Report on the

Enhanced ASR Evaluation

City of Wichita

Project No. 71395

July 2014

Enhanced ASR Evaluation

prepared for

City of Wichita
Wichita, KS

July 2014

Project No. 71395

prepared by

Burns & McDonnell Engineering Company, Inc.
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City of Wichita
Enhanced ASR Evaluation
Project No. 71395

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LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
AOC	Assimilable Organic Carbon
AOP	Advanced Oxidation Process
ASR	Aquifer Storage and Recovery
BMcD	Burns & McDonnell
CFS	Cubic Feet per Second
EBWF	Equus Beds Well Field
ELISA	Enzyme-Linked Immunosorbent Assay
GCMS	Gas Chromatograph Mass-Spectrometer
ISPS	Intake Structure Pump Station
KDHE	Kansas Department of Health & Environment
KDWR	Kansas Division of Water Resources
LAR	Little Arkansas River
MG	Million Gallons
MGD	Million Gallons Per Day
MOU	Memorandum of Understanding
MR	Molar Ratio of Hydrogen Peroxide to Ozone Transferred
MWTP	Main Water Treatment Plant
NPDES	National Pollutant Discharge Elimination System
PST	Production Surge Tank
RB	Recharge Basin
RRB	Residuals Return Basin

Abbreviation	Term/Phrase/Name
RRW	Recharge and Recovery Well
RST	Recharge Surge Tank
SSS	Side Stream Storage
SSSB	Side Stream Storage Basin
SWPS	Settled Water Pump Station
SWTP	Surface Water Treatment Plant
TOC	Total Organic Carbon
UF	Ultrafiltration

CHAPTER 1 - PURPOSE, SCOPE, & BACKGROUND

This section of the report details the purpose and scope of work to enhance the ASR project with goals of increasing recharge capacity, utilizing more of the LAR flow, and improving recharge operations. These enhancements reflect several elements of the planned Phase III expansion of the ASR system and utilization of side stream storage.

Wichita water demands were recently updated and have been modified based on recent trends of reduced per customer use. Year 2060 typical demand average day is projected to be 73 MGD and the maximum day demand is projected to be 146 MGD. The demands for 1 and 2 percent drought increase the year 2060 average day to 83 MGD and the maximum day to 166 MGD. The MWTP capacity is currently listed as 160 MGD but several projects are proposed at the plant that could impact treatment flexibility and capacity.

SCOPE OF WORK

Scope items for the enhanced ASR Project are as follows:

- Raw Water Intake:
  - Evaluate average annual potential number of days and quantities of water available from the Little Arkansas River with diversion rates of 30 MGD, 45 MGD and 60 MGD. Use data from USGS gauges at Sedgwick and Valley Center.
  - Determine facilities required at raw water intake to capture 49.5 MGD and 66 MGD and also provide pre-sedimentation for all diversion rates.
  - Evaluate facilities required to divert 16.5 MGD, 33 MGD, 49.5, and 66 MGD to the Side Stream Storage facility.
  - Evaluate head requirements of existing raw water pumps to determine if they are capable of pumping to either the ASR Treatment Plant or the Side Stream Storage facility.
  - Evaluate water quality related operational impacts.
  - Determine if there are any water rights issues associated with utilizing the Side Stream Storage facilities.
  - Determine pipeline sizes, configuration, and potential routes for a pipeline to new Side Stream Storage facilities based on various diversion quantities. Consider alternative connection requirements to existing raw water pipeline (assume same pipeline used for inflow and outflow from Side Stream Storage facilities.
  - Evaluate risks of potential regulatory obstacles.

- Side Stream Storage Facilities:
    - Evaluate storage capacity options of Side Stream Storage facilities on the proposed site and prepare conceptual design of Side Stream Storage facilities (goal- at least 600 acre feet.
    - Identify alternate/supplemental sites.
    - Determine pumping facility requirements to pump water from Side Stream Storage facilities to the ASR Treatment Plant for 16.5 and 33 MGD flow rates.
    - Determine if adequate electrical service is available to the site of Side Stream Storage facilities, and if not, what improvements may be needed.
    - Determine average annual additional recharge capacity gained from use of Side Stream Storage facilities.
    - Evaluate risks of potential regulatory obstacles.

- ASR Treatment Plant:
    - Determine O&M impacts to ASR Treatment Plant associated with use of Side Stream Storage facilities.
    - Evaluate NPDES permit considerations if membrane waste is returned to the River under lower flow conditions.
    - Evaluate risks of potential regulatory obstacles.

- Recharge Facilities:
    - Determine number and potential locations for additional recharge facilities to optimize recharge capabilities.
    - Include use of recharge/recovery wells and recharge basins at new sites and existing sites owned by the City.
    - Include evaluation of sites based on ownership of sites and potential ease of obtaining new sites based on ownership.
    - Determine size and locations of new pipelines required to achieve additional recharge and recovery capacity.
    - Evaluate risks of potential regulatory obstacles.

- Recharge/Recovery Enhancement:

- Evaluate options and permit modifications that would provide opportunities to enhance recharge capacities/credits through regulatory adjustments that may be available, including:
- Direct Recharge Credits for water diverted from Little Arkansas River whether recharged or diverted directly to the City's Water Treatment Plant
- Ability to use existing raw water pipelines for simultaneous recharge and recovery (compared to existing requirements to isolate pipelines during recharge).
- Evaluate the use of parallel pipelines to enhance recharge/recovery capabilities.
- Evaluate, using average annual recharge opportunities, the time required to store enough water to meet a 2% and a 1% drought occurrence when combined with the City's other water sources. Provide Modsim modeling support.
- Evaluate risks of potential regulatory obstacles.

- New Pipeline from Equus Beds:
  - Analyze hydraulic model to determine appropriate size and routing of new raw water pipeline from Southeast portion of Equus Beds Well Field to the City of Wichita. Include evaluation of impacts to piping at Main Water Treatment Plant (MWTP).
  - Determine potential routes for new pipeline.
  - Evaluate risks of potential regulatory obstacles.

BACKGROUND INFORMATION

Another purpose of this report is to discuss some of the history of the ASR project, discuss hurdles and lessons-learned that have come from Phase I and Phase II of the project and, overall, to address the viability of the enhanced ASR option. In order to do this, several questions have been raised by other parties and the City of Wichita, in conjunction with BMCD, has addressed them. The questions and responses are detailed in Appendix B of this report.

In addition to these questions and responses, an effort was made to discuss all parties and expertise that have contributed to the development of multiple water supply options. The following information was adapted from a presentation given to the City Council in a workshop on July 22, 2014.

Beginning in January of 2013, Professional Engineering Consultants (PEC) developed water supply demand projections using data from the Metro Area Planning Department (MAPD). After the demand projections were completed, SAIC developed water supply and drought scenario models. This was shortly followed by river modelling efforts by High County Hydrology using data from CSU and previous

BMCD studies. After the river model was created, data was provided by USGS regarding river flows and Equus Beds hydrology. As a result of this work from seven industry experts, nine different water supply options were presented to the City Council on April 8, 2014. After these options were presented to City Council, water economists at Metering Technology Consultants and Water DM reviewed the financial analysis models and the role of conservation within each option. Shortly after, water planning efforts narrowed down to two supply options, each of which includes long-term conservation efforts coupled with a new water supply either from El Dorado reservoir or from enhancements to the ASR project. After the options were narrowed down to only two, the City of Wichita selected BMCD to perform a 1% design on the enhanced ASR project. As part of this study, BMCD engineers worked with engineers from Black & Veatch who were representing the City of El Dorado. The two parties worked together to primarily discuss the opinions of probable costs developed for each project and to ensure that the two projects were being evenly compared. Generally, modifications made to either capital costs or O&M budget estimates were conservative and had the basic effect of inflating ASR costs.

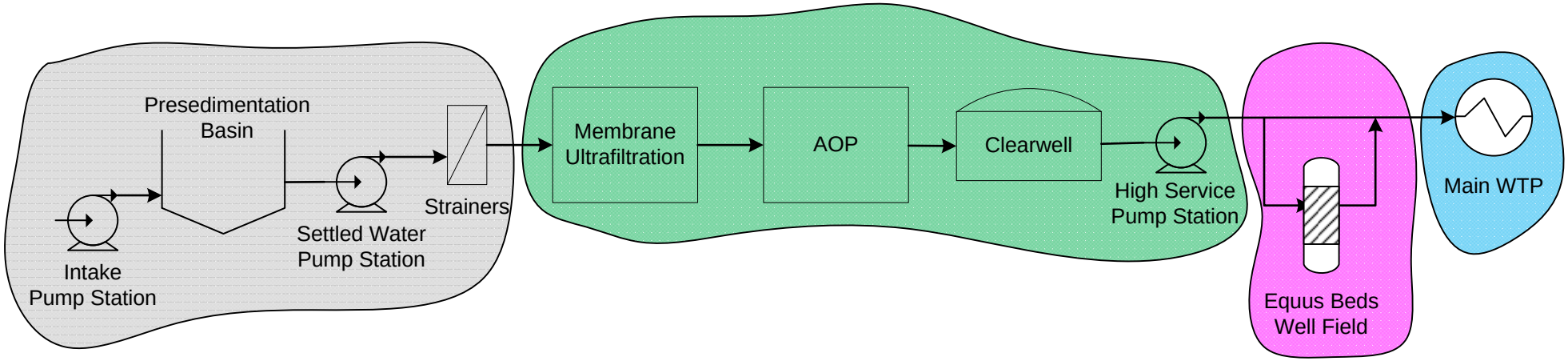
CHAPTER 2 - EXISTING INFRASTRUCTURE

This section of the report discusses raw water system infrastructure, specifically, the Equus Beds Well Field (EBWF) and Aquifer Storage and Recovery (ASR) facilities, as shown in Figure 2-1. The EBWF includes 31 production wells, 35 recharge/recovery wells, 1 recharge well, two recharge basins, and approximately 65 miles of well field piping ranging in size from 12-inch to 66-inch in diameter. The well field has the capacity to produce approximately 72 Million Gallons per Day (MGD) and recharge up to 40 MGD. Recharge capacity is directly related to water conditions within the well field area. Individual recharge well capacities are lower under high water level conditions and higher when aquifer water levels are lower. Thus there is an inverse relationship between the total system recharge capacity and production capacity.

Recharge facilities were developed in two phases, ASR Phase I and ASR Phase II. The ASR Phase I facilities include three bank storage diversion wells, a 7 MGD surface water diversion and a 7 MGD ballasted flocculation treatment plant that have a capacity to capture and recharge up to 10 MGD from the Little Arkansas River about 4 miles north of Halstead via four recharge wells and one recharge basin. Phase I facilities help protect the well field from the Burrton oil field brine plume that is migrating into the well field. The ASR Phase II facilities include a 66 MGD intake with 33 MGD of pumping capacity, a 33 MGD pre-sedimentation basin with strainers and pumps, a 66 MGD raw water line to the Surface Water Treatment Plant (SWTP), and a 33 MGD SWTP. Phase II also includes 31 recharge recovery wells, one recharge basin, and replaced pipes, tanks, power lines and a SCADA system that had outlived their useful service life. Phase II also connected Phase I facilities to the remainder of the well field.

PHASE II INTAKE AND SWTP

As part of Phase II of the City's ASR project, the existing SWTP was designed to receive surface water from the Little Arkansas River (LAR) and treat the water for aquifer recharge and diversion to the Main Water Treatment Plant (MWTP). As shown in Figure 2-1, the main SWTP processes are membrane ultrafiltration (UF) and an advanced oxidation process (AOP).



Process Flow Diagram

Capacity Summary

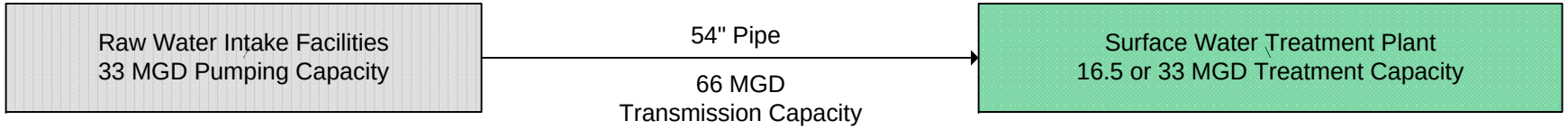


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Figure 2-1

City of Wichita, Kansas
Enhanced ASR

Existing ASR Phase II
SWTP Facilities

The process begins at the LAR intake site where submersible pumps are installed in a concrete intake structure. This structure contains nine bays for a total of nine intake pumps and a total pumping capacity of 66 MGD. Currently, there are five pumps, four duty and one standby, installed in the intake structure for a total pumping capacity of 33 MGD. The intake bays also contain a submersible mixer to keep solids in suspension and a screen to protect the bays from accumulating large debris from the river. The intake pumps are connected through a header, pass through a splitter structure, and deliver water to the presedimentation basin.

The presedimentation basin is located adjacent to the intake and provides settleable solids removal. This 2.7 million gallon (MG) tank essentially serves as a clarifier with scraper mechanism but does not include chemical addition. At a flow rate of 16.5 MGD the retention time inside the presedimentation basin is approximately 235 minutes. Higher flow rates reduce the retention time proportionately.

Water from the presedimentation basin overflows through a 48” pipe to the Settled Water Pump Station (SWPS). The SWPS contains two can-style pumps designed to pump 33 MGD through a series of 5 strainers to the membrane influent trough at the SWTP. The strainers use a 500-micron screen to remove solids prior to the membrane treatment process.

The membrane treatment process removes solids, reduces turbidity and removes giardia and crypto. The membranes use a pore size of 0.04 micron to achieve the removals shown in Table 2-1.

The advanced oxidation process was designed to destroy atrazine from the LAR water while also mitigating bromate formation. The AOP also provides a secondary barrier to crypto/giardia and viruses by inactivating any that remain after the membrane process. Atrazine is an herbicide used in the region which enters the river in storm runoff. The AOP uses ozone and hydrogen peroxide to create hydroxyl radicals which destroy atrazine. The system dosages and the tubular-style reactors are also designed to limit bromate formation due to the elevated levels of bromide that can occur in the LAR. The existing AOP equipment is capable of generating 4,200 lbs/day of ozone which is a dosage of 15 mg/L for 30 MGD of flow. Finished water quality goals from the SWTP are summarized in Table 2-1 below.

Table 2-1 SWTP Treatment Goals

Parameter	Influent	Effluent
Turbidity (NTU)	1,000	<0.1
Atrazine (µg/L)	20	<3
Bromide (µg/L)	300	NA
Bromate (µg/L)	NA	<10
Crypto	2-log Removal	
Giardia	3-log Removal	
Virus	4-log Removal	

After the AOP, water is sent to a 1.4 MG clearwell at the SWTP site. This clearwell is a concrete tank with approximately 9 feet of storage below grade and 9 feet of storage above grade. This acts as a flow equalization tank between the treatment processes and High Service Pump Station (HSPS). HSPS contains two split-case centrifugal pumps designed to pump 30 MGD to the Equus Beds Well Field (EBWF) for recharge and/or diversion to the MWTP.

LAR WATER TRANSMISSION TO SWTP

A 2.5 mile 54-inch raw water line conveys water from the SWPS to the SWTP and has a capacity of 66 MGD. The line is constructed primarily of carbon steel and includes combination air/vacuum relief valves every ½ mile. A 24-inch residuals return line runs parallel to the raw water line and conveys residuals from the SWTP back to the LAR for discharge. This line is also constructed of carbon steel and discharges to a manhole at the intake site prior to discharging to the LAR. The routing of these pipes is shown below in Figure 2-2.

1:14,000

0 0.125 0.25
Miles

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Figure 2-2
City of Wichita, KS
Enhanced ASR

Existing SWTM and RR Piping

WELL FIELD

The EBWF includes a number of production and recharge facilities as listed below:

- Common to production and recharge:
  - 35 recharge/recovery wells (RRWs);
  - Pipeline and valves that allow the pipelines to be used for either recharge or recovery;
  - Two chlorination stations for periodic chemical treatment of the pipelines to help minimize bacteria growth in the pipelines;
  - Two storage tanks that also provide hydraulic control; and
  - A SCADA system was designed to control and monitor the production and recharge components of the system.
- Production only:
  - 31 production wells.
- Recharge:
  - 1 recharge well (a recharge well was constructed in lieu of a recharge basin and was given a special classification for permitting);
  - A flow control structure to divert recharge water to the MWTP – facility was installed for multiple purposes as follows: 1) provides additional operational flexibility and allows for additional recharge by diverting 3 to 15 MGD to the MWTP as the SWTP can only treat in 15 or 30 MGD increments; and 2) divert up to 15 MGD to the MWTP for additional supply saving water from the EBWF and Cheney for use during dry periods;
  - Three bank storage wells; and
  - Two recharge basins.

Wells

Production wells are intended for pumping purposes only. Typically, a small well house contains the discharge valves and meter, and the production well is located outside. Production wells throughout the well field range in total depth between approximately 55 and 250 feet, depending on the aquifer formation at the well sites. All of these well sites can be converted to recharge/recovery wells in the future.

RRWs are designed with valves to control the flow into the aquifer through down tubes entering the casing below the anticipated static water level. They are also capable of pumping for redevelopment purposes or production. Each well has a well house which contains the meter, motor controls and other associated equipment. RRWs throughout the well field range in total depth between approximately 48

and 267 feet. Equipment is installed in all of the wells to monitor water levels in and near the well locations.

Maintaining the production capacity of the wells is required in order to assure adequate water supply. Well field staff has developed a schedule for doing chlorination treatments for each well, based on historical performance for each of the wells. During chlorination, high dosage chlorinated water is added to the well in order to oxidize iron bacteria that can plug the screens of the well and formation around the well. Additionally, well field staff has assembled the equipment that allows them to do complete these treatments without having to obtain an outside contractor. Generally wells are chlorinated once per year. Besides chlorination, production wells also need periodic chemical treatments to remove mineralization from the well screen which is required every few years by an outside contractor.

When Recharge wells are receiving water they also receive particulate materials remaining from the treatment process and particulates picked up from the pipelines during transmission to the wells. Because these materials can plug the well's screens from the inside, the wells need to be redeveloped to remove the particles. This is done by pumping the well, preferably at a slightly higher rate than the normal production rate. The frequency with which the recharge wells need to be redeveloped is based on the performance of the wells. A schedule for redevelopment for each well will be developed with additional operation and review of the SCADA "Historian" data. Currently, wells are redeveloped after one to two weeks of recharging. A summary of existing RRWs and their recharge capacities is shown below in Table 2-2.

The recharge capacity of any given recharge well is directly related to the static water level. The recharge capacity at lower static water levels is higher. Higher static water levels result in lower recharge capacities thus more recharge wells are required to recharge at a given rate when static water levels within the well field are higher. The static water levels observed within the wellfield in 1993 are considered to be the lowest recorded static water levels. Water levels have improved significantly since 1993 primarily due to increased use of Cheney and decreased use of the EBWF. Modeling indicates that required future use, particularly during an extended drought will result in water levels returning to or below the water levels observed in 1993.

Table 2-2 Existing RRW Recharge Capacity Summary

Phase 2 Well #	Well TD (ft)	*Post Construction Calculated Recharge Rate (gpm)*		
		1993 WSL	**Current WSL**	**High WSL**
MR-02	220	850	523	100
MR-04	217	540	327	50
MR-06	250	1200	1200	430
MR-08	255	1200	687	190
MR-10	246	1050	715	170
MR-11	246	1200	732	190
MR-13	227	1200	1200	360
MR-14	203	1160	486	140
MR-18	175	1200	646	350
MR-19	189	290	160	40
MR-20	150	1010	454	180
MR-22	192	1170	520	200
MR-23	202	1200	581	280
MR-26	200	1050	535	220
MR-42	262	310	234	80
MR-43	115	980	232	230
MR-44	95	620	22	20
MR-45	168	420	143	140
MR-47	165	690	238	200
MR-48	47	1200	975	290
MR-50	264	780	470	120
MR-51	200	60	118	50
MR-55	43	957	264	260
MR-56	165	670	134	130
MR-57	255	320	35	40
MR-58	150	1200	710	360
MR-59	235	690	237	110
MR-60	244	1200	1200	350
MR-61	249	1200	873	330
RR-05	269	890	497	260
RR-01	124			
RR-02	257			
RR-03	165			
RR-04	125			
Total (gpm)		26,507	15,149	5,870
Total (MGD)		38.2	21.8	8.5

Tanks

Two surge tanks were constructed as part of ASR Phase II. These tanks provide hydraulic control, equalization, and water hammer relief for the well field. The first, located in Sedgwick County near 109th St. N. and 167th St. W., is referred to as the Production Surge Tank (PST) and it provides hydraulic control for EBWF production. It is 92.9 feet tall, has a nominal capacity of 2.9 MG, and a working capacity of 2.5 MG. This tank was constructed as a replacement for a previously existing surge tank that was in very poor condition. The second tank, located in Harvey County near SW 72nd St. and Spring Lake Rd., is referred to as the Recharge Surge Tank (RST) and provides hydraulic control, equalization, and water hammer relief during recharge and production. It is 109.9 feet tall, has a nominal capacity of 2 MG, and a working capacity of 1.9 MG

Pipelines

Well field pipelines range from 12-inch up to 66-inch diameter and their arrangement serves multiple purposes. All of the EBWF production is ultimately conveyed through a single 66-inch waterline which starts at the southwestern crosstie and connects at the MWTP. The primary purpose of the well field is to deliver raw water through the 66-inch waterline to the MWTP. Piping is configured in a manner such that there are several routes for raw water to get from the wells to the 66-inch waterline which allows for maintenance of wells and recharge of wells while still sending production water to the MWTP. A map of the well field piping is shown below in Figure 2-3.

Pipeline sizes range from 66-inch to 12-inch and include ductile iron and concrete cylinder pipe and PVC pipe materials. The well field staff has previously been responsible for repairing any pipeline breaks that occur in the EBWF pipeline system; however, well field staff no longer has the experience or materials necessary to make the repairs. Large repairs require the rental of heavy equipment to facilitate the repairs.

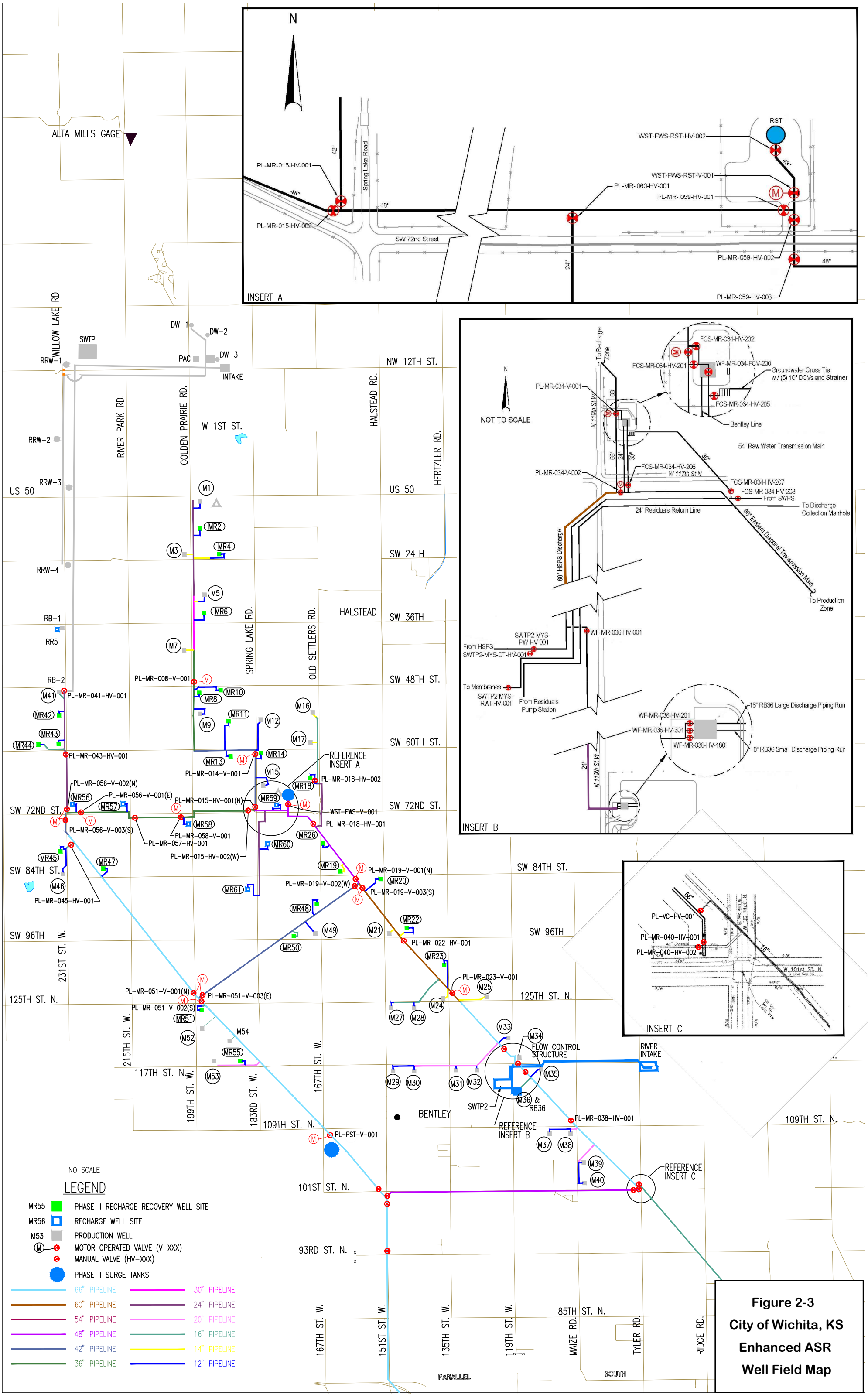


Figure 2-3
City of Wichita, KS
Enhanced ASR
Well Field Map

Other Recharge Facilities

Existing recharge facilities noted above include Recharge Basin 2 (RB2) and Recharge Basin 36 (RB36), three bank storage diversion wells, and the flow control structure. RB2 was installed as part of ASR Phase I and was connected to the remainder of the well field as part of ASR Phase II. RB36 was originally constructed as part of the recharge Demonstration Project and was expanded as part of ASR Phase II. The flow control structure at Well 34 was added to ASR Phase II to provide additional water for recharge by diverting water from the recharge system to the MWTP in Wichita.

RB2 is located at Well 41 in the northwestern portion of the well field as shown in Figure 2-3 and has 2.7 acres of bottom area with the capability to recharge approximately 3.5 MGD average over a typical recharge event. Water can be recharged from either the ASR Phase I or Phase II facilities.

RB36 is located at Well 36 directly east of the SWTP as shown in Figure 2-3 and has two acres of bottom area. It has the capability to recharge approximately 7 to 10 MGD average over a typical recharge event, but has the capacity to accept up to 15 MGD for limited periods. RB36 can be recharged from the ASR Phase II recharge system via a set flow and is used to maintain level in RST.

Recharge basins act like filters and therefore can plug over time. Recharge basins are designed to allow the access of earth movers and scrapers in and out of the basin to remove the top layer of material that may be reducing recharge capacity or plugging the basin. If the water entering the recharge basins comes from the SWTP, it will be free of most particulates, and it is anticipated it will be several years between basin cleanings.

Three bank storage diversion wells were installed as part of ASR Phase I and are located two miles east of the Phase I plant near Golden Prairie Rd. and NW 12th St. Each well can divert about 700 gpm while conforming to KDWR drawdown limit of 10 feet at a distance of 660 feet from each well. Bank storage wells can operate above LAR flows of 57 cfs from April 1 to September 30 and 20 cfs from October 1 to March 31.

The flow control structure provides the city the ability to divert 3 to 15 MGD of recharge water from the EBWF to the MWTP. As the SWTP can only run at 15 and 30 MGD, this facility was required to help balance the system. This facility includes a control valve linked to a flow meter and SCADA to direct the preset flow to the MWTP.

POWER

The power and electrical transmission system was rebuilt as part of ASR Phase II. This included the following components that replaced the EBWF infrastructure, much of which was over 60 years old:

- 50 miles of power lines; and
- A 138/12.4 KV substation adjacent to the SWTP.

SCADA

The SCADA system was rebuilt as part of ASR Phase II. This included the following components that replaced that EBWF infrastructure, much of which was over 10 years old:

- 35 radios;
- 4 repeaters;
- Four antenna structures; and
- Two servers.

RAW WATER TRANSMISSION TO MWTP

Raw water is currently conveyed from the EBWF to the MWTP through a 66-inch main installed in 1957. This main runs from Well 45 in the well field to the 21st and Hoover area where the Cheney 60-inch line connects to the 66-inch EBWF main. This main also connects with two 66-inch mains which run from this location to the MWTP. This allows the water to be blended or one 66-inch main to be used for EBWF water and the other for Cheney water.

CHAPTER 3 - REGULATORY ISSUES & CONSIDERATIONS

There are a number of significant regulatory issues associated with the ASR project. The Wichita ASR project was the first aquifer recharge project in the State of Kansas, and at the time the project was proposed there were no regulations in-place to manage the project. As the concept design for the project was being developed and the Recharge Demonstration Project was underway, the City worked closely with the various State and Federal regulators to develop regulations appropriate for the proper administration of the project. The two most significant sets of regulations for the project are the Kansas Department of Health and Environment's (KDHE) Class V underground injection regulations, and the Kansas Department Agriculture, Division of Water Resources (DWR) ASR regulations. Also of significance is the KDHE National Pollutant Discharge Elimination System (NPDES) regulations related to handling waste from the surface water treatment plants.

DWR REGULATIONS

The regulations used by DWR to administer the ASR project are mostly contained in KAR 5-12-1, KAR 5-12-2, and KAR 5-22-10. In addition, the definitions included in KAR 5-1-1 help provide clarification of the terms used in the previously mentioned regulations. In addition to the ASR regulations, there are also regulations related to the operation of bank storage diversion wells, and those are addressed in KAR 5-22-17.

The regulations describe how an ASR project is defined, how the boundaries of an ASR project is determined, the information needed to obtain an ASR permit, and how to complete the annual accounting necessary to determine the recharge credits that are available for recovery from an ASR project. The accounting method adopted by DWR requires an annual report to DWR and the Groundwater Management District (GMD2). The accounting process utilizes a computer model to account for natural and artificial recharge, groundwater inflow and outflow, evaporation and transpiration, groundwater diversions from all non-domestic wells, infiltration from streams and rivers, groundwater discharges to streams and rivers and calculated recharge credits. The annual accounting report is due to DWR by August 1st of each year. Following approval of the annual accounting report a letter is issued by DWR authorizing recharge credits available for withdrawal in the following calendar year. For example, recharge activities conducted in 2013 will be summarized and defined within the annual accounting report completed and submitted in 2014. Following approval of the accounting report the resulting recharge credits and previously established credits are then available for withdrawal in 2015.

Water Availability

The regulations and permits also describe the flows in the Little Arkansas River that must be exceeded before the City can withdraw water from the River. The flows in the River must be in excess of the "base flow" (the amount of flow obtained from the aquifer) and also meet all senior water rights. Those conditions vary depending on the location. The Phase I facilities can operate when flows in the River are above 57 cfs from April 1 to September 30 and above 20 cfs from October 1 to March 31. The Phase II facilities can operate anytime flows in the River exceed 30 cfs at the Valley Center gauge operated by the USGS.

Index Cells

To assist in managing the ASR project, the project area was broken down into 38 "Index Cells", each about 4 square miles in size. The concept of using Index Cells, and their approximate size, was originally developed by the Kansas Geological Survey as an acceptable management tool to use to help regulate the ASR project. The Index Cells were identified prior to the start-up of construction activities, and monitoring wells were constructed in each Index Cell. Water quality samples were also collected from all of the monitoring wells to establish a baseline water quality for each Index Cell. Using information obtained from the USGS, the DWR has established a "top" of the ASR project as the water levels that existed in 1940, before the City constructed the EBWF, and established the "bottom" of the ASR project as the water levels that existed in 1993, which were the lowest water levels recorded in the EBWF. Those levels have now been assigned to each Index Cell, using the site of the monitoring well assigned to each Index Cell. In addition to the "top" assigned to each Index Cell, a further restriction has been placed on the City that restricts the City from recharging at a site where water levels are less than 10 feet below land surface. That restriction was placed in an effort to avoid impacts to basements and lagoons. When recharge credits are calculated for the project, they are allocated for each Index Cell. Modification of the methodology utilized to define the upper and lower boundary conditions of an ASR project are currently being considered.

ASR Storage Capacity

In 1993 the City altered its water use strategy, and started taking more water out of Cheney Reservoir, and thus reducing the amount of water withdrawn from the EBWF. It is currently estimated that the dewatered portion of the aquifer that existed in 1993 could hold approximately 120,000 acre feet of water. At that time water levels were as much as 40 feet lower than their predevelopment levels of 1940. For comparison purposes, the conservation storage of Cheney Reservoir is 164,000 acre feet. Since 1993, because of reduced water use by the City, the EBWF has recovered about 67,000 acre feet, and water

levels have increased as much as 20 feet. The reduced production levels from the EBWF will likely not be sustainable as increasing future demands result in increased use of the EBWF.

Recharge Credits and the 1993 Levels

When the ASR regulations were developed, the first set of ASR permits was issued in 2005 which included the restrictions regarding the recovery of recharge credits when water levels are below 1993 levels. During the permitting process there were assumptions made about the 1993 water levels, and the water level recoveries that had been experienced since 1993. The drought conditions of 2011 and 2012 have highlighted some conditions in the aquifer that may not be controllable by the City that could impact the recharge credits available to the City. Those observations indicate that some adjustments may need to be pursued in order to assure that the City gets the appropriate recharge credits it has accumulated if drought conditions reoccur. Making adjustments to the definition of the "bottom" of the ASR project could assure that the City can obtain all of the recharge credits it is should have available even under drought conditions. Discussions with DWR regarding the modification of the ASR boundary definitions and existing recharge credit recovery restrictions have been positive. DWR has expressed a willingness to move toward a regulatory framework that will ensure the viability of the ASR program.

Additional Appropriations for Side Stream Storage

Discussions with DWR have determined that if the side-stream storage concept is constructed that there will be no impacts on the current ASR appropriations. One issue that may have to be addressed involves the diversion rate approved for the Phase II river intake structure. The current appropriation allows for an annual diversion of 45,230 Acre Feet per year, which is adequate to support side stream storage, but it has a maximum withdrawal rate of 60 MGD (41,667 gpm). An increase in the proposed diversion rate above the currently authorized diversion rate would require a permit modification or a new permit.

Conjunctive Use Recharge Credits

Alternative methodologies and or accounting procedures for the development and accumulation of recharge credits are currently being considered. The alternate strategies are focused on increasing the efficiency of the ASR Program from an operational, maintenance, energy and required infrastructure stand point. A regulatory adjustment that the City may want to pursue is to seek to obtain of recharge credits for water withdrawn from the Little Arkansas River, even if that water is not directly recharged into the EBWF. Under this concept the City would obtain recharge credits for water obtained from the Little Arkansas River that replaces water that would have been produced from the EBWF.

Multi-Year Flex Accounts

In 2011 the Legislature modified the water appropriations rules to allow for multi-year flex accounts. Those regulations allow a water user to obtain a five-year term permit that distributes their appropriation over a five-year period rather than in just an annual appropriation. There is the potential that those new regulations could provide some additional flexibility in regard to the City's water rights.

KDHE REGULATIONS

Class V Injection Regulations

KDHE has issued the Class V injection permits for the project which establish the water quality standards the project must meet. Essentially, the regulations require that the water quality of recharge water, in terms of chemical constituents, must meet the drinking water standards. The constituents of major concern in the project have been atrazine (a pesticide that has been found in the river), arsenic and chlorides. Atrazine concerns are generally limited to the capture of surface water while arsenic is generally associated with water captured from bank storage wells. In terms of disinfection, the water recharged into wells must meet the same microbial removal standards as drinking water, but not the disinfection standard as drinking water, which requires the water to have a minimum chlorine residual when it reaches all customers in a distribution system. Having chlorine in the recharged water would be inappropriate, so the presence of chlorine in the recharge water is essentially the sole difference between recharge water and tap water. Water which is recharged through recharge basins is required to meet the chemical constituent requirements for tap water, but not the microbial removal standards, as the sand in the recharge basins have been shown to be adequate to remove microbials before the water reaches the groundwater. The use of Side Stream Storage facilities would have no impact on water quality recharged into the aquifer or the regulatory requirements associated with recharge activities.

NPDES Permit

The City currently has a NPDES permit from KDHE to discharge waste from the ASR Phase II surface water treatment plant to the Little Arkansas River. One of the conditions of the permit is that the discharge does not deposit residuals that alter the flow in the River. If the Side Stream Storage Facility is utilized, the flows in the river will be lower when the treatment plant is operating and returning waste to the river under lower flow conditions than currently experienced. Analysis of flow duration curves from the USGS will be utilized to evaluate the potential impacts of discharge under lower flow conditions. The surface water treatment plant generally discharges 3 MGD or 4.6 cfs, while treating 30 MGD. Based on observations of the current conditions, it appears that flows lower than 65 cfs will result in adequate dilution and mixing. Currently no flow related limits restrict discharge back to the LAR.

CHAPTER 4 - WATER AVAILABILITY

This section of the report discusses the availability of water supply from the LAR for recharge as well as potential methods to increase recharge quantities. Availability is based on LAR flows measured at the Sedgwick and Valley Center gauges utilizing the period of record from calendar year 1923 through 2013. This report uses the full period of record to evaluate water availability.

LIMITS OF AVAILABILITY

A number of factors limit the availability of flow from LAR for recharge. These include primary factors such as variable streamflow, downstream water rights, minimum diversion flow, time of year, and several water quality parameters. The limitations of variable streamflow and minimum diversion flows are discussed in detail in the Water Supply Modeling section of this report and water quality parameters are discussed below.

Bromide and Atrazine Concentrations

Concentrations of atrazine and bromide in the LAR can limit the availability of water. The AOP was originally designed to treat water according to the parameters shown in Table 2-1. Since the original design, the operation of the AOP has been studied and optimized to allow for more-specific chemical dosages to treat specific combinations of atrazine and bromide. The upper limits of atrazine and bromide are generally 30 µg/L and 430 µg/L, respectively; however, they cannot occur at the same time and still meet plant effluent goals. The table below shows the intended AOP dosing scenarios for each combination of bromide and atrazine. Areas shown in dark gray are the limits of operation based on atrazine and bromide concentrations in the raw water. Atrazine and bromide concentrations shown in Table 4-1 are in µg/L and ozone dosages are in mg/L.

Table 4-1 AOP Dosing Scenarios

Raw Atrazine	Percent Reduction	AOP Dose (Ozone/MR)				
		Br<150	150<Br<200	200<Br<300	300<Br<350	350<Br<430
<3	40%	7/0.5	7/0.5	7/0.5	7/0.5	7/0.7
3 to 4	50%	8/0.5	8/0.5	8/0.5	8/0.5	8/0.7
4 to 5	65%	10/0.5	10/0.5	10/0.5	10/0.7	
5 to 10	80%	12/0.5	12/0.5	12/0.7		
10 to 20	90%	14/0.7	14/0.7			
20 to 30	93%	15/0.7				

There is little data available to aid in predicting what bromide and atrazine concentrations will be in the raw water. However, based on available data from an extended event in 2013 and smaller events in 2014, some general trends have been observed.

During the beginning stages of a river event, atrazine concentrations tend to be high. It is expected that this is due to early runoff washing atrazine from agricultural users into the LAR and its tributaries. Figure 4-1 below shows atrazine trends relative to flow in the LAR at the Sedgwick gauge. Atrazine concentrations are from the river intake and river flow is at the Sedgwick gauge at 7:00 a.m. on the day indicated. This chart clearly shows elevated atrazine concentrations at the beginning of the river event which quickly decline afterwards. Figure 4-2 shows a similar trend for the river event in 2014.

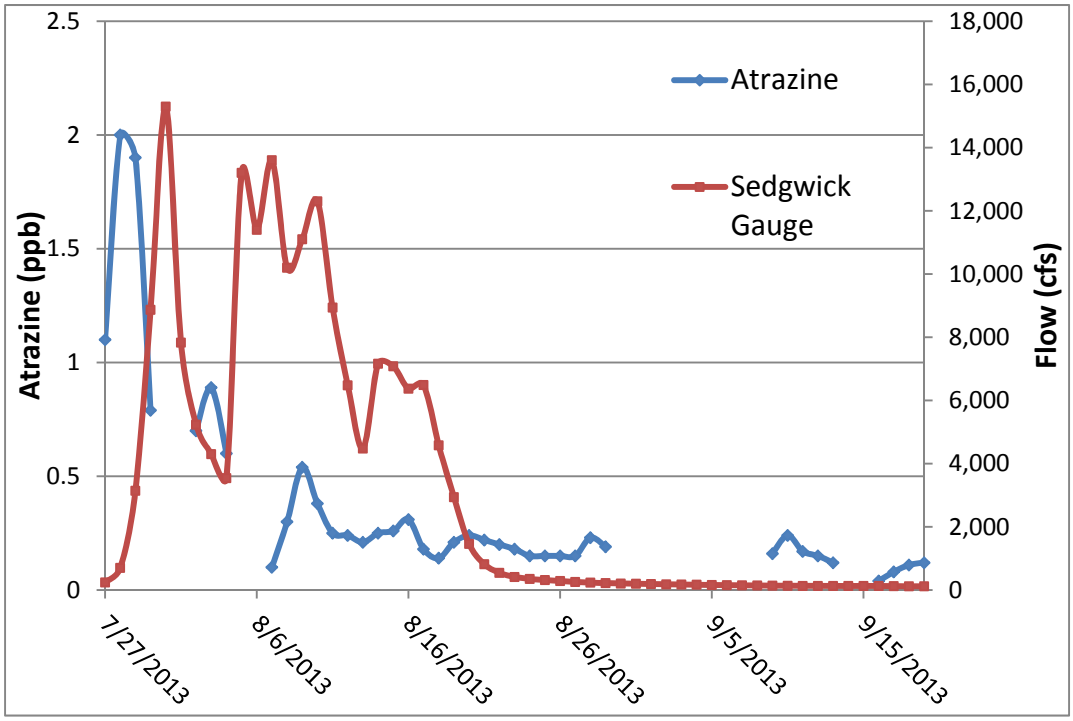


Figure 4-1 2013 Atrazine Trends

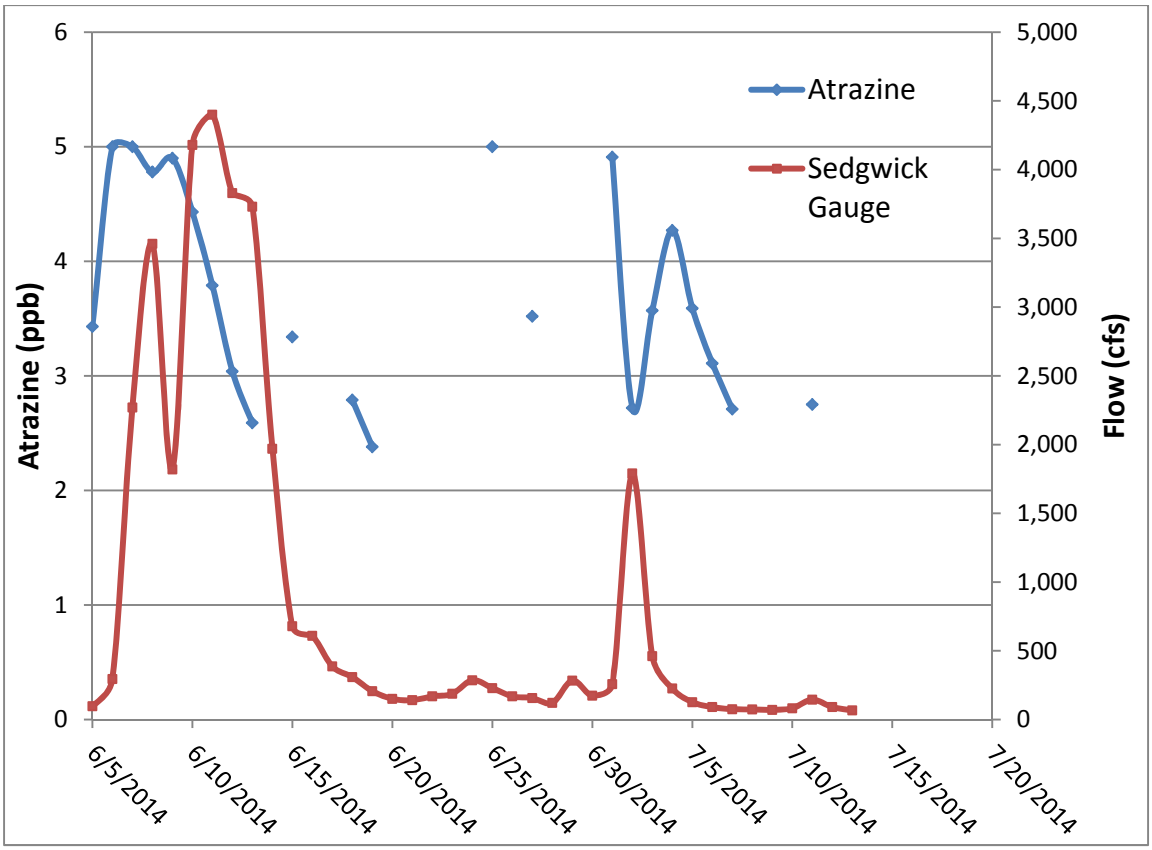


Figure 4-2 2014 Atrazine Trends

During the same river event in 2013, bromide concentrations exhibited a different trend than atrazine. Figure 4-3 below shows bromide trends relative to flow in the LAR at the Sedgwick gauge. Bromide concentrations are from the river intake and river flow is at the Sedgwick gauge at 7:00 a.m. on the day indicated. This chart clearly shows lower bromide concentrations at the beginning of the river event which start to increase as river flow decreases.

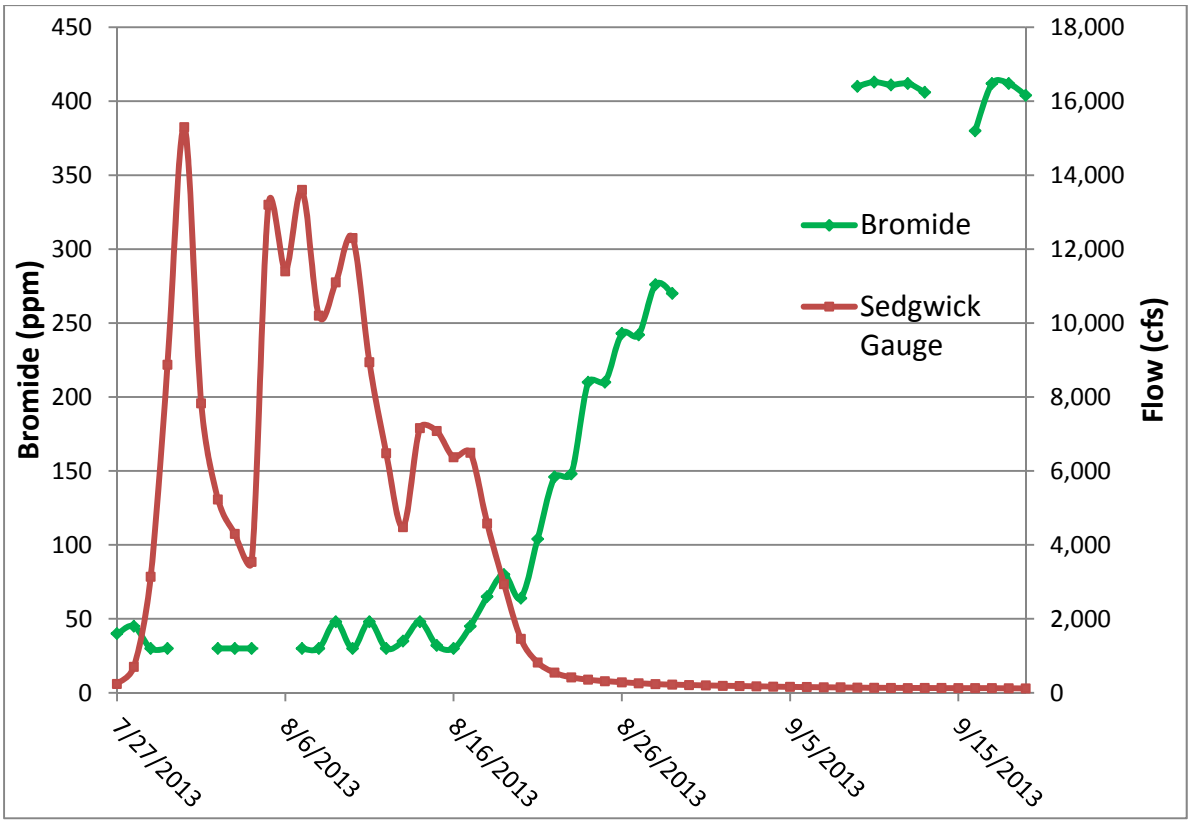


Figure 4-3 2013 Bromide Trends

Figure 4-4 shows similar data for the 2014 river event. However, this event started with two days of elevated bromide concentrations. This is likely due to a short river event which occurred shortly before the major event started. It is anticipated that the previous event provided enough flow to pull bromide from natural sources but did not provide enough flow to dilute the concentration.

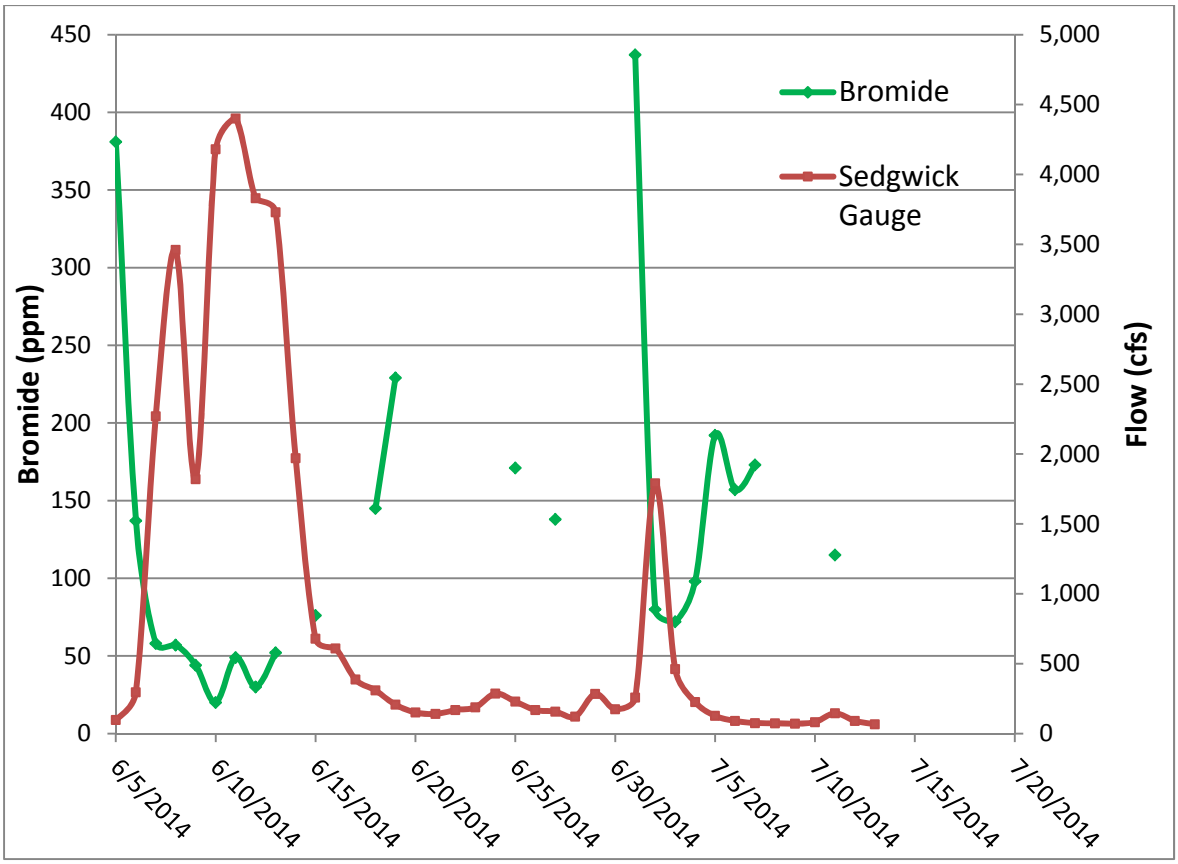


Figure 4-4 2014 Bromide Trends

The river events above varied in strength (maximum river flow) and duration. These factors could have an effect on when bromide concentrations begin to increase during a river event. In 2013, bromide concentrations began to increase when river flow reached approximately 4,000 cfs. Maximum flow during this event was approximately 15,300 cfs which means that bromide began to increase when river flow reached approximately 26 percent of the maximum event value. In 2014, bromide concentrations began to increase when river flow reached approximately 1,000 cfs. Maximum flow during this event was approximately 4,400 cfs which means that bromide began to increase when river flow reached approximately 23 percent of the maximum event value. As more data is gathered over future river events, this trend can be further evaluated.

WATER SUPPLY MODELING

A hydrologic, water balance-type simulation model of the City's ASR water supply system was developed to help quantify its supply capability, both for the existing system and with potential enhancements. The difference between the system's existing and enhanced supply capability represents

the potential benefits of these system enhancements. Since there is no reliable way to predict future hydrologic conditions, the simulation model utilizes historical data as a surrogate. The structure of this water balance model, data sources, assumed operating scenarios and modeling results are discussed in the following sections.

Model Architecture

The water balance model was developed using Microsoft's Excel spreadsheet software.[1] All source data used by the model and model results are stored as individual worksheets in a single Excel workbook file. A copy of this workbook file is enclosed on the CD-ROM. The worksheets in this file and their contents are described below.

- Model Runs worksheet — This worksheet contains the assumptions that can vary with each different scenario or model run. These parameters include the assumed operating mode; configuration indexes for the LAR intake, settled-water pump station and bank storage wells; storage basin index; model simulation period; and flags to determine if new bank storage wells are included, the desired stream flow dataset and model output mode. This worksheet also contains the user interface that is used to launch simulation runs based on these scenarios;
- Base Assumptions worksheet — The Base Assumptions worksheet lists those model parameters that are constant for all model runs, such as LAR flow triggers that signal when the LAR intake or bank storage wells can be operated;
- Pump Station worksheet — This worksheet lists configuration information — number of installed pumps and the minimum and maximum pumping capacity of each pump — for all of the various pump station configurations considered;
- Storage Basin worksheet — The Storage Basin worksheet contains elevation (or depth)-pool area-storage tables for each different storage basin alternative along with minimum and maximum operating elevations, seepage rates, and a configuration index for the basin's discharge pump station;
- Daily TS worksheet — This worksheet contains average daily flow data for the LAR along with daily precipitation data when available;
- Monthly TS worksheet — The Monthly TS worksheet contains total monthly precipitation and lake evaporation rates;

[1] The model was developed using Microsoft Excel, version 2010, but should be compatible with Excel 2007 and more recent versions.

- Hourly TS worksheet — This worksheet contains hourly LAR discharge data. These hourly data cover the period since October 2007 only; and
- Results worksheets — The remaining worksheets in the model's workbook file contain the daily simulation results for each executed model run. These worksheets are named based on the model number and the corresponding description listed in the Model Runs worksheet (for example, the worksheet with simulation results for model number 1 with description "Existing Base" is named "01-Existing Base."

The water balance model is contained in a macro-enabled Excel workbook file named "Wichita Enhanced ASR Model.xlsm." The bulk of the calculation engine for the simulation model was developed using custom procedures and class modules coded using Microsoft Visual Basic for Applications (VBA). VBA is the embedded programming language that is available in Excel and the other applications of the Microsoft Office suite (Word, Access, PowerPoint, Outlook, etc.).

Although the primary time series data used in the model are average daily values, the simulation model uses an hourly time step to keep step-to-step changes in basin storage and other parameters small. Except for quality assurance checks and trouble shooting, these hourly simulation data are then rolled up and reported as daily totals or average discharges.

As discussed later in this chapter, three different ASR enhancement options were considered with the possible addition of Alternative A–SWTP Bypass to any of these base options. The water balance model was designed to simulate an enhanced ASR supply system that most closely matches Option 3 plus Alternative A. That is, the hydraulic connections to a potential Side Stream Storage Basin (SSSB) are located between the settled-water pump station and SWTP and it is possible to continue diverting water to the SSSB at the same time as water is being supplied to the SWTP from this basin. However, these modeling results and estimates of potential enhancement benefits should be applicable regardless of which enhancement option may be selected. Each of these model components and their assumed operating criteria are discussed further below.

Model Input Data and Operating Assumptions

The input data used in the water balance model can be classified into two general categories: (1) climatic and hydrologic time series data and (2) physical parameters and operating assumptions for the existing ASR system and potential enhancements. These topics are covered in subsequent sections.

Climatic Data

Both daily and monthly climatic data were utilized in the model. The sources and periods of record for these climatic data are described below:

- Precipitation — Both daily and total monthly precipitation data were utilized in the model to estimate direct gains to a potential storage basin. These data were all collected at the National Weather Service office at Wichita's Mid-Continent Airport. The period of record for the daily precipitation data is January 1954 through December 2013. Total monthly precipitation data are available from January 1922 through December 2013. In the model, the daily precipitation data were used when available and the monthly data was used prior to 1954. When using the monthly data, this precipitation was assumed to be evenly distributed across the month (that is, daily precipitation depths were assumed equal to the total monthly precipitation divided by the number of days in that month).

- Lake Evaporation — Evaporative losses from a potential storage basin were estimated from monthly evaporation data for the project vicinity. Wichita Water Utilities' staff has been collecting pan evaporation data at Cheney Reservoir since September 1965 and continues to do so at present. Lake (free water surface) evaporation was estimated from these monthly pan evaporation data by multiplying by a pan coefficient of 0.7. Monthly lake evaporation rates for earlier time periods (January 1922 through August 1965) were previously estimated by Burns & McDonnell in 2008 using its ETCALC computer model, which was calibrated against the available data from Cheney Reservoir. The derivation of these data is documented in the report "Reservoir Evaporation Rates" (Burns & McDonnell, 11/14/2008). As with precipitation, lake evaporation was assumed to be evenly distributed across each month.

LAR Discharge Data

Average daily and instantaneous hourly discharge data were obtained from the U.S. Geological Survey's (USGS) National Water Information System (NWIS) for two stream gauges on the Little Arkansas River. These gauges are listed in Table 4-2.

Table 4-2 USGS Stream Gauges

Site Number	Site Name	Period of Record*	Drainage Area (sq. miles)
07144100	L Arkansas R near Sedgwick	10/01/1993-present	1,165
07144200	L Arkansas R at Valley Center	06/10/1922-present	1,250
*Period of record for average daily flow data. Instantaneous hourly data begins 10/1/2007.			

The City's LAR intake is located only about two miles downstream of the Sedgwick stream gauge so the flow available at the intake is considered to be roughly equivalent to the recorded flow at this gauge. The period of record for the Sedgwick gauge however, is only approximately 20.5 years long. In order to capture the broadest range in possible wet and dry hydrologic cycles, a much longer simulation period is desirable.

The historical flow record at the Sedgwick gauge was extended using data available at the Valley Center gauge. This gauge is located just a few miles farther downstream and has a period of record over 92 years long. If the runoff from the watersheds of these two gauges was truly uniform then the flow at these two gauges should be proportional to their respective contributing drainage areas; however, there are many variables in addition to drainage area that impact stream flow quantities, so this ideal rarely exists in nature. Therefore, a regression analysis was completed to compare the average daily flow data at these two gauges across their overlapping period of record (10/01/1993 through 06/04/2014) to obtain the best possible discharge adjustment ratio.

The regression analysis for the Sedgwick and Valley Center gauges was limited to days when the flow at Valley Center is less than 250 cfs because flows in this range are of most interest. Higher flows greatly exceed the capacity of the existing and potential intake facilities, so the accuracy of estimated high flow is less important. Figure 4-5 contains a scatter plot that compares these flow data and a best-fit linear regression line with a zero intercept.

As shown on this graph, the best-fit ratio between the historical flows at Sedgwick and Valley Center to be 0.861, which is about 7.6 percent less than their drainage area ratio of 0.932. In the simulation model, daily flows at Sedgwick (and the LAR intake) prior to October 1993 were estimated using the recorded flow at Valley Center times this best-fit ratio of 0.861. The resulting average annual flows at the Sedgwick gauge are plotted in Figure 4-6 to show how hydrologic conditions have varied across the period of record.

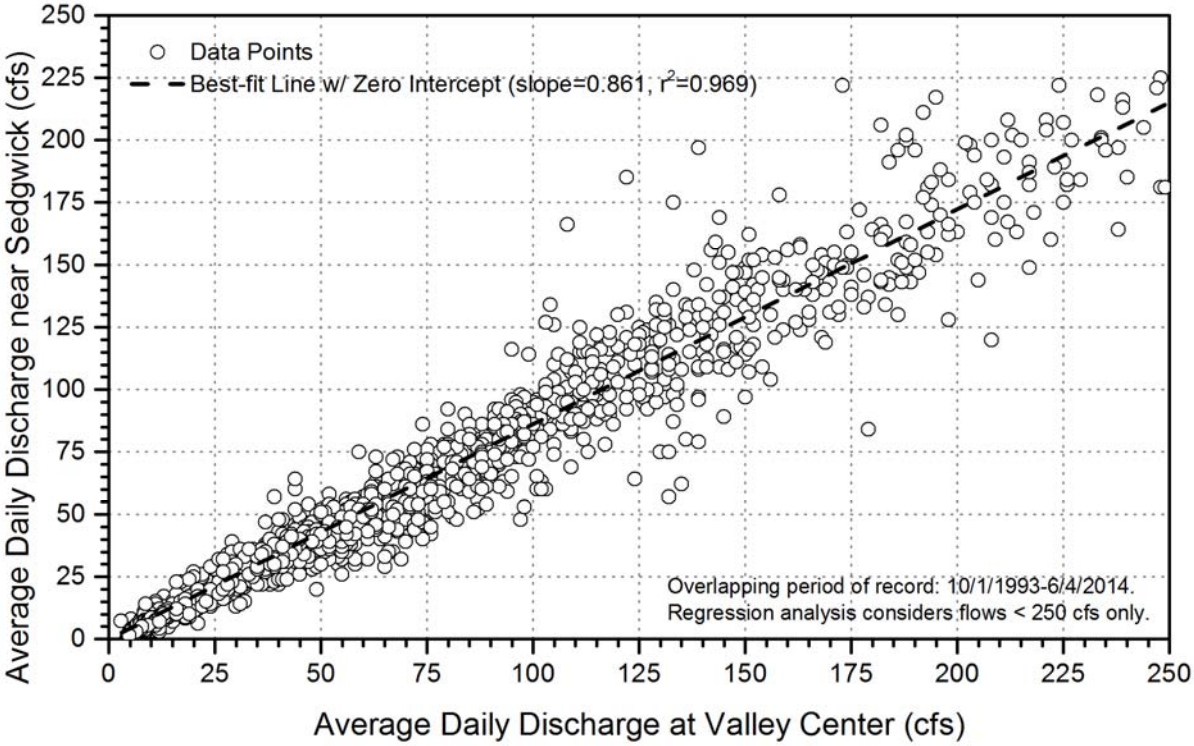


Figure 4-5 Little Arkansas River Flow Comparison

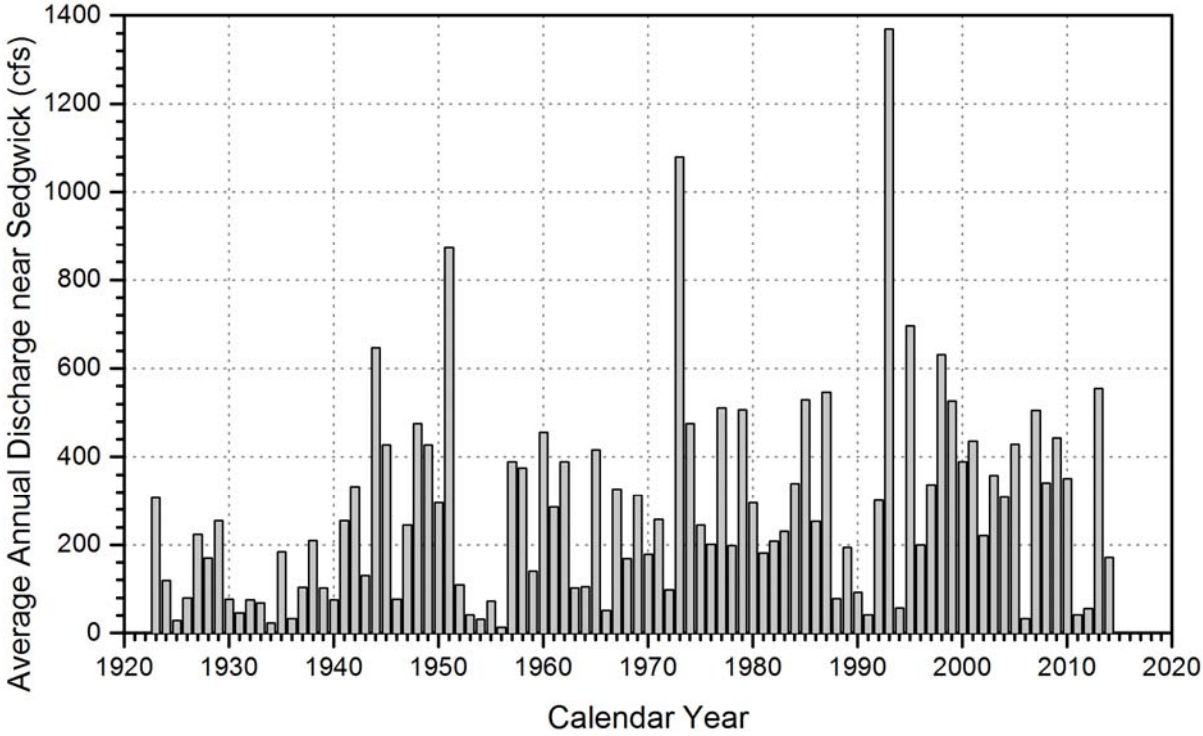


Figure 4-6 Average Annual LAR Flow Near Sedgwick

LAR Intake

The existing LAR intake contains four 8.25 MGD, single-speed pumps, with a fifth pump as standby. Under the ASR enhancement options, the throughput of this intake could be expanded up to 66 MGD by adding additional 8.25 MGD pumps. It was assumed that the first two of any future pumps to be installed in the intake would have variable frequency drives (VFDs) to provide for additional operating flexibility. This same assumption was applied to expansions of the SWPS and to a potential new Side Stream Storage (SSS) discharge pump station. With inclusion of VFDs, it was assumed a pump's throughput could be adjusted to any flow rate between 50 and 100 percent of capacity.

Operation of the LAR intake was assumed to be limited by a number of criteria, both base restrictions that relate to river flow rates and time of year, and advanced restrictions that attempt to mitigate the water quality concerns address previously in this chapter. The base operating restrictions are as follows:

- The LAR intake cannot be operated unless the flow in the river at Sedgwick is equal to 65 cfs or more. At this time, the first two intake pumps can be started to withdraw 16.5 MGD from the river, which leaves a residual flow of approximately 40 cfs to flow downriver. At higher flow rates, additional pumps can be started as long as the residual flow in the river never falls below 40 cfs; and

- Operation of the ASR supply system is also limited to a window that starts March 15 and ends November 15 each year.

The above base operating restrictions apply to all model runs. The user also has the option of further restricting LAR intake operation based on the advanced operating restrictions listed below.

- Since atrazine concentrations tend to be highest at the start of an operating event, delay intake operation for 12 hours after river flow exceeds the 65 cfs flow trigger. This brief delay will provide an opportunity to flush some of the atrazine downstream and prevent it from impacting SWTP operation;

- Do not operate intake when river flow exceeds 12,500 cfs.

- Bromide concentrations tend to increase toward the end of an operating event. Therefore, discontinue intake operation when river flow falls back below 100 cfs on the recession limb of an event's hydrograph. A flow rate of twice this limit (200 cfs) was used to signal that the flow peak has occurred. That is, once the river flow exceeds 200 cfs and then decreases to 100 cfs, the

intake was disabled. If a flow event occurs where the flow never exceeds 200 cfs, then intake operation could continue until the flow rate falls below the base 65 cfs flow trigger.

Presedimentation Basin

The presedimentation basin is not explicitly considered in the simulation model. Although this basin has a capacity of 2.7 MG and may be emptied for cleaning between operating events, it was assumed to remain full at all times in the simulation model. Therefore, all LAR withdrawals through the intake are delivered without modification to the SWPS.

Settled Water Pump Station

The settled water pump station currently includes two 16.5 MGD pumps on VFDs. Up to two additional 16.5 MGD pumps could be added to this station under the potential enhancement options. Any new pumps are assumed to be equipped with VFDs to provide operational flexibility. In the simulation model, discharge from the SWPS is first routed directly to the SWTP when possible. For model runs that include a SSSB, excess discharge from the settled-water pump station is routed to the SSSB, unless it is already full.

Surface Water Treatment Plant

The existing SWTP includes two treatment trains, each with fixed, raw-water feed and treated-water output rates of 16.5 MGD and 15 MGD, respectively. These treatment trains must be operated at full capacity or not at all; partial capacity operation is not allowed. Feed water to the SWTP can come directly from the SWPS or from the SSSB's discharge pump station, when present.

The number of treatment trains is a variable that can be changed with each model run, but the primary purpose of these ASR enhancement options is to increase system throughput without the major expense of adding more treatment capacity. Therefore, all of the model runs discussed below assume that only the two existing treatment trains are present.

Side Stream Storage Basin

Alternative SSSBs are characterized in the simulation model by inputting a table that relates pool elevation (or depth), pool surface area, and storage volume for each basin. The other basin input variables include an index that defines the characteristics of its discharge pump station, seepage rate, and minimum and maximum operating levels. Although the following parameters can be varied with each model run, they were assumed to be common for all of the runs discussed below that included a SSSB; the only variable adjusted between model runs is the basin's size and storage capacity.

- As described previously, the SSSBs are assumed to have a maximum operating depth of ten feet, so that further deliveries from the settled-water pump station are disabled when the basin's depth reaches this value. If a precipitation event should occur while the basin is already full, it is possible that its depth could exceed ten feet for brief periods. No overflow spillway is assumed for these basins;

- As a further restriction, a minimum operating depth of 0.5 foot is assumed. Deliveries to the SWTP are suspended when the depth of the water in a basin fell below half a foot. Evaporation and seepage losses continue until the basin should dry out completely;

- The discharge pump station for the SSSB is assumed to include three 11 MGD pumps, each equipped with VFDs;

- Although the model includes a provision to account for seepage losses at a fixed rate of inches per day, this seepage rate was assumed to be zero in the model runs discussed below. It was assumed that fine sediments delivered to the basin will quickly seal the basin's bottom and limit further seepage or the basin will have a clay bottom to minimize leakage.

When applicable, the simulation model calculates a water balance for the SSSB for each hour during the simulation period. This water balance includes consideration of the following volumes:

- Inflow from settled water pump station;

- Precipitation gains (current day's precipitation depth times basin surface area);

- Evaporation loss (current day's evaporation rate times basin surface area);

- Seepage loss (seepage loss rate time basin surface area); and

- Basin discharge to SWTP through its discharge pump station.

The basin storage at the end of each hourly time step is calculated as its starting storage plus precipitation gain less evaporation and seepage losses and withdrawals.

Modeling Results

Once development and testing of the water balance model was completed, it was executed for a number of different scenarios to test the impact of a SSSB on SWTP production and the additional water supplied by Alternative A as described below.

Impact of Side Stream Storage Basin

The impact of the three ASR enhancement options was investigated by executing a series of model runs with various sizes of SSSB. These runs were executed both with the base operating restrictions only and with inclusion of the advanced restrictions. The City currently operates with the advanced restrictions. The results of these model runs are summarized in Table 4-3. Figure 4-7 is a graphical presentation of the average annual SWTP production data from this table.

Table 4-3 Impact Summary for Side Stream Storage Basin

Operating Restrictions	Base Storage Basin Size (acres)	Average Annual SWTP Production (1923-2013)		Average Annual SWTP Operation (1923-2013)*		Average Annual Bank Storage Well Prod.
		Volume (MG)	Percent Increase	Hours	Days	Volume (MG)
Base	0	2,816	---	2,518	104.9	3,779
	20	3,297	16.7	2,686	111.9	3,767
	40	3,468	23.1	2,817	117.4	3,767
	60	3,598	27.8	2,916	121.5	3,767
	80	3,690	31.0	2,994	124.8	3,767
Advanced	0	2,341	---	1,925	80.2	3,781
	20	2,734	16.8	2,217	92.4	3,773
	40	2,953	26.2	2,393	99.7	3,773
	60	3,105	32.6	2,515	104.8	3,773
	80	3,219	37.5	2,607	108.6	3,773

*Operation hours and days do not distinguish between whether one or both treatment trains are operating.

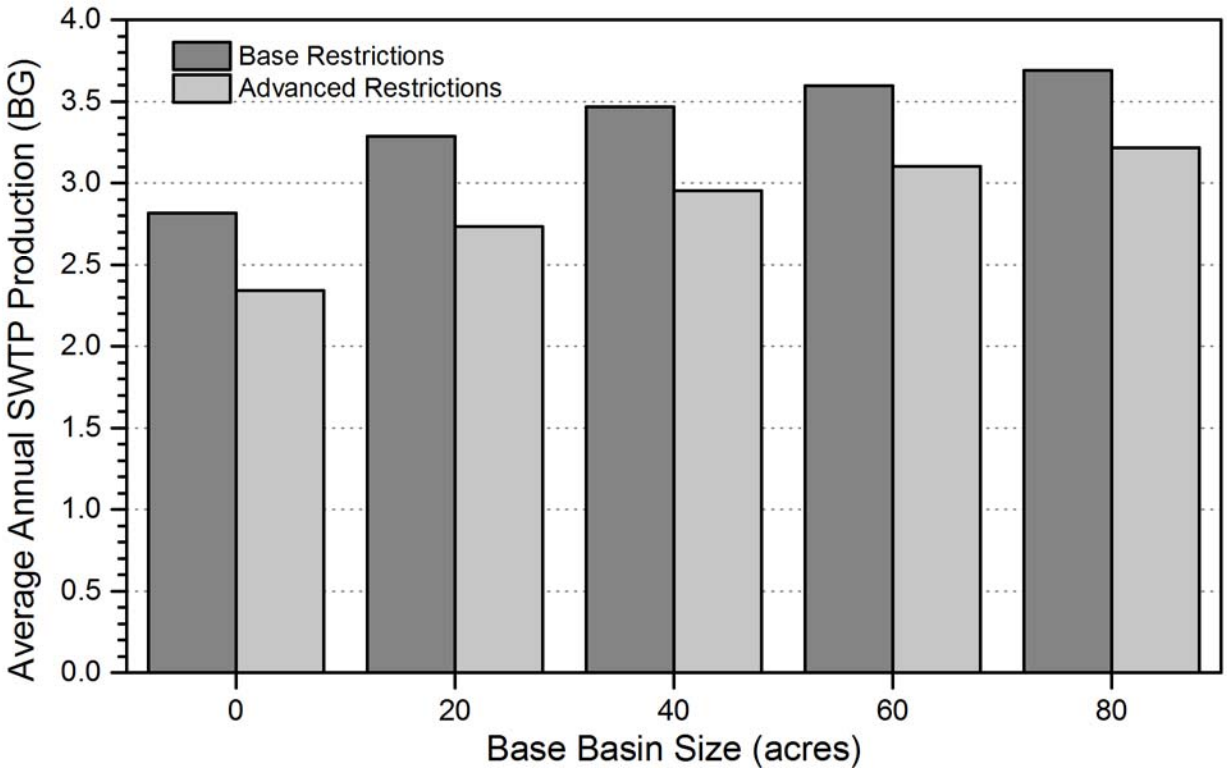


Figure 4-7 Summary of Side Stream Storage Basin Impacts

Review of Table 4-3 shows development of an 80-acre side stream storage basin at the ASR site could increase average SWTP production by 31 percent with base operating restrictions and 37.5 percent with the advanced operating restrictions. The impact is more significant with the advanced operating restrictions because the basin helps mitigate some of the impacts of these more stringent restrictions. Review of the data shows that additional storage beyond the 80 bottom acre SSSB has diminishing returns.

Impact of Alternative A–SWTP Bypass

In addition to the enhancement options that consider development of a SSSB, an option for installation of a SWTP bypass line and additional bank storage wells downstream of the LAR intake was considered. Bank storage water will be relatively clean compared to surface water, and will potentially be sent directly to the MWTP through the bypass line without the need for initial treatment at the SWTP. These new bank storage wells were assumed to consist of 8 or 9 wells with an aggregate pumping capacity of 15

MGD.[2] These new wells could be operated whenever there is sufficient stream flow in the LAR at the Valley Center stream gauge. A minimum residual river flow was assumed to accommodate downstream water rights and support fish & wildlife benefits.

The water balance model was revised to allow the user to include these new bank storage wells as an option. In truth, the model results show the operation of these new bank storage wells is largely independent of ASR supply system operation. Although there will be small depletions in river flow whenever the ASR intake is operating, these depletions did not prove to be significant in estimating the potential production of these new bank storage wells. The average annual production of these new wells varied over a small range from 3,767 to 3,781 MG/year, which is equivalent to year-round average of approximately 10.3 MGD.

Average Daily vs. Hourly Flow Sensitivity Analysis

The simulation model uses recorded or estimated average daily flow rates at Sedgwick as its primary input data. There is always a danger though on streams that exhibit flashy behavior (that is, with flow rates that can vary significantly over short periods) that using average daily flow rates can overestimate the real capture efficiency at a pump station.

This phenomenon is illustrated by the following example. Figure 4-8 shows a plot of average daily vs. instantaneous hourly LAR discharge rates for 12/11/2007.[3] On this date, the average daily flow in the river was 73 cfs, but hourly flow rates started at 37 cfs at midnight and increased to 239 cfs by the end of the day.

[2] The modeling results discussed below are based on nine wells with 1.67 MGD capacity each.
[3] The date selected for this example is outside of the normal ASR system operating window, but this restriction was ignored for the purposes of this illustration.

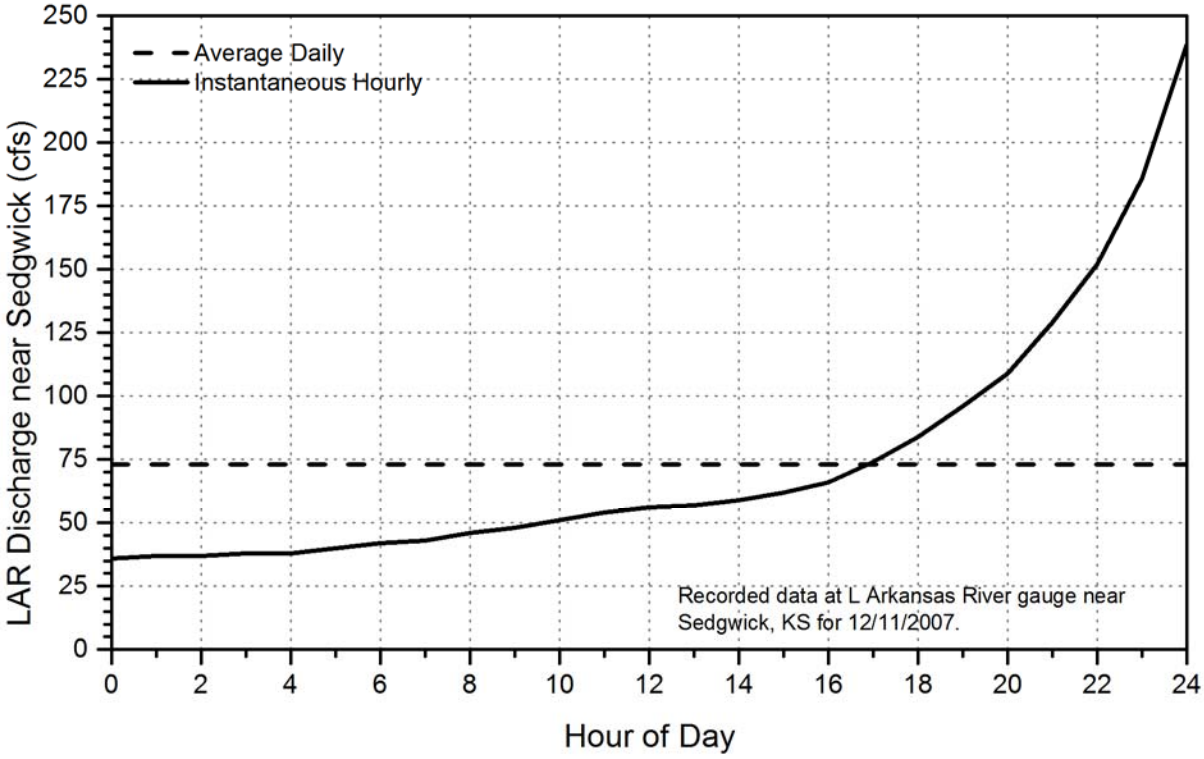


Figure 4-8 Daily vs. Hourly Flow Comparison

With the existing ASR supply system, an average flow of 73 cfs would imply that one treatment train could be operated for the entire day under base operating rules or 12 hours with the advanced operating restrictions. However, considering actual hourly flow rates shows one train could be operated for 3 hours and both for 6 hours. With the advanced operating restrictions, the 12-hour flush period would not allow any SWTP operation on this date. Total treated water production on this example date varies as follows:

- Average daily flow with base restrictions: 30 MG
- Average daily flow with advanced restrictions: 15 MG
- Hourly flow with base restrictions: 18.75 MG
- Hourly flow with advanced restrictions: 0 MG

In this extreme example, using average daily flow data would overestimate SWTP production by 37.5 to 100 percent. To test the significance of this phenomenon on a longer-term basis, a series of four model

runs was executed using a six-year period of record, 10/1/2007–9/30/2013.[4] These model runs are summarized in Table 4-4. With base operating restrictions, use of average daily flow data is shown to overestimate treated water production by an average of 4.2 percent and by 5.3 percent with the advanced operating restriction. These long-term values are considered to be fairly modest and give credence to the use of average daily stream flow data in the simulation model.

Table 4-4 Summary of Daily vs. Hourly Flow Sensitivity Analysis

Operating Restrictions	Flow Dataset	Average Annual WTP Production (MG)	Average Annual SWTP Operation (hours)
Base	Average Daily	2,617	2,355
Advanced	Average Daily	2,151	1,762
Base	Hourly	2,507	2,246
Advanced	Hourly	2,036	1,661

Additional Hydrogeology Information

During the course of this study, questions from the public arose regarding the knowledge of the aquifer, its ability to sustain the proposed enhancements, and regulatory requirements necessary to do so. Regulatory requirements have been discussed in Chapter 3 of this report but additional information was provided, by the City of Wichita, to address the public's questions. This information used data from the USGS that has not yet been published and, therefore, is withheld from this version of the report but will be provided as Appendix C at a later date.

ENHANCED AVAILABILITY

A number of opportunities are available to improve the availability of flow from the LAR for recharge. These include use of side stream storage basin(s) and bank storage wells. Side stream storage allows the City to increase diversions from the LAR during above-base flow events and divert flow to a combination of the side stream storage and the SWTP. Additionally, short duration events can be conveyed to side stream storage and the basin water pumped to the SWTP at the City's convenience.

Potential impacts of these enhancements on available flow are based on the following improvements:

- Side Stream Storage Basin with 268 MG of capacity near the existing intake site; and

[4] The simulation period used in this analysis is limited by the availability of hourly flow data.

- Side Stream Storage Basin with 202 MG of capacity at property currently owned by the City and 268 MG with purchase of additional property.

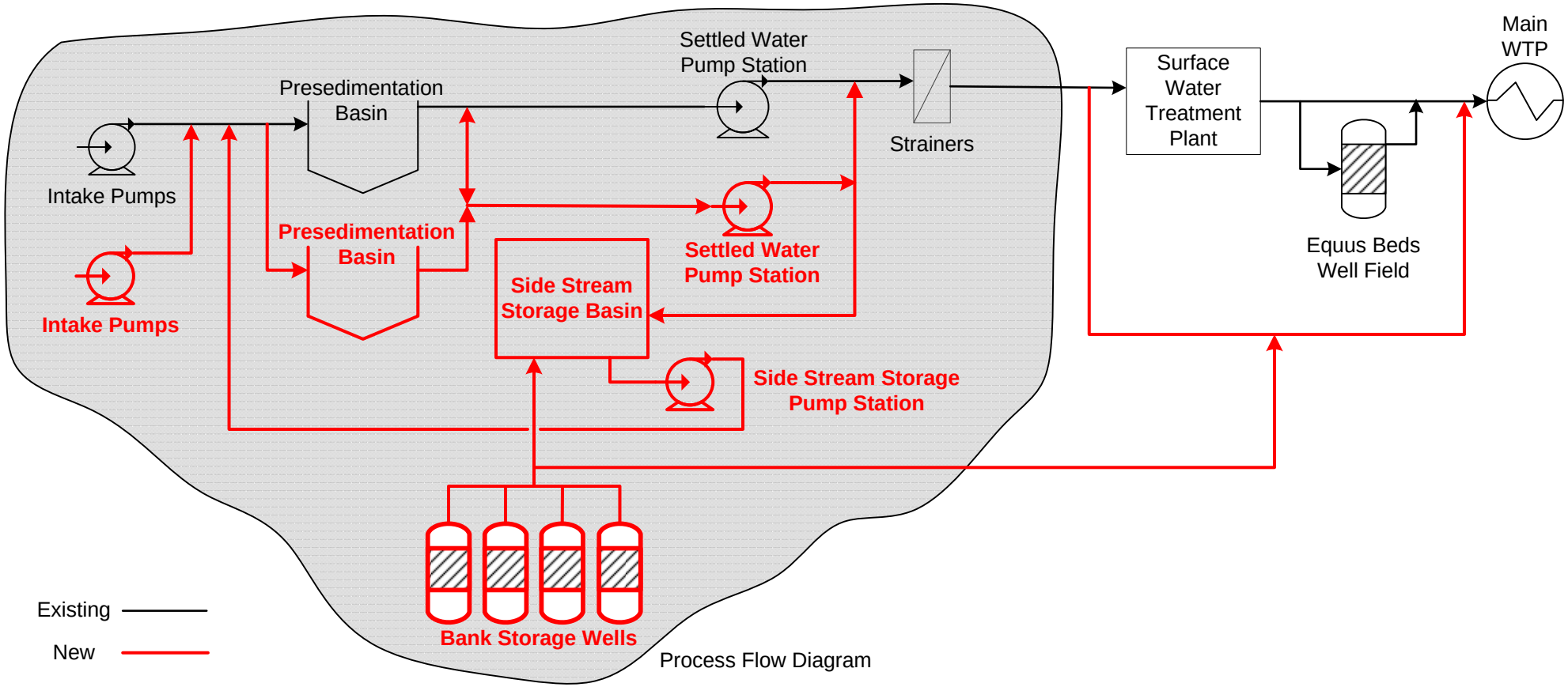
Option No. 1 – Side Stream Storage (SSS) at Intake Site

Option No. 1 positions SSS near the LAR intake site. The process flow diagram for Option No. 1 is illustrated in Figure 4-9. The concept for this option includes the new SWPS with VFDs and additional piping/valves to convey the flow to either the SWTP or SSSB. SSSB water will be pumped back to the head of a presedimentation basin after an event is over, the intake pumps are off, and the existing SWPS is pumping water to the SWTP. Potential operating schemes for Option No. 1 are exclusive to one another and are listed below:

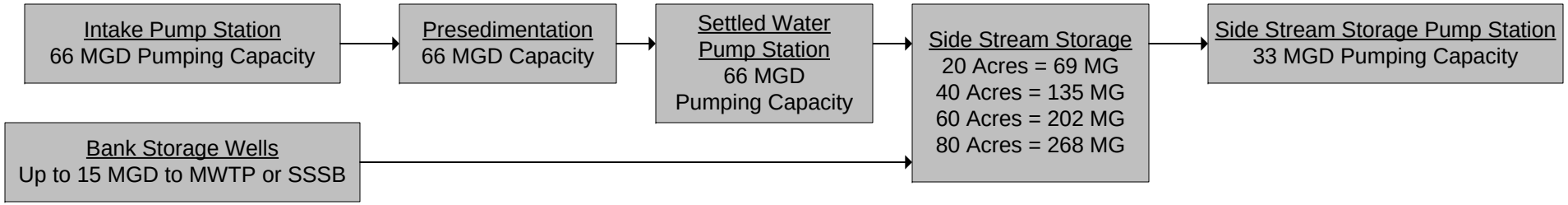
- Generally described as filling SSS; pump up to 66 MGD from new and/or existing SWPSs to SSS;

- Generally described as filling SSS and pumping to SWTP in parallel; pump up to 33 MGD from new SWPS to SSS utilizing the new presedimentation basin and pump 16.5 or 33 MGD from existing SWPS to SWTP concurrently utilizing the existing presedimentation basin; and

- Generally described as draining SSS and pumping to SWTP in series; pump 16.5 or 33 MGD from SSS Pump Station to a presedimentation basin and pump 16.5 or 33 MGD from the new and/or existing SWPS to SWTP.



Capacity Summary (total for each component)



Notes:
1. Acreage listed for Side Stream Storage Capacity is based on the bottom area of the basin.

NOT TO SCALE

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Figure 4-9

City of Wichita, Kansas Enhanced ASR

Option No. 1: Side Stream Storage @ Intake Site

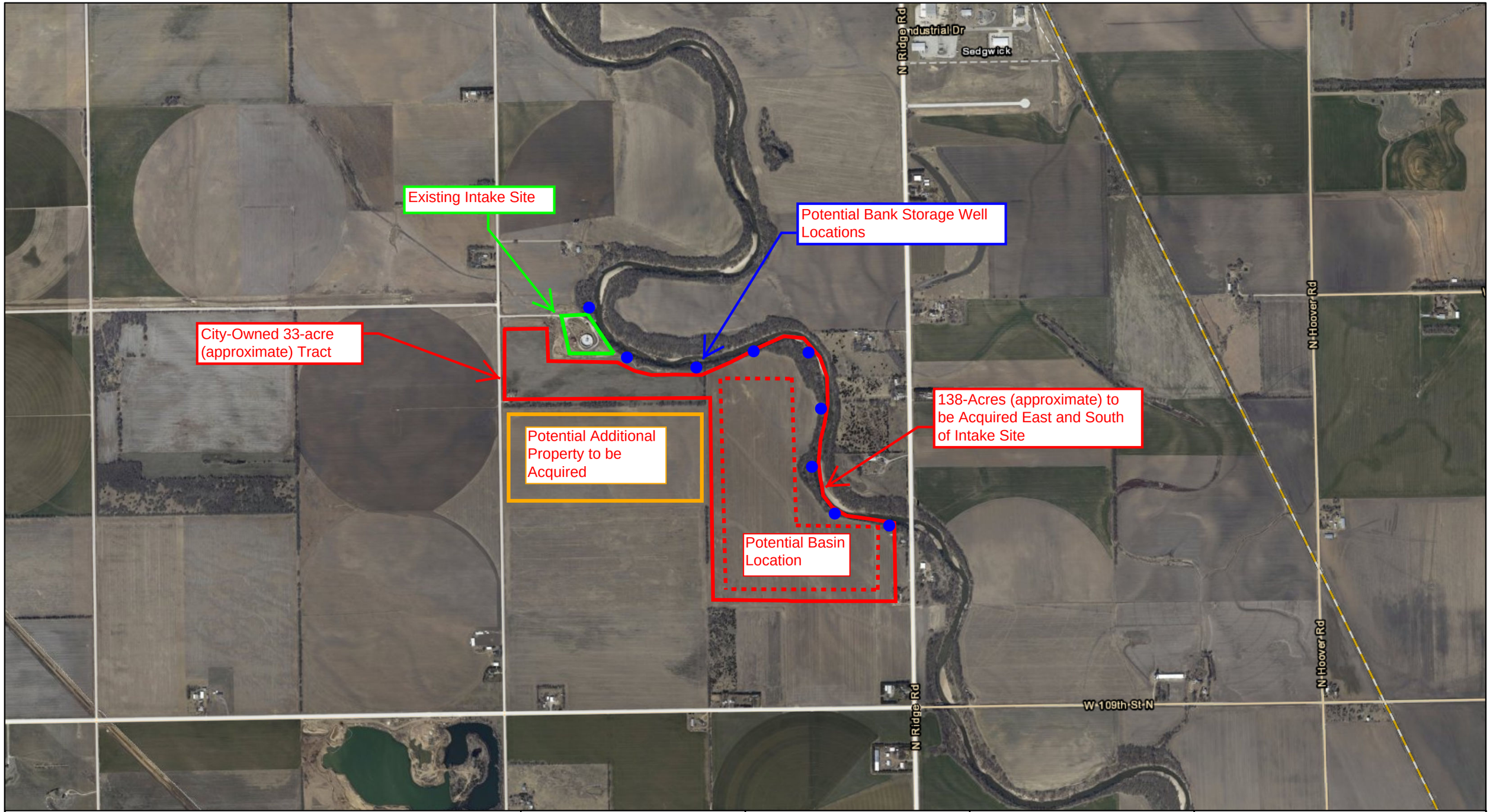

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Figure 4-10

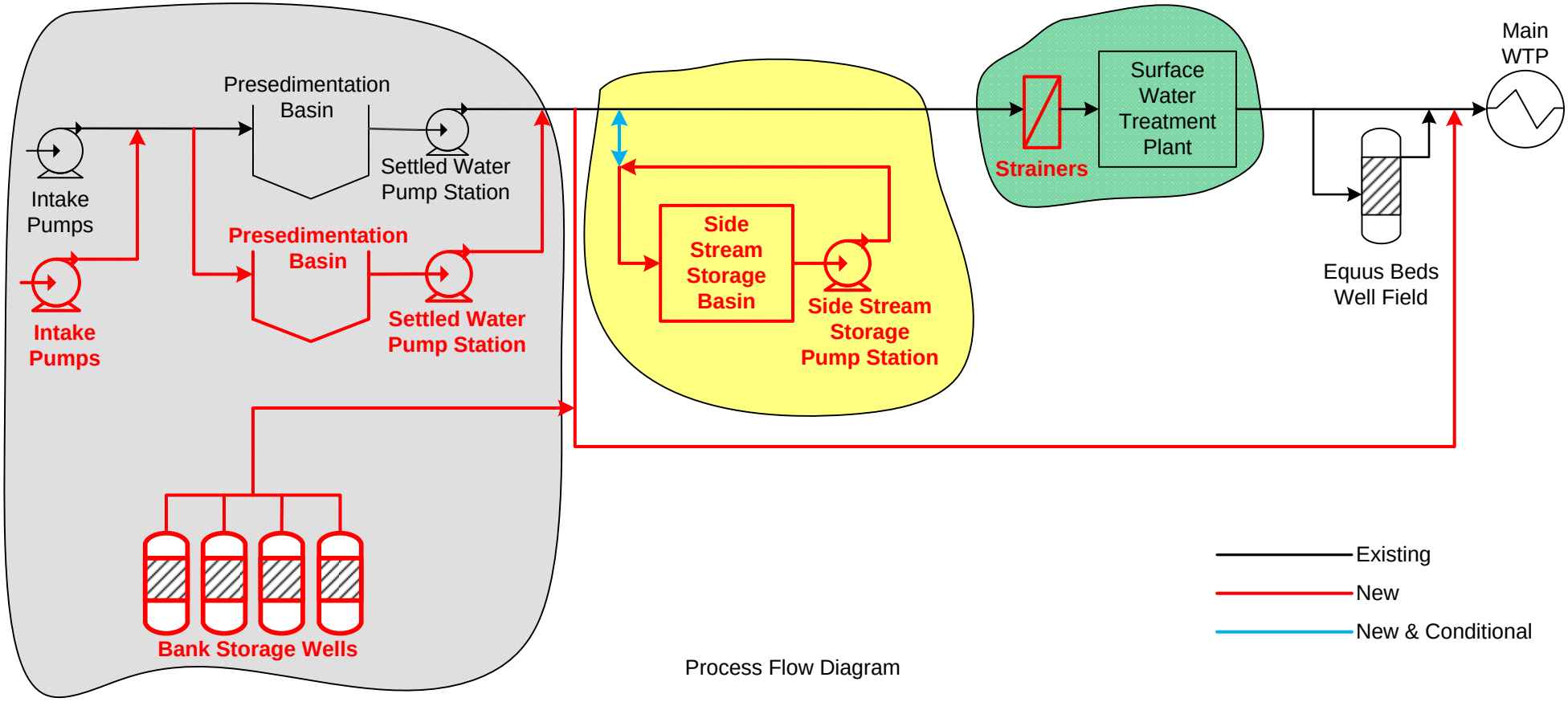
City of Wichita, Kansas Enhanced ASR

Option No. 1: Side Stream Storage @ Intake Facility

Option No. 2 – Side Stream Storage at North Property

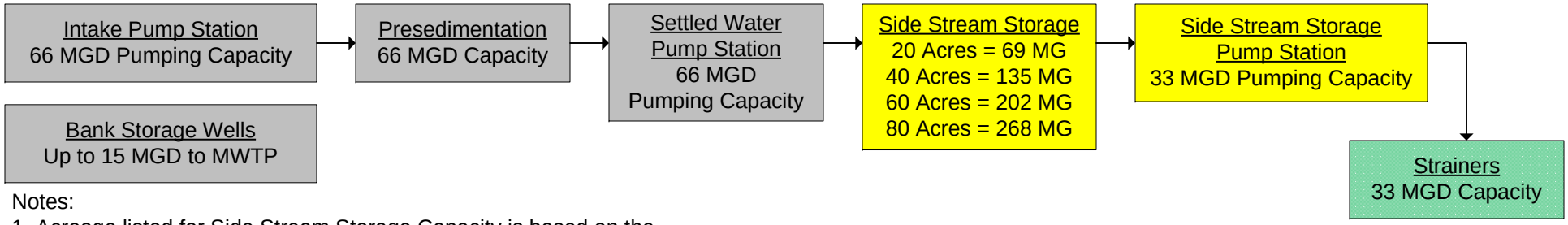
Option No. 2 positions SSS at the existing City-owned property north of the SWTP near the intersection of North 119th Street West and Southwest 125th Street. The process flow diagram for Option No. 2 is illustrated in Figure 4-11. This option requires a new presedimentation basin and new SWPS, relocation of the basket strainers from the Intake Facility to the SWTP, approximately 1 mile of 54-inch transmission from the existing 54-inch at Well 34 (Flow Control Structure) to the SSSB, and a 33 MGD SSS Pump Station. Operationally, after the SSSB has reached a capacity, the pump station conveys SSS through the same 54-inch transmission line supplying the SSSB; the pumping capacities would match the SWTP capacities of 16.5 MGD and 33 MGD. The transmission hydraulics from the SSS pump station to the SWTP are illustrated in Figure 4-11 and described below:

- Pump 16.5 MGD from SSS Pump Station to SWTP; and
- Pump 33 MGD from SSS Pump Station to SWTP.



Process Flow Diagram

Capacity Summary (total for each component)



Notes:
1. Acreage listed for Side Stream Storage Capacity is based on the bottom area of the basin.
2. "New & Conditional" = flow direction is conditional; water is either pumped to Side Stream Storage (via SWPS) or it is pumped to the SWTP (via SSS pump station

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Figure 4-11

City of Wichita, Kansas Enhanced ASR

Option No. 2: Side Stream Storage @ North Property

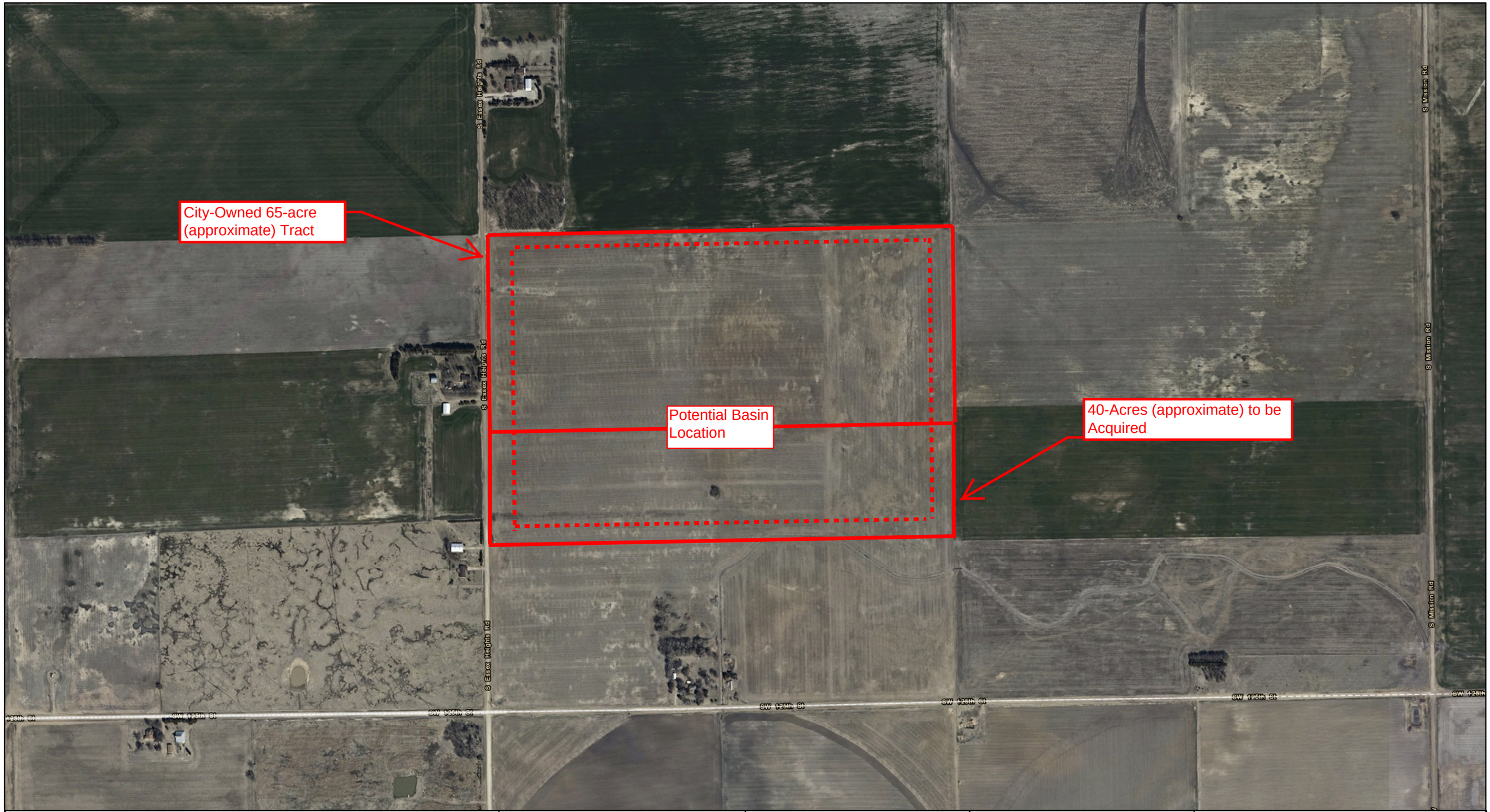

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Figure 4-12

City of Wichita, Kansas Enhanced ASR

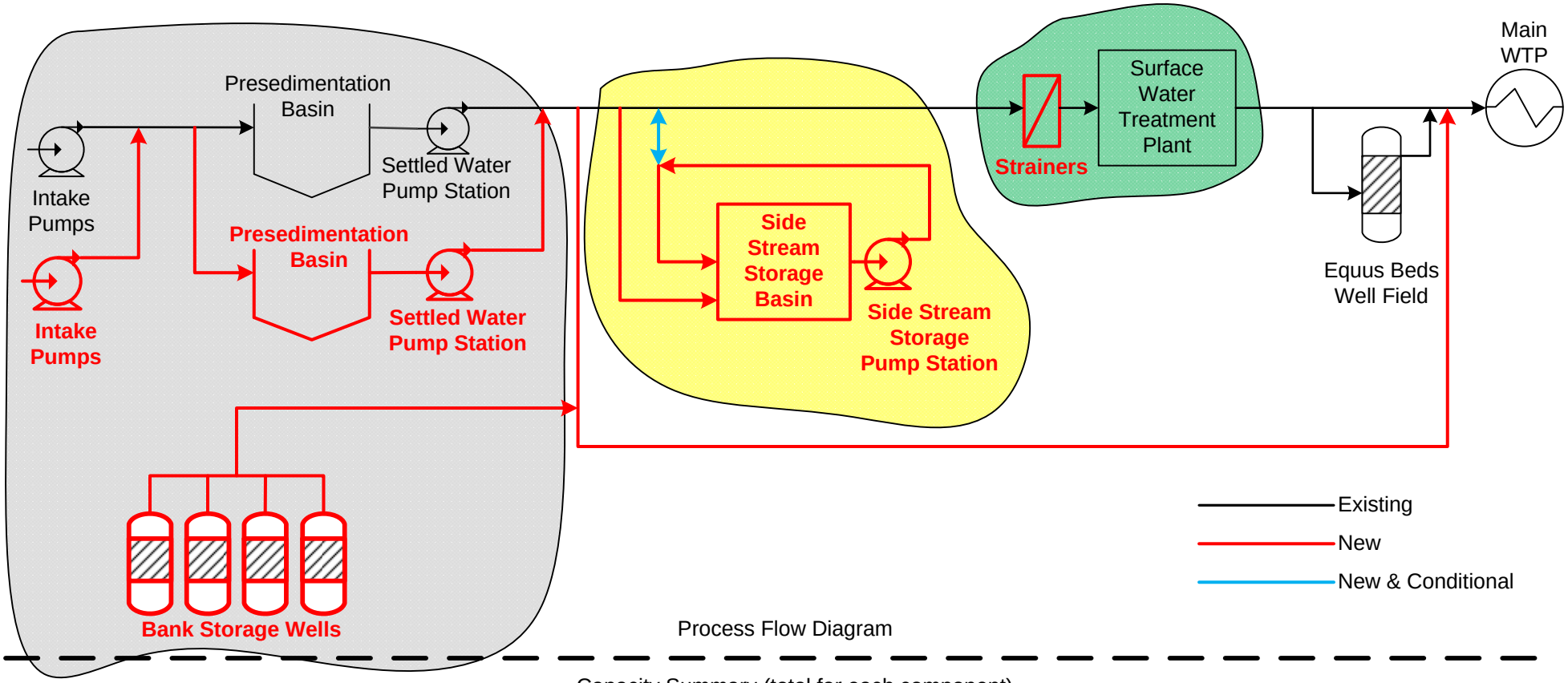
Option No. 2 & 3: Side Stream Storage @ North Property

Option No. 3 – Side Stream Storage at North Property w/Dual Transmission

The process flow diagram for Option No. 3 is illustrated in Figure 4-13. SSS is evaluated at the same location as Option No. 2; the difference between these options is Option No. 3 includes parallel 42-inch transmission mains branching from the existing 54-inch transmission at Well 34 to the SSSB as opposed to a single 54-inch transmission main characterized by Option No. 2. The SSS pump station capacities described in Option No. 2 are in effect for Option No. 3. The parallel transmission mains, referred to as Lines A and B, enhance the operational capability of SSS by enabling concurrent supply to the SSSB via Line A and SSS pumping to the SWTP via Line B. The transmission hydraulics for concurrent SSS supply and pumping operations via dual transmission are described below.

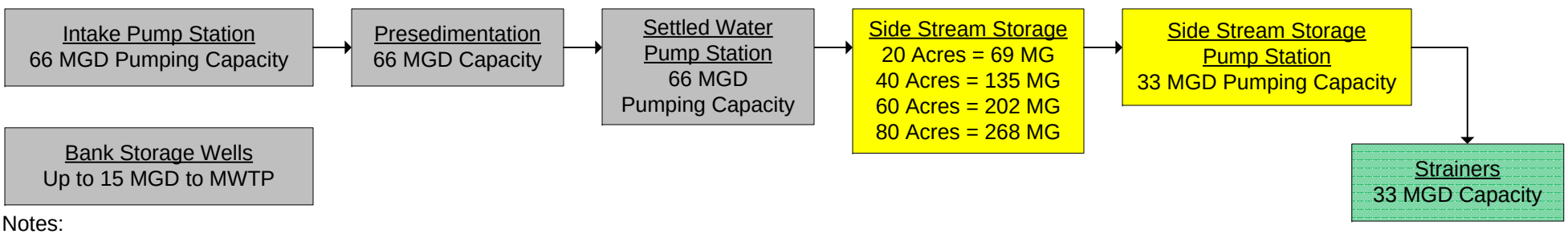
- Pump 33 MGD from SWPS to SSS and pump 16.5 MGD from SSS Pump Station to SWTP; and
- Pump 49.5 MGD from SWPS to SSS and pump 33 MGD from SSS Pump Station to SWTP

For clarity, the hydraulics described in the bulleted list above, depict the same operating condition, just at varying flowrates. The dual transmission associated with Option No. 3 can also be used in a similar fashion to Option No. 2, wherein up to 66 MGD is conveyed directly to the SSS; in this mode of operation, the SSS Pump Station is off.



Process Flow Diagram

Capacity Summary (total for each component)



Notes:
1. Acreage listed for Side Stream Storage Capacity is based on the bottom area of the basin.
2. "New & Conditional" = flow direction is conditional; water is either pumped to Side Stream Storage (via SWPS) or it is pumped to the SWTP (via SSS pump station

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Figure 4-13

City of Wichita, Kansas Enhanced ASR

Option No. 3: Side Stream Storage @ North Property With Dual Transmission

CHAPTER 5 - RAW WATER INTAKE FACILITIES

This section of the report discusses the design capacity of the existing raw water intake facilities, expansion capacity, and recommended improvements associated with implementing SSS.

While Phase II of the river intake facility was constructed to deliver 33 MGD to the SWTP, the majority of the facility was designed and constructed to accommodate expansion to 66 MGD for Phase III. To increase the river intake facility capacity to 66 MGD, the following improvements are recommended:

- Installation of four raw water pumps, check valves, and flow meters in the remaining four bays of the intake structure and associated electrical, controls and instrumentation;
- Construction of a second 33MGD presedimentation basin; and
- Potential construction of a new SWPS, without basket strainers, depending on the selected option.

RAW WATER PUMPS

The existing intake structure contains the bays needed for four additional pumps. After the intake pumps, new check valves and flow meters will need to be installed, similar to the existing five trains. The header after the pumps was constructed with a blind flange so that future pumps can easily be connected to the same header. The existing river intake structure and the accommodations for future expansion can be seen below in Figure 5-1. These accommodations will be needed for any of the options listed above, regardless of the location of the side stream storage basin.

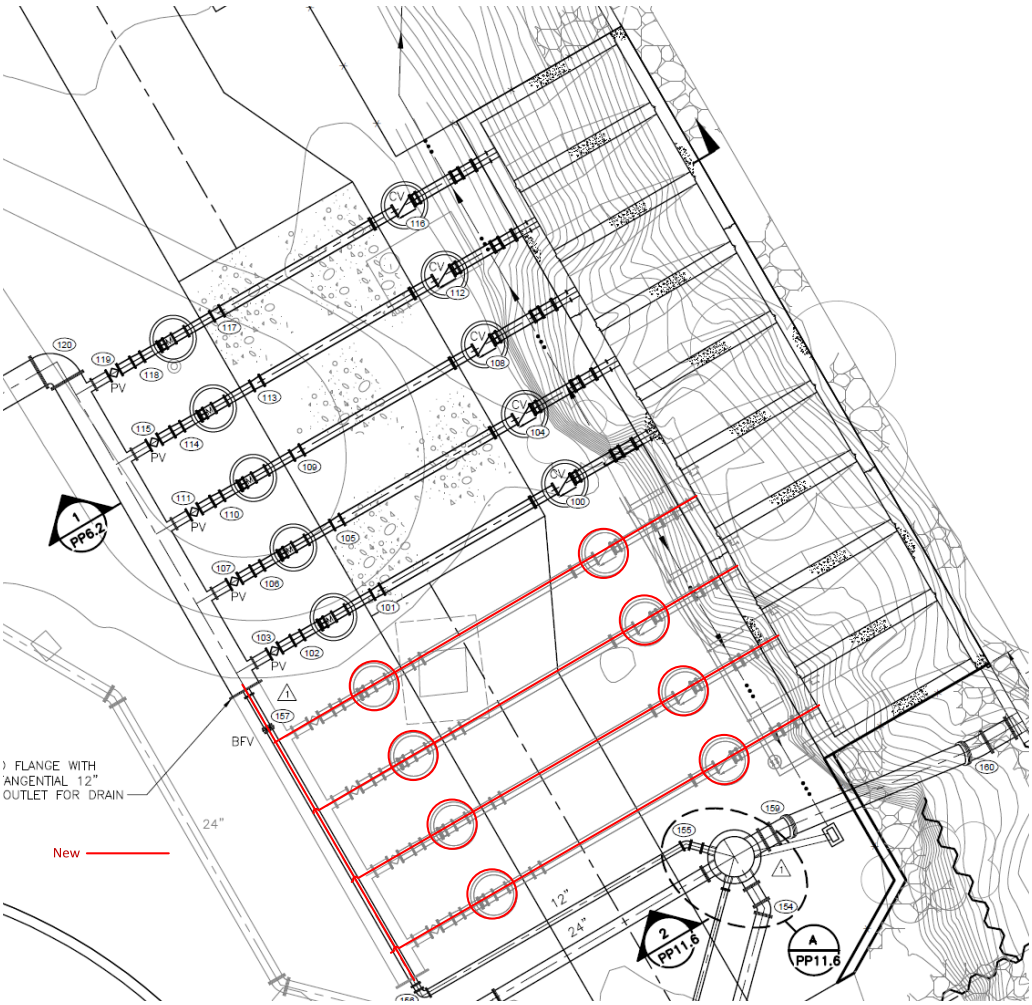


Figure 5-1 Intake Structure

PRESEDIMENTATION BASIN

A new presedimentation basin will be required to aid in the removal of settleable solids for the additional diversion. The intake site was graded so that a new basin can be constructed directly north of the existing basin. Additionally, a splitter structure was installed during Phase II so that raw water can be evenly split between the two basins. The new installation will require piping to be routed from the existing splitter structure to the new presedimentation basin. The site layout and proposed location of the new presedimentation basin can be seen below in Figure 5-2. A new presedimentation basin is recommended for all of the options listed above, regardless of the location of the side stream storage basin. A new presedimentation basin will facilitate the return of the readily settleable solids to the river under the flow conditions similar to those currently experienced.

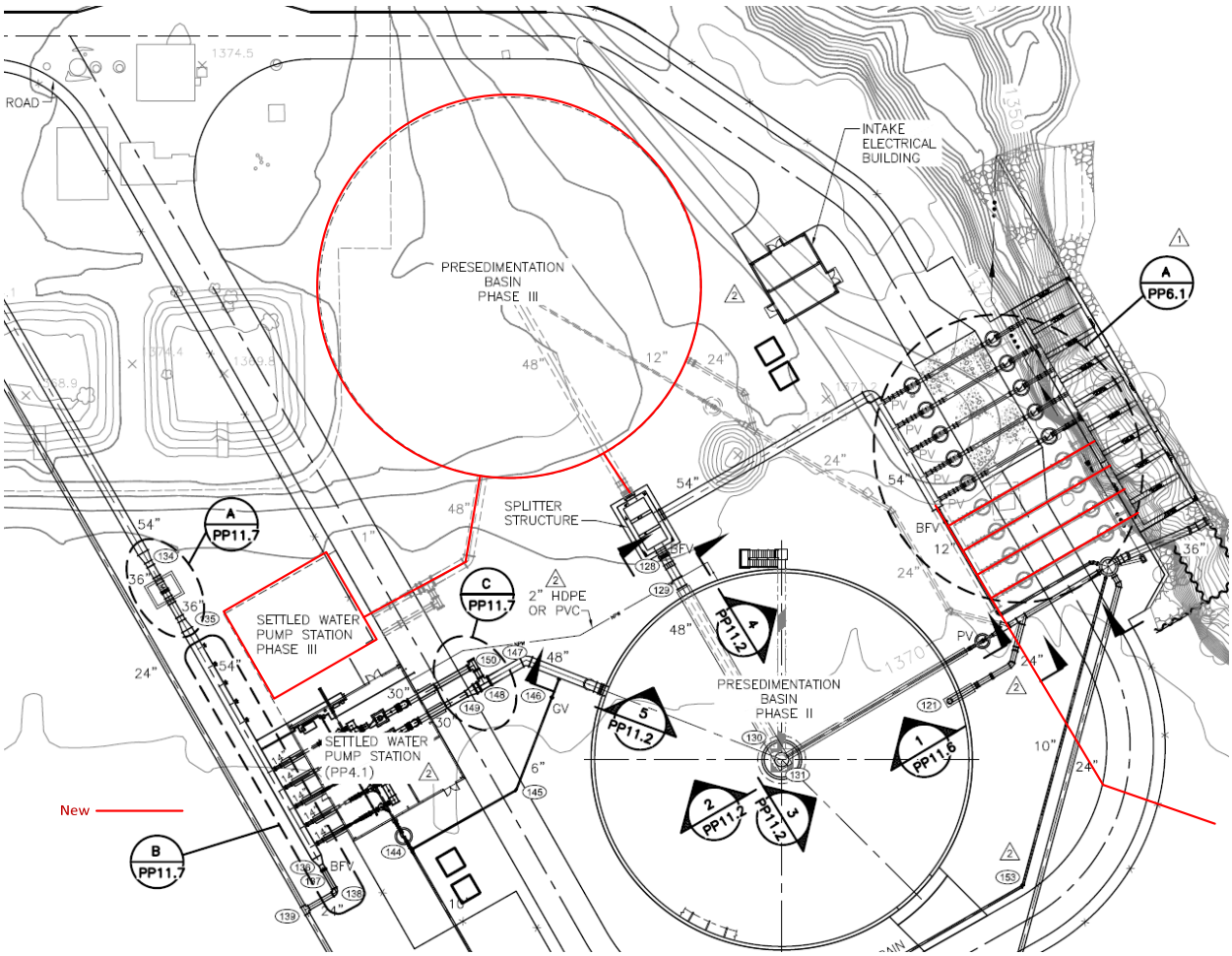


Figure 5-2 Intake Site Layout

NEW SETTLED WATER PUMP STATION

A new SWPS will need to be constructed at the intake facility for all options except Option 1. This is required to pump 66 MGD of water to the SWTP and the side stream storage basin. As shown in Figure 5-2, space is allocated at the existing SWPS for the previously-planned location of the Phase III SWPS. It can be seen in the figure that the original plan was to construct another SWPS directly north of the existing building, and connect piping to the existing header which includes capped connections for future piping.

BASKET STRAINER LOCATION

The location shown in Figure 5-2 is still acceptable for the new SWPS; however, one potential change that should be considered is the location of basket strainers. The basket strainers in the existing SWPS are provided to protect the membranes from debris and therefore need to be located upstream of the membranes but downstream of the closest source of water. For Option 1, no changes would be necessary

to the existing basket strainers. Options 2 and 3 would require a new SWPS but, with the SSSB located at the north property, 33 MGD of basket strainers will be required downstream of the SSSB. Therefore, for Options 2 and 3, it is recommended to relocate the existing basket strainers to the SWTP site.

Costs opinions for this relocation, as shown in Table 4-1, are based on the new strainer area being a precast concrete building similar to the existing SWPS. This opinion also assumes that the existing strainers will be used with their existing control panel, backwash pumps, and instrumentation.

OPINIONS OF PROBABLE COST

Opinions of probable cost are based on construction and other cost allowances including contingency, engineering, surveying, legal, and other related costs. Intake Facility improvement-related costs are summarized in Table 5-1. Unit cost data and component cost information for the proposed improvements are based on historical projects and vendor's cost information and are based on an Engineering News Record Construction Cost Index (ENR-CCI) of 10902.72 for Kansas City, Missouri for June 2014.

Project costs include construction costs, contingencies, and other costs. The total includes contingency, engineering and other costs, which vary by project. Contingency covers items that are not anticipated, changes in conditions, or other factors that may increase the cost.

Other costs account for technical, professional and special services that are required to execute the project. These include environmental, technical, and geotechnical studies, land and right-of-way appraisals and negotiations, design and resident engineering fees, construction material testing, legal fees, project insurance, land surveying and legal descriptions, project design surveying, operation and maintenance manuals, and personnel training. Land and right-of-way costs are included in the cost opinions based on factors provided by the City of Wichita.

These order-of-magnitude cost opinions are based on experience and judgment as a professional consultant combined with information from past experience, vendors, and published sources, such as Means. Burns & McDonnell does not guarantee that the actual rates, costs, etc. will not vary from the opinions and projections developed herein. This statement applies to all sections of this report hereinafter.

To provide opinions of probable cost for the aforementioned enhancements, costs from the ABC Partners Schedule of Values for the Phase II A1 contract were used. The original scheduled values were rescheduled based on the amount of work in the new enhancements. For example, since five raw water pumps were installed in Phase II but only four additional pumps were needed, the rescheduled value

would be 4/5 of the Phase II cost. In addition, a construction cost escalation multiplier was placed on all values to account for the increase in costs between 2010 when Phase II began, and present time. This construction cost multiplier is the ratio of ENR Construction Cost Indices from the two time periods. These opinions will be detailed in the Appendices but a summary is shown below in Table 5-1.

Table 5-1 Intake Facility Opinions of Probable Cost

		Option 1	Option 2	Option 3
New Intake Pumps		$2,000,000	$2,000,000	$2,000,000
New Presed Basin		$2,600,000	$2,600,000	$2,600,000
New SWPS		$1,400,000	$1,400,000	$1,400,000
Basket Strainer Relocation		$0	$900,000	$900,000
Project Cost Subtotal		*$6,000,000*	*$6,900,000*	*$6,900,000*
Contingency	**30%**	$1,800,000	$2,100,000	$2,100,000
Construction Cost Subtotal		*$7,800,000*	*$9,000,000*	*$9,000,000*
Permitting	**1%**	$80,000	$90,000	$90,000
PE	**10%**	$780,000	$900,000	$900,000
CE	**3%**	$230,000	$270,000	$270,000
Owner's Admin	**8%**	$620,000	$720,000	$720,000
Non-Construction Subtotal	***22%***	*$1,710,000*	*$1,980,000*	*$1,980,000*
TOTAL CAPITAL COST		**$9,510,000**	**$10,980,000**	**$10,980,000**

CHAPTER 6 - BANK STORAGE DIVERSION WELLS

A bank storage diversion well is a well drilled adjacent to a river or stream that captures water from the stream during above base flow events. If there is a hydraulic connection between the river and the adjacent aquifer, during recharge conditions water can be pumped from the aquifer and recharged by water from the river. Thus, there is no impact on the aquifer caused by the bank storage well. Bank storage conditions occur when a river or stream is flowing above the base flow conditions, and water from the river is temporarily pushed into the aquifer. The ASR Phase I facilities contains three Bank Storage Diversion wells. Each of those wells is capable of pumping 700 gpm, and during above base flow events in the Little Arkansas River they can produce 3 MGD that is used to recharge the aquifer.

A study completed in 2011 examined the potential to place additional bank storage wells along the Little Arkansas River on City property downstream of the Phase II river intake near 117th St. N. and Tyler Rd. One of the advantages of using bank storage diversion wells is that the water quality obtained from the wells is better than the water obtained directly from the river. The water in the Little Arkansas River contains a large amount of sediment and some chemical constituents, such as atrazine, that must be removed prior to recharging the water. The water obtained from bank storage diversion wells generally does not have those constituents because the clays and sands in the river bank remove them before they reach the diversion well. However, arsenic can be present in the aquifer, so caution is required in siting bank storage diversion wells to avoid high arsenic locations. If the arsenic exceeds the drinking water standards, additional treatment may be required.

The study completed in 2011 reviewed potential bank storage sites on the property the City currently owns at the river intake site, which contains approximately 1,500 feet of river bank. The study included construction of a full scale test well which was capable of pumping 900 gpm. During the study, the well was pumped during a high flow event in the River and the testing was able to validate that the well functioned as a bank storage well, and that the water quality met all drinking water standards. The study evaluated the use of vertical wells, slant wells and horizontal collector wells at the site, and found that any of the construction techniques would work. The study also showed that vertical wells had a lower cost per million gallons produced, even though horizontal wells could produce more volume. The study projected that three vertical wells, each with the capability of producing up to 2 MGD, could be constructed at the site, with a total construction cost of approximately $5.6 million. This total construction cost included a new pipeline to carry bank storage water to either the Phase II water treatment plant or the EBWF pipeline system.

There have been recent discussions with property owners adjacent to the City's property at the intake site, and the potential exists that the City could obtain access to more land adjacent to the River and be able to install additional bank storage wells. It the City was able to obtain access to additional sites along the river bank, and was able to install a total of nine bank storage wells along the river, these wells have been estimated to have the capability of capturing up to 15 MGD of bank storage water at a cost of approximately $11.7 million. This cost includes the cost of the wells, a well field collection pipeline, and two miles of 30 inch diameter transmission pipeline to transport the water to either the SWTP or to the EBWF cross-tie line at 109th Street.

Bank storage wells are also able to operate at times when the surface water intake is not available. The intake structure is not capable of effectively capturing flows in the river below 65 cfs even though the regulatory limit for capturing water is at flows higher than 30 cfs. Bank storage wells would be able to capture water in the river at flows between 65 and 30 cfs.

There are a number of alternatives available to the City to use the water obtained from bank storage wells, including pumping it directly to the MWTP as a replacement for EBWF water, using it as an additional source of water for the ASR project, and pumping to the SSSB to extend recharge opportunities during low end above base flow events. The use of bank storage water for conveyance to the MWTP is evaluated in this report. The impact of using bank storage well water in the SSSB or recharging it is not evaluated at this time as sending the water to the MWTP and saving EBWF water is the most economical operating scheme.

In 2008 the City signed a Memorandum of Understanding (MOU) with GMD2 related to the ASR project. At that time GMD2 had concerns about the use of bank storage wells. In response to those concerns, in the MOU the City committed to develop at least 67 MGD of surface water diversion facilities for recharge based on an ultimate 100 MGD ASR system. Since that time the City has successfully operated the bank storage wells in Phase I, as well as bank storage wells at the Bentley Well field, therefore there is significant evidence that the bank storage concept can be properly implemented. The development of the Side Stream Storage Facility could be viewed as meeting the commitments established in the MOU.

It can be seen from Table 4-3 in Chapter 4 that these bank storage wells will have the capability to provide approximately 3,700 MG/yr of water in addition to the water obtained through SSS. Opinions of probable cost for the bank storage wells and the SWTP bypass piping are shown below in Table 6-1.

Table 6-1 Bank Storage Wells and SWTP Bypass Piping

Bank Storage Wells		$2,900,000
Distribution Piping		$400,000
Power/Electrical		$700,000
SWTP Bypass Piping		$3,400,000
Project Cost Subtotal		*$7,400,000*
Contingency	**30%**	$2,220,000
Construction Cost Subtotal		*$9,620,000*
Permitting	**1%**	$100,000
PE	**10%**	$960,000
CE	**3%**	$290,000
Owner's Admin	**8%**	$770,000
Non-Construction Subtotal	**22%**	*$2,120,000*
TOTAL CAPITAL COST		**$11,740,000**

CHAPTER 7 - SIDE STREAM STORAGE FACILITIES

This section of the report discusses the feasibility for SSS with respect to site layout for the enhanced ASR options presented in Chapter 4, SSSB volume, and transmission. A brief summary of these options is listed below:

- Option No. 1 – SSS at the intake site;
- Option No. 2 – SSS at the City-owned property north of the SWTP site (near the intersection of North 119th Street West and Southwest 125th Street); and
- Option No. 3 – same location as Option No. 2 but with dual transmission to SSS.

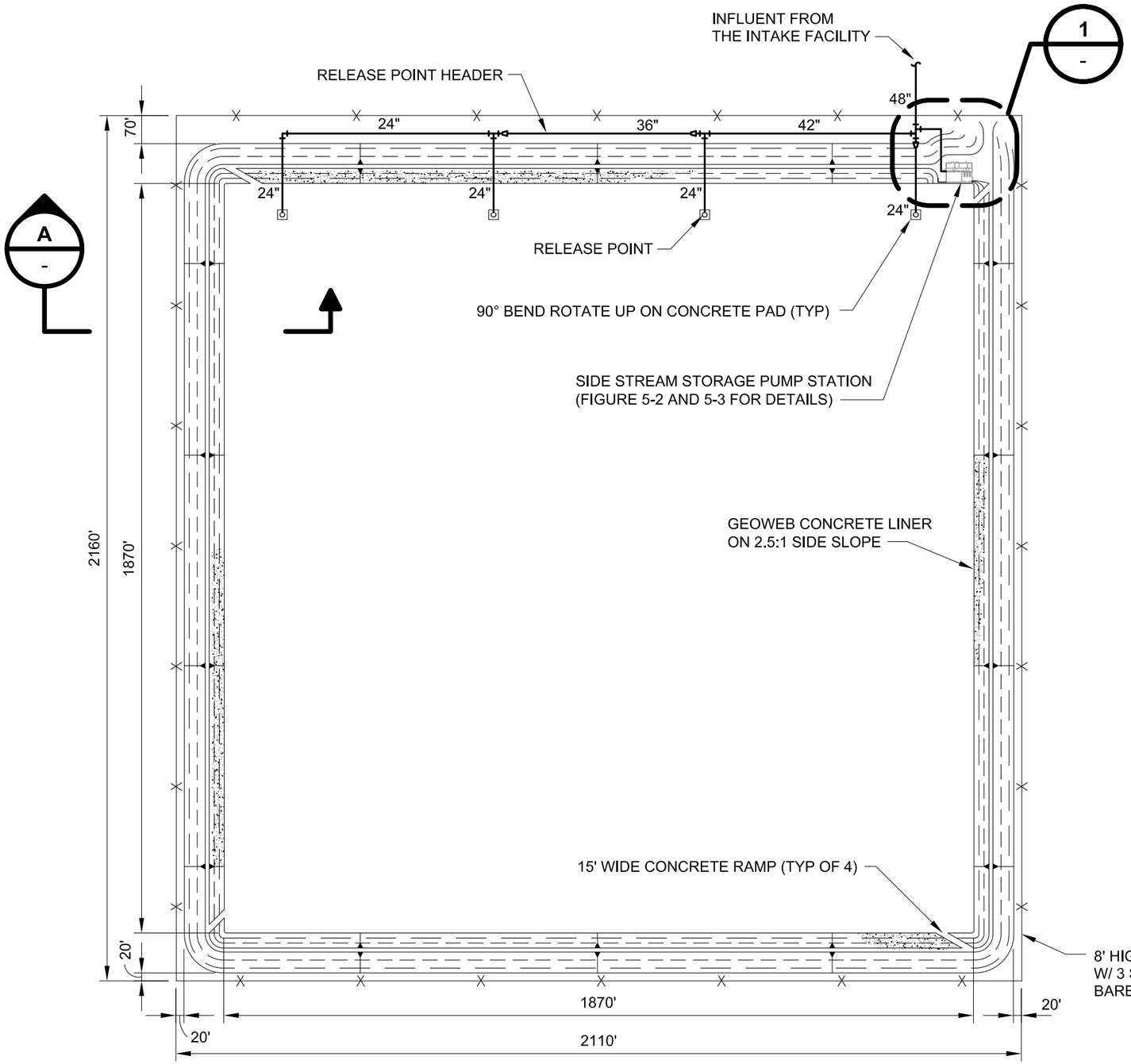
SITE LAYOUT

Generally speaking, the facility components for SSS include the SSSB, discharge piping network within the basin, 33 MGD SSS pump station, site/civil work, and power. These facility components are illustrated in Figure 7-1; it is important to note that this figure is conceptual and the actual SSSB shape is location specific. SSSB volumes are characterized by the bottom area of the basin at 20 acres, 40 acres, 60 acres, and 80 acres.

SSSB design parameters consist of a berm approximately 13 feet above existing grade for a total basin depth of 15 feet. The total depth includes 2 feet of freeboard and 2 feet of excavation below existing grade within the interior of the SSSB. The berm has interior side slopes of 2.5H:1V lined with a concrete filled geoweb placed on top of a geotextile fabric to mitigate erosion. Exterior side slopes are assumed to be 4H:1V and seeded. A conservative shrinkage factor of 20 percent was used for cut and fill volumes based on the site having soil characteristics consistent with the surrounding area. Site work assumes all spoils are used on site. The active storage volume and fill/drain duration based on a working depth of 10 feet, the design parameters stated above, and a 33 MGD transfer rate are listed in Table 7-1 below.

Table 7-1 Active Storage Volumes and Fill/Drain Durations at 33 MGD

SSSB Bottom Area (acres)	Active Storage Volume (MG)	Fill/Drain Time (days)
20	69	2.1
40	135	4.1
60	202	6.1
80	268	8.1



SIDE STREAM STORAGE BASIN - SITE PLAN

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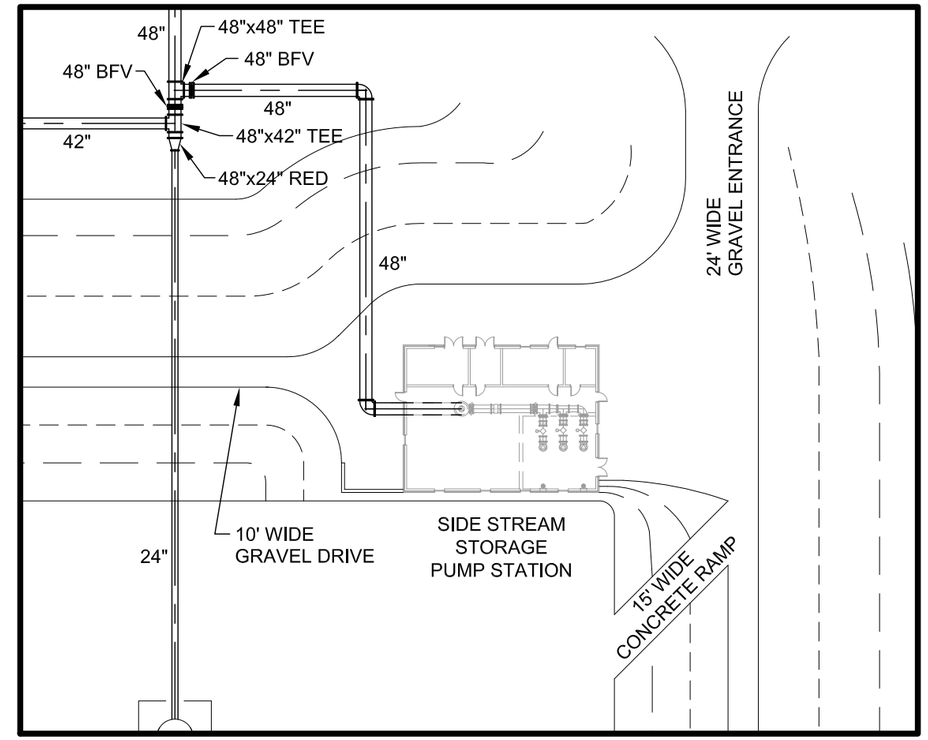

DETAIL 1 -

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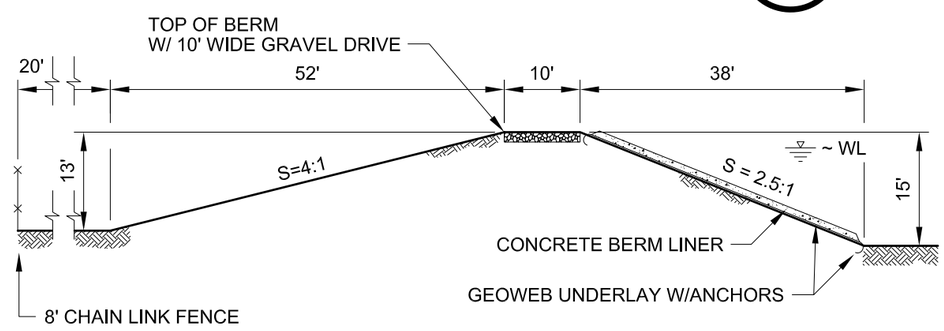

SECTION A -

NOT TO SCALE

Figure 7-1
CITY OF WICHITA, KANSAS
ENHANCED ASR
SIDE STREAM STORAGE
BASIN LAYOUT

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Discharge piping within the SSSB could consist of four release points sized for hydraulic similitude and to minimize pipe velocity. Piping to each release point is 24-inches in diameter and sized for 8.25 MGD each and the release point header may vary from 24 to 42-inches in diameter. For clarity, the discharge piping will be unique to the location; but for the purposes of cost estimating, the piping as shown in Figure 7-1 is applied to all options.

A 33 MGD pump station is proposed at the SSSB with the associated building, piping, and pumping equipment included in the cost opinion. A masonry block building with brick exterior is approximately 3,100 square feet in size and includes an electrical room, mechanical room, restroom, office space, and adequate clearance for piping and bridge crane. Three submersible pumps are sized for 11 MGD each assuming firm capacity is not required. Power supply for the pump station is assumed to be inadequate or non-existent at the site; therefore, approximately 2 miles of electrical construction to supply the pump station with power is included in the cost opinion.

The opinion of probable cost for the SSS facility components discussed in this section at varying storage volumes is listed Table 7-2 below:

Table 7-2 Side Stream Storage Facility Opinion of Probable Cost

		80 Acre	60 Acre	40 Acre	20 Acre
Storage Basin & Site Work		$7,300,000	$5,800,000	$4,300,000	$2,600,000
33 MGD Pump Station		$2,500,000	$2,500,000	$2,500,000	$2,500,000
Discharge Piping Network		$800,000	$800,000	$800,000	$800,000
Power Supply		$200,000	$200,000	$200,000	$200,000
Project Cost Subtotal		$10,800,000	$9,300,000	$7,800,000	$6,100,000
Contingency	**30%**	$3,200,000	$2,800,000	$2,300,000	$1,800,000
Construction Cost Subtotal		$14,000,000	$12,100,000	$10,100,000	$7,900,000
Permitting	**1%**	$140,000	$120,000	$100,000	$80,000
PE	**10%**	$1,400,000	$1,210,000	$1,010,000	$790,000
CE	**3%**	$420,000	$360,000	$300,000	$240,000
Owner's Admin	**8%**	$1,100,000	$1,000,000	$800,000	$600,000
Non-Construction Subtotal	**22%**	$3,060,000	$2,690,000	$2,210,000	$1,710,000
TOTAL CAPITAL COST		$17,060,000	$14,790,000	$12,310,000	$9,610,000

Option No. 1 – Side Stream Storage at Intake Site

The site layout for SSS with Option No. 1 includes acquiring approximately 138 acres of property immediately southwest of the intake pump station. The City currently owns approximately 33 acres immediately south of the intake site and could also be used for SSS. Utilizing both sites enables the City to either buildout the City-owned property and purchase additional property as needed to meet the desired SSSB volume as illustrated in Figure 4-10 or locate the entire SSSB volume within the 134-acre acquisition property. Transfer piping length is assumed to be approximately 2,000 ft of 54-inch diameter pipe. The cost opinion for the transfer pipe and land acquisition is listed below in Table 7-3.

Table 7-3 Option No. 1 Transmission & Land Acquisition Opinions of Probable Cost

54-inch Transfer Pipe		$1,080,000
Land Acquisition of 138-Acre Tract		$480,000
Project Cost Subtotal		*$1,560,000*
Contingency	**30%**	$470,000
Construction Cost Subtotal		*$2,030,000*
Permitting	**1%**	$20,000
PE	**10%**	$200,000
CE	**3%**	$60,000
Owner's Admin	**8%**	$160,000
Non-Construction Subtotal	**22%**	*$440,000*
TOTAL CAPITAL COST		**$2,470,000**

Option No. 2 – Side Stream Storage at North Property

The existing City-owned site, referred to as the North Property, only includes approximately 65 acres. An 80-acre bottom area SSSB requires a total of 105 acres; therefore, the City will need to acquire an additional 40 acres to accommodate a SSSB of this volume as shown in Figure 4-12. This option also requires approximately 5,700 linear feet of 54-inch transmission. The cost opinion for transmission and land acquisition associated with Option No. 2 is listed below in Table 7-4.

Table 7-4 Option No. 2 Transmission & Land Acquisition Opinions of Probable Cost

54-inch Transmission		$3,100,000
Additional 40 Acres Required		$140,000
Project Cost Subtotal		*$3,240,000*
Contingency	**30%**	$970,000
Construction Cost Subtotal		*$4,210,000*
Permitting	**1%**	$40,000
PE	**10%**	$420,000
CE	**3%**	$130,000
Owner's Admin	**8%**	$340,000
Non-Construction Subtotal	**22%**	*$930,000*
TOTAL CAPITAL COST		**$5,140,000**

Option No. 3 – Side Stream Storage at North Property w/Dual Transmission

SSS location is the same for Option No.'s 2 and 3 therefore the land acquisition cost is the same. The primary difference between these is that Option No. 3 includes dual, or parallel, 42-inch transmission mains for enhanced operational flexibility. The cost opinion for transmission and land acquisition associated with Option No. 3 is listed below in Table 7-5.

Table 7-5 Option No. 3 Transmission & Land Acquisition Opinions of Probable Cost

Parallel 48-inch Transmission		$4,800,000
Additional 40 Acres Required		$140,000
Project Cost Subtotal		*$4,940,000*
Contingency	**30%**	$1,500,000
Construction Cost Subtotal		*$6,440,000*
Permitting	**1%**	$60,000
PE	**10%**	$640,000
CE	**3%**	$190,000
Owner's Admin	**8%**	$520,000
Non-Construction Subtotal	**22%**	*$1,410,000*
TOTAL CAPITAL COST		**$7,850,000**

CHAPTER 8 - ASR PHASE II SWTP

This section of the report discusses modifications made to the Phase II SWTP. Primarily, this section will describe the changes associated with relocating basket strainers to the SWTP and discusses required operational changes.

BASKET STRAINER RELOCATION

As previously discussed, it is recommended to relocate the existing basket strainers to the SWTP if Option 2 or 3 is selected. This allows the existing set of strainers to treat water from either the presedimentation basin or from the side stream storage basin. This option helps eliminate the need and associated capital and operational costs for a second set of strainers that are required if the existing strainers are left in-place.

The proposed location is at the SWTP, northeast of Membrane Area A, directly north of the Residuals Return Basin (RRB). This location allows for a tie-in to the existing 42” pipe that feeds the membranes and also allows strainer backwash to be discharged to the RRB (10” line). Opinions of probable cost for this basket strainer relocation are shown in Table 4-1 and a general site layout is shown in Figure 8-1.

OPERATIONAL CHANGES

To accommodate the SSSB and the increase in the volume of water recharged annually, extended run times for the plant will also increase chemical usage, maintenance activities and staffing requirements. Other operational changes regarding water quality and treatment process operation may also be required based on the water quality of the water from the SSSB – these could increase or decrease typical operational costs compared to above base flow event operation.

Operability

A significant challenge exists in that the existing SWTP does not operate on a regular schedule and is dependent on river events. This inconsistent operation causes frequent startups and shutdowns where processes are taken in and out of service, placed in short-term or long-term storage, and not used for an unknown period of time. This is difficult on both equipment and operators.

The SSS basin will help alleviate these challenges in that the plant will run more consistently. The increased storage volume will increase the duration of operation and will potentially eliminate multiple shutdowns/startups. More-consistent operation will decrease the need to “debug” startup issues, shutdown issues, storage requirements, etc. and will allow both the equipment and operators to focus on normal operations and produce more water.

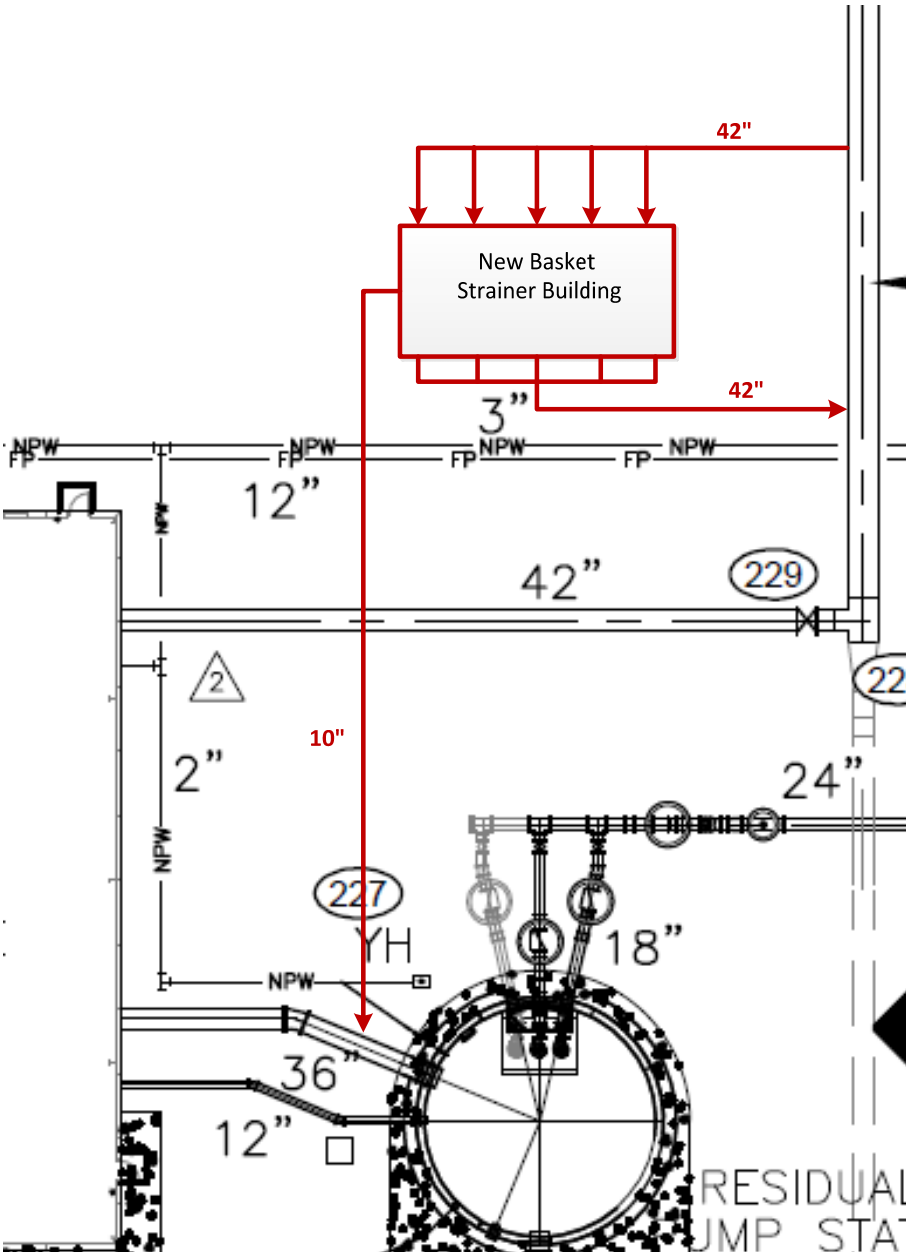

Figure 8-1 New Basket Strainer Location

Staffing

Currently the EBWF maintenance staff consists of eight employees. This staff primarily consists of well field maintenance mechanics, high line electricians, and instrumentation technicians. Historical job descriptions and water supply duties of the EBWF staff include the following: operation of the wells; well maintenance; periodic chlorination of EBWF pipelines for maintenance; pipeline repairs; pump maintenance; groundskeeping; and high line repairs.

This staff has been responsible for operating the Phase I and Phase II ASR facilities, including the Phase II SWTP while also maintaining the well field. These combined duties have led to extended working hours, deferred maintenance on equipment, and deferred regular training for staff. Well field maintenance staff has also been supplemented at times with staff from other areas of the Utility, to provide some temporary assistance during operation of the SWTP; but providing appropriate training has been difficult for the temporary workers, and stresses the other parts of the Utility when their work is deferred. It should be noted that this is an existing issue, not one created by the enhanced ASR option.

During operation of the ASR SWTP, the following staffing is recommended to assure proper and safe operations:

- 2 operators per shift, 2 shifts per day to provide 24 hour operations;
- 1 chemist and/or laboratory analyst; 2 shifts per day
- 1.25 maintenance workers, varying days and shifts;
- 1 operations manager, 1 shift per day;
- 1 process specialist 1 day per week (potential outside contract); and
- 1 half-time clerical (1 FTE shared between well field and SWTP operations).

This staff is required only to operate the Phase II SWTP and does not include staff to maintain/operate the remaining well field facilities (high lines, substation, pipelines, etc.). When the SWTP is not in operation, it is assumed that the staff shown above would be available for maintenance and other activities in either the EBWF or other areas of the Utility, but they would need to be available for staffing the SWTP when operations resume without disrupting those other activities.

If the proposed side stream storage concept is implemented, an increase in staff to operate the SWTP and maintain the well field will be required. The current mode of operation has worked for short river events, but the extended hours and deferred maintenance cannot be continued with longer run times. Therefore, it is recommended that the above staff be added so that operators can operate the plant and other staff can maintain the well field.

Analytical Equipment

The additional staffing mentioned above includes a chemist or laboratory technician. Currently, this analytical work is performed by laboratory staff at the MWTP and samples are taken from the well field back to the MWTP. Analyses is required for bromide and atrazine in the LAR since these are the primary water quality factors that determine treatment protocols, and can also limit plant run times and water availability. The "travel" time to the lab causes delays and does not allow for the SWTP to operate in an optimized manner as the water quality data is always several hours old. With equipment and personnel at the SWTP, treatment adjustments can be made immediately at the SWTP based on the changes to the raw water quality; this allows the operational decisions and adjustments to be implemented much faster increasing the volume of recharge water while decreasing chemical costs. Lastly, decisions will be based on "live" data in lieu of trends.

As shown in Table 3.1, the AOP is capable of treating atrazine concentrations up to approximately 30 µg/L; however, the plant is currently not run when atrazine concentrations are greater than 5µg/L. The reason that atrazine currently limits plant run times is that the atrazine analysis method being used at the SWTP is the Enzyme-Linked Immunosorbent Assay (ELISA) method. That method's maximum detection limit is 5.0 µg/L and therefore, above 5.0 µg/L, the exact concentration is unknown. This uncertainty has led to operating the plant when atrazine levels as detected in the ELISA test are below 5.0 µg/L.

In order to more-accurately measure the atrazine concentration in the raw water, a Gas Chromatograph Mass-Spectrometer (GCMS) method is required instead of the ELISA method. Placing that instrument at the SWTP instead of the Water and Wastewater Laboratory at the MWTP would eliminate transport of samples to the MWTP (approximately 20 miles away) and allow more frequent sampling. There have also been concerns about the potential to operate a GCMS at the Water and Sewer Laboratory because of its proximity to the shop area of the MWTP and gases and odors generated in a shop environment. Depending on the way the instrument is set up, it would probably require a chemist to properly operate the instrument. An opinion of probable cost for a new GCMS system is shown below in Table 8-1.

Table 8-1 GCMS Opinion of Probable Cost

GCMS		$100,000
Miscellaneous Lab Supplies		$15,000
Project Cost Subtotal		*$115,000*
Contingency	**30%**	$35,000
Construction Cost Subtotal		*$150,000*
Permitting	**0%**	$0
PE	**0%**	$0
CE	**0%**	$0
Owner's Admin	**8%**	$12,000
Non-Construction Subtotal	**8%**	*$12,000*
TOTAL CAPITAL COST		**$162,000**

Variable Influent Water Quality

The side stream storage option will extend plant run times and will also provide a water quality buffer between the LAR and the SWTP. As previously discussed, the SWTP is currently limited due to atrazine and bromide concentrations in the LAR. This limitation is based on instantaneous grab samples from the LAR at the intake site. With side stream storage, there will be a large quantity of water that can provide dilution and water quality equalization before the water enters the SWTP. This could potentially result in a more-consistent quality entering the SWTP, but could also result in a different water quality than what has been treated thus far. Therefore, operators will need to be cognizant of changing water qualities entering the SWTP with each river event and how the treatment process will need to be adjusted to accommodate the different water qualities.

Increased Chemical Usage

Since the SWTP will be operated more frequently and at longer intervals, chemical usages will increase with longer plant run times and increased water production quantities. The following chemicals are used at the SWTP:

- Sodium Hypochlorite – membrane cleaning;
- Citric Acid – membrane cleaning;
- Sodium Bisulfite – membrane backwash dechlorination;

- Sodium Hydroxide (Caustic) – membrane neutralization;
- Liquid Oxygen – for ozone generation in the AOP; and
- Hydrogen Peroxide – dosage into AOP.

All of these chemicals will see increased usage with extended plant run times. However, there are no additional chemicals anticipated to accommodate the side stream storage option. The vast majority of costs associated with ASR are fixed; therefore, as recharge quantities increase, the unit cost/gallon of water decreases.

Increased Maintenance

Similar to chemical usages, increased plant run times will also increase maintenance at the SWTP. It is not anticipated that the side stream storage option will create additional maintenance activities, only that the longer run times will cause the current activities to be performed more frequently. These maintenance items include:

- Membrane Replacement;
- Ozone Generator Dielectric Replacement;
- Chilled Water Refill;
- Pump/Blower Lubrication;
- Chemical Metering Pump Calibration;
- Analytical Instrument Calibration; and
- Flow Meter Calibration.

AOC Considerations

Another operational consideration is increased chlorination of the wells due to the influence of Assimilable Organic Carbon (AOC). AOC is the portion of organic carbon that can be used by bacteria as a nutrient source. Total Organic Carbon (TOC) originates in the raw water from the LAR. Some of this TOC is transformed into AOC through the AOP which is then sent to the recharge wells. In the aquifer, AOC provides a food source for bacteria which can be turned into biomass. This biomass builds in the aquifer and has the potential to plug wells, plug the formation and, ultimately, limit the capacity for

recharge to the aquifer through the recharge wells. It should be noted that AOC has been discussed as a concern in the past and will not be increased due to Enhanced ASR, but only due to increased run times.

During the AOP pilot study, it was shown that AOC leaving the AOP can be as high as 3 mg/L when ozone dosages are at 15 mg/L. During AOP optimization testing, it was shown that reducing ozone dosages to 7 to 8 mg/L reduces the AOC concentration to approximately 1 to 2 mg/L.

To lessen the potential effects of AOC fouling in the aquifer, there are several possibilities but only one that is feasible. Removing more of the TOC upstream of the membranes would reduce the amount of AOC formed but would also require a new filtration system such as granular activated carbon or greensand. Similarly, AOC could be removed downstream of the AOP but would require a biological process. A more-feasible option would be to increase the frequency/intensity of shock chlorination in the well field. This chlorination process would potentially break down biomass and prevent it from fouling the aquifer.

To gain a better understanding of the effects of AOC fouling, additional field data will need to be collected. Additional field data should include AOC in the AOP effluent; AOC coming out of the wells during redevelopment; and pressures, water levels and recharge rates during recharge. This data should be obtained at a later date so that recharge capabilities can be accurately estimated and so that required chlorination frequencies can be accurately determined.

O&M COST COMPARISON

With the changes in operation of the SWTP mentioned above, there will be a change in O&M cost. In an attempt to make an estimate of the changes in O&M cost, existing costs, new costs, and the change in costs were evaluated. To refine these O&M costs and make a more-accurate comparison with the El Dorado option, the City of Wichita assembled the following information. A complete O&M cost estimate was prepared using the City of Wichita's existing cost estimating model which incorporates chemical costs, electrical costs, staffing, and renewal/replacement costs. Renewal and replacement costs are often not included in their O&M cost model; however, the El Dorado option including renewal and replacement so it was included in the enhanced ASR option to make an accurate comparison. The following assumptions were made while developing the O&M costs for the enhanced ASR option.

- The total O&M cost shown below is an incremental cost. These are costs that will be in addition to the existing ASR O&M which will result only from the enhanced ASR option.

- O&M costs for mechanical equipment, basins, and pipelines are based on 1% of the estimated construction cost.
- Chemical costs and electrical costs are based on estimated increases in run time, estimated pump horsepowers, and are based on actual historical costs.
- O&M for the added electrical distribution system is based on actual historical costs.
- The costs below are based on Option 1 unit prices, without the dedicated recharge pipe network.

The resulting incremental O&M cost for the enhanced ASR option is approximately $2.8M/year as shown in the tables below.

Table 8-2 Annual Costs for ASR Improvements - Provided by City of Wichita

			Fixed or Variable	Cost Basis	Cost (per unit or year)	Total Cost	Assumptions
Reservoirs - Only additional costs resulting from this alternative							
1	Additional Phase II Intake Pumps		Fixed	$ / year	$ 20,000.00	$ 20,000.00	1% of construction cost
2	Additional Phase II Presedimentation Basin		Fixed	$ / year	$ 26,000.00	$ 26,000.00	1% of construction cost
3	Expansion of Phase II Settled Water Pump Station		Fixed	$ / year	$ 14,000.00	$ 14,000.00	1% of construction cost
4	Raw Water Pump Station		Fixed	$ / year	$ 25,000.00	$ 25,000.00	1% of construction cost
2	Bank Storage w/SWTP Bypass		Fixed	$ / year	$ 74,000.00	$ 74,000.00	1% of construction cost
3	Other Reservoirs	Side Stream Storage Res.	Fixed	$ / year	$ 73,000.00	$ 73,000.00	1% of construction cost
Wells - Only additional costs resulting from this alternative							
1	Recharge Recovery Wells - Submersible Pump	Other Reservoirs	Fixed	$ / year	$ 141,000.00	$ 141,000.00	1% of construction cost
2	Other Wells	Recharge Basins	Fixed	$ / year	$ 20,000.00	$ 20,000.00	1% of construction cost
3	Electricity		Variable	$ / AF	$ 25.93	$ 129,650.00	
Treatment - This represents additional treatment costs at ASR							
1	Electricity		Variable	$ / AF	$ 94.10	$ 470,500.00	
2	ASR Ops Chemicals		Variable	$ / AF	$ 100.56	$ 502,800.00	
Pumping - Only additional costs resulting from this alternative							
1	Electrical Distribution System		Fixed	$ / year	$ 39,000.00	$ 39,000.00	From historical O&M costs
2	Electricity		Variable	$ / AF	$ 24.29	$ 121,450.00	
		Annual O&M				**$ 1,656,400**	
		Renewal & Replacement				**$ 1,141,000**	
		Total Annual Costs				**$ 2,797,400**	

Table 8-3 Renewal and Replacement Costs - Provided by City of Wichita

Location	Pick-List Components	Capacity, Size, or Length	Option No. 1 SSS @ Intake Site
Raw Water Facility	Intake Pumps/EIC (MGD)	33	$2,000,000
	Presedimentation Basin (MGD)	33	$2,600,000
	SWPS (MGD)	33	$1,400,000
	Subtotal		**$6,000,000**
Side Stream Storage	SSSB: 80 bottom acres (MG)	268	$7,300,000
	SSS Pump Station (MGD)	33	$2,500,000
	Bank Storage w/ SWTP Bypass	15	$7,400,000
	Power Transmission		
	54" Transmission1 (LF)	2,000/5,700	$1,100,000
	42" Transmission2 (LF)	11,400	
	Land Acquisition	138/40/40	$480,000
	Subtotal		**$18,780,000**
Surface WTP	Basket Strainer Bldg. & Yard Piping	33	
	Demolition @ Existing SWPS		
	Analytical Equipment: GCMS		$100,000
	Miscellaneous Lab Supplies		$15,000
	Subtotal		**$115,000**
Well Field	20 RRWs at New Sites		$14,100,000
	10 RRWs at Existing Sites		$7,100,000
	2 Recharge Basins		$2,000,000
	Power Transmission (miles)	13	$3,000,000
	Planned Transmission to ASR Phase III RRWs		$16,700,000
	Subtotal		**$42,900,000**
Transmission to MWTP	66" from SE Crosstie to 21st & Hoover (miles)	11	$47,000,000
	36" from 21st & Hoover to MWTP (miles)	2	$7,000,000
	Land Acquisition (acres)	158	$590,000
	Subtotal		**$54,590,000**

Project Cost Subtotal	$122,385,000
Less Land Acquisition	($1,070,000)
Less Lab Supplies & Equipment	($115,000)
Less Costs for Existing Sites	($7,100,000)
Asset Value of New Infrastructure	**$114,100,000**
Annual Renewal & Replacement at 1% of Asset Value	**$1,141,000**

CHAPTER 9 - RECHARGE & RECOVERY ENHANCEMENTS

WELL FIELD AND AQUIFER CAPACITY

An estimate of the number of wells required for this concept was completed for this evaluation. This estimate was based on a design recharge capacity of 30 MGD and a production capacity of 107 MGD. Based on City of Wichita's estimate, 107 MGD from the EBWF is required to meet the future peak demand in year 2060.

RRWs will be constructed in a manner similar to the existing wells including the following:

- Valves to control the flow into the aquifer through drop tubes entering the casing below the anticipated static water level; and
- Capable of pumping for redevelopment purposes or production; and
- A well house constructed to house the meter, motor controls and other associated equipment.

The system design needs to account for the full range of anticipated recharge flow rates so that it will be able to recharge the full 30 MGD on a daily basis based on current water levels. Using the available data from the 34 existing RRWs, recharge capacity is estimated for wells placed in various zones of the well field. The anticipated flow rates are used to estimate the total number of recharge wells required.

In addition, it is anticipated that some wells will be out of service due to mechanical difficulties and regular maintenance. For the purposes of this study, it has been assumed that 10 percent of the RRWs could be out of service and spares are included accordingly.

ADDITIONAL WELLS TO BE CONSTRUCTED

A total of 20 RRWs added to the existing 30 Phase II RRWs are required to reliably recharge 30 MGD at current water levels. Thirty potential sites for new wells are identified in Figure 9-1. A test boring program would be undertaken to investigate the 30 sites and determine the optimal locations for the 20 RRWs. Table 9-1 summarizes the projected recharge capacity at each of the sites based on aquifer depth, saturated thickness, and recharge data from existing RRWs. Ten additional RRWs would be constructed on existing sites to replace existing production wells, to maintain production capacity and provide additional recharge flexibility.

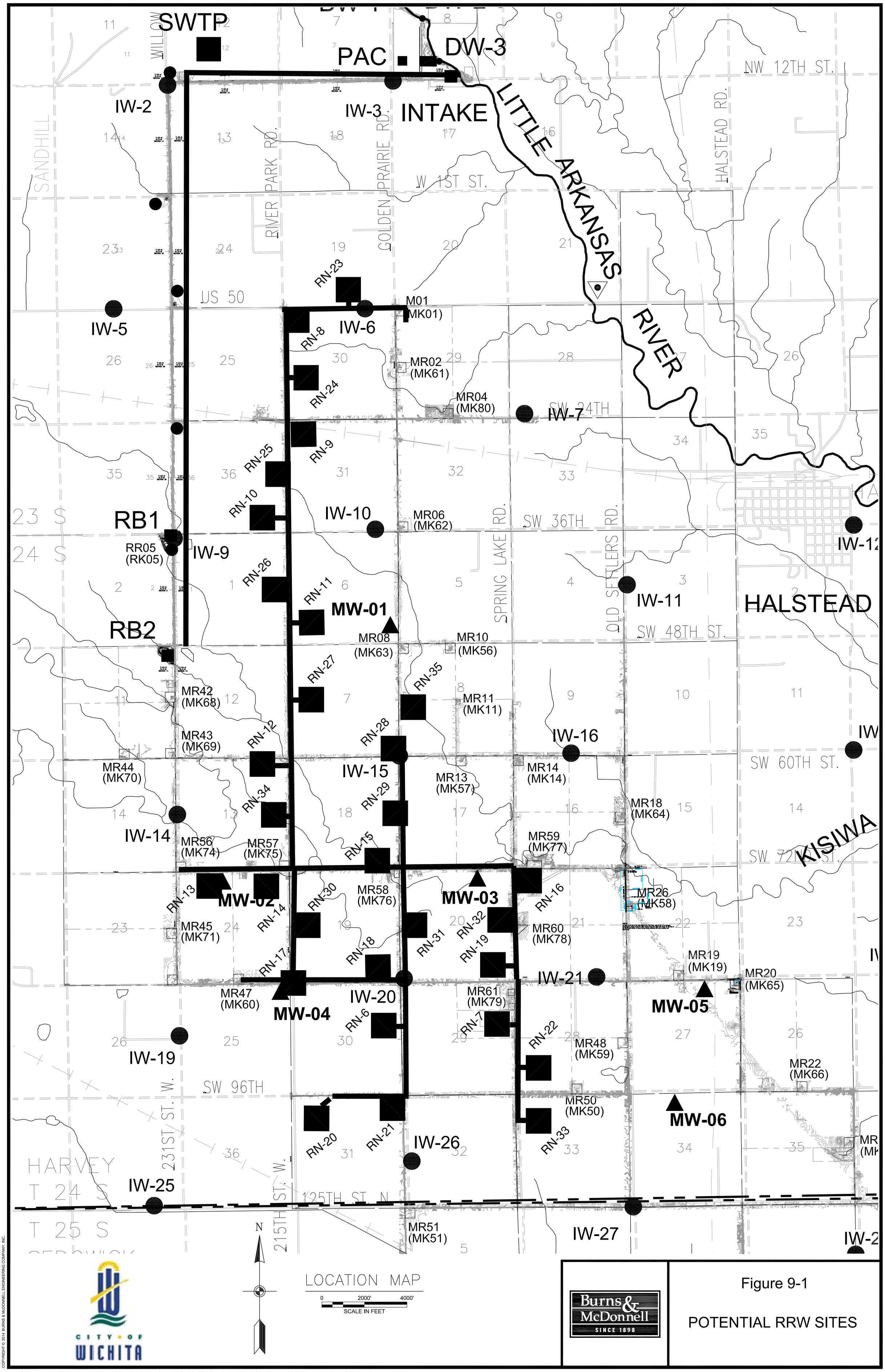

Figure 9-1

POTENTIAL RRW SITES

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Table 9-1 New RRW Projections

Phase III Well #	Anticipated Well TD (ft)	*Post Construction Calculated Recharge Rate (gpm)*		
		1993 WSL	**Current WSL**	**High WSL**
RN-6	245	983	692	216
RN-7	240	983	692	216
RN-8	230	983	692	216
RN-9	200	694	312	166
RN-10	240	983	692	216
RN-11	255	700	385	138
RN-12	260	700	385	138
RN-13	240	983	692	216
RN-14	260	700	385	138
RN-15	255	700	385	138
RN-16	240	983	692	216
RN-17	220	983	692	216
RN-18	245	983	692	216
RN-19	250	983	692	216
RN-20	235	983	692	216
RN-21	230	983	692	216
RN-22	240	983	692	216
RN-23	235	983	692	216
RN-24	220	983	692	216
RN-25	220	983	692	216
RN-26	255	700	385	138
RN-27	260	700	385	138
RN-28	250	983	692	216
RN-29	250	983	692	216
RN-30	240	983	692	216
RN-31	255	700	385	138
RN-32	250	983	692	216
RN-33	240	983	692	216
RN-34	260	700	385	138
RN-35	250	983	692	216
Total (gpm)		26,944	17,928	5,803
Total (MGD)		38.8	25.8	8.4

Opinions of probable cost for the 20 new wells at new sites are shown below in Table 9-2.

Table 9-2 New Well Opinion of Probable Cost

Wells		$2,500,000
Well Building w/ pumps, piping, etc		$6,400,000
Electrical		$4,000,000
Site Work		$1,100,000
Land Acquisition		$100,000
Project Cost Subtotal		*$14,100,000*
Contingency	**30%**	$4,200,000
Construction Cost Subtotal		*$18,300,000*
Permitting	**1%**	$180,000
PE	**10%**	$1,800,000
CE	**3%**	$500,000
Owner's Admin	**8%**	$1,500,000
Non-Construction Subtotal	**22%**	*$3,980,000*
TOTAL CAPITAL COST		**$22,280,000**

Opinions of probable cost for the 10 RRWs at existing sites are shown below in Table 9-3.

Table 9-3 Existing Site Wells Opinion of Probable Cost

Wells		$1,300,000
Well Building w/ pumps, piping, etc		$3,200,000
Electrical		$2,000,000
Site Work		$500,000
Land Acquisition		$100,000
Project Cost Subtotal		*$7,100,000*
Contingency	**30%**	$2,100,000
Construction Cost Subtotal		*$9,200,000*
Permitting	**1%**	$90,000
PE	**10%**	$900,000
CE	**3%**	$300,000
Owner's Admin	**8%**	$700,000
Non-Construction Subtotal	**22%**	*$1,990,000*
TOTAL CAPITAL COST		**$11,190,000**

RECHARGE BASINS

The existing well field includes two recharge basins. These basins have proven to function with a wide range of reliability with one capable of recharging at high rates and one at lower rates. However, basins can provide significant recharge ability in addition to substantial operational flexibility in the well field and are essential for start-ups, shutdowns, etc. While detailed hydraulics and hydrogeological investigations will be required to properly site basins, it is recommended that one new basin be constructed in the well field for each additional 15 MGD of recharge capacity. Costs for two new basins have been included in the opinion of probable cost.

WELL FIELD TRANSMISSION ALTERNATIVES

Two alternatives are evaluated to recharge 30 MGD with respect to well field transmission. Alternative No. 1 includes the transmission requirements as planned for ASR Phase III and allows the well field to continue operating in production and recharge zones, as is current mode of operation for recharge events. Alternative No. 1 requires approximately 14 miles of new transmission ranging in size between 8-inch and 42-inch within the well field that will connect the existing raw water network to the ASR Phase III RRW sites. The opinion of probable cost for Alternative No. 1 assumes rural transmission:

Table 9-4 Alternative No. 1 for Well Field Transmission Opinion of Probable Cost Table

8-inch Rural Raw Water Piping/Transmission		$20,000
12-inch Rural Raw Water Piping/Transmission		$1,600,000
16-inch Rural Raw Water Piping/Transmission		$1,700,000
24-inch Rural Raw Water Piping/Transmission		$6,400,000
30-inch Rural Raw Water Piping/Transmission		$3,600,000
36-inch Rural Raw Water Piping/Transmission		$2,000,000
42-inch Rural Raw Water Piping/Transmission		$1,400,000
Project Cost Subtotal		*$16,700,000*
Contingency	**30%**	$5,000,000
Construction Cost Subtotal		*$21,700,000*
Permitting	**1%**	$220,000
PE	**10%**	$2,200,000
CE	**3%**	$650,000
Owner's Admin	**8%**	$1,700,000
Non-Construction Subtotal	**22%**	*$4,800,000*
TOTAL CAPITAL COST		**$26,500,000**

Alternative No. 2 includes a dedicated recharge piping network from the SWTP to the existing Phase II RRWs and to the future Phase III RRWs capable of transmitting 30 MGD recharge capacity. Under this alternative, the recharge mode operates independent of the normal production mode. This enables the City to perform both operations simultaneously based on which RRWs remain in production and which RRWs are transitioned to recharge. Alternative No. 2 requires approximately 32 miles of new transmission ranging in size between 8-inch and 42-inch extending to the existing ASR Phase II RRWs and approximately 15 miles of new transmission ranging in size between 8-inch and 24-inch extending from the dedicated Phase II recharge piping network to the future Phase III RRWs. For clarity, the total length of Alternative No. 2 is greater than Alternative No. 1 because a dedicated recharge piping parallels the existing well field piping system.

The total well field transmission required for a dedicated recharge pipe network is approximately 47 miles and the total opinion of probable cost is approximately $83,000,000. This cost opinion is separated in Tables 9-5 and 9-6 to better characterize the dedicated transmission costs required for the Phase II RRWs and the dedicated transmission costs required for future Phase III RRWs.

Table 9-5 Alternative No. 2 for Phase II Well Field Transmission Opinion of Probable Cost Table

8-inch Rural Raw Water Piping/Transmission		$60,000
12-inch Rural Raw Water Piping/Transmission		$6,100,000
16-inch Rural Raw Water Piping/Transmission		$1,900,000
20-inch Rural Raw Water Piping/Transmission		$1,300,000
24-inch Rural Raw Water Piping/Transmission		$10,400,000
30-inch Rural Raw Water Piping/Transmission		$4,800,000
36-inch Rural Raw Water Piping/Transmission		$2,300,000
42-inch Rural Raw Water Piping/Transmission		$13,500,000
Project Cost Subtotal		*$40,400,000*
Contingency	**30%**	$12,100,000
Construction Cost Subtotal		*$52,500,000*
Permitting	**1%**	$530,000
PE	**10%**	$5,300,000
CE	**3%**	$1,600,000
Owner's Admin	**8%**	$4,200,000
Non-Construction Subtotal	**22%**	*$11,600,000*
TOTAL CAPITAL COST		**$64,100,000**

Table 9-6 Alternative No. 2 for Phase III Well Field Transmission Opinion of Probable Cost Table

8-inch Rural Raw Water Piping/Transmission		$20,000
12-inch Rural Raw Water Piping/Transmission		$5,700,000
16-inch Rural Raw Water Piping/Transmission		$1,300,000
20-inch Rural Raw Water Piping/Transmission		$560,000
24-inch Rural Raw Water Piping/Transmission		$4,400,000
Project Cost Subtotal		*$12,000,000*
Contingency	**30%**	$3,600,000
Construction Cost Subtotal		*$15,600,000*
Permitting	**1%**	$160,000
PE	**10%**	$1,600,000
CE	**3%**	$470,000
Owner's Admin	**8%**	$1,200,000
Non-Construction Subtotal	**22%**	*$3,400,000*
TOTAL CAPITAL COST		**$19,000,000**

WELL FIELD IMPROVEMENTS SCHEDULING

The improvements discussed above include the required numbers of wells (RRWs and production wells) to meet the City desired future capacity of 107 MGD from the EBWF. These 81 wells include 55 existing production wells with production water rights, six existing Phase II RRWs, and 20 new Phase III RRWs with access to recharge credits. Ongoing replacement efforts should continue as part of Phase III with replacement of ten production wells with RRWs. Selection of production wells to be replaced should be based on well condition, age, recharge potential, and well capacity.

CHAPTER 10 - RAW WATER TRANSMISSION MAIN

This chapter discusses raw water transmission generally described as transmitting well field production to the Main WTP. Two scenarios are evaluated with the same water supply contributions to the Main WTP, but under different transmission arrangements. The parameters applied to each scenario are listed below:

- Total well field production of approximately 107 MGD from a combination of existing ASR Phase II well and future Phase III wells;
- Cheney Reservoir/pump station water supply contribution of approximately 59 MGD;
- Total water supply contribution to the Main WTP of 166 MGD; and
- No Bentley or local well field water supply contribution.

SCENARIO NO. 1

Scenario No. 1 evaluates the additional transmission required to deliver 107 MGD from the well field to 21st and Hoover where the existing Cheney 60-inch transmission joins the existing EBWF 66-inch transmission. At 21st and Hoover, two existing 66-inch transmission mains then deliver raw water to the MWTP. A new 66-inch transmission main is more than adequate to deliver 107 MGD from the well field to 21st and Hoover and ultimately to the MWTP. This pipeline extends from the southeast corner of the well field piping network at the junction of a 66-inch (southeast alignment from the SWTP) and 48-inch (east/west alignment) pipe. The total length of the new 66-inch is approximately 12 miles and the cost opinion is based on a combination of urban, about 2 miles, and rural transmission, about 10 miles, as listed below in Table 10-1.

Table 10-1 66-inch Raw Water Transmission Opinion of Probable Cost

66-inch Rural Raw Water Piping/Transmission		$47,000,000
Project Cost Subtotal		*$47,000,000*
Contingency	**30%**	$14,100,000
Construction Cost Subtotal		*$61,100,000*
Permitting	**1%**	$610,000
PE	**10%**	$6,100,000
CE	**3%**	$1,800,000
Owner's Admin	**8%**	$4,900,000
Non-Construction Subtotal	**22%**	*$13,400,000*
TOTAL CAPITAL COST		**$74,500,000**

SCENARIO NO. 2

Scenario No. 2 includes a 36-inch transmission main connected to the new 66-inch transmission main at 21st and Hoover as discussed in Scenario No. 1. The assumptions made for the connection locations and lengths are listed below:

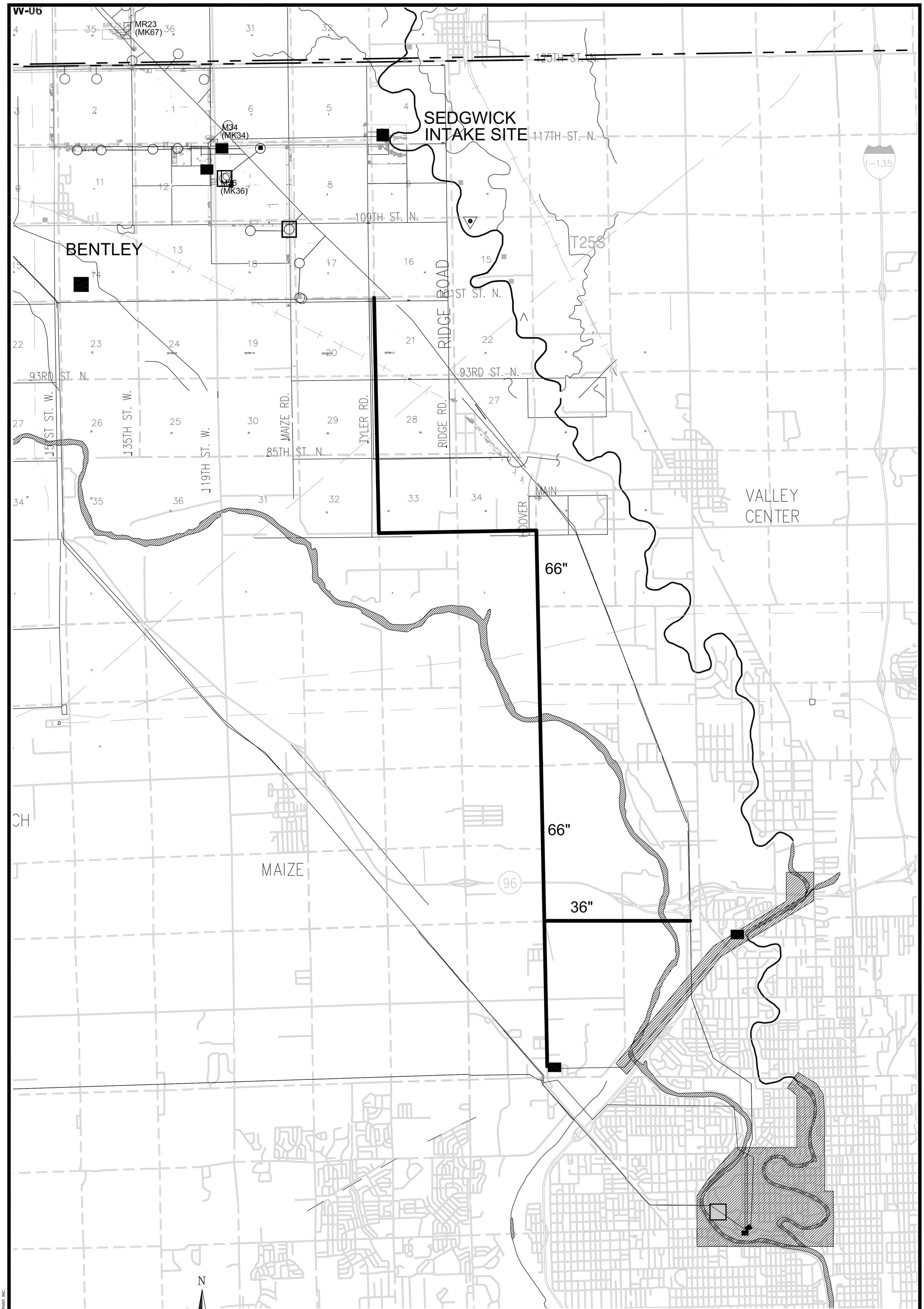
- Connection to the new 66-inch transmission main described in Scenario No. 1 is approximately 2 miles north of 21st and Hoover. The 36-inch transmission alignment jogs east for 2 miles and ties into the existing 48/36-inch slip-lined pipe that jogs south to the Main WTP; and
- Total length of new 36-inch transmission is approximately 2 miles.

The opinion of probable cost for the new 36-inch pipe is listed below in Table 10-2.

Table 10-2 36-inch Raw Water Transmission Opinion of Probable Cost

36-inch Rural Raw Water Piping/Transmission		$7,000,000
Project Cost Subtotal		*$7,000,000*
Contingency	**30%**	$2,100,000
Construction Cost Subtotal		*$9,100,000*
Permitting	**1%**	$90,000
PE	**10%**	$910,000
CE	**3%**	$270,000
Owner's Admin	**8%**	$730,000
Non-Construction Subtotal	**22%**	*$2,000,000*
TOTAL CAPITAL COST		**$11,100,000**

Addition of this pipeline adds about 22 MGD of capacity to the raw water delivery system. Both pipelines are shown below in Figure 10-1.



LOCATION MAP

0 3000' 6000'

SCALE IN FEET

Figure 10-1

RAW WATER
TRANSMISSION MAIN
EBWF TO MWTP

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J:\WICHITA\71395 - SB272\ENHANCED ASR\ENGINEERING\HYDROLOGY\GROUNDWATER\FIGURE 10-1.DWG 7/14/2014 5:04 PM JOLIPHANT

CHAPTER 11 - SUMMARY & CONCLUSIONS

This section of the report discusses the project conclusions including cost opinions, and recommendations for each portion of the project.

Modeling showed that under base restrictions, a SSS option with an 80-acre SSSB could produce approximately 3,690 MG annually through the SWTP. With advanced restrictions and an 80-acre SSSB, this system could produce approximately 3,219 MG annually.

Bank storage wells will also add significantly to the amount of water produced from this system. Since bank storage wells can operate much more of the year, their withdrawal is much less limited. Modeling showed that bank storage wells could produce approximately 3,773 MG annually if 15 MGD of bank storage wells are installed.

Changes necessary to the existing intake site include 4 new intake pumps, a new presedimentation basin, and a new SWPS. The new presedimentation basin will aid in the removal of settleable solids and the new SWPS will convey water to the SSSB or to the SWTP. These changes are recommended regardless of which option is selected or where the SSSB is located.

Modeling showed that an 80-acre basin is the optimal size for side stream storage. Larger basins start seeing diminishing returns and smaller basins limit the amount of water produced annually. The basin will be earthen with a total depth of 15 feet including 2 feet of freeboard. The recommended 80-acre basin will provide approximately 268 MG of storage.

The existing SWTP will require minimal changes with the possible exception of basket strainer relocation if either Option 2 or 3 is selected. Staffing and maintenance efforts will increase due to the extended run times of the SWTP but not due to the side stream storage concept itself.

A total of 20 new RRWs and one new recharge basin are recommended to recharge water to the EBWF. Pricing has been included for these 20 RRWs, two recharge basins, plus ten additional RRWs to replace existing/aging wells. Well field piping has been shown with two options: one that extends the existing pipe network to the new RRWs and another option that would construct a dedicated recharge network to all RRWs. At this time, a dedicated recharge network is not the recommended option.

A new 66-inch transmission main will be added to route raw water from the SE corner of the well field to the MWTP. It is recommended that this transmission main be routed to 21st and Hoover and not the entire distance to the MWTP. The two 66-inch existing lines that run from 21st and Hoover to the MWTP have

adequate capacity to supply water from both Cheney Reservoir and the well field at the projected 2060 demands. The new 66-inch line from the well field has adequate capacity to deliver 107 MGD of future well field demand to 21st and Hoover.

The opinions of costs discussed within this report are summarized in Table 11-1 below. At this time, Option No. 1 is the recommended option which has a potential total cost of approximately $231M, but only $194M as recommended without the dedicated recharge network. Not only is this option the most economically-feasible, but it also offers significant operational flexibility with the SSSB located at the river intake and bank storage wells near the facility. The combination of side stream storage, bank storage wells, new recharge wells, and a new transmission main has the potential to deliver an average additional 6,992 MG annually (21,395 AFY) to the MWTP.

In addition to these conclusions, the City of Wichita has performed their own cost analyses which incorporate capital and O&M costs over the projected planning period to arrive at a total project cost. The cost for the enhanced ASR option was compared to the El Dorado option in the ProForma shown below in Tables 11-2 and 11-3. In summary, the total project cost of the raw water El Dorado option is approximately $416M compared to $421M for the enhanced ASR option. However, the ASR option has numerous added benefits and therefore will be the recommended option.

Table 11-1 Enhanced ASR Opinion of Probable Cost Summary

Location	Pick-List Components	Capacity, Size, or Length	Option No. 1	Option No. 2	Option No. 3
			SSS @ Intake Site	SSS @ North Property	SSS @ North Property w/Dual Transmission
Raw Water Facility	Intake Pumps/EIC (MGD)	33	$2,000,000	$2,000,000	$2,000,000
	Presedimentation Basin (MGD)	33	$2,600,000	$2,600,000	$2,600,000
	SWPS (MGD)	33	$1,400,000	$1,400,000	$1,400,000
Side Stream Storage	SSSB: 80 bottom acres (MG)	268	$7,300,000	$7,300,000	$7,300,000
	SSS Pump Station (MGD)	33	$2,500,000	$2,500,000	$2,500,000
	Bank Storage w/ SWTP Bypass	15	$7,400,000	$7,400,000	$7,400,000
	Power Transmission	--	--	$230,000	$230,000
	54" Transmission1 (LF)	2,000/5,700	$1,100,000	$3,100,000	--
	42" Transmission2 (LF)	11,400	--	--	$4,800,000
	Land Acquisition	138/40/40	$480,000	$140,000	$140,000
Surface WTP	Basket Strainer Bldg. & Yard Piping	33	--	$858,000	$858,000
	Demolition @ Existing SWPS	--	--	$50,000	$50,000
	Analytical Equipment: GCMS	--	$100,000	$100,000	$100,000
	Miscellaneous Lab Supplies	--	$15,000	$15,000	$15,000
Well Field	20 RRWs at New Sites	--	$14,100,000	$14,100,000	$14,100,000
	10 RRWs at Existing Sites	--	$7,100,000	$7,100,000	$7,100,000
	2 Recharge Basins	--	$2,000,000	$2,000,000	$2,000,000
	Power Transmission (miles)	13	$3,000,000	$3,000,000	$3,000,000
	Planned Transmission to ASR Phase III RRWs	--	$16,700,000	$16,700,000	$16,700,000
	Dedicated Recharge Pipe Network (optional)	--	$40,400,000	$40,400,000	$40,400,000
Transmission to MWTP	66" from SE Crosstie to 21st & Hoover (miles)	12	$47,000,000	$47,000,000	$47,000,000
	36" from 21st & Hoover to MWTP (miles)	2	$7,000,000	$7,000,000	$7,000,000
	Land Acquisition (acres)	170	$590,000	$590,000	$590,000
Project Cost Subtotal			*$122,385,000*	*$125,183,000*	*$126,883,000*
Contingency		**30%**	$36,716,000	$37,555,000	$38,065,000
Construction Cost Subtotal			*$159,101,000*	*$162,738,000*	*$164,948,000*
Permitting		**1%**	1,590,000	1,630,000	1,650,000
PE		**10%**	15,910,000	16,270,000	16,490,000
CE		**3%**	4,770,000	4,880,000	4,950,000
Owner's Admin		**8%**	12,730,000	13,020,000	13,200,000
Non-Construction Subtotal		**22%**	35,000,000	35,800,000	36,290,000
TOTAL CAPITAL COST w/SSSB @ 80 Bottom Acres			**$194,101,000**	**$198,538,000**	**$201,238,000**
TOTAL CAPITAL COST w/ Dedicated Recharge Pipe Network			**$231,700,000**	**$236,100,000**	**$238,800,000**

Table 11-2 El Dorado Raw Water Option ProForma - Provided by City of Wichita

Costs for New Water from 2018 - 2060 (43 Years)

Assumptions	
Non-Drought Take (MGD)	10,000,000
Drought Take (MGD)	10,000,000
Base Purchase Rate	$1.14
Base Annual Operating Costs	$0
Sales Tax Revenue	$200,000,000
Wichita Capital Costs	$0
El Dorado Capital Costs	$87,000,000
Storage Costs	$0
Rate Inflation	2.68%
Operating Inflation	2.68%

Impact Summary	
Sales Tax Funding	$200,000,000
Additional Water Purchase Costs	$215,764,801
Wichita Operating Costs	$0
Total Costs	$415,764,801
Total Revenue Impact	2.2%
Final Year of Pre-Payment	2038
Year Drought Protection Ends w/o Cons.	2030
Required Annual Conservation	0.35%

Table 11-3 Enhanced ASR Option ProForma - Provided by City of Wichita

Costs for New Water from 2018 - 2060 (43 Years)

Assumptions	
Non-Drought Take (MGD)	-
Drought Take (MGD)	-
Base Purchase Rate	$0.00
Base Annual Operating Costs	$2,800,000
Sales Tax Revenue	$200,000,000
Wichita Capital Costs	$200,000,000
El Dorado Capital Costs	$0
Storage Costs	$0
Rate Inflation	0.00%
Operating Inflation	2.68%

Impact Summary	
Sales Tax Funding	$200,000,000
Additional Water Purchase Costs	$0
Wichita Operating Costs	$221,230,820
Total Costs	$421,230,820
Total Revenue Impact	2.3%
Final Year of Pre-Payment	Not Applicable
Year Drought Protection Ends w/o Conservation	2030
Required Annual Conservation	0.35%

APPENDIX A - WATER REGULATIONS

K.A.R. 5-1-1. Definitions.

(e) “Aquifer storage” means the act of storing water in the unsaturated portion of an aquifer by artificial recharge for subsequent diversion and beneficial use.

(f) “Aquifer storage and recovery system” means the physical infrastructure that meets the following conditions:

(1) Is constructed and operated for artificial recharge, storage, and recovery of source water; and

(2) consists of apparatus for diversion, treatment, recharge, storage, extraction, and distribution.

(g) “Artificial recharge” means the use of source water to artificially replenish the water supply in an aquifer.

(k) “Basin storage area” means the portion of the aquifer's unsaturated zone used for aquifer storage that has defined horizontal boundaries and is delimited by the highest and lowest index water level elevations.

(l) “Basin storage loss” means that portion of artificial recharge naturally flowing or discharging from the basin storage area.

(s) “Conjunctive use” means the safe-yield management and operation of an aquifer in coordination with a surface water system to enhance the use of the total water supply availability in accordance with the provisions of the water appropriation act.

(kkk) “Recharge credit” means the quantity of water that is stored in the basin storage area and that is available for subsequent appropriation for beneficial use by the operator of the aquifer storage and recovery system.

K.A.R. 5-22-1. Definitions.

(c) “Aquifer storage” means the act of storing water in the unsaturated portion of an aquifer by artificial recharge for subsequent diversion and beneficial use.

(d) “Aquifer storage and recovery system” means a physical infrastructure that meets the following conditions:

(1) Is constructed and operated for artificial recharge, storage, and recovery of source water; and

(2) consists of apparatus for diversion, treatment, recharge, storage, extraction, and distribution.

(l) “Basin storage area” means the portion of the aquifer’s unsaturated zone used for aquifer storage that has defined horizontal boundaries and is delimited by the highest and lowest index water levels.

(m) “Basin storage loss” means that portion of artificial recharge naturally flowing or discharging from the basin storage area.

(ee) “Recharge credit” means the quantity of water that is stored in a basin storage area and that is available for subsequent appropriation for beneficial use by the operator of the aquifer storage and recovery system.

K.A.R. 5-12-1. Aquifer storage and recovery permitting.

(a) An operator may store water in an aquifer storage and recovery system under a permit to appropriate water for artificial recharge if the water appropriated is source water. The requirements of article 12 of the rules and regulations adopted by the Kansas department of agriculture, division of water resources are in addition to any requirements of the Kansas department of health and environment concerning underground injection wells, including article 46 of the rules and regulations adopted by the Kansas department of health and environment.

(b) Each application for a permit to appropriate water for artificial recharge shall describe the horizontal and vertical extent of the basin storage area in which the source water will be stored.

(1) The horizontal extent shall be determined by a closed boundary within which the recharge system used to store the water will be physically located. The recharge system may include recharge pits, recharge trenches, recharge wells, or other similar systems that cause source water to enter the storage volume of the basin storage area, either by gravity flow or by injection. The basin storage area may be subdivided into smaller areas representative of the areas that may be recharged by the individual recharge systems.

(2) The vertical extent shall be defined by a minimum and a maximum index water level for the basin recharge storage area, or for each subdivided area within the basin storage area if the basin storage area is subdivided. The minimum index water level shall be the lowest water level within the basin storage area, or smaller subdivided area if the basin storage area is subdivided, that occurred within the 10 years before the filing of the application for a permit to appropriate water, or a period of time longer than 10 years demonstrated by the applicant to reflect the lowest water level. If the basin storage area is subdivided, measurements from the same year shall be used to determine the minimum index water level for each subdivision. The maximum index water level shall represent the maximum storage potential for the basin storage area.

(c) An application for a permit to appropriate water for artificial recharge shall set forth the maximum annual quantity and maximum rate of diversion of source water.

(d)(1) Each application for a permit to appropriate water for artificial recharge shall include a methodology for accounting for water stored in a basin storage area both on an annual basis and on a cumulative basis so that recharge credits can be calculated. If more than one application for a permit to appropriate water for artificial recharge relates to the same aquifer storage and recovery system, each application shall use the same methodology for accounting for water stored in the basin storage area. The accounting of the water balance of all water entering and leaving the basin storage area shall be determined by using sound engineering methods based on actual measurements, generally accepted engineering methodology, or a combination of both.

(2) Approval of any application for a permit to appropriate water for artificial recharge shall be contingent upon the chief engineer's approval of the method for accounting for the basin storage area.

(e) An applicant for recovery of water stored by the holder of a permit to appropriate water for artificial recharge to store water in a basin storage area shall obtain a permit separate from the aquifer storage permit to appropriate water for beneficial use for each well used to recover the water stored. The maximum annual quantity of water that may be appropriated for this purpose shall be no more than the maximum cumulative recharge credits available to the operator of the aquifer storage and recovery system. These credits shall be determined by the accounting methodology approved under a permit to appropriate water for artificial recharge pertaining to the aquifer storage and recovery system. In determining whether diversion of the annual quantity impairs other water rights, the following data may be considered by the chief engineer:

(1) The maximum storage volume available in the basin storage area;

(2) the spatial distribution of recharge and withdrawal systems;

(3) the maximum rate of diversion at which the water will be withdrawn; and

(4) any other relevant information.

Recharge credits may be accumulated over more than one year, and any amount of recharge credits available may be withdrawn in accordance with the permit if the withdrawal does not impair other water rights.

(f) The approval of application, if the water to be diverted is the water artificially recharged into the basin storage area, shall be conditioned upon the following:

(1) Generally accepted engineering methodology;

(2) a maximum annual quantity that does not exceed the recharge credits; and

(3) an annual reporting that complies with K.A.R. 5-12-2. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-712; effective Sept. 22, 2000.)

K.A.R. 5-12-2. Aquifer storage and recovery accounting.

(a) In addition to annual water use reporting requirements pursuant to K.S.A. 82a-732, and amendments thereto, on June 1 of each year the permit holder of an aquifer storage or recovery system shall report an accounting of water in the basin storage area to the chief engineer and to any groundwater management district identified in subsection (c) of this regulation. The annual report for the preceding calendar year shall account for all water entering and leaving the basin storage area and shall specifically compute the amount of recharge credits held in the basin storage area.

(b) The report shall be in the form prescribed by the chief engineer and shall address the items in the water balance for the basin storage area, which may include the following amounts:

(1) Natural and artificial recharge;

(2) groundwater inflow and outflow;

(3) evaporation and transpiration;

(4) groundwater water diversions from all nondomestic wells;

(5) infiltration from streams;

(6) groundwater discharge to streams;

(7) the calculated recharge credits; and

(8) any other information that in the opinion of the chief engineer is pertinent to the basin storage and surrounding areas.

The annual accounting shall specifically take into account the amounts of natural recharge, artificial recharge, groundwater inflow, groundwater outflow, evapotranspiration, and groundwater pumpage. Groundwater pumpage shall include recharge credits withdrawn as well as pumpage from all nondomestic wells in the basin storage area. The annual accounting shall include any additional items within a basin storage area that would be necessary to determine the amount of recharge credit available for recovery.

(c) If any part of the basin storage area is within the boundaries of a groundwater management district, the permit holder of any aquifer storage or recovery system shall furnish a copy of the annual report to the district board for comments by June 1 of each year.

(d) If a groundwater management district receives an annual report, the district may provide comments to the chief engineer if the comments are submitted to the chief engineer within 30 days of the district's receipt of the report identified in subsection (c) of this regulation.

(e) The permit holder may be required by the chief engineer to submit additional information pertinent to the system. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-712; effective Sept. 22, 2000.)

K.A.R. 5-12-4. Aquifer storage and recovery systems in a groundwater management district.
A groundwater management district may recommend rules and regulations pertaining to monitoring and accounting requirements for that portion of the basin storage area that falls within the district's boundaries. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711, K.S.A. 82a-712, and K.S.A. 82a-1028(o); effective Sept. 22, 2000.)

K.A.R. 5-22-17. Bank storage wells.
(a) Each applicant for one or more bank storage wells shall demonstrate all of the following:

(1) The hydraulic connection from the streambed and banks to each bank storage well screen is sufficient to transmit bank storage water from the bed and banks of the stream to each bank storage well screen at a rate sufficient to sustain the authorized rate of diversion of the well or wells.

(2) Within seven days after the pumping of all bank storage wells has ceased, the water level in each bank storage well, or a monitoring well located within 100 feet of that bank storage well, will recover to an elevation equal to or greater than the water level elevation immediately before the bank storage well began to pump, adjusted for any regional groundwater level changes not caused by the pumping of the bank storage well.

(3) The naturally occurring and artificially induced rate of infiltration from the bed and banks of the stream when bank storage is occurring will be sufficient to meet the following conditions:

(A) Equal or exceed the authorized rate of diversion of all of the bank storage wells;

(B) prevent impairment caused by all bank storage wells; and

(C) prevent groundwater mining caused by all bank storage wells.

(b) If an application for a bank storage well is approved by the chief engineer, the applicant shall install one or more water-level measurement tubes at locations that will allow adequate monitoring of groundwater quality and groundwater levels within the area where the annual cone of depression of the bank storage well or wells could be greater than 0.5 feet. Each water-level measurement tube shall be constructed and maintained in accordance with K.A.R. 5-6-13. (Authorized by K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Nov. 12, 2004.)

K.A.R. 5-22-10. Aquifer storage and recovery system: data reporting requirements.
(a) Each person operating an aquifer storage and recovery system of which all or part of is within the boundaries of the district shall file an annual report with the district no later than June 1 for the previous calendar year. The report shall contain the water balance in the basin storage area

and, in addition to the information required by K.A.R. 5-12-2, information about the following, as specified:

(1) Source water:

(A) The type;

(B) the quantity of water available;

(C) the quantity of water surface water and bank storage water diverted;

(D) the basin storage loss; and

(E) the chemical, physical, radiological, and biological quality for each type of source water diverted;

(2) Aquifer storage:

(A) The artificial recharge techniques used;

(B) the quantity of source water recharged by each technique used;

(C) the total quantity of source water stored in the basin storage area; and

(D) the chemical, physical, radiological, and biological quality for each type of water stored;

(3) Recovery of stored water:

(A) A monthly and annual summary of recharge credits withdrawn from each recovery well; and

(B) the chemical, physical, radiological, and biological quality of the water recovered; and

(4) Hydrologic conditions:

(A) The quarterly index water levels;

(B) the key groundwater quality parameters;

(C) the monthly and annual precipitation quantities;

(D) the annual groundwater withdrawals from all wells except domestic wells;

(E) the annual streamflow, including baseflows and above-baseflow stage;

(F) a summary of the conjunctive use amounts; and

(G) the water supply and demand forecast for the next three years.

(b) The operator of the aquifer storage and recovery system shall furnish the district with whatever analyses, data, and other supporting documentation are necessary to understand and verify the report.

(c) The board shall review the report and submit its findings and recommendations to the chief engineer regarding the report no later than September 1 of the calendar year in which the report is required to be

filed. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Dec 10, 2004.)

(G) the water supply and demand forecast for the next three years.

(b) The operator of the aquifer storage and recovery system shall furnish the district with whatever analyses, data, and other supporting documentation are necessary to understand and verify the report.

(c) The board shall review the report and submit its findings and recommendations to the chief engineer regarding the report no later than September 1 of the calendar year in which the report is required to be filed. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Dec 10, 2004.)

APPENDIX B - ASR BACKGROUND QUESTIONS & RESPONSES

The following is a list of public questions and responses provided by the City of Wichita regarding the history of the ASR project, hurdles and lessons-learned and the viability of the enhanced ASR option.

1. Does Phase I Work?

Yes, Phase I achieved its intended purpose of testing potential treatment process and approaches for the future phases of ASR. It continues to provide recharge water through bank storage wells to slow down salt intrusion into the aquifer. The treatment plant was constructed primarily to pilot test different processes for treating water. It has temporarily closed, pending a review of how best to maximize its efficiency.

Phase I was intended as a $27M full-scale pilot as recommended by the Blue Ribbon Panel. Original design capacity was for 10 MGD; 3-MGD from bank storage wells and 7-MGD from the Surface Water Treatment Plant (SWTP). During plant operation, it was shown that the optimal plant flow was approximately 3.5 MGD due to water quality changes in the Little Arkansas River. Due to the reduced efficiency and Staff's commitment to Phase II it was decided in 2009 to temporarily moth-ball the SWTP and re-evaluate its abilities. Re-evaluating its abilities includes several projects regarding solids handling, permitting (permit has been acquired), and potential treatment changes. Existing Capital Improvement Program (CIP) money is allocated to perform some of these projects to help bring the Phase I SWTP back on-line. These improvements can be made anytime, but will be completed after any Phase II lessons can be incorporated.

Bank storage wells continue to operate with a capacity of 1 or 2 MGD. This capacity can be increased to 3 MGD with the purchase of additional property and installation of another bank storage well.

2. Has Phase II been fully commissioned at 30 MGD?
3. Can we pump 30 MGD through Phase II?
4. Have we run Phase II for longer than 10 minutes at a time?

Yes, all of the constructed Phase II facilities have been commissioned at 30 MGD. The facilities have been run at 15 MGD for significant amounts of time. Phase II facilities were operated for a short time at 30 MGD to prove equipment functionality. The Phase II treatment plant runs at either 15 MGD or 30 MGD.

The original Phase II design assumed that 30 wells could recharge the aquifer at 30 MGD during normal, non-drought conditions. Since commissioning the improvements, the wells have been able to provide recharge of 15 MGD to less than 30 MGD. Adequate capacity exists in the aquifer to recharge 30 MGD by adding wells at new locations. The 1% design conducted by an independent engineering firm (Burns & McDonnell) confirmed that the full 30 MGD can be injected into the aquifer during non-drought conditions.

5. Did the City fail to commission Phase II due to a lack of technical expertise?

No, the City has led the commissioning/operations effort but continues to engage experts on a regular basis.

6. Did we release the contractor before resolving problems at Phase II?
7. Was the contractor held responsible for costs to resolve Phase II problems?
8. Are microbes corroding the pipes, and if so, are we hiring a firm to study how to fix it?

9. Do we have leaking pipes and failing reactors today?

The City has continued to work with all Phase II contractors to address issues throughout the construction process. Multiple punchlists were developed and all issues were addressed at the Contractor's expense. Punchlist items regarding the SWTP included the following:

- *Microbial-Induced Corrosion: corrosion in several pipes in the SWTP was observed and studied at the contractor's expense, using corrosion experts. These issues have been resolved and there are currently no leaking pipes or failing reactors. Furthermore, continued monitoring of this corrosion suggests that it has ceased, due to some operational changes as suggested by the contractor and equipment manufacturers.*
- *Ozone Leaks: ozone leaks in the reactor distribution panels have been dealt with by the Contractor at their expense and, currently, ozone leaks are not limiting the run time of the plant. Nuisance leaks are typical in an ozone system. We continue to respond to them through appropriate maintenance.*
- *Membrane Fouling: any membrane fouling issues observed during commissioning have been resolved. This was resolved at the contractor's expense.*
- *Pipe Bursting: This issue has been resolved at the contractor's expense.*

A memorandum of understanding was developed with the contractor to ensure that these issues were resolved before being released. In addition to correcting the above issues, the contractor is also providing 2,000 units of assistance for technical expertise, trade services, etc. to be used at the City of Wichita's discretion. The 2,000 units are calculated based on labor hours and the level of technical expertise provided. For example, an hour provided by a laborer equals a single unit, while an hour of a senior engineering manager would be worth five units.

10. Does the treatment plant take out atrazine and bromide?
11. When is water available in the river, accounting for atrazine and bromide levels?

Yes, the treatment plant destroys atrazine and limits the formation of bromate. The presence of atrazine and bromide in the source water was always anticipated. The process has been optimized to effectively adjust treatment to manage operation within the expected range of water quality. Water quality conditions that prevent operation of the SWTP are expected to occur less than 10% of the time.

12. Last summer, did the hydrogen peroxide in the water sent directly to town destroy chlorine residuals and make the water unsafe?

No, chlorine residuals at the Main Water Treatment Plant (MWTP) were never affected and safe drinking water standards were maintained. Hydrogen peroxide residual is anticipated as an element of the treatment process. Process optimization efforts have been focused on establishing a dosing protocol that minimized the level of hydrogen peroxide residual. Water produced at the SWTP is permitted to be sent to the MWTP by KDHE and DWR. Any occurrence of sending water to the MWTP is carefully monitored and controlled. At no time has peroxide residual been detected at the MWTP nor has the ability to maintain chlorine residual been negatively impacted.

13. Have we evaluated arsenic leaching into the aquifer?

Yes, a study addressing the impact of aquifer recharge on arsenic levels within the aquifer was completed in 2010. The results of the study indicated that elevated arsenic levels due to recharge are not expected.

Aquifer water quality impacts will continue to be monitored and documented. Adjustments will be incorporated into the program as appropriate.

14. Are there problems with the Phase II recharge wells in which we are losing capacity?

No. Currently, well capacity and performance is consistent with expectations. Maintaining well capacity requires appropriate operation and maintenance.

15. Is ASR adequately staffed, both in terms of number of employees and the level of technical expertise to run the plant and electrical system?

Current staffing is adequate but not sustainable. Construction of ASR Phase I was accompanied by a significant increase in staffing levels in order to manage increased levels of activity/responsibility. It has always been anticipated that additional staff would be required to operate ASR Phase II. Existing staff have been provided training and have been utilized in conjunction with the commissioning process. Outside contractors have been used to support current operations. The commissioning of ASR Phase II is providing the opportunity to identify the staff members and technical capabilities required to safely and efficiently operate ASR and all well field facilities.

It is anticipated that new staff or contract services will be added. There will be ongoing efforts to match work requirements to staffing. The Water Utility has a $1 million contingency each year to cover emergencies and costs such as new ASR staffing. Part of the contingency funding will be used through 2015 to cover staffing needs. This approach allows the City to determine the appropriate number of positions and mix of technical expertise to permanently staff ASR. The permanent staffing model will be incorporated into the 2016 budget.

16. Can we purchase enough land for a storage reservoir, recharge basins, etc., considering our relationship with area landowners?

It is fully anticipated that land can be acquired to accommodate future ASR and well field construction. The City of Wichita has experienced opposition with some property acquisition in the well field since the 1930s. There is no indication to us that the status of that opposition has changed such to make it any more difficult than it has been in the past.

17. Will a storage reservoir work, considering depth limitations?
18. Was a study conducted previously that rejected the idea of a side stream storage reservoir?

Yes, a storage reservoir will work with a basic soil-balance type construction. The basin will be primarily above-grade, with approximately 2 feet below-grade for an approximate 80-acre basin. A very high-level study was completed during the Phase II preliminary design. The study was intended to identify the cost and general design criteria associated with the addition of side stream storage to Phase II. Primarily due to fiscal constraints, it was decided not to incorporate side stream storage into Phase II, but would remain as a possible future addition.

19. Have we considered bank storage wells to increase diversion capacity?

Yes, bank storage wells are a significant component of the Enhanced ASR option. Bank storage wells in the right proximity are less expensive; however, the most economical option, consistent with Groundwater Management District No. 2 (GMD2) commitments, includes both side stream storage and bank storage wells.

20. Can additional diversion wells be permitted?

Yes, Division of Water Resources (DWR) has confirmed that they are willing to work with us on new diversion wells. Previous objections to diversion wells were based on the misconception that these wells were incorrectly constructed or designed. A moratorium was placed on new diversion wells by GMD2 and has since expired. Subsequent to Phase I, a study was performed to clear-up these misconceptions. This study gave the City of Wichita confidence that more bank storage wells can be utilized.

21. Why did the City sole source the 1% design, with the same contractor that's been involved with ASR previously?
22. Is any independent firm auditing the work of Burns & McDonnell?

Burns & McDonnell (BMCD) have been involved in the water supply planning efforts for some time and have extensive experience with ASR and Wichita's water supply. BMCD was working with City Staff on the most recent water planning efforts. Staff shared with the public that BMCD assisted staff with identifying future water options and developing preliminary cost estimates. Later it was decided that a 1% design was needed to address multiple questions about the ASR option and that it was necessary to complete the work in 5 weeks. It was decided that BMCD should be selected on an emergency sole-source contract based on their experience with ASR, their familiarity with the water resource options, and the five-week time constraint. As such, BMCD was the firm best-positioned to complete the project in the time allowed. The contract was approved by Purchasing, Law, the City Manager's office, and the City Council.

In 2010 the ASR project was halted for an audit by an independent engineering firm, including the work of BMCD. Additionally, the project has been reviewed on two occasions by two technical committees. No problems with BMCD's work or designs were identified. City Staff is currently reviewing the 1% design report provided by BMCD.

23. Did we learn lessons from our Phase I project that were incorporated into Phase II?

Yes, multiple lessons were learned and applied to Phase II. The development of regulatory framework to govern an ASR project was not yet established during Phase I but was established between Phases I and II. This regulatory framework was directly applied to Phase II.

Phase I taught us that the process selected was potentially not the most conducive to this operation and therefore, a different treatment process was selected for Phase II. Phase I was used to pilot several filtration processes for Phase II including membrane treatment, which is currently installed and functioning properly in Phase II.

The lessons learned regarding hydrogeology and its effect on basin locations made a significant impact on Phase II. Phase I taught us that basin location can significantly change recharge capacities, much of which is unknown until after construction. This taught us to rely more on recharge wells than on recharge basins to put water in the ground.

Phase I also taught us lessons regarding automated controls, groundwater quality monitoring, project approaches, and how to manage projects of this size.

24. Will the City follow a competitive bid process if ASR proceeds?

Yes, if ASR proceeds, the City will use a competitive purchasing process.

APPENDIX C - ADDITIONAL HYDROGEOLOGY INFORMATION

This Appendix will contain a message sent by the City of Wichita to address several questions from the public regarding knowledge of the Equus Beds Aquifer and its ability to sustain the enhanced ASR Option. This information is withheld from this version of the report and is pending publication of data from the USGS.

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