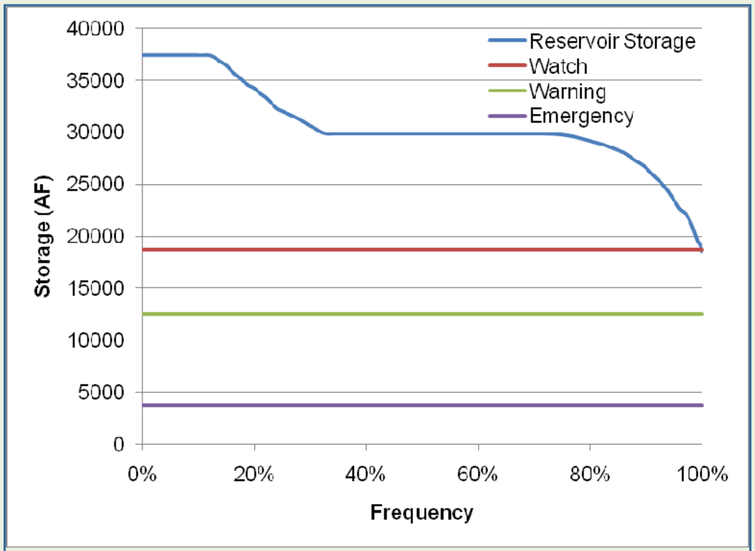

Figure 9. Elk City Reservoir Storage Frequency

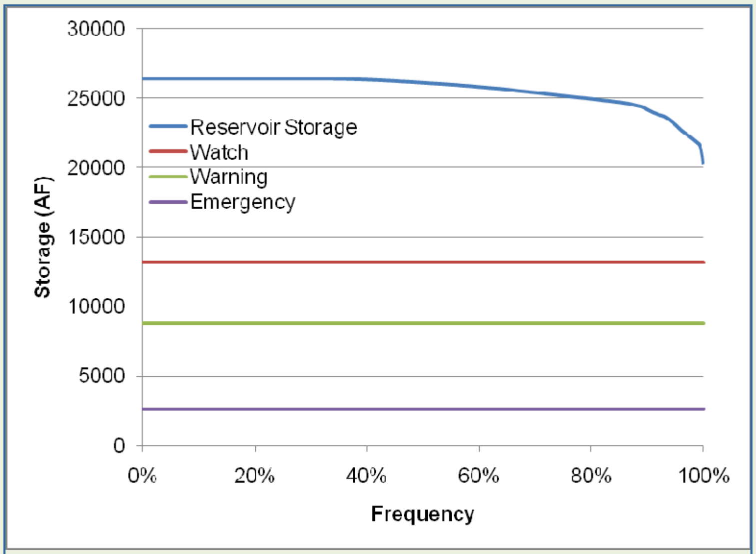

Figure 10. Big Hill Reservoir Storage Frequency

Streamflow at Target Locations

The MOA has monthly target flows at three United States Geological Survey (USGS) stream gages in the Verdigris basin. The gages and their monthly targets are listed in Table 1.

The following figures illustrate the percentage of time during the OASIS model drought simulation each stream gage exceeds a given stream flow, and compares the stream flow duration curve with the monthly target flows.

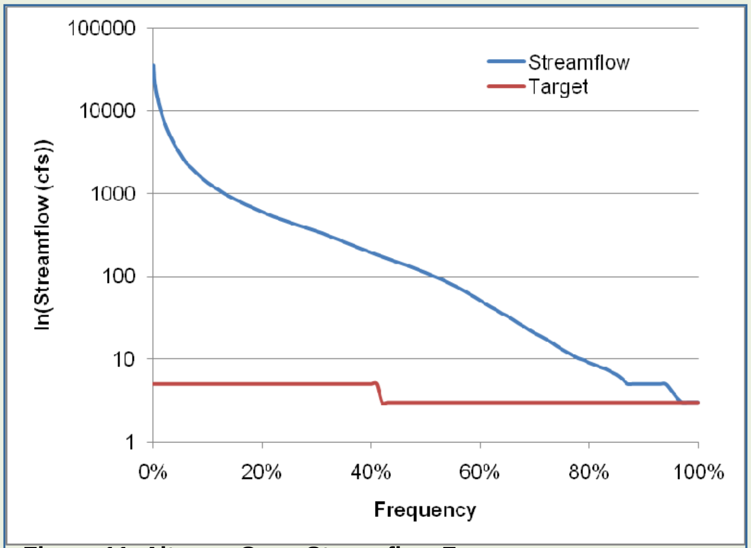

Figure 11. Altoona Gage Streamflow Frequency

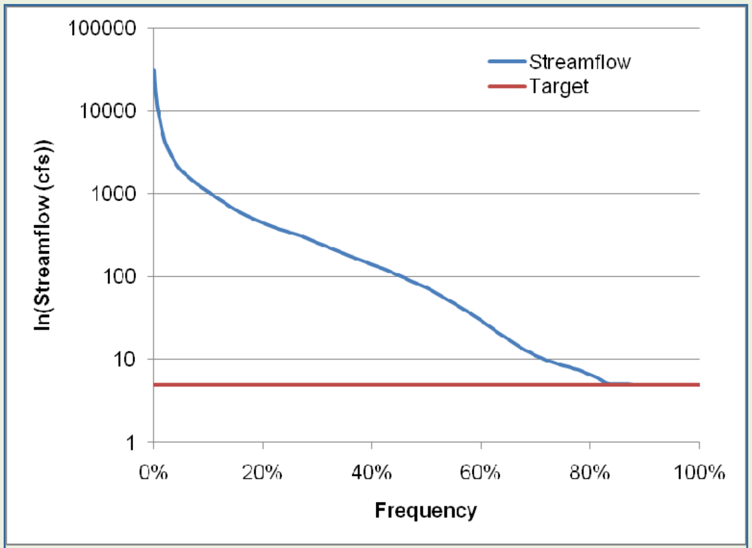

Figure 12. Fredonia Gage Streamflow Frequency

Gage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Altoona	3	3	3	3	5	5	5	5	5	3	3	3
Fredonia	5	5	5	5	5	5	5	5	5	5	5	5
Independence	35	35	35	35	35	35	35	35	35	35	35	35

Table 1. Monthly Flow Targets (cfs) at USGS Stream Flow Gages

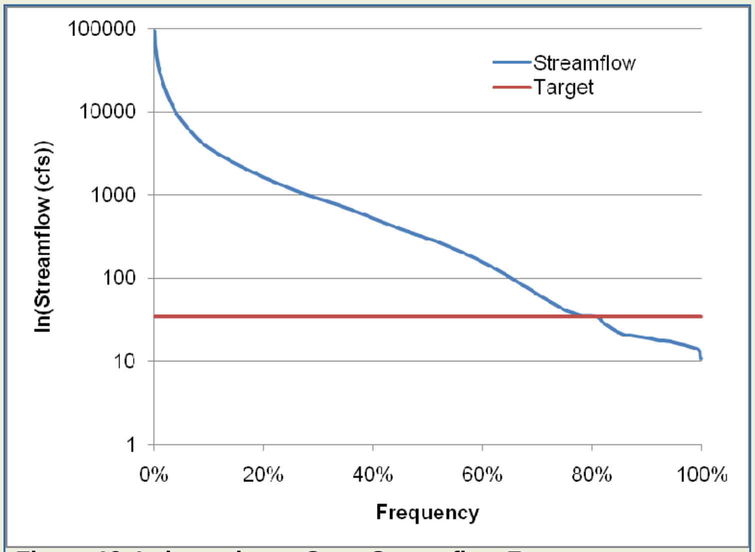

Figure 13. Independence Gage Streamflow Frequency

The target flows at the Altoona and Fredonia stream gages are met or exceeded 100% of the time during the OASIS model simulation. The MOA allows for releases to be made from Toronto and Fall River reservoirs to meet the target flows at Altoona and Fredonia, respectively. In the simulation, there is sufficient storage in each of the reservoirs to make releases to meet the flow targets. The target flows at the Independence stream gage is met or exceeded about 80% of the time during the OASIS model simulation. The MOA allows for releases to be made from water quality storage in Elk City Reservoir to meet the target flow at Independence; however, the water quality storage in Elk City Reservoir is evacuated every year from February 15 to September 1 to meet the elevation requirements of the LLMP. The percentage of time the target flow at the Independence stream gage cannot be met is directly related to the amount of time there is no water quality storage remaining in Elk City Reservoir.

Water User Shortages

During the model simulation, Elk City Reservoir water marketing customers may experience shortages because their contract quantities do not provide enough water to meet their demands when natural flows are insufficient.

Demands

Demands in the Verdigris basin will likely be steady or decrease over the next 40 years. Specific areas may increase during that time period; however, demands used in the OASIS model are typically higher than recent demands and should account for any projected increases over the next 40 years. Although OASIS demands are higher than recent demands, they do not account for the total authorized quantity for the water rights in the basin. Table 2 summarizes the municipal demands used in the OASIS model, as well as 2009 water use, projected 2040 water use, and the total quantity authorized by the municipalities' water rights.

Public Water Supplier	OASIS Demand (af/yr)	2009 Water Use (af/yr)	Projected 2040 Water Use (af/yr)	Water Right Authorized Quantities (af/yr)
PWWSD #4	1,395	1,059	1,160	**
Coffeyville	4,500	2,189	2,466	4,603**
Independence	2,500	1,781	1,674	4,714
PWWSD #23	2,500	1,204	2,160	2,916
Neodesha	1,000	408	390	4,023
Toronto	138	29	22	138

Table 2. OASIS Demands for Public Water Suppliers

*Members of PWWSD #23
**See Table 3 for Water Marketing Contract Maximum

Demands from water marketing customers are based on current contracts only. It may be useful to determine how the system responds if demands are set assuming the total authorized quantity of water rights is used and all of the reserve capacity in Elk City Reservoir and all of the future use storage in Big Hill Reservoir is contracted to new or existing customers. Table 3 shows the current water marketing customers at Elk City and Big Hill reservoirs as well as the potential yield of water marketing storage from each of the reservoirs.

Marketing Customer	Contract Max (af/yr)	Potential Marketing (af/yr)
Coffeyville	921	
Coffeyville Resources	1,866	
Elk City Reservoir	**2,787**	**9,750**
PWWSD #4	1,395	
Big Hill Reservoir	**1,395**	**9,300**

Table 3. Current Water Marketing Customers and Potential Water Marketing Yield (Acre feet/year)

The following figures compare the percentage of time during the OASIS model drought simulation each reservoir exceeds a given storage for current marketing and water demands with the storage for potential fully committed marketing and water right demands.

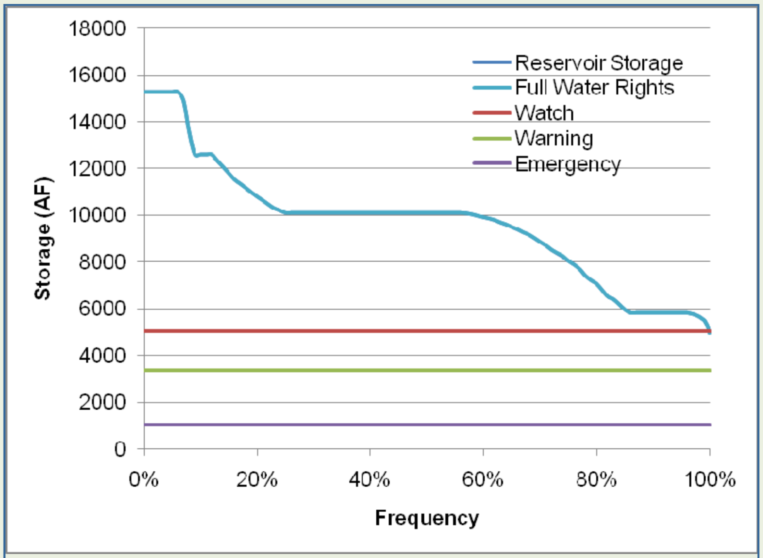

Figure 14. Toronto Reservoir Storage Frequency (Current vs. Fully Committed)

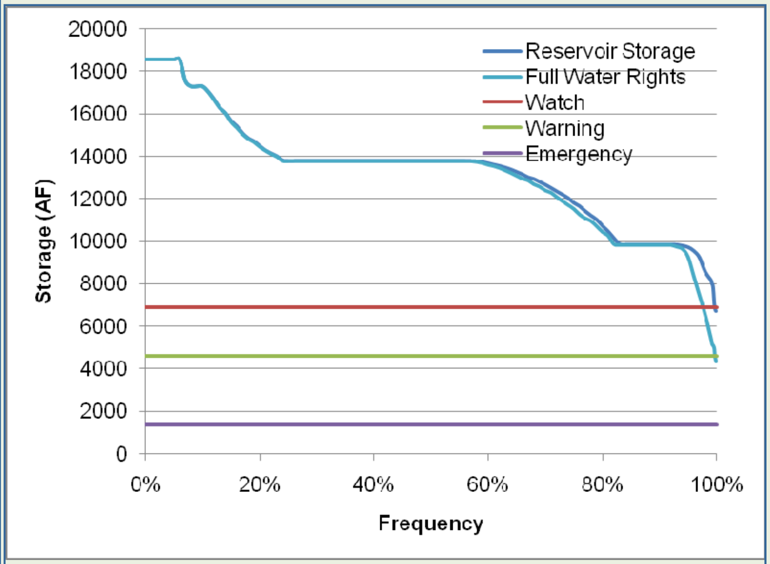

Figure 15. Fall River Reservoir Storage Frequency (Current vs. Fully Committed)

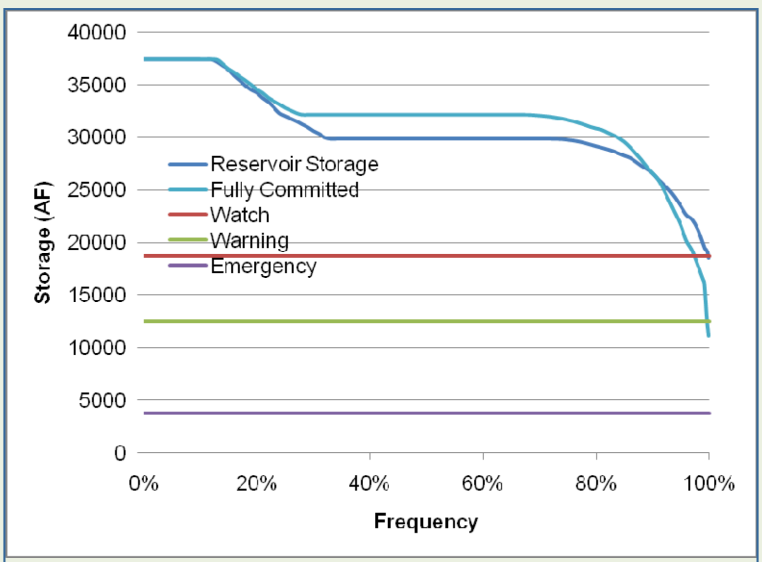

Figure 16. Elk City Reservoir Storage Frequency (Current vs. Fully Committed)

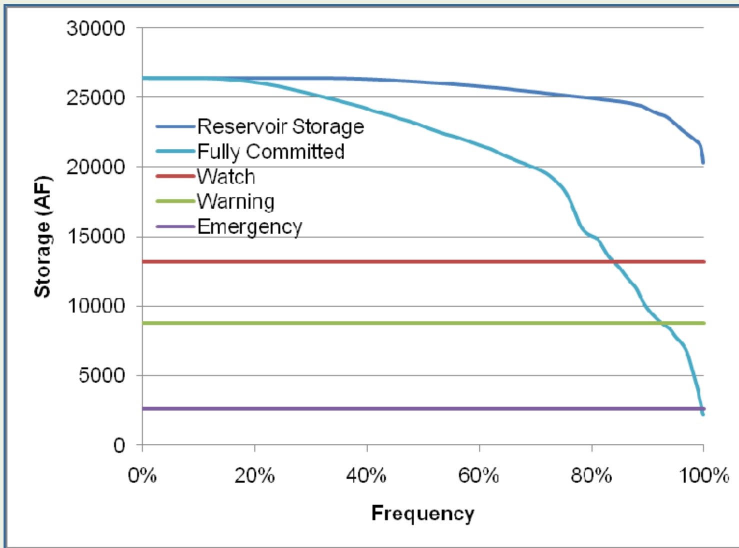

Figure 17. Big Hill Reservoir Storage Frequency (Current vs. Fully Committed)

Recommendation: Compare the benefits of development of a water assurance district or an improved river/reservoir water management system to ensure sufficient supplies for all water users served by Fall River, Toronto and Elk City reservoirs.

Communities along the main stem of the Fall and Verdigris rivers explored the possibility of establishing a water assurance district during 2004-2005 in order to better manage the system of reservoirs to distribute stored water throughout the basin when and where it is needed. An assurance district would also reduce the inequity in the system caused by the fact that payment is only required for use of water stored in Elk City and Big Hill reservoirs. As of 2010, no assurance district has been established.

Releases are made from the federal reservoirs to satisfy downstream water supply needs in accordance with the MOA discussed above between the KWO Kansas Water Offce and DWR. The MOA was updated in 2006 and provides that water needs in the upper portion of the basin are satisfied with releases from Fall River and Toronto reservoirs. Water needs in the lower part of the basin, below the confluence of the Elk River with the Verdigris River, are satisfied with releases from Elk City Reservoir. Water supply storage in Elk City Reservoir is used by the city of Coffeyville and Coffeyville Resources through marketing contracts. An assurance district, or an alternative arrangement for assuring adequate supply to downstream users, would further improve the ability of the state to maximize water storage releases from the reservoirs in the most beneficial manner. It is unlikely that revising the MOA will improve water supply reliability in the Verdigris basin.

Recommendation: Identify options for supply and demand management: reservoir pool raise, pool re-allocation, dredging, new supplies, modification of reservoir operations and conservation measures.

Water supply reliability can be improved by increasing the water supply, reducing the demand for water, or a combination of the two. Alternatives being evaluated for improving water supply reliability include sediment removal, reallocation, structural restoration, demand management, reservoir operational changes, new reservoirs, off-stream storage and watershed management. Most of these alternatives have been evaluated by KWO and are discussed in greater detail throughout Volume III of the Reservoir Roadmap.

The Verdigris basin includes several reservoirs used for public water supply purposes, shown in Figure 18.

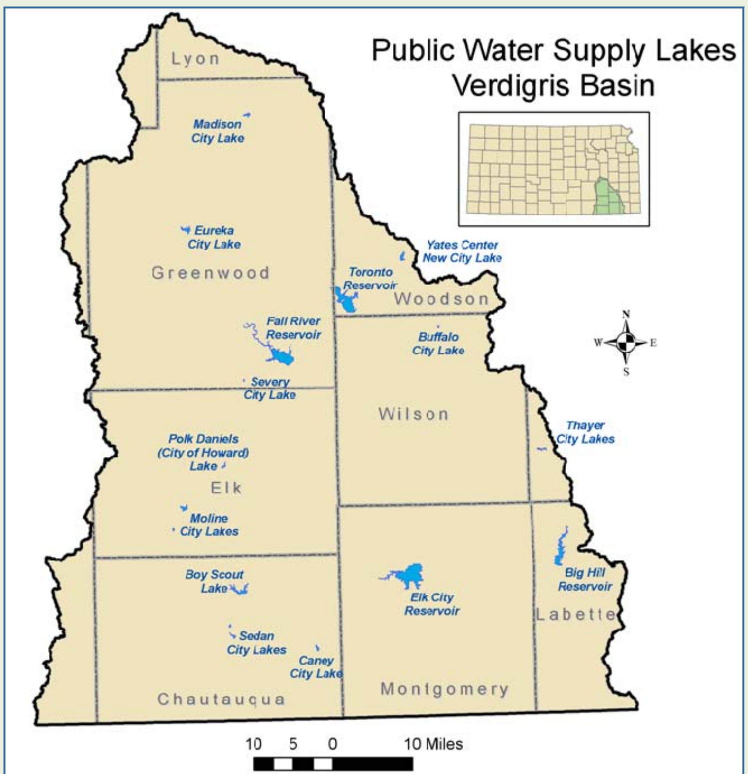

Figure 18. Verdigris Basin Water Supply Reservoirs

Although the reservoirs vary in many aspects, including size and ownership of the water supply, they are all important due to their water storage capabilities. Sedimentation and poor water quality are affecting these reservoirs and have the potential to reduce their reliability as a source of water. One option to ensure water supply storage capacity in the basin is to construct new reservoirs as the existing reservoirs continue to fill with sediment and decline in water quality; however, most of the best sites for reservoirs have already been utilized. Therefore, restoration of the existing reservoirs may provide the best value to restore water supply reliability. This section identifies potential restoration approaches appropriate for each of the water supply reservoirs in the Verdigris basin and strategies for prioritizing the restoration activities.

Potential Restoration Approaches

There are numerous potential restoration alternatives that could be applicable for each reservoir, depending on the type and severity of problems at the reservoir. Alternatives include sediment removal, reallocation, and structural restoration (dams, diversion structures, treatment facilities).

Sediment Removal

Sediment is typically removed from a reservoir by dredging. Dredging is the process of excavating sediment from the bottom of the reservoir and disposing of the sediment at a different location. There are several different types of dredges that are typically mounted on a boat or barge for operation in the reservoir. The collected sediment is usually pumped into a sediment basin where it precipitates out of suspension allowing much of the water in the dredge slurry to return to the system. Benefits of dredging include significant removal of sediment to maintain an existing reservoir site. Potential drawbacks include cost, time required to restore reservoir storage capacity, and environmental concerns with sediment disposal. Dredging is a potential option in all of the reservoirs in the Verdigris basin; however, the benefit per cost may be greatest in reservoirs that have a lower sedimentation rate.

Another method of removing sediment from a reservoir is flushing. Flushing is the process of drawing down the reservoir to create river-like flow conditions in the reservoir, re-suspending sediment that has deposited on the reservoir bottom and transporting it through the gates in the dam to the river downstream. There are several potential problems with using flushing to remove sediment from the reservoir, including a potential lack of inflow refilling the evacuated storage in a timely manner and what happens with the re-suspended sediment as it travels downstream.

Reallocation

Reallocation of storage is only a potential restoration option in the four federal reservoirs in the Verdigris basin. Reallocation of storage is a process by which the Corps of Engineers (Corps) changes the designation for a specified portion of storage in a federal reservoir. In the interest of restoring or increasing water supply storage, storage could be reallocated from water quality storage, flood pool storage, or another storage owned by the Corps. If storage is reallocated from flood pool to water supply, a permanent increase in the conservation pool elevation typically results. A reallocation study by the Corps compares the benefits of increased water supply storage to the potential detriments caused by lost flood or water quality storage capacity, shoreline effects caused by the higher permanent pool, and environmental effects due to increased backwater upstream of the reservoir.

Structural Restoration

Structural restoration is applicable for any structure associated with the reservoir or required to provide water supply from the reservoir, including the dam, water supply diversion structures and water treatment facilities.

The structural restoration most likely to occur at the federal reservoirs is restoration of the gates, valves and other associated mechanical equipment that will reduce the amount of water lost downstream due to leakage. Tainter gate rehabilitation at Toronto and Fall River reservoirs is scheduled to take place in 2010 and 2011. The Corps has released water from storage at Toronto and Fall River reservoirs to hold their elevations two feet below conservation pool in order to complete the restoration.

Increasing the dam height at a federal reservoir is unlikely for several reasons. An increase in dam height will require the Corps to obtain additional land to compensate for the increase in potential flood storage. The costs associated with land purchase, permits and construction could be quite significant.

Increasing dam height may be the only way to increase the pool elevation at city lakes with no flood pool. The condition of the dam is an important consideration in these lakes because they may be older than the federal dams or not as well constructed. Some of the same factors must also be considered before increasing the dam height of a city lake, especially if the new lake elevation will encroach on private property near the lake.

Strategies for Prioritizing Restoration Alternatives

The effectiveness of restoration approaches will vary depending on the needs of each reservoir. Factors affecting the prioritization of restoration alternatives include alternative sources of water supply (Table 4), rate of water supply lost due to sedimentation (Table 5), projected growth of demands (Table), feasibility and benefits of the restoration approach and cost of restoration.

Reservoir	Public Water Supplier	Other Source
Big Hill Lake	PWWSD #4	
Elk City Lake	Coffeyville	Verdigris River
Fall River Lake	PWWSD #23, Neodesha	Fall River
Toronto Lake	Toronto	Yates Center
Boy Scout Lake	PWWSD #20	
Buffalo City Reservoir	Buffalo	PWWSD #23
Caney City Lake	Caney	Little Caney River
Eureka Lake	Eureka	Tribs to Fall & Verdigris
Madison City Lake	Madison	2 Wells
Moline Reservoir	Moline	City Lakes (#1 & #2)
Polk Daniels	Howard	Elk River
Sedan City Lakes (N & S)	Sedan	PWWSD #20
Severy City Lake	Severy	Salt Creek
Thayer City Lakes (New & Old)	Thayer	PWWSD #23
Yates Center MPSL	Yates Center	City Lake

Table 4. Public Water Suppliers Using Water Supply Reservoirs

Public Wholesale Water Supply District #4 (PWWSD #4) is the only public water supplier that does not have a source of water other than their water supply reservoir (Big Hill Lake). Since the sedimentation rate of Big Hill Lake is relatively low and there is a significant yield of uncommitted storage that could be available for PWWSD #4, water supply should not be a problem for PWWSD #4 in the foreseeable future.

Reservoir	Year Constructed	Original Volume (AF)	Current Volume (AF)	Rate of Volume Lost (AF/yr)	% Original Volume Lost
Big Hill	1974	27,215	26,586	17	2
Elk City	1962	52,261	37,360	310	29
Fall River	1946	30,401	18,869	180	38
Toronto	1954	27,320	15,010	220	45
Boy Scout					
Buffalo	1960		1,631*		
Caney					
Eureka	1939	3,690	3,032	9	18
Madison	1970	1,445	1,265	5	12
Moline	1937		1,590*		
Polk Daniels	1968	777	619	4	20
Sedan	1965	780	767	<1	2
Severy	1938		115*		
Thayer	1960		560*		
Yates Center	1990	2,720	1,762	48	35

Table 5. Impact of Sedimentation on Verdigris Basin Water Supply Reservoirs
* 2000 Capacity

Table 5 summarizes the percentage of volume lost for each of the water supply reservoirs in the Verdigris basin.

The sedimentation rate and/or percentage of storage lost to sedimentation are highest at Elk City, Fall River, Toronto, and Yates Center reservoirs. The effects of sedimentation in the federal reservoirs were evaluated using the OASIS model. The following figures compare the percentage of time during the OASIS model drought simulation each federal reservoir exceeds a given storage under current conditions with the storage after 40 years of sedimentation.

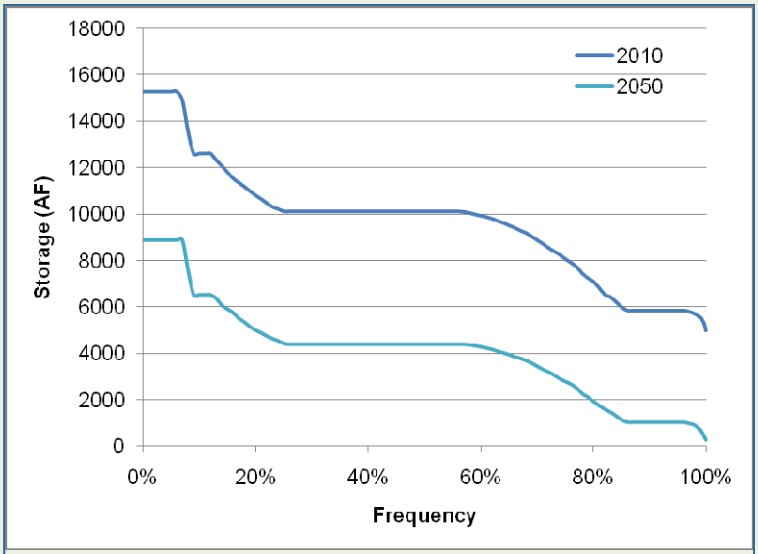

Figure 19. Toronto Reservoir Storage Frequency (2010 vs. 2050)

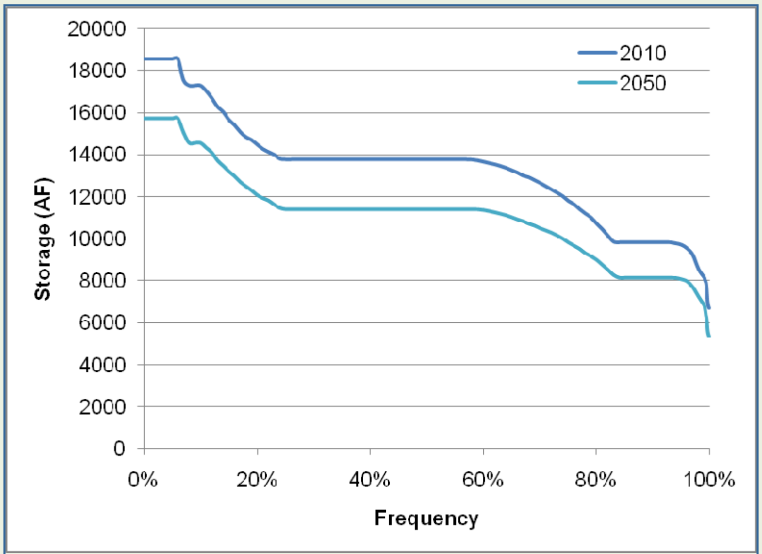

Figure 20. Fall River Reservoir Storage Frequency (2010 vs 2050)

The highest projected growth in water use for public water suppliers using water supply reservoirs in the Verdigris basin is associated with PWWSD #23. The primary water source for PWWSD #23 is Fall River; however,

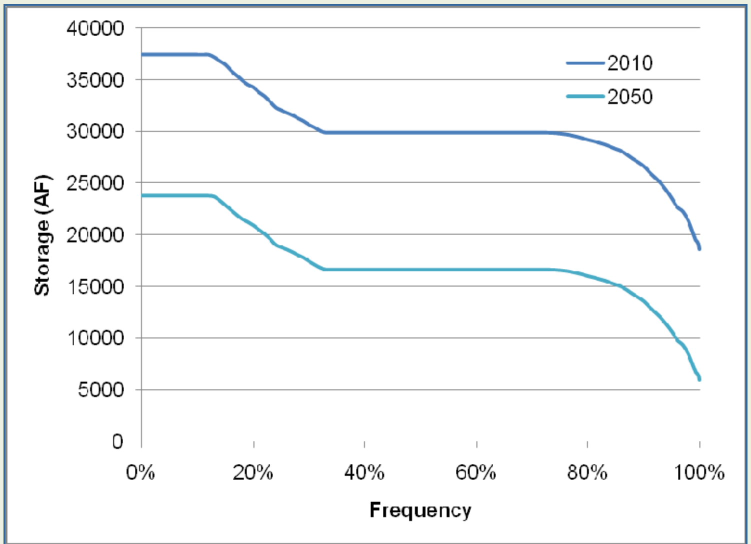

Figure21_. Elk City Reservoir Storage Frequency (2010 vs

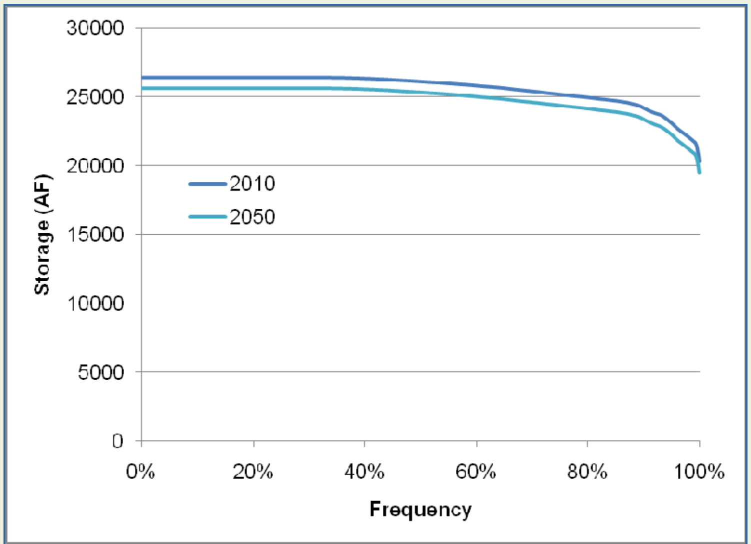

Figure 22. Big Hill Reservoir Storage Frequency (2010 vs.

Public Water Supplier	2009 Water Use (AF)	Projected 2040 Water Use (AF)
PWWSD #4	1,059	1,160
Coffeyville	2,189	2,466
PWWSD #23	1,204	2,160
Neodesha	408	390
Toronto	29	22
Buffalo*	36	22
Caney	287	343
Eureka	350	259
Madison	73	145
Moline	48	85
Howard	82	93
Sedan	116	168
Severy	35	70
Thayer*		67
Yates Center	165	170

Table 6. Water Use Demands for Public Water Suppliers Using Water Supply Reservoirs
* Members of PWWSD #23

when natural river flows are too low, the river is supplemented with releases from Fall River Reservoir. The two other public water suppliers with a relatively high demand from water supply reservoirs are PWWSD #4 and Coffeyville. Coffeyville's primary source is the Verdigris River, but it also has a water marketing contract with KWO for stored water from Elk City Reservoir. PWWSD #4 does not have access to natural flows; their only source of water is a marketing contract with KWO for stored water from Big Hill Reservoir.

Reservoir Operational Changes

Operational decisions and management practices of the four federal reservoirs in the Verdigris basin can be evaluated for the purpose of improving water supply. The difficulty lies with making changes to these operations because of their potential effects on flood control and environmental issues. The Corps requires significant study before an operational change can be made to a federal reservoir.

Operational changes that improve water supply can be made by increasing the amount of water stored in the reservoir or by reducing the amount of sediment that settles in the reservoir. The amount of water stored in the reservoir can be increased by changing the minimum release schedule and the lake level management plan (LLMP).

Reservoir Minimum Releases

The minimum release schedule for a federal reservoir is typically set to meet instream flow requirements for wastewater discharge assimilation and fish and wildlife support. Federal reservoirs in the Verdigris basin have the following minimum release schedules.
Minimum releases are typically met by inflows that are bypassed through the reservoirs; however, if these inflows are not sufficient to meet the required minimum releases, stored water is released. In Elk City Reservoir,

	Month											
Reservoir	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Toronto	3	3	3	3	3	3	5	5	5	3	3	3
Fall River	3	3	3	3	3	3	5	5	5	3	3	3
Elk City	5	5	5	5	5	5	5	5	5	5	5	5
Big Hill	0	0	0	0	0	0	0	0	0	0	0	0

minimum releases are made from water quality storage. In Toronto and Fall River reservoirs, storage is not divided into separate pools. The minimum releases from these reservoirs are low enough that reducing the releases is unlikely.

Lake Level Management Plans

Lake Level Management Plans (LLMPs) are seasonal fluctuations in the reservoir surface elevation with the goal of increasing the beneficial use of the reservoir. LLMPs are developed through a coordinated effort between the KWO, the Corps and the Kansas Department of Wildlife & Parks (KDWP), each receiving input from stakeholders with an interest in the reservoirs. Toronto, Fall River, and Elk City reservoirs each have a LLMP, which are shown in the following figures.

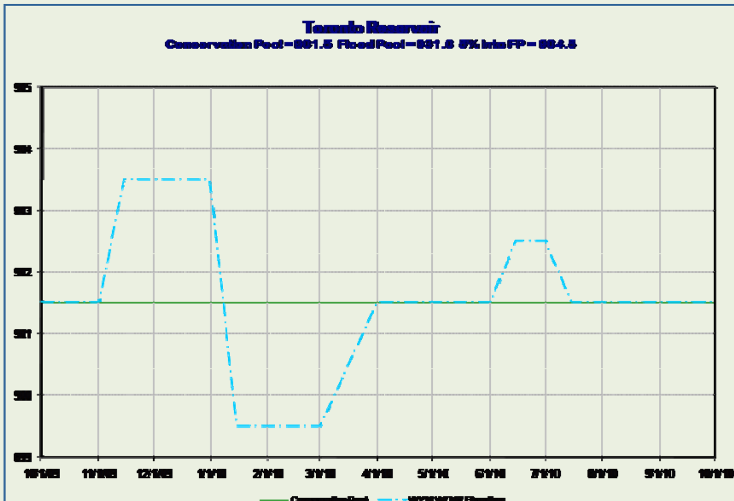

Figure 23. Toronto Reservoir Lake Level Management Plan

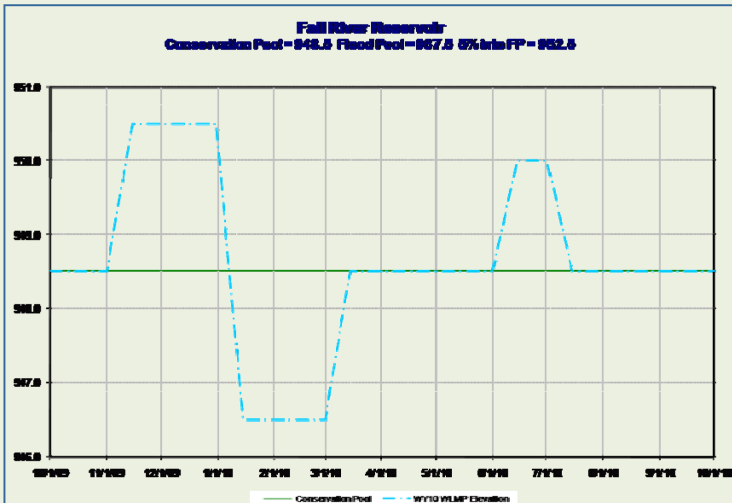

Figure 24. Fall River Reservoir Lake Level Management

In each of these reservoirs, storage is evacuated below the normal conservation pool for a period of time during the year. In Elk City Reservoir, all of the water quality storage is evacuated during the drawdown in February. A portion of the reserve capacity storage is also evacuated.

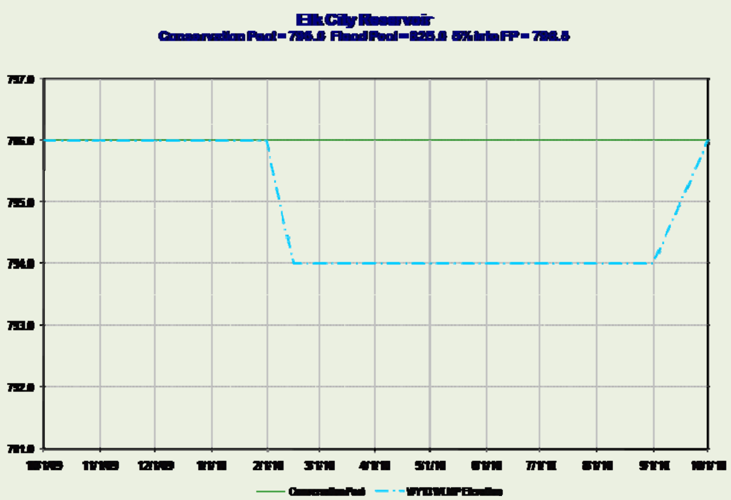

Figure 25. Elk City Reservoir Lake Level Management Plan

Review of plans for potential modifications to consider:

Toronto Reservoir

This is a balanced plan with water above and below normal conservation pool. The winter drawdown has relatively low risk due to the fact that the lake is allowed to fill in the spring, when there is a high probability of refill. The negative impacts of keeping more water in storage by modifying the plan to reduce the drawdown and increasing the amount of time the target elevation is at or above normal conservation pool would probably outweigh potential benefits.

Fall River Reservoir

This plan is also balanced but Fall River Reservoir is relied upon more heavily than Toronto Reservoir to meet downstream municipal and industrial demand. Consideration could be given to raising the summer target elevation.

Elk City Reservoir

This is not a balanced plan. Target levels above normal conservation pool are not allowed due to levee issues. Potential exists to increase supply by reducing drawdown extent, shortening the duration of the minimum target elevation, modifying the time of year for the drawdown, developing a drought trigger, or not allowing a LLMP for Elk City. All of these modifications should be considered.

Big Hill Reservoir

There has not been a LLMP developed for Big Hill for several years. Consideration could be given to development of a plan that would include a target elevation above normal pool.

Reservoir Sedimentation Management

Reservoir sedimentation management strategies can include one or more of the following techniques:

- Reducing sediment inflows;
- Managing sediment in the reservoir;
- Removing sediment from the reservoir;
- Replacing lost storage; and/or
- De-commissioning the reservoir

Operational techniques for preventing sediment from settling when sediment laden water enters the reservoir or removing accumulated sediment include multilevel selective withdrawal, changes in lake level management plans, inflow routing, sluicing, density current venting and flushing. Most of the techniques involve reducing the residence time of sediment laden water in the reservoir, thereby reducing sedimentation. A problematic issue is that the greatest amount of sediment entering the reservoir is during high flow (flood) events, typically the time when reservoir operators want to store the water to avoid downstream flooding. Implementation of these methods of sediment management will require significant study and changes to the Corps reservoir water control manuals.

Water Conservation

Maintaining or increasing a reservoir's storage is important in ensuring its reliability as a water supply source, but restoration approaches can be quite expensive and are more likely to be long term solutions. There are times when the availability of water supply needs to increase quickly, inexpensively or temporarily.

Water conservation is a management tool that can provide multiple benefits. Water conservation is the most cost-effective and environmentally sound way to reduce demand for water. Conservation has been a priority for the State of Kansas for a number of years. The Kansas

Water Resources Planning Act provides statutory authorization for addressing water quantity management in the *Kansas Water Plan*. This Act established long-range goals for the management, conservation and development of the waters of the state, including:

- The prevention of the waste of the water supplies of the state, and;
- The protection and conservation of the water resources of the state in a technologically and economically feasible manner.

Kansas Water Plan Objectives

- Reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30% or more unaccounted for water.
- Reduce the number of irrigation points of diversion for which the amount of water applied in acre-feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- All non-domestic points of diversion meeting predetermined criteria will be metered, gaged or otherwise measured.
- Conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Municipal and Other Public Water Suppliers

Conservation Plans

Conservation plans, as currently prepared and implemented, provide a management tool for the public water supplier that improves efficiency but may or may not reduce the quantity used. To be most effective the plans must be implemented and maintained. Of the 70 public water suppliers in the Verdigris basin, 46 have developed a water conservation plan.

Municipal water conservation goals are based on a system's size, water consumption in gallons per capita per day (GPCD) and the average GPCD for the region. GPCD calculations are based on amounts of water sold for residential and commercial uses, free uses and unaccounted for water. For this analysis, large utilities are those serving 10,000 people or more; medium utilities are those serving 500 to 9,999 people; and small utilities are those serving fewer than 500 people. The Verdigris basin OASIS model includes municipal users that either have a water right on the Verdigris, Fall or Elk rivers or Big Hill Creek downstream of the federal reservoirs, or have a marketing contract with the State of Kansas for water from a federal reservoir. A summary of water use for municipal users in the OASIS model is included in Table 7.

Municipalities with a high water use relative to the regional average may improve water supply reliability by implementing conservation practices. Municipalities with a high percentage of unaccounted for water will likely reduce their water use by reducing the amount of unaccounted for water.

Municipal User	2008 GPCD	2008 Regional Avg. GPCD	2008 Percent Difference	2008 Percent Unaccounted For	5 Year Avg GPCD
Coffeyville	177	128	38	15	195
Independence	147	128	15	27	146
Neodesha	118	96	23	7	132
Toronto	98	89	11	13	93
PWWSD 04[1]	77	93	-17	23	84
PWWSD 23[1, 2]	88	93	-5	14	99

Table 7. Summary of Water Use for Municipal Users in the Verdigris Basin OASIS Model

[1] In some instances a member did not report 2008 water use; 2007 data were used instead.
[2] Three members did not report water use for more than 5 years; regional averages were used instead.

Technical Assistance

The Kansas Rural Water Association (KRWA) under contract with the KWO provides technical assistance to public water supply operators, managers and local administrators on issues critical to public water systems. The program includes on-site technical assistance for rural water districts and municipal water systems. KRWA provides bookkeeping assistance, water rate structuring, water conservation plan development, distribution system and treatment plant reviews/analyses, leak detection, meter testing, well and distribution line cleaning and emergency assistance.

Drought Triggers

Public water supply conservation plans include locally determined response to drought triggers. Triggers are developed by and for the local water system. The 2007 Kansas Municipal Water Conservation Plan Guidelines provide suggestions for this planning. The Guidelines also include triggers for water marketing reservoirs.

Municipal drought stage triggers indicate certain levels of water shortage or other drought conditions have been reached. Triggers may be storage or distribution system capacity, peak demand or some other utility determined condition. Each trigger acts as a signal to begin implementation of appropriate actions for that stage and specific goals are identified as the desired outcome for each stage. Appropriate conservation practices in the areas of education, management and regulation are developed and set under each stage. A public water supplier should enact the appropriate stage whenever a trigger is reached. Delay in action may lead to a major disruption of the water supply system at a later time.

Three to four stages are considered appropriate in response to drought to trigger practices or actions. The first three stages; water watch, water warning and water emergency are appropriate for all public water suppliers. A fourth stage, water rationing, is for possible use by public water suppliers in an extreme emergency. Goals for a water warning and a water emergency should be quantifiable, specifically describing the water status and targeting water user awareness, reducing overall demand and reducing peak demand.

Recommendation: Begin incorporation of demand management into water utility plans. Demand management should also include education of and interaction with the development community and include existing local authorities.

Evaluation of Conservation

The effects of demand management through conservation practices by municipalities were evaluated using the OASIS model. The model was run with municipal demands reduced by 25% based on estimates of potential conservation capabilities provided in the conservation plans of municipalities in the Verdigris basin. Elk City Reservoir responded the most to conservation practices due to the relatively large use of water marketing storage by the City of Coffeyville and Coffeyville Resources. Fall River, Toronto and Big Hill reservoirs did not respond as much because of the lower municipal use from each of those reservoirs.

Results of the model runs for Elk City Reservoir in the year 2050 are shown in Figure 1
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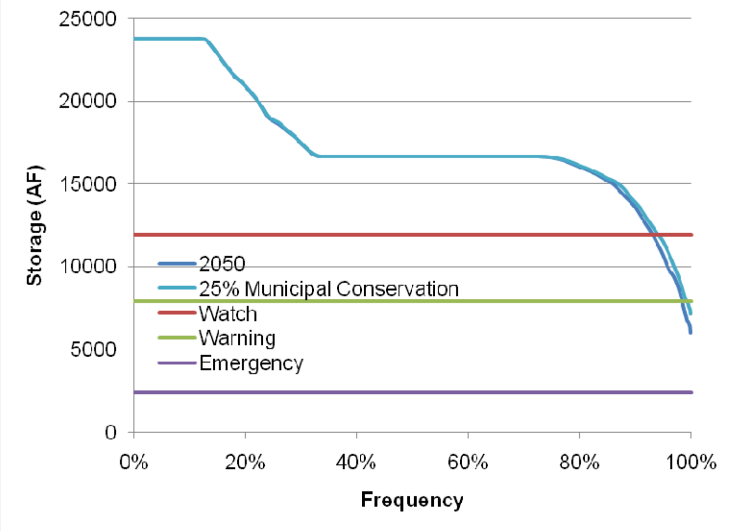

Figure 26. Elk City Reservoir Capacity Frequency Comparison

Industrial Water Use

The 1986 Kansas Industrial Water Conservation Plan Guidelines were prepared for use by industrial water users to assist them in developing a water conservation plan. The Verdigris MOA requires municipal and industrial water right owners who benefit from reservoir storage to adopt and implement a water conservation plan. Additionally, Coffeyville Resources is required to have a water conservation plan as a condition of their water marketing contract from Elk City Reservoir. These plans are somewhat limited in total conservation because these industries typically cannot reduce the amount of process water used without reducing production or shutting down.

Irrigation Water Use

While irrigators make up about eight percent of the water use in the Verdigris basin, they influence water availability in the system during specific months of the year. Irrigation water conservation plan guidelines were revised in 2006. Conservation plans are generally only required by DWR for irrigators who are not in compliance with the terms of their water right; however, continued improvements to irrigation technology may reduce their water use.

Recreation Water Use

Recreational water users account for less than one percent of the water use in the Verdigris basin and influence water availability in the system during specific months of the year. Most recreational users in the Verdigris basin pump water from the river to create habitat for water fowl. These users coordinate with DWR to ensure there is sufficient water available for them to pump; conservation measures are not typically required. Water conservation plan guidelines have not been developed for recreational water use.

Recommended Actions

- Evaluate the LLMP at Elk City Reservoir to potentially increase downstream water supply by reducing drawdown extent, shortening the duration of the minimum target elevation, modifying the time of year for the drawdown, developing a drought trigger, or not allowing a LLMP.
- Coordinate with the Corps to study the use of reservoir operational techniques to reduce sedimentation in the reservoirs.
- Continue aid to public water suppliers in developing and maintaining water conservation plans.
- Continue technical assistance to public water suppliers in determining the source of unaccounted for water.
- Explore sediment removal and/or reallocation options at Fall River Reservoir
- Work with WRAPS groups and other local stakeholders to develop and implement plans for sediment reduction at Fall River, Elk city and Toronto reservoirs. Implement protection measures for Big Hill Reservoir.
- Determine sources of sedimentation at Yates Center Reservoir and implement specific reduction methods.
- Thoroughly evaluate operational and management changes to improve supply.
- Develop a Lake Level Management Plan for Big Hill Reservoir.
- Coordinate with the Corps to study use of reservoir operational techniques to reduce sedimentation in the reservoirs.

Resources

1. Kansas Water Office. 2007. Surface Water Supply and Demand Projections for Selected Basins in Eastern Kansas.

2. Kansas Water Office. 2006. Kansas Municipal Water Use.

3. Kansas Water Office. 2007. Kansas Municipal Water Conservation Plan Guidelines.

4. Kansas Water Office. 2002. Status Report: State of Kansas, Water Marketing and Assurance Programs, Multipurpose Small Lakes Program.

5. KDHE. 2006. Public Water System Capacity Development Assessment.
6. Kansas Department of Health and Environment. 2006. Public Water Supplies Drought Vulnerability Assessment.

7. Kansas Department of Agriculture, Division of Water Resources. 2006. Public Water Suppliers, Sources and Purchasers.

8. P:\Basin_Resource_Condition_Reports\Water Resource Conditions 2002\Population and Water Demand.doc

9. State Water Resource Planning Act. K.S.A. 82a-901a.

10. US Army Corps of Engineers. Toronto Water Control Manual.

11. US Army Corps of Engineers. Fall River Reservoir Water Control Manual.

12. US Army Corps of Engineers. Elk City Reservoir Water Control Manual.

13. US Army Corps of Engineers. Big Hill Reservoir Water Control Manual.

14. Kansas Water Office. Lake Level Management Plans WY 2010 Report.

15. Baker, Debra & deNoyelles, Frank. Can Reservoir Management Reduce Sediment Deposition? References

16. Kansas Water Office. 1986 Kansas Industrial Water Conservation Plan Guidelines.