EXPERT REPORT: Case No. 18 WATER 14014

for

Don Henry, Assistant Director, City of Wichita Public Works and Utilities

a) Consulted for: Municipal Water Utility Management and planning, including the history of the City's water resources, history and trends in the aquifer, 1993 water levels and the purposes of the changes contemplated by the City's current ASR proposal
b) The grounds for Don Henry's opinions are knowledge of pertinent information presented in City of Wichita's Response to Production Request of Equus Beds Groundwater Management District No.2 and City of Wichita's Responses to Intervener's Production Requests, as referenced in the summaries of the respective opinions below, and in several cases, excerpted and attached for convenience of reference.
c) Don Henry's factual observations and opinions, as presented in the Proposal documents and summarized herein, include:
    i. Expert opinions based on factual observations:
        - 1.0 Introduction
            – <u>The Wichita City Council decided in April of 2014 to utilize a 1% exceedance probability drought for water resource planning for future water supplies.</u>

              On several occasions in 2014, Wichita City Council considered a Strategic Plan in which improvements to the City's water supply were contemplated. During this process, it was determined that protection from the conditions of 1% drought should be attained through contemplated improvements. On August 5, 2014, the Council approved the Strategic Plan and its implementation through a Special Question Election.

              Presentations and other documents considered during development of the Strategic Plan are presented in the Exhibits: Strategic Plan.

              Excerpted pages 7-8 of Exhibits: Strategic Plan are presented as Attachment A.

            – <u>The evaluation of current ASR permit conditions relative to drought has identified the 1993 levels as a limitation that will restrict the City's access to ASR recharge credits during prolonged drought.</u>

On multiple occasions, Wichita has presented analyses demonstrating the basis of our concerns for ASR credit accessibility. Applicable documents are presented in the Exhibits: Proposal Correspondence. Excerpts (pages 1-5 & 9-15) are provided as Attachment B-1.

On November 15, 2016, the City provided additional analyses to GMD2 to demonstrate ASR recharge credits would not be available, especially under high aquifer demand scenarios where the City and other users would have to utilize consecutive years of full base water rights in the EBWF to meet demands. This correspondence (pages 40-47 of Exhibits: Proposal Correspondence) is provided as Attachment B-2.

- The aquifer within the EBWF has recovered to nearly 100% full pre-development conditions, and higher groundwater levels limit the recharge capacity of the City's ASR program.

  Water Levels exhibited in January 2016 in the Central Wichita wellfield area are calculated to be 41,000 acre-feet less than the predevelopment storage. Excerpted pages 9 and 12 from USGS 2016-5165 (Exhibits: Reports) are provided as Attachment C-1.

  Predevelopment storage in the Central Wichita wellfield area was calculated to be 1,025,000 acre-feet in USGS 2016-5165 (identified in Production). Excerpted page 15 is provided as Attachment C-2.

  Figure 14 of the Proposal demonstrates that sustainable recharge rates with 2016 water levels are often less than the individual well's minimum recharge rate, resulting in no recharge at that well. Excerpted Figure 14 is provided as Attachment C-3.

- The water left in the aquifer as a result of utilizing Little Arkansas River flows would be considered as an ASR Aquifer Maintenance Credit (AMC) with similar characteristics to the current ASR recharge credits.

  Section 3.4 of the Proposal presents anticipated permit conditions applicable to AMC's that at similar to current ASR recharge credits. Excerpted Section 3.4 is provided as Attachment D-1.

  Additional considerations proposed by the City, as permit conditions on May 22, 2018 are provided as Attachment D-2.

- 2.0 proposed ASR minimum index levels

  - The Wichita City Council adopted the Drought Response Plan in 2013.

Excerpted pages 46-49 of Exhibits: Drought Response, presented as Attachment E-1, show City Council minutes.

- The Drought Response plan will reduce demand at the customer level and has the effect of extending the viability of both Cheney Reservoir and the EBWF during prolonged drought.

  Excerpted pages 44-45 of Exhibits: Drought Response, presented as Attachment E-2, indicate water use restrictions and penalties for violations.

  Excerpted pages 4-5 of Exhibits: Drought Response, presented as Attachment E-3, estimate extension of water supplies after reducing demand.

- Table 2-1: City of Wichita Drought Response Plan (DRP) Stages
  - The planned reductions in water use increase as the 12-month average percentage of Conservation Pool decreases.

    Table 2-1 summarizes parameters of Attachment A of the Proposal. An excerpt is presented as Attachment F to this report.

- 3.2 City of Wichita ASR Program Development
  - The reductions in water demand have shifted the need for ASR recharge credits from a normal daily source of supply to a long-term resource only required during extended drought.

    Appendix A to Attachment D of the Proposal shows projected daily demands from 1993 higher than more current projections presented in 2013. The Appendix is presented as Attachment G-1 to this report.

  - The focus of the ASR program on drought mitigation allows for the same water quantity and water quality benefits as originally envisioned and results in utilization of ASR recharge credits less frequently.

    An informational factsheet, Modified ASR Lower Index Levels and Aquifer Maintenance Credits: An Overview, presents a briefing of Wichita's ASR program and proposed changes. The City proposes to keep the aquifer as full as possible, and use ASR credits less frequently, enabled by the proposed permit changes. This factsheet is provided as Attachment H-1, and was provided in Exhibits: Additional Exhibits.

Many benefits of a full Equus aquifer are discussed in the 2009 Environmental Impact Statement; excerpted pages 15-16 from Chapter 1: Introduction; Purpose and Need, as well as pages 103-129 from Chapter 4: Environmental Consequences; Water Resources, are presented as Attachment H-2. This document was provided in Exhibits: ASR Environmental Impact Statement.

- 3.3 Benefits of ASR Aquifer Maintenance Credits (AMCs)

  - <u>The availability of water in the Little Ark River for diversion would remain identical to the base flow and seasonal limits developed as part of the ASR Phase 1 and Phase 2 permitting process.</u>

    No changes to applicable permits to appropriate water at Phase 1 are presented by the Proposal. Further, the Proposed AMC Permit Conditions (Section 3.4) limit ASR Phase 1 Recharge and Recovery wells to recovery of physical recharge only. Proposed permit condition 2 limits accrual of all recharge credits to the rate and quantity authorized by the ASR Phase 2 surface water right, which is provided as Attachment I. This excerpt of City's Production is not included in Exhibits.

  - <u>Use of this water directly replaces diversions that would otherwise be required from the EBWF resulting in an equal amount of groundwater effectively left in storage to the benefit of all aquifer users.</u>

    Accrual of AMC's capitalizes on water that would otherwise remain unused, as part of above-base flow conditions. AMC's will only be accrued when the aquifer is full, protecting water quality in the aquifer and streams.

- 3.4 Proposed AMC Permit Conditions

  - <u>The proposed Permit Conditions present that the City is willing to adhere to project parameters that are in the public interest.</u>

    Conditions excerpted from the Proposal, and subsequently clarified by Wichita on May 22, 2018, are presented as Attachments J-1 & J-2. These documents have been submitted as Exhibits in Proposal and Proposal Communications.

ii. Expert opinions based on scientific analyses:

- The requested adjustments to the lower Minimum Index Levels for recovery of ASR credits is in the public interest.

– The lower Index Levels will enable the City to defer use of accumulated ASR credits until later in a drought. This will allow the City to focus its efforts on maximizing its use of Cheney, using water that would otherwise be lost to evaporation.

  Use of ASR credits less frequently, because they can be accessed later in drought, causes fewer fluctuations in the aquifer levels and will serve to keep the aquifer more full in average non-drought conditions.

  Higher aquifer conditions are known to slow, but not stop, progress of the Burrton chloride plume.

  Summary and Conclusions of USGS Open-File Report 2014-1162 (presented with Exhibits: Chloride Simulation) are provided as Attachment K.

  Short-duration uses of ASR credits during drought will accelerate the plume's progress by as much as 40%, but the rate during average years (between drought) will be attenuated.

  Less frequent use of ASR credits reduces the risk of impairment of wells adjacent to the City's wellfield.

  While the proposed minimum index levels are below the previously established levels, review of modeled performance of non-City wells in the vicinity of the Wichita wellfield was undertaken during modeling. Water levels at such wells were evaluated to verify that the wells continued to pump even during periods of modeled low water levels. Impairment was not indicated during the modeled 1% drought with increased pumping associated with recovery of Credits.

  Response to Intervenor's Production Request No. 13 is provided as Attachment L.

  Modeling data have been provided in the subdirectory Model in the City of Wichita's Responses to Production Requests of Equus Beds Groundwater Management District No. 2.

– The requested adjustments to the minimum Index Levels for ASR Credit recovery is reasonable; the revised limits will prevent Wichita from utilizing these resources during a severe drought with conditions worse than the 1930's. The revised levels will constrain Wichita's use to times when the aquifer is above 83% full in the Basin Storage Area.

  Figure 11 of the Proposal is provided as Attachment M.

Cross-section profiles of the aquifer lithology in the Wichita wellfield area area provided as Attachment N. These profiles present water level information that show the proposed water levels in locations beyond the Index wells, in predevelopment (1940) and 1993 conditions. This document, as well as the unmodified originals from Section VII of the 2000 Concept Design Study, have been provided previously in Exhibits.

d) Don Henry is a City of Wichita employee; his compensation is publicly available.

e) Don Henry's qualifications are as presented in the City of Wichita's Preliminary Expert Disclosure.

f) Don Henry's factual observations and opinions are as presented above in this Expert Report, ASR Permit Modification Proposal, cover letter, and supporting appendices.

Don Henry, Assistant Director, City of Wichita Public Works and Utilities

The City is creating a new Water Resources Plan to ensure a stable water supply through 2060. This is in response to public input ranking water as the top community priority, as well as Governor Brownback's call to create water sustainability statewide over the next 50 years. The effort follows a Drought Response Plan, which triggers emergency conservation measures in a drought, that was approved by the City Council in October 2013.

Recommendations for conservation and new water sources are linked to each other and to drought planning. Adding new supply and reducing water usage should be done in concert to provide enough water during drought years without impacting revenue in years with normal water usage. Doing so maximizes the operational benefit (extending the water supply) and the financial benefit of protecting utility revenue streams.

Highest Citizen Priority

Wichitans have ranked a reliable water supply as their most important priority. Last year's community survey showed that 85% of the public is willing to pay for water reliability—that is substantially more than the second highest priority (streets at 66%).

The community survey was conducted in April 2013 and was then followed by the ACT-ICT engagement process. The ACT-ICT efforts involved more than 2,000 people through 102 different community meetings. Those meetings yielded the same results as the community survey—that Wichitans value a reliable water source above other priorities.

Design Drought

Protecting water sources during periods of drought is an important part of long-term water supply planning. The concept of a design drought is used in planning efforts. These design droughts contain varying conditions of hot, dry weather and are factored into water planning models to plan for drought resistance. Design droughts are measured by chance of occurrence in a given year. Thus, a 2% drought has a 2% chance of beginning this year, while a 1% drought is half as likely.

Guidelines from the State of Kansas require communities to plan for a minimum of a 2% drought, which occurs roughly every 50 years. The five-year drought in the 1950s is an example of such conditions. However, 1% droughts—similar to the 1930s Dust Bowl period—do occur and have a more substantial impact on the water supply.

Another way to compare 1% and 2% droughts is to consider the public impact of instituting the City's Drought Response Plan. More stages of the drought plan would be implemented, and the length of time in the more severe drought stages would be longer, in a 1% drought. For instance, a 1% drought would require 71 months of outdoor watering bans, while a 2% drought would require only 11 months. Also, indoor usage would be reduced by 15% for 20 months during a 1% drought; this stage is not included in the 2% drought plan.

Planning for a more severe design drought will reduce the time customers experience challenging water restrictions. The severity of these conditions in the drought plans increases the importance of appropriate water supply planning. The combination of new water supply and conservation efforts can decrease the likelihood of implementing drought plans.

Amount of Time in Each Drought Stage		
	2% Drought	**1% Drought**
Stage 1 Voluntary Conservation	20 months	17 months
Stage 2 Outdoor Watering Once a Week	29 months	21 months
Stage 3 Outdoor Watering Ban	11 months	51 months
Stage 4 Outdoor Watering Ban and 15% Reduction in Indoor Usage	—	20 months

Water Conservation

Determining the economic viability of conservation and new supply is important to making sound decisions. Staff created an economic model based on three factors: the cost savings from delaying need for a new supply; revenue lost from reducing demand beyond current levels; and the expenses from instituting conservation strategies. This model marks down costs to 2014 levels to provide a clear economic gain or cost. The model was verified by water conservation economists who concluded that, "in our opinion, the City of Wichita is using appropriate methodology to evaluate the economic impact of water conservation."

The following table shows three items recommended for inclusion in the 2014 conservation program. They would be funded with the remaining funds from the 2013 rebate program, which reduced usage by 0.44%. The rebate program for 2014 would be modified from last year's conservation program to include more items and it would be offered to more customers. Ranges for costs and water savings are provided due to the uncertainty of how many customers will participate. This will serve as a pilot program and provide data to better estimate the benefits of future conservation options.

Finally, two studies would commence to determine the viability of future conservation efforts aimed at outdoor and industrial usage, which could both be high-yield conservation strategies. These studies will analyze incentives for different types of turf and drought-resistant plantings, capacity for private wells, and technology for recycling water in industrial processes.

2014 Water Conservation Program			
		Full Implementation—Annual Totals	
Action	**2014 Costs**	**Cost**	**Water Savings**
Offer a Modified Rebate Program	$450,000	$1.2m—$3.0m	0.39 - 0.95 MGD (0.68% - 1.67%)
Study Landscape Incentives	$75,000	*Unknown—will be determined during the studies*	
Study Industrial Re-Use	$75,000		

CITY OF WICHITA

Department of Public Works & Utilities

David Barfield, P.E.
Chief Engineer
Division of Water Resources
Kansas Department of Agriculture
109 SW 9th St.
Topeka, KS 66612-1283

May 24, 2013

RE: Requested Modification to Limitations on Water Rights

Dear Mr. Barfield,

Upon completion of the City of Wichita's (City) Recharge Demonstration Project in 2001, the City entered into discussions with the Division of Water Resources (DWR) and Groundwater Management District No. 2 (GMD2) to create appropriate regulations for bank storage wells and the City's Aquifer Storage and Recovery (ASR) project. The Demonstration Project was focused around identifying and refining the most efficient method for capturing, treating and recharging above base flows in the Little Arkansas River into the Equus Beds Wellfield (EBWF). The regulatory development phase focused on all aspects of a recharge program including the establishing the framework and methodology for storing and recovering water. A variety of methods were discussed for setting up the recharge credit accounting methodology for the ASR project. These methods included using water level changes to determine recharge credits, or the use of computer modeling to determine recharge credits.

The City initially contemplated using changes in water levels to manage recharge credits. However, based on their success with computer modeling in two interstate lawsuits, DWR decided that computer modeling would be the appropriate tool to administer the ASR project. Regulations were developed for the project (K.A.R. 5-12-1) requiring the use of computer modeling, and that the horizontal extent and a vertical extent of the basin storage area be defined to provide a reasonable means of calculating the potential storage.

The horizontal extent of the basin storage area was determined to be bounded by the Little Arkansas and Arkansas Rivers, and the expected areas of influence from both artificial recharge injection and recovery. This area was divided into 38 index cells, as shown in Figure 1. An

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index well was to be installed in each index cell as a water level monitoring point for regulatory purposes.

The vertical extent of the basin storage area was chosen based on historic high water levels at predevelopment (1940) in each of the 38 index cells, and was further limited in areas where protection for underground structures was a priority. The bottom of the basin storage area was calculated by the United States Geological Survey (USGS) using interpolation of water levels from a year of historic lows (January 1993) for each of the index cells.

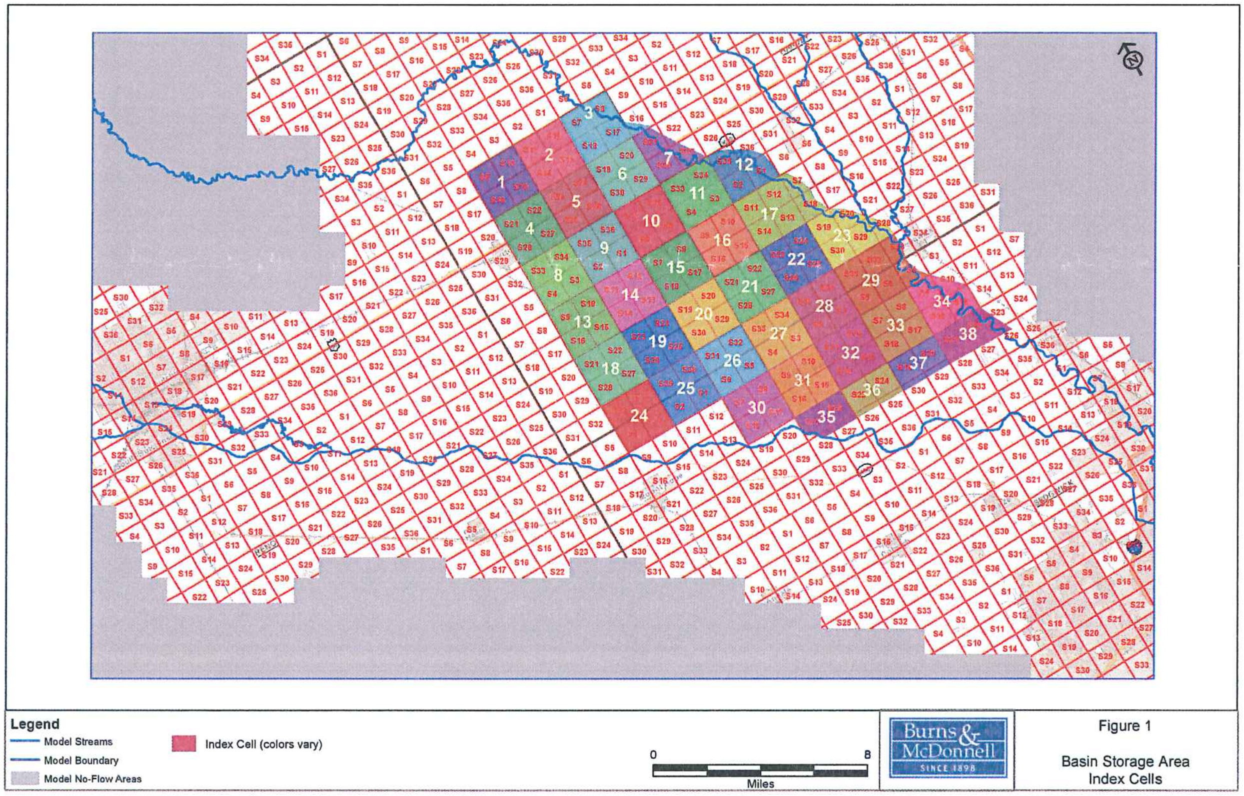


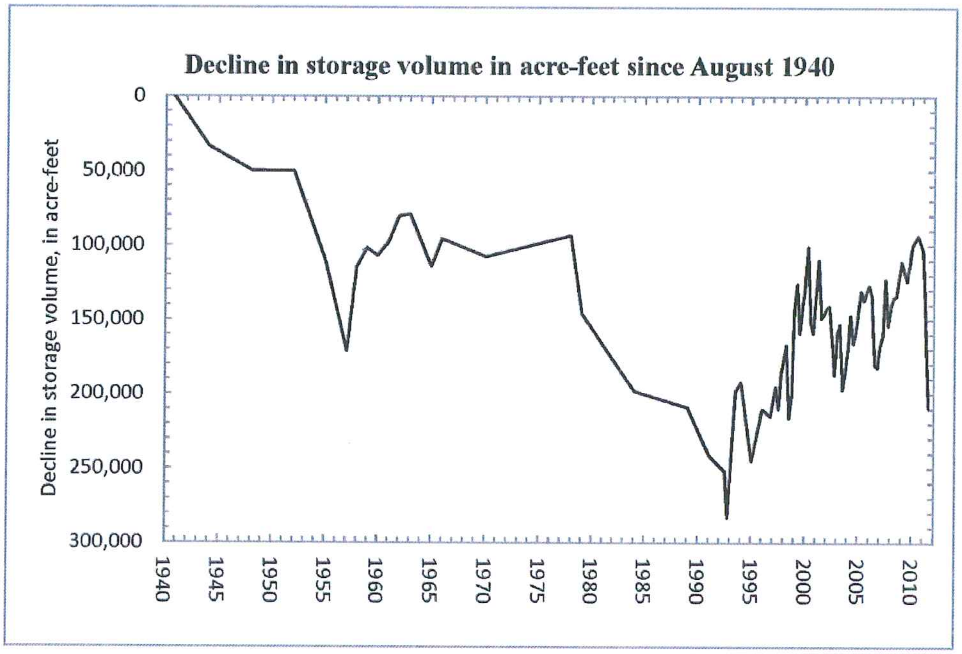
Figure 1
Basin Storage Area Index Cells

During the discussion and approval process for the Phase I ASR applications, DWR staff and the City agreed that using the 1993 levels as the bottom of the basin storage area was a reasonable and conservative number at the time. This decision was partially based on the fact that water levels could have been much lower in years after 1993 if the City had not made the unilateral decision to temporarily reduce water use from the Equus Beds Aquifer (Equus Beds). Thus the total storage volume was estimated based on historic "high" or predevelopment water levels and the 1993 water levels as estimated by USGS. It should be noted that the established 1993 water levels are under review by USGS, DWR and GMD2.

In 1993, the City began to implement various components of the City's Integrated Local Water Supply Plan(ILWSP). This included using more water from Cheney Reservoir and reducing withdrawals from the Equus Beds. The USGS estimated that by January of 1993 the aquifer in the area surrounding the basin storage area had lost 255,000 acre-feet from predevelopment storage volume (1940). Thus 225,000 acre-feet represents the approximate storage capacity within the recharge basin as defined by the established upper and lower limits. As part of the

ILWSP strategy the City reduced its withdrawals from the Equus Beds by nearly 50% from typical annual quantities produced prior to 1993.

Due to the significant change in water use strategy by the City in 1993, the USGS estimated that about 60,000 acre-feet of water had been restored to the Equus Beds in the basin storage area by 2003. By January of 2009 the project area had recovered 144,000 acre feet, or about 56 percent of the losses that occurred between 1940 and 1993. The average cumulative water-level change from October 1992 to January 2010 was a rise of approximately8.7 feet. Shown below is a copy of a water storage graph for the project area as prepared by the USGS.



When the water appropriations were issued by DWR in July of 2005 for Phase I of the ASR project, the Findings and Orders of the Chief Engineer fully described how recharge credits were to be administered. Within the Findings and Orders for Phase I, Conclusion No. 13 specifically addressed the availability of recharge credit withdrawal in relation to the index water levels and the bottom of the basin storage area

ASR Phase I Conclusion No. 13 - *"That if the project is operated so that recharge credits cannot be withdrawn if the static water level in the index well is below the lowest index water level for that index well, the public interest in not diverting Equus Beds groundwater will be protected."*

Additionally within the Findings and Orders for the Phase I ASR applications, Order No. 8 describes the availability of recharge credit withdrawal in relation to index water levels and the bottom of the basin storage area:

ASR Phase I Order No. 8 – *"That water shall only be injected into the basin storage area by means of the injection wells when the water level at any required monitoring well located within 660 feet of an injection well is 10 feet or more below the land surface elevation at those observation wells; that recharge credits may be withdrawn from a cell only when recharge*

credits are available from the cell and the static water level at its index well is above the lowest index level; however, water may be recharged when the static water level is below the lowest index level in that well."
The individual approval conditions for each recharge and recovery well also limited the withdrawal of recharge credits to periods when water levels remain above the lowest index water level in the appropriate cell (Permit Approval Condition No. 19):

Permit Approval Condition No. 19 – *"That the proposed recovery of water artificially recharged by the City shall only occur when recharge credits are determined to be available from the corresponding cell, and the static water level is above the elevation established as the lowest index water level in that corresponding cell."*

A primary purpose of Phase I of the ASR project was to begin the formation of a freshwater barrier to the salt water contamination moving towards the wellfield from the Burrton area. Both Conclusion No. 13 and Order No. 8, stem from the principle that withdrawal of recharge credits during periods when water levels are below those that existed in 1993 would not serve the public interest because it would deteriorate any established hydraulic barrier created from recharge injection. Therefore, the limitations to the recharge credit withdrawal relative to the lowest index water levels for Phase I (January 1993) were largely based on maintaining water quality in the City's well field with a hydraulic barrier. However, it should be noted that water levels in the barrier area can experience significant declines during dry or drought periods, even without the removal of recharge credited from ASR Phase 1 wells.

In 2009 the appropriations for the wells in Phase II of the ASR project were issued, and virtually duplicated the approval conditions covered in the Phase I appropriations. This included the individual limitation to withdraw recharge credits to periods when water levels are above the lowest index water level (January 1993).

Examination of the USGS storage chart indicates that during the recent drought, a concerning pattern is emerging. While the City has not increased its usage from the Equus Beds and continues to use only about 50% of its available water appropriations in the Equus Beds, water levels have still declined substantially since 2009. The recent declines can be attributed to the combination of drought (less recharge), and increased irrigation use within the basin storage area. This pattern indicates water levels in the basin storage area for both Phase I and Phase II are not solely dependent on the amount of water that the City utilizes, and that it is conceivable that water levels may return to the 1993 levels despite the fact that the City is only using part of its allocation in the area.

The recent water level changes demonstrate that it is appropriate to make modifications to the administration of the City's ASR project. It is now apparent that increased water use from irrigation users during drought conditions can cause significant declines in water levels not considered when the ASR appropriations were granted, and that the City should be in a position to recover available recharge credits even when water levels are below the 1993 index water levels.

Phase II of the ASR project was implemented with the goals of supply development, restoration of the Equus Beds as a resource, and to provide a sustainable water supply during periods of drought. While the City has been emphasizing surface waters since 1993, the City will be forced to rely on allocations from the basin storage area if surface water sources become depleted or unavailable. If irrigation use, or the City being forced to utilize more of its allocation, causes the index water levels to drop below the 1993 water levels, the recharge credits created by the City would not be available at a time when they are most needed.

The City is therefore requesting the DWR revise the individual water appropriations granted for Phase II of the ASR project to allow for the withdrawal of recharge credits when they are available, and remove the restrictions limiting recharge credit withdrawal when levels are below the 1993 index water level. This change will allow the City to operate Phase II of the ASR project as intended (storage for when other resources are limited). The storage capacity of the basin storage area will not change under the request, only the ability to recover recharge credits when they are available as determined by the ASR accounting and DWR authorization.

This request would be applied to water rights: #46,714 to #46,733, #47,178 to #47,181 and #47,448 to #47,453 as well as recharge credit recovery rights associated with ASR Phase 2 Municipal wells authorized by Files HV006, #388 and #1006.

The City would be willing to meet with your staff to provide any additional information that may be required to fully consider this request.

Respectfully,

Michael G. Jacobs, P.E.
Interim Water Resources Engineer

Relief from 1993 Levels Request 2013-05-21.docx

CITY OF WICHITA

Department of Public Works & Utilities

David Barfield, P.E.
Chief Engineer
Division of Water Resources
Kansas Department of Agriculture
109 SW 9th St.
Topeka, KS 66612-1283

February 11, 2014

RE: Requested Modification of K. A. R. 5-12-1 and to Conditions and Limitations on ASR Phase II Water Rights

Dear Mr. Barfield,

On December 9th 2013, The City of Wichita (City) met with Division of Water Resources (DWR) staff to discuss the various permit conditions and limitations of the City's Aquifer Storage and Recovery (ASR) project. Topics discussed included the regulations that define the methodology for establishing boundary conditions for ASR projects and; conditions within the ASR permits which limit the recovery of established recharge credits to times in which water table elevations are above the lowest historic aquifer levels which were recorded in January of 1993. As a result of these discussions the City of Wichita presents the following information and makes the following formal requests.

ASR Project Geometry:

Regulations were developed for the project (K.A.R. 5-12-1) requiring that the horizontal extent and vertical extent of the basin storage area be defined. The horizontal extent of the basin storage area was determined to be bounded by the Little Arkansas and Arkansas Rivers, and the expected areas of influence from both artificial recharge injection and recovery. This area was divided into 38 index cells, as shown in Figure 1. An index well was to be installed in each index cell as a water level monitoring point for regulatory purposes.

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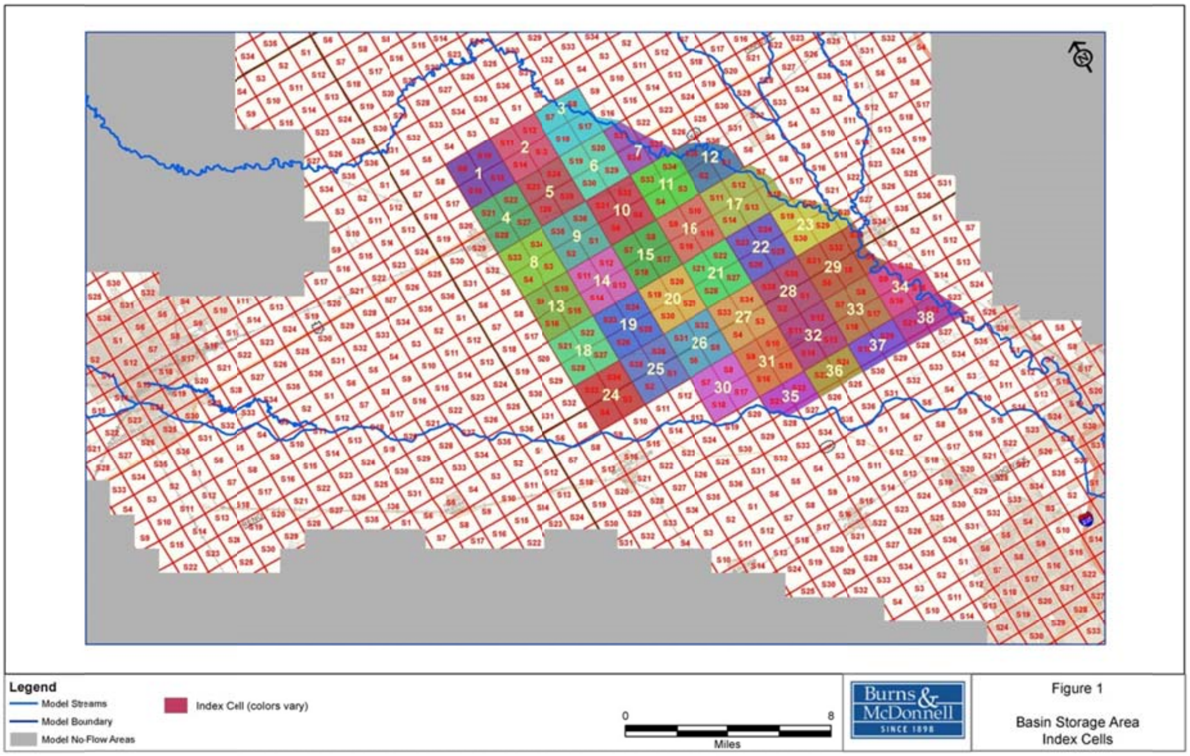

Figure 1

Basin Storage Area Index Cells

The upper vertical extent of the basin storage area was chosen based on historic high water levels associated with predevelopment (1940) conditions in each of the 38 index cells. The bottom of the basin storage area was calculated by the United States Geological Survey (USGS) using interpolation of water levels from a year of historically-low water levels (January 1993) for each of the index cells as defined within K. A. R. 5-12-1(b)(2).

K.A.R. 5-12-1(b)(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."*

Formal Request:

Based on the operation of the ASR system and previous discussions with DWR, it is requested that K. A. R. 5-12-1 be modified to allow the lower vertical extent of an artificial recharge project area to be better defined by the geologic limits of the storage area such as bedrock or other impermeable boundaries within the project area. Detailed well logs and elevations of bedrock are available for each of the 38 index cells. These well logs would allow for simple and accurate calculations of the lowest vertical extent of the storage area for each index cell. The original methodology used to calclate the maximum storage potential of an artificial recharge project should remain unchanged.

Recharge Credit Recovery:

When the water appropriations were issued by DWR in July of 2005 for Phase I of the ASR project, the Findings and Orders of the Chief Engineer described how recharge credits were to be administered. Within the Findings and Orders for Phase I, Conclusion No. 13 specifically addressed the availability of recharge credit withdrawal in relation to the index water levels and the bottom of the basin storage area

ASR Phase I Conclusion No. 13 - *"That if the project is operated so that recharge credits cannot be withdrawn if the static water level in the index well is below the lowest index water level for that index well, the public interest in not diverting Equus Beds groundwater will be protected."*

Additionally within the Findings and Orders for the Phase I ASR applications, Order No. 8 re-iterates the availability of recharge credits:

ASR Phase I Order No. 8 – *"That water shall only be injected into the basin storage area by means of the injection wells when the water level at any required monitoring well located within 660 feet of an injection well is 10 feet or more below the land surface elevation at those observation wells; that recharge credits may be withdrawn from a cell only when recharge credits are available from the cell and the static water level at its index well is above the lowest index level; however, water may be recharged when the static water level is below the lowest index level in that well."*

The individual approval conditions for each recharge and recovery well also limited the withdrawal of recharge credits to periods when water levels remain above the lowest index water level in the respective cell (Permit Approval Condition No. 19):

Permit Approval Condition No. 19 – *"That the proposed recovery of water artificially recharged by the City shall only occur when recharge credits are determined to be available from the corresponding cell, and the static water level is above the elevation established as the lowest index water level in that corresponding cell."*

A primary purpose of Phase I of the ASR project was to reduce the hydraulic gradient in the area and therefore slow the salt water contamination moving towards the wellfield from the Burrton area. Both Conclusion No. 13 and Order No. 8, stem from the principle that withdrawal of

recharge credits during periods when water levels are below those that existed in 1993 would not serve the public interest because it would deteriorate the hydraulic gradient established by recharge injection.
The limitations to the recharge credit withdrawal relative to the lowest index water levels for Phase I (January 1993) were largely based on maintaining water quality in the City's well field with a reduced hydraulic gradient. However, it should be noted that water levels in the area can experience significant declines during dry or drought periods, even without the removal of recharge credits from ASR Phase I wells.

In 2009 the appropriations for the wells in Phase II of the ASR project were issued, and virtually duplicated the approval conditions covered in the Phase I appropriations. These appropriations were applied to both existing well locations and proposed new recharge recovery well locations. This included the individual limitation to withdraw recharge credits to periods when water levels are above the lowest index water level (January 1993).

The historic decline in storage volumes within the EBWF area have been calculated by USGS and are illustrated in Figure 2. Examination of the declines in storage volume indicates that during the recent drought, a concerning pattern is emerging.

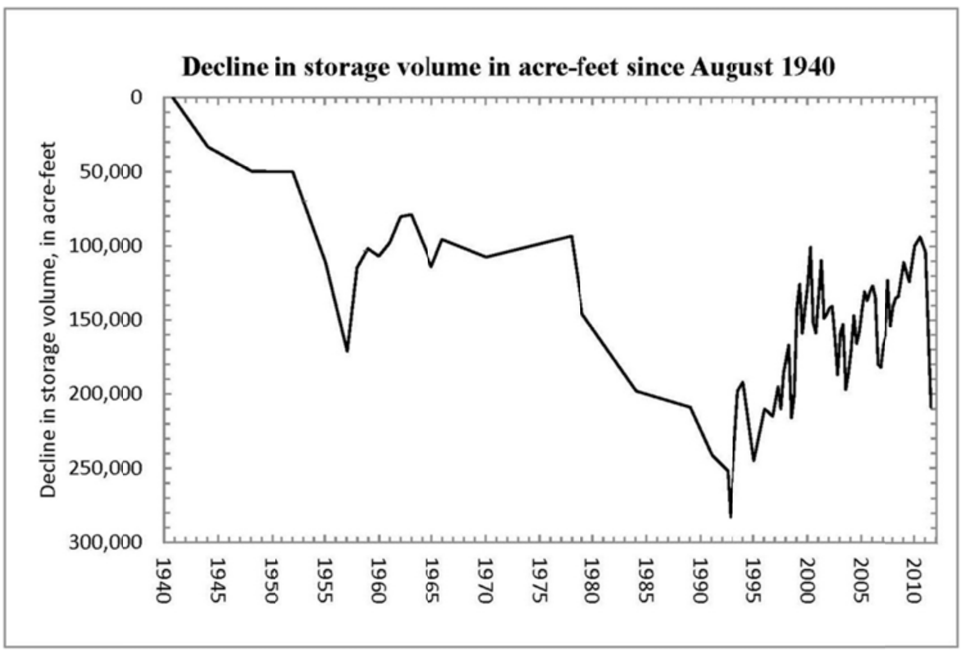

Figure 2

While the City has not increased its usage from the Equus Beds and continues to use only about 50% of its available water appropriations in the Equus Beds, water levels have still declined substantially since 2009. The recent declines can be attributed to the combination of drought (less recharge), and increased irrigation use within the basin storage area

This pattern indicates water levels in the basin storage area for both Phase I and Phase II are not solely dependent on the amount of water that the City utilizes, and that it is conceivable that water levels may rapidly return to the 1993 levels or below despite the fact that the City is only using part of its allocation in the area.

Formal Request:

The recent decline in water levels demonstrates that it is appropriate to make modifications to the administration of the City's ASR project. The City is therefore requesting that DWR revise the conditions associated with individual water appropriations granted for Phase II and future recharge/recovery appropriation permits for the ASR project to allow for the withdrawal of recharge credits when they are available, and remove the restrictions limiting recharge credit withdrawal when levels are below the 1993 index water level.

This change will allow the City to operate the ASR project as intended (established storage for times when other resources are limited). The storage capacity of the basin storage area will not change under the request, only the ability to recover recharge credits when they are available as determined by the ASR accounting and DWR authorization.

This request would be applied to water rights: #46,714 to #46,733, #47,178 to #47,181 and #47,448 to #47,453 as well as recharge credit recovery rights associated with ASR Phase II Municipal wells authorized by Files HV006, #388 and #1006 as well as future ASR applications. Modification of ASR Phase I water rights is not included as part of this request.

The City appreciates your consideration and would be happy to meet with your staff to provide any additional information that may be required to fully consider this request.

Respectfully,

Michael G. Jacobs, P.E.
City of Wichita
Public Works & Utilities
Water Planning and Production Manager

Doug Schemm
Division of Water Resources
Kansas Department of Agriculture
Building 282, Forbes Field
6531 SE Forbes Ave., Suite B
Topeka, KS 66619

October 10, 2014

RE: Requested Modification of K. A. R. 5-12-1 and to Conditions and Limitations on ASR Phase II Water Rights

Dear Mr. Schemm,

The City of Wichita respectfully requests an update in regard to the status of modifications listed above. The modifications were originally reqested in a letter dated February 11, 2014. Specific details related to and supporting the request are outlined within the letter. The formal requests are listed below and a copy of the letter is attached for your reference.

Formal Request:

Based on the operation of the ASR system and previous discussions with DWR, it is requested that K. A. R. 5-12-1 be modified to allow the lower vertical extent of an artificial recharge project area to be better defined by the geologic limits of the storage area such as bedrock or other impermeable boundaries within the project area. Detailed well logs and elevations of bedrock are available for each of the 38 index cells. These well logs would allow for simple and accurate calculations of the lowest vertical extent of the storage area for each index cell. The original methodology used to calclate the maximum storage potential of an artificial recharge project should remain unchanged.

Formal Request:

The recent decline in water levels demonstrates that it is appropriate to make modifications to the administration of the City's ASR project. The City is therefore requesting that DWR revise the conditions associated with individual water appropriations granted for Phase II and future recharge/recovery appropriation permits for the ASR project to allow for the withdrawal of recharge credits when they are available, and remove the restrictions limiting recharge credit withdrawal when levels are below the 1993 index water level.

The primary points of interest include clarification regarding the schedule and procedure for consideration of the outlined requests.

The City truly appreciates your consideration and looks forward to your response.

Respectfully,

Michael G. Jacobs, P.E.
City of Wichita
Public Works & Utilities
Water Planning and Production Manager

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Department of Public Works & Utilities

11/15/2016

Tim Boese
District Manager
Groundwater Management District No. 2
313 Spruce Street
Halstead, KS 67056

Re: ASR Permit Modifications - GMD2 Data Review and Coordination

Dear Mr. Boese:

The existing permit conditions for the City of Wichita's (City) ASR project define the lowest vertical extent of the basin storage area, and currently restrict recharge credit recovery to periods when water levels are above a specific lower index water level. The lowest index water levels for the basin storage area are currently established by the lowest historic water levels within the Equus Beds Wellfield (EBWF), which were recorded January of 1993. The State of Kansas Division of Water Resources (DWR) recently modified K.A.R 5-12-1 in acknowledgement that additional flexibility was needed in both existing and future ASR projects with respect to the defined bottom of the basin storage area.

The City has now identified that ASR recharge credits would not be available, especially under high aquifer demand scenarios where the City and other users would have to utilize consecutive years of full base water rights in the EBWF to meet demands. This finding inherently requires the City to evaluate a reasonable alternative lower vertical extent for the existing ASR basin storage area that ensures recharge credits are available throughout periods of high aquifer demand.

The City and GMD2 have been working collaboratively to examine and project the impacts to groundwater levels in the EBWF and ASR basin storage area during consecutive years of drought and high aquifer demand and how, based on the current lowest index water levels permitted for the project, the decreased groundwater levels will affect the City's ability to access recharge credits when they are needed most.

The aquifer model presented in USGS Scientific Investigations Report 2013-5042 has been utilized to represent the response of the Equus Beds aquifer during an eight-year drought. The aquifer has been assumed to start the modeled drought relatively full, emulating its condition in January 2011. Environmental parameters and reported water use from the drought conditions of 2011 and 2012 were utilized to represent stresses on the aquifer. Pumping from the aquifer by City of Wichita wells was modeled in three ways: full use of our vested water right, use of ASR recharge credits above the 1993 water levels only, and use of ASR recharge credits later in the drought. Model inputs are presented in Attachment A.

Several demonstrative figures have been prepared, and have been attached for your review. These present a comparison between the modeled results and the aquifer conditions that existed in early 1993. Attachments B & C represent the extent and magnitude to which the modeled post-drought conditions indicate the depth to water in the Basin Storage Area

CITY OF WICHITA

Department of Public Works & Utilities

will be below the USGS-interpolated 1993 water level. Model results for use of ASR recharge credits under current regulations (Attachment B) indicate a significant depletion of the aquifer below the 1993 levels. Model results allowing use of ASR credits only when needed to satisfy City demand later in the drought (Attachment C) indicate a reduction in the magnitude and extent of aquifer depletion. A direct comparison of the model runs for existing and modified ASR regulations (Attachment D) illustrates the positive impact to the aquifer under modified regulations by facilitating judicious and flexible ASR credit use. The potential simulated water level increases between existing and modified ASR regulations are further illustrated by comparing the resultant modeled water level elevations at the geographic location for each index well (Attachment E).

In order to maintain progress in establishing and describing the requisites for modification to the City's existing ASR permits, the City of Wichita is providing the results of recent groundwater modeling efforts that reproduce and provide further refinement of previously presented information and assertions. These include the following hard copy and electronic file resources:

1. Input Files for the following runs of the USGS Equus Beds MODFLOW model (Electronic File Submission)
   a. Run 1 - Base Line Scenario, utilizing 40,000 Acre-Feet throughout drought
   b. Run 2 - ASR Current Regulation Credit Utilization and Availability scenario
   c. Run 3 - ASR Modified Regulation Credit Utilization and Availability scenario
2. Model Input Table illustrating pumping and hydrologic stress components (Attachment A)
3. Spreadsheets providing summaries of pumping data including annual City Water Rights, ASR Credits, Agricultural use, and Industrial use by type, year, and quantity breakdown according to DWR provided data (Electronic File Submission)
4. Output files for the following runs of the USGS Equus Beds MODFLOW model (Electronic File Submission)
   a. Run 1 - Base Line Scenario, utilizing 40,000 Acre-Feet throughout drought
   b. Run 2 - ASR Current Regulation Credit Utilization and Availability scenario
   c. Run 3 - ASR Modified Regulation Credit Utilization and Availability scenario
5. Spreadsheets and tables illustrating ASR credit unavailability during progressive years of drought and various aquifer demands for each model run (Electronic File Submission)
6. Post Processing Figures
   a. Comparison of Model Run 2 ASR Current Regulation Credit Utilization and Availability results to original USGS interpolated 1993 water level raster (Attachment B)
   b. Comparison of Model Run 3 Modified Current Regulation Credit Utilization and Availability results to original USGS interpolated 1993 water level raster (Attachment C)
   c. Comparison of Model Run 3 to Model Run 2 results illustrating improvement in water levels from added ASR credit availability and utilization flexibility (Attachment D)
   d. Comparison of index well water levels between existing and modified ASR regulations (Attachment E)

Office of the Director

City Hall • Eighth Floor • 455 North Main • Wichita, Kansas 67202-1606

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The City requests that GMD2 provide a documented response detailing the District's concurrence in regards to the provided groundwater modeling results by no later than December 15th of 2016.

Sincerely,

Alan King
Director of Public Works & Utilities

Enclosure **<u>Groundwater Modeling Files & Results</u>**

cc: David Barfield, P.E., Chief Engineer
Lane LeTourneau, P.G., Water Appropriation Program Manager
Joseph T. Pajor, Deputy Director, Public Works & Utilities
Don Henry, Assistant Director, Public Works & Utilities
Daniel Clement, Burns & McDonnell
Brian Meier, Burns & McDonnell
Scott Macey, Assistant Division Manager, Public Works & Utilities

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Base Line Scenario - EQUUS BEDS USGS MODFLOW Model Run No. 1

Initial Aquifer Conditions *Modeled Jan 2011*

Drought Year	Year1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
City Demand Equus Base	20941	20745	40000	40000	40000	40000	40000	40000
ASR Credits Used	0	0	0	0	0	0	0	0
Total Equus	20941	20745	40000	40000	40000	40000	40000	40000
City Demand Cheney	52688	51339	23823	32225	23823	23823	32084	29943
City Demand Total	73629	72084	63823	72225	63823	63823	72084	69943
Irrigation Demand	2011 Reported Use	2012 Reported Use	2011 Reported Use	2011 Reported Use	2012 Reported Use	2011 Reported Use	2011 Reported Use	2012 Reported Use
Climate Data	2011	2012	2011	2012	2011	2012	2011	2012
River Data	2011	2012	2011	2012	2011	2012	2011	2012

ASR Current Regulations - Equus Beds USGS MODFLOW Model Run No. 2

Initial Aquifer Conditions *Modeled Jan 2011*

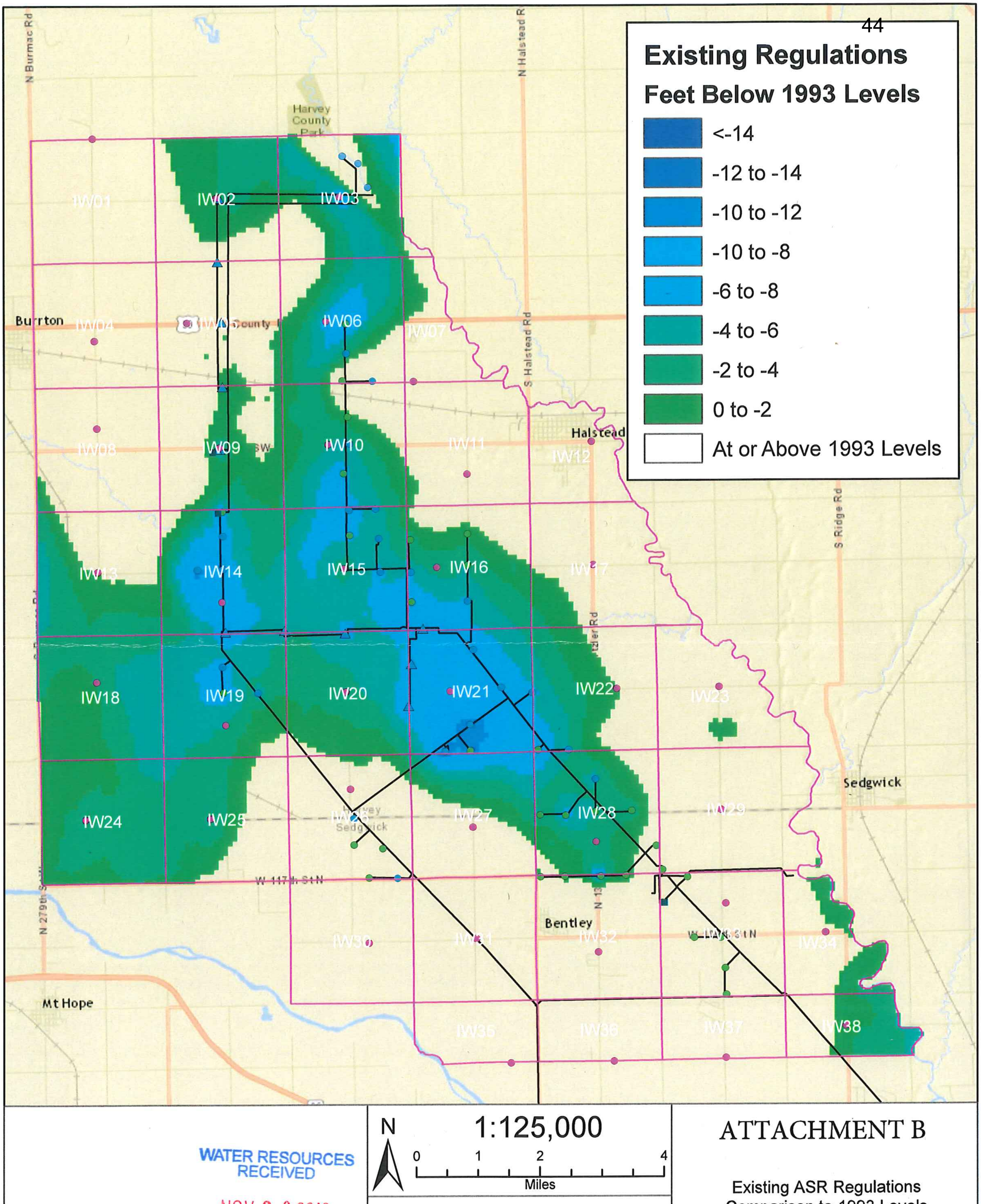
Drought Year	Year1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
City Demand Equus Base	20941	20745	40000	40000	40000	40000	40000	40000
ASR Credits Used	0	0	18500	17500	10500	8500	5000	5000
Total Equus	20941	20745	58500	57500	50500	48500	45000	45000
City Demand Cheney	52688	51339	5323	14725	13323	15323	27084	24943
City Demand Total	73629	72084	63823	72225	63823	63823	72084	69943
Irrigation Demand	2011 Reported Use	2012 Reported Use	2011 Reported Use	2011 Reported Use	2012 Reported Use	2011 Reported Use	2011 Reported Use	2012 Reported Use
Climate Data	2011	2012	2011	2012	2011	2012	2011	2012
River Data	2011	2012	2011	2012	2011	2012	2011	2012

ASR Modified Regulations - Equus Beds USGS MODFLOW Model Run No. 3

Initial Aquifer Conditions *Modeled Jan 2011*

Drought Year	Year1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
City Demand Equus Base	20941	20745	40000	40000	40000	40000	40000	40000
ASR Credits Used	0	0	0	0	0	0	0	4351
Total Equus	20941	20745	40000	40000	40000	40000	40000	44351
City Demand Cheney	52688	51339	23823	32225	23823	23823	32084	25592
City Demand Total	73629	72084	63823	72225	63823	63823	72084	69943
Irrigation Demand	2011 Reported Use	2012 Reported Use	2011 Reported Use	2011 Reported Use	2012 Reported Use	2011 Reported Use	2011 Reported Use	2012 Reported Use
Climate Data	2011	2012	2011	2012	2011	2012	2011	2012
River Data	2011	2012	2011	2012	2011	2012	2011	2012

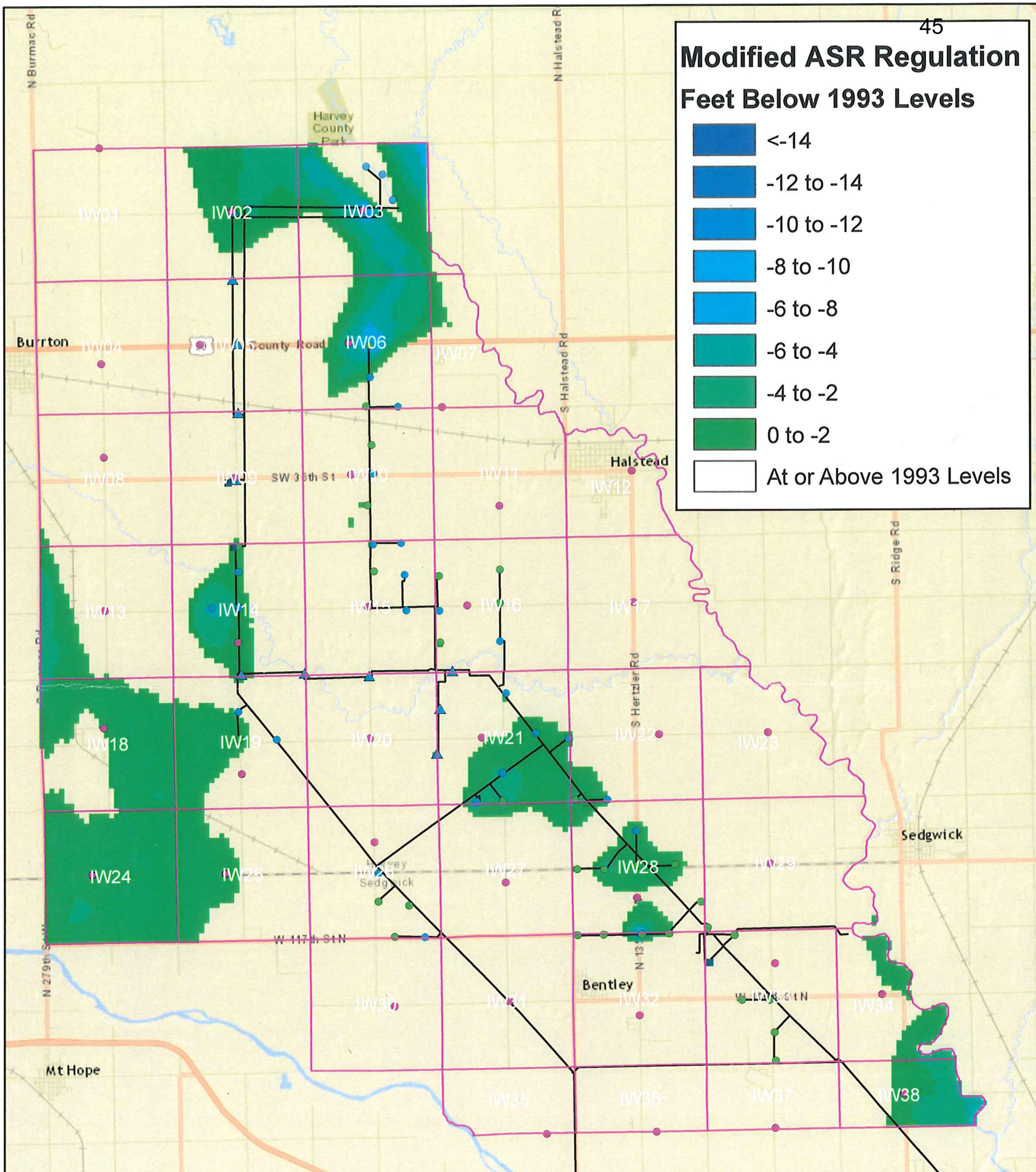
ATTACHMENT A



BURNS McDONNELL

ATTACHMENT B

Existing ASR Regulations
Comparison to 1993 Levels
Ending Conditions of Drought



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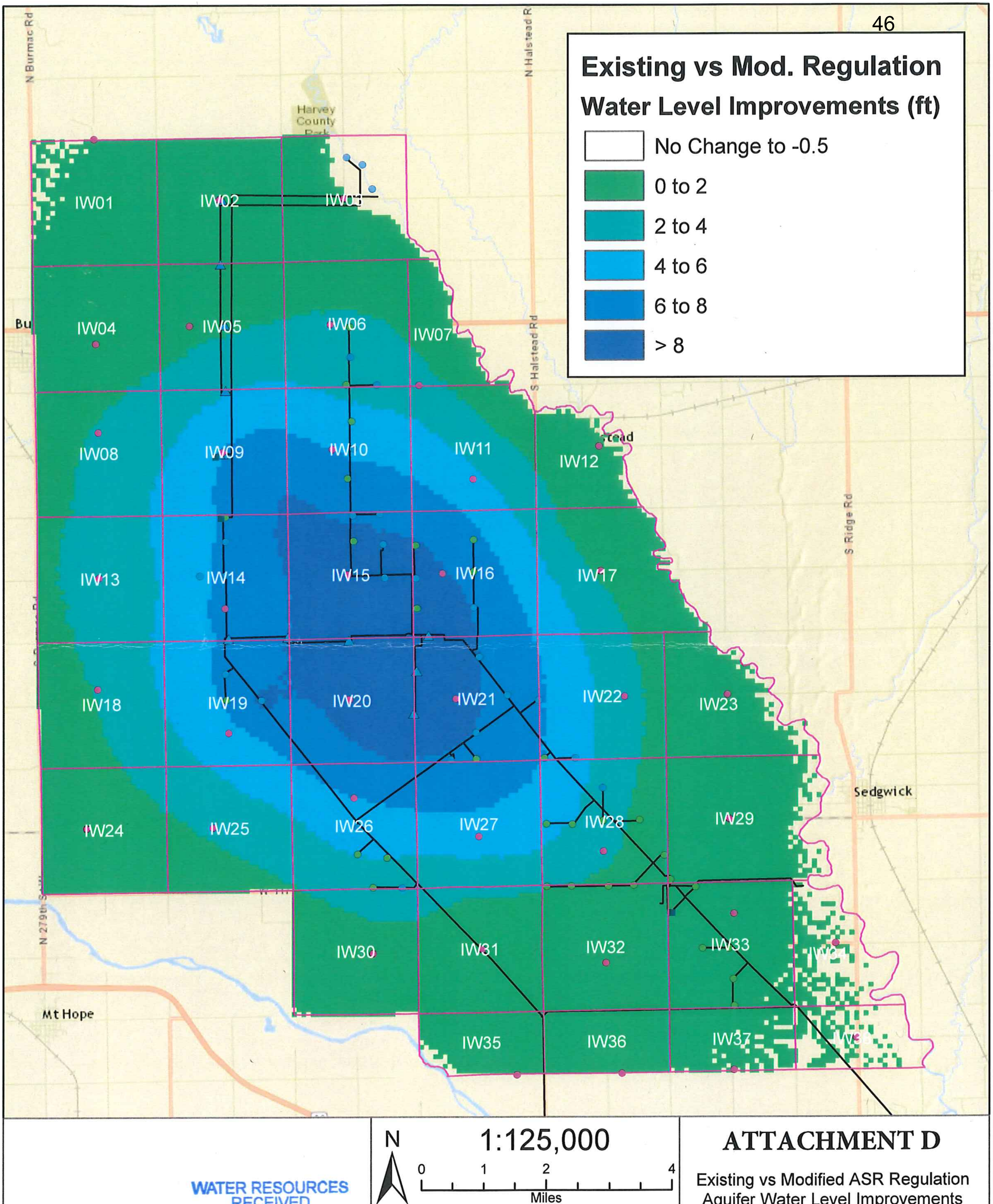
BURNS McDONNELL

ATTACHMENT C

Modified ASR Regulations to 1993 Levels Comparison Ending of Simulated Drought



BURNS McDONNELL

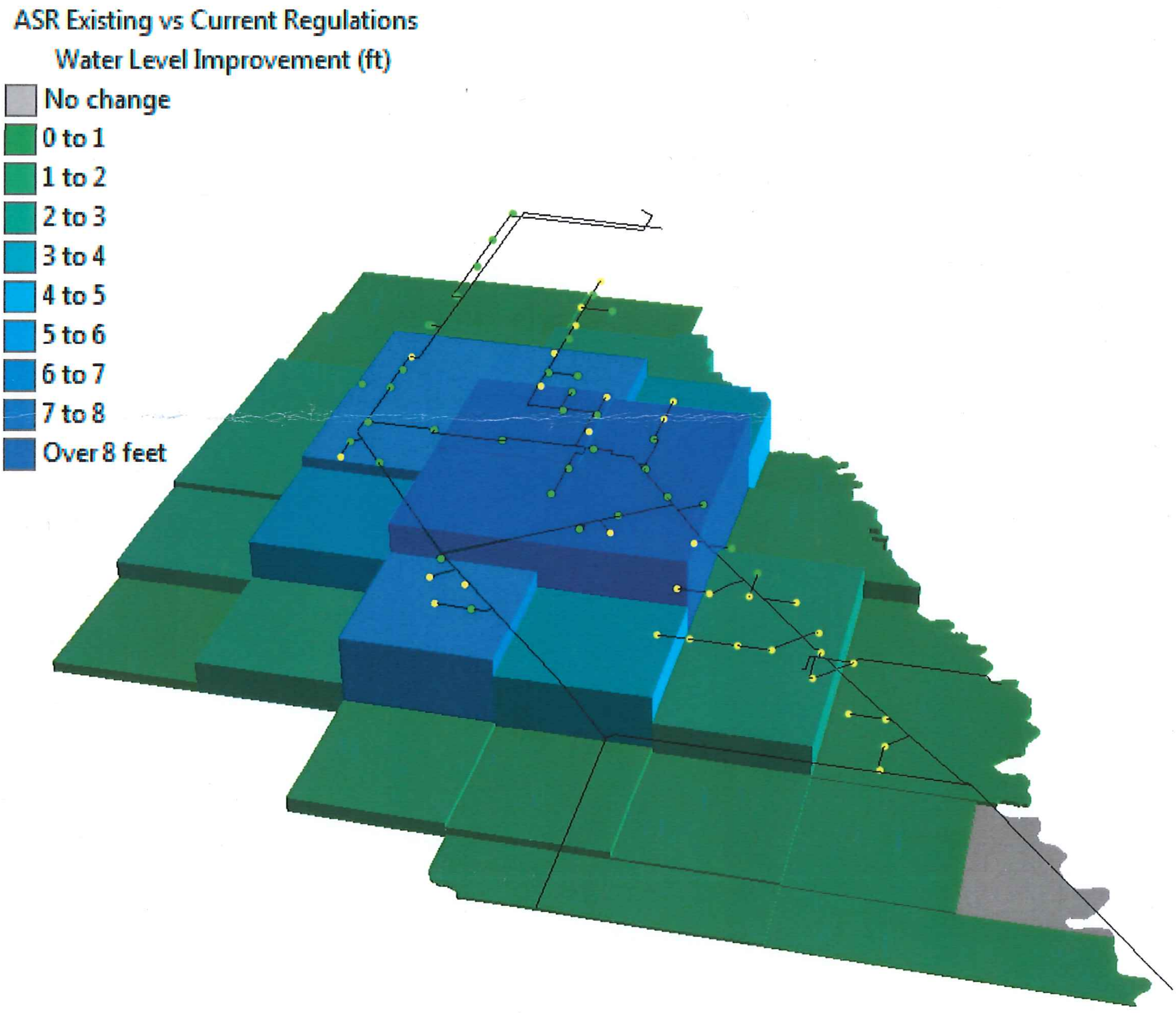
ATTACHMENT D

Existing vs Modified ASR Regulation
Aquifer Water Level Improvements
Under Modified ASR Index
Cell Lower Elevations

ATTACHMENT E

Water Level Improvements by Index Well

Under Modified ASR Credit Recovery Regulations



and higher precipitation leading to more recharge of the aquifer (about 41.3 inches of precipitation in 2015 compared to about 27.7 inches in 2014, with a 30-year average precipitation of 32.7 inches across the study area) (National Oceanic and Atmospheric Administration, 2016b). There was also an increased volume of artificially recharged water in 2015. The ASR project recharged about 1,770 acre-ft in 2015 compared to about 950 acre-ft in 2014 (U.S. Geological Survey, 2016a). The January 2016 storage volume in the study area was about 74,000 acre-ft less than the predevelopment storage volume. The storage-volume increase since the historic low of 1993 was about 121,000 acre-ft, a 62-percent recovery of the storage lost from predevelopment to 1993 (table 1, figs. 6–9).

Table 1. Storage-volume changes in the *Equus Beds* aquifer near Wichita, Kansas, since predevelopment (pre 1940) and since 1993 to January 2016 for the study area, the basin storage area, and the central Wichita well field area.

[--, not applicable]

End of time period	Storage-volume changes	
	Since predevelopment (acre-feet)	Since 1993 (acre-feet)
Study area		
1993	[1]-195,000	--
January 2012	[1]-125,000	[2]70,000
July 2012	[1]-175,000	[2]20,000
January 2013	[1]-154,000	[2]41,000
January 2014	[1]-116,000	[2]79,000
January 2015	[1]-135,000	[1]60,000
January 2016	-74,000	121,000
Basin storage area		
1993	[1]-188,000	--
January 2012	[1]-112,000	[2]76,000
July 2012	[1]-155,000	[2]33,000
January 2013	[1]-134,000	[2]54,000
January 2014	[1]-108,000	[2]80,000
January 2015	[1]-119,000	[1]69,000
January 2016	-68,000	120,000
Central Wichita well field area		
1993	[1]-121,000	--
January 2012	[1]-59,000	[2]62,000
July 2012	[1]-74,000	[2]47,000
January 2013	[1]-69,000	[2]52,000
January 2014	[1]-63,000	[2]58,000
January 2015	[1]-65,000	[1]56,000
January 2016	-41,000	80,000

[1]Storage-volume change previously reported in Whisnant and others (2015).

[2]Storage-volume change previously reported in Hansen and others (2014).

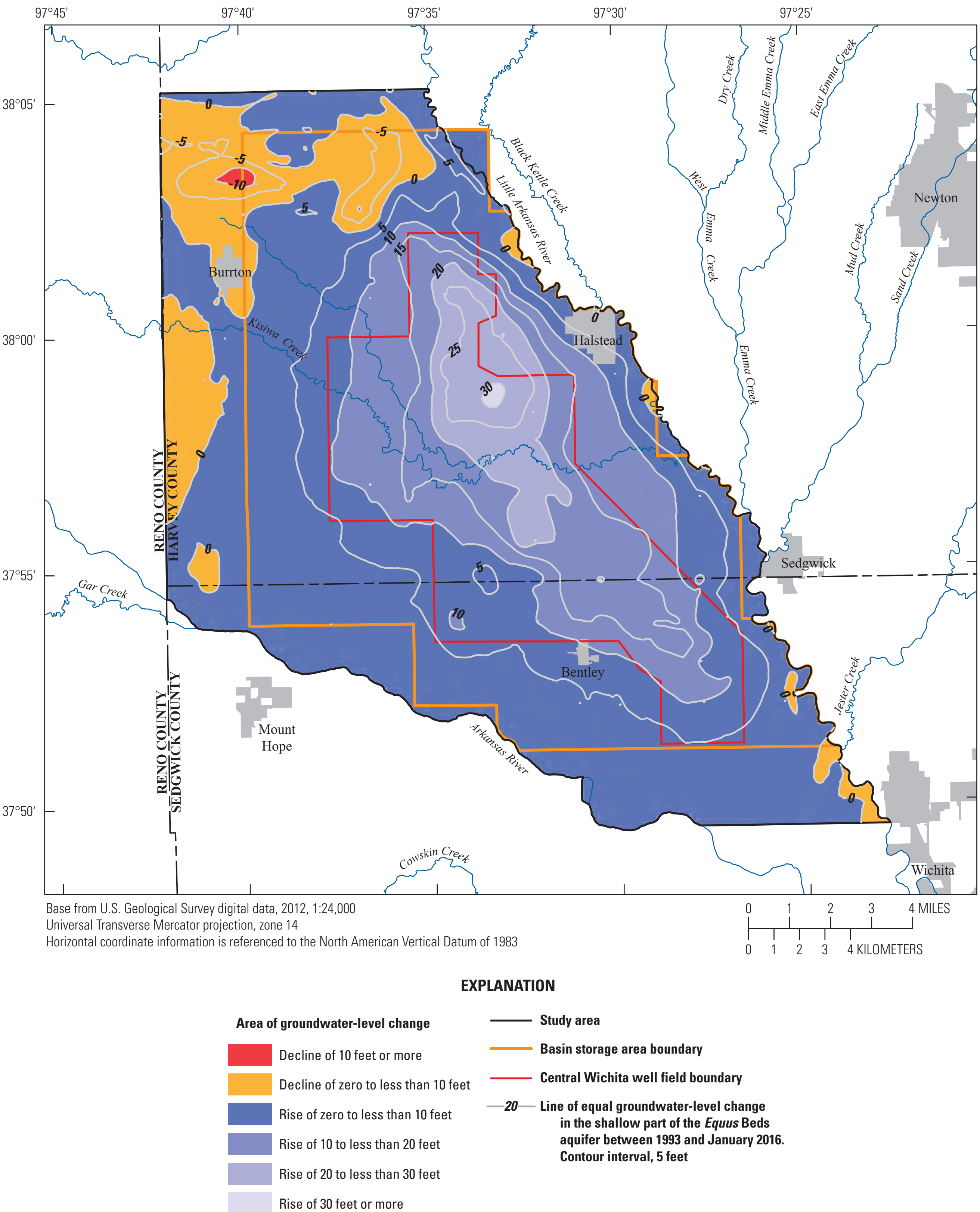


Figure 8. Groundwater-level changes in the shallow part of the *Equus* Beds aquifer in and around the Wichita well field in south-central Kansas between 1993 and January 2016.

Table 2. Average groundwater-level changes, storage-volume changes, and total aquifer storage volume in the *Equus* Beds aquifer for various study areas near Wichita, south-central Kansas, predevelopment to January 2015.

[Predevelopment is defined as before substantial pumpage began in the area. 1993 is defined as historic low water levels. --, not applicable; <, less than]

Area (figs. 1, 4, and 6)	End of time period	Average water-level change (feet)						Total aquifer storage volume (acre-feet)	Storage-volume changes				Storage-volume change since 1993 as a proportion of storage-volume change from predevelopment to 1993 (percent)	Percent of total aquifer storage volume
		Since predevelopment			Since 1993				Since predevelopment (acre-feet)	Since 1993				
		Measured	Measured and interpolated	Raster[1]	Measured	Measured and interpolated	Raster[2]			Subtraction[3] (acre-feet)	Raster[4] (acre-feet)	Difference between subtraction and raster as a proportion of subtraction (percent)		
Shallow part of the *Equus* Beds aquifer														
Study area														
	Predevelopment	--	--	--	--	--	--	[3]3,192,000	--	--	--	--	--	100
	1993	-20.99	-19.45	-10.77	--	--	--	--	-195,000	--	--	--	--	94
	January 2012	-11.42	-10.58	-6.89	5.43	5.12	3.88	--	-125,000	70,000	70,100	<1	36	96
	July 2012	-11.93	-11.99	-9.66	3.11	4.43	1.11	--	-175,000	20,000	20,100	<1	10	95
	January 2013	-12.29	-10.50	-8.50	3.04	4.79	2.26	--	-154,000	41,000	41,000	0	21	95
	January 2014	-12.63	-9.38	-6.41	7.80	7.77	4.37	--	-116,000	79,000	78,900	<1	40	96
	January 2015	-10.85	-9.23	-7.43	6.03	6.93	3.30	--	-135,000	60,000	59,800	<1	31	96
Basin storage area														
	Predevelopment	--	--	--	--	--	--	[3]2,400,000	--	--	--	--	--	100
	1993	-25.87	-19.66	-14.08	--	--	--	--	-188,000	--	--	--	--	92
	January 2012	-14.01	-10.90	-8.44	6.20	8.37	5.58	--	-112,000	76,000	75,200	<2	40	95
	July 2012	-14.68	-12.52	-11.64	3.50	5.00	2.39	--	-155,000	33,000	32,200	<3	18	94
	January 2013	-15.84	-11.51	-10.04	3.74	5.69	4.01	--	-134,000	54,000	54,000	0	29	94
	January 2014	-15.32	-10.30	-8.18	8.62	8.58	5.89	--	-108,000	80,000	79,400	<1	43	96
	January 2015	-13.18	-11.31	-8.92	7.13	7.85	5.10	--	-119,000	69,000	67,900	<2	37	95
Central part of the study area														
	Predevelopment	--	--	--	--	--	--	[3]1,025,000	--	--	--	--	--	100
	1993	-31.01	-24.18	-23.04	--	--	--	--	-121,000	--	--	--	--	88
	January 2012	-15.51	-12.56	-11.20	10.74	6.64	11.84	--	-59,000	62,000	62,000	0	51	94
	July 2012	-17.07	-13.41	-14.13	9.00	10.30	8.91	--	-74,000	47,000	46,700	<1	39	93
	January 2013	-17.52	-13.07	-13.19	7.95	10.18	9.85	--	-69,000	52,000	51,600	<1	43	93
	January 2014	-16.35	-12.76	-12.10	12.18	12.09	10.94	--	-63,000	58,000	57,300	<2	48	94
	January 2015	-14.67	-12.92	-12.36	10.65	11.73	10.54	--	-65,000	56,000	55,200	<2	46	94

Figure 14 - Example ASR Operations Plan
Based on 2016 City of Wichita Groundwater Level Measurements

Recharge Well Name	Static Groundwater Level Measured Below Top of Well Casing January 2016	Static Groundwater Elevation Measured January 2016	Maximum Groundwater Elevation at 10' Below Ground Surface	Water Column Available for Recharge	Sustainable Specific Injectivity	Maximum Calculated Sustainable Recharge Rate	Maximum Well Infrastructure Recharge Rate	Minimum Well Infrastructure Recharge Rate	Available Physical Recharge Capacity
	(feet)	(feet)	(feet)	(feet)	gpm/ft	gpm	gpm	gpm	gpm
MR02 (MK61)	37.60	1396.90	1420.3	23.40	5	117	1,000	125	0
MR04 (MK80)	37.69	1393.97	1418.42	24.45	8	196	1,000	125	196
MR06 (MK62)	34.45	1401.45	1421.7	20.25	8	162	1,200	150	162
MR08 (MK63)	28.61	1397.19	1411.6	14.41	12	173	1,100	150	173
MR10 (MK56)	29.96	1395.94	1411.7	15.76	8	126	1,000	125	126
MR11 (MK11)	28.96	1393.84	1409.65	15.81	8	126	700	150	0
MR13 (MK57)	23.30	1395.9	1405.1	9.20	15	138	1,200	250	0
MR14 (MK14)	29.00	1390.2	1405.51	15.31	11	168	800	225	0
MR18 (MK64)	23.04	1384.99	1390.7	5.71	10	57	1,000	150	0
MR19 (MK19)	25.16	1378.72	1391.68	12.96	7	91	350	150	0
MR20 (MK65)	25.00	1376.2	1384.4	8.20	7	57	1,200	150	0
MR22 (MK66)	25.41	1371.79	1381.1	9.31	6	56	700	150	0
MR23 (MK67)	27.60	1368.6	1377	8.40	7	59	700	100	0
MR26 (MK58)	23.89	1382.57	1391.3	8.73	13	113	1,200	150	0
MR42 (MK68)	26.54	1404.72	1416.4	11.68	6	70	700	100	0
MR43 (MK69)	18.67	1412.59	1414.1	1.51	8	12	700	100	0
MR44 (MK70)	16.20	1415.06	1415	0.00	7	0	625	50	0
MR45 (MK71)	17.34	1409.46	1412.6	3.14	14	44	400	125	0
MR47 (MK60)	17.88	1405.82	1409.5	3.68	5	18	500	50	0
MR48 (MK59)	25.94	1383.76	1395.5	11.74	10	117	1,100	175	0
MR50 (MK50)	24.94	1385.24	1398.25	13.01	4	52	325	250	0
MR51 (MK51)	20.37	1391.13	1399.34	8.21	4	33	200	100	0
MR55 (MK73)	15.31	1391.89	1393	1.11	30	33	1,200	225	0
MR56 (MK74)	15.96	1410.24	1412	1.76	13	23	525	75	0
MR57 (MK75)	25.62	1398.08	1409.5	11.42	4	46	500	50	0
MR58 (MK76)	23.98	1394.65	1402.6	7.95	12	95	1,200	125	0
MR59 (MK77)	24.74	1388.97	1396.6	7.63	7	53	650	100	0
MR60 (MK78)	32.27	1389.93	1408	18.07	9	163	1,200	150	163
MR61 (MK79)	25.02	1389.62	1399.9	10.28	11	113	1,000	150	0
					Total (GPM)	**2,513**	**23,975**	**3,975**	**819**
					Total (MGD)	**3.62**	**34.52**	**5.72**	**1.18**

3.3 Benefits of ASR Aquifer Maintenance Credits (AMCs)

To continue to incentivize groundwater conservation and to address the challenges of establishing physical recharge credits in an aquifer that has recovered to levels near pre-development, the City is proposing an alternative procedure for establishing recharge credits during periods of high groundwater levels. In-lieu of implementing a pumping strategy to increase the storage capacity within the EBWF, the quantity of water diverted from the Little Arkansas River that cannot be physically recharged through the ASR system could be sent to the City's main water treatment plant to directly meet City water demands. The capture and use of transient surface water in the Little Arkansas River directly offsets groundwater that would have been pumped to meet daily demand and to create physical ASR recharge capacity. The City is proposing that the water left in storage because of utilizing Little Arkansas River flows be considered a ASR Aquifer Maintenance Credit (AMC) with similar characteristics to the current ASR recharge credits.

The availability of water in the Little Ark River for diversion would remain identical to the base flow and seasonal limits developed as part of the ASR Phase 1 and Phase 2 permitting process. The Little Arkansas River water that cannot be physically recharged using the ASR system would be put to a beneficial use by transmission to the City for treatment and distribution. Use of this water directly replaces diversions that would otherwise be required from the EBWF resulting in an equal amount of groundwater effectively left in storage to the benefit of all aquifer users.

3.4 Proposed AMC Permit Conditions

The City's ASR system facilitates a unique physical link between surface water flows in the Little Arkansas River and groundwater storage in the EBWF. Direct diversions of above-baseflow water from the Little Arkansas River to the City to meet daily demands during periods of limited physical ASR recharge capacity directly offsets diversions from the EBWF. This effectively leaves groundwater in storage within the EBWF. Direct diversions to the City of above-baseflow water from the Little Arkansas River to meet daily demands during periods of limited physical ASR recharge capacity would result in the generation of an AMC in an amount established by the proposed accounting process discussed later within this proposal. The water diverted from the Little Arkansas River may be used for direct aquifer recharge, diverted to the City for treatment and distribution, or both depending on the condition of the aquifer. The City will continue to maintain an ASR operational priority focused on development of physical recharge credits when and where groundwater levels are at elevations that facilitate physical recharge capacity. The following list represents the key components and generally anticipated permit conditions that would guide the operations and accounting of AMCs:

1. Physical recharge activities will continue to occur during periods when aquifer conditions facilitate adequate physical recharge capacity defined by an annual ASR Operations Plan.
2. The rate of accrual of all recharge credits cannot exceed the constructed physical diversion capacity of the ASR system including direct surface water diversions and future bank storage wells, and will be limited to the rate and quantity authorized by Water Right No. 46627.
3. ASR Phase I RRW's are not eligible to receive AMCs, only physical recharge at Phase I RRW's or recharge basins will result in the development of an ASR recharge credit.
4. The estimated aquifer storage volume in the CWSA during initial implementation of the ILWSP by the City and during the conceptual development of the ASR program is estimated at 120,000 AF (see Attachment H, page 13) therefore the combined total quantity of AMCs and physical recharge credits cannot exceed 120,000 AF. The proposed 120,000 AF limit on the combined total quantity of AMCs and physical recharge credits represents an estimated 11.7% of total available aquifer storage within the CWSA
5. The fundamental differences between the processes used to generate physical recharge credits and AMCs will require an alternative or modified accounting process for AMCs.
6. AMCs would be accumulated based on the metered quantity of water diverted from the Little Arkansas River via direct surface water diversions or water captured via bank storage wells and sent directly to the City.
7. A straight-forward spreadsheet accounting process will be adopted similar to other existing water management conservation programs in the State.
    a. A uniform and equal annual distribution throughout the EBWF to all authorized City points of diversion within the EBWF based on the annual quantity of water diverted from the Little Arkansas River sent directly to the Wichita MWTP.
    b. Uniform distribution of AMCs to all authorized City points of diversion within the wellfield reasonably reflects historic wellfield operations at locations where groundwater has effectively been left in storage within the aquifer due to the development and utilization of Little Arkansas River flows.
    c. After distribution and assignment of AMC quantities by point of diversion, an acceptable AMC accounting process will track the quantity of AMCs stored within each Index Cell.

3.5 ASR Physical Recharge & ASR Operations Plan

To illustrate the City's commitment to conducting physical recharge activities during periods when the aquifer permits physical recharge capacity, the City is proposing the use of an annual ASR Operations

CITY OF WICHITA

Department of Public Works & Utilities

May 22, 2018

David Barfield
Chief Engineer
Kansas Department of Agriculture
Division of Water Resources
1320 Research Park Drive
Manhattan, Kansas 66502

RE: City of Wichita Aquifer Storage and Recovery (ASR) Permit Modification Proposal

Dear Mr. Barfield:

On March 12, 2018, the City of Wichita (City) submitted "ASR Permit Modification Proposal Revised Minimum Index Levels & Aquifer Maintenance Credits" for your consideration. Prior to and following that submission the City conducted an informal engagement process with interested parties. Information received prior to the submission of the document helped inform the proposed conditions under which certain changes could be made to allow the City's ASR project to better provide drought resilience for the City's utility customers. This letter provides additional clarifications to our proposal based on the remainder of the informal engagement process.

With this submittal, the City considers the informal engagement to be completed and that it is time for the formal process you have recommended to begin. Time is of the essence to the City as we seek to improve the position of the largest water utility in the state to weather a drought.

1. The source water considered eligible for Aquifer Maintenance Credits (AMCs) would be the metered water from the ASR processes required prior to transmission to City's Main Water Treatment Plant.

2. As to the distribution of AMCs, the City offers the following additional information/perspective:

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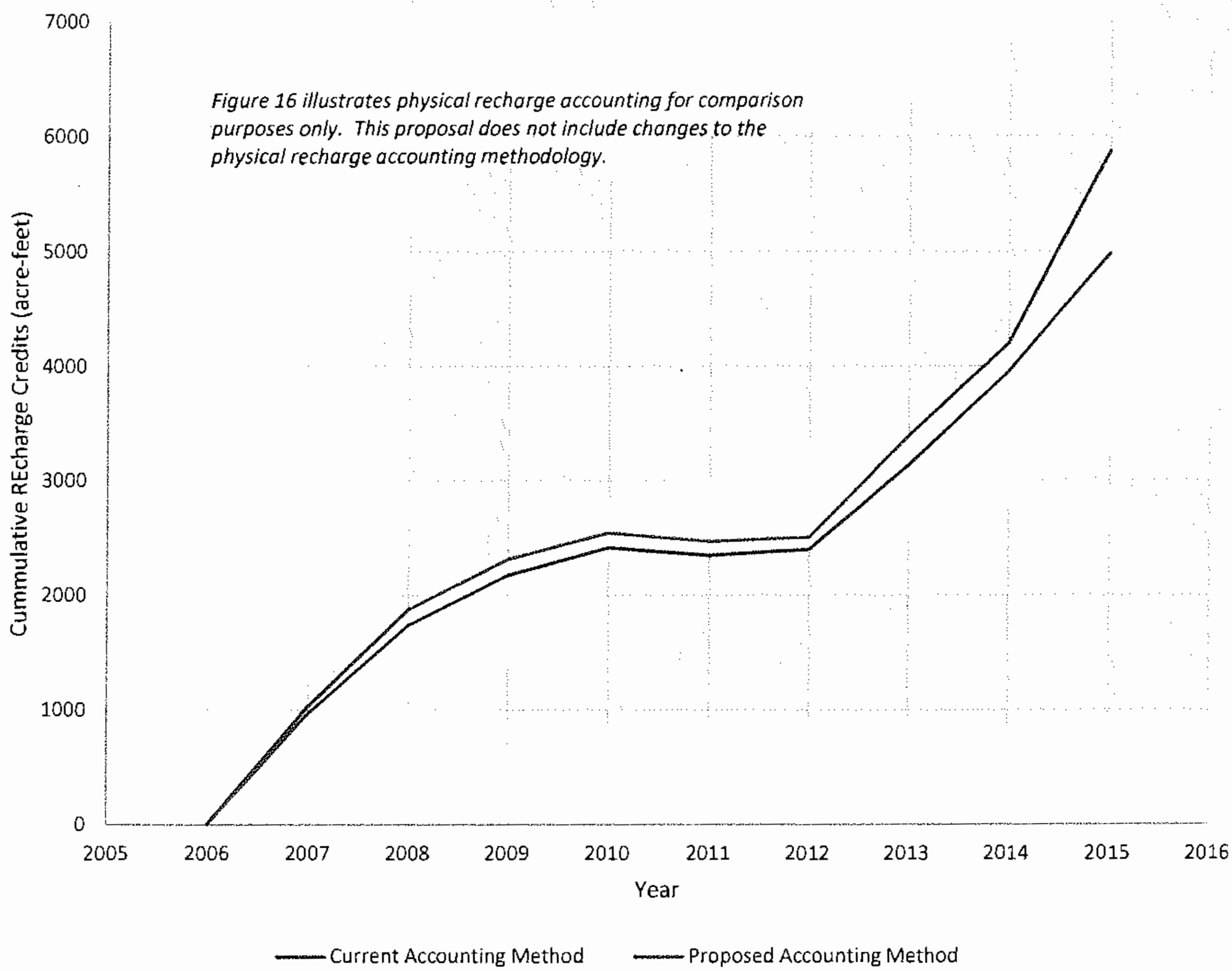
- Recharge credits are accumulated within Index Cells, not by well/s.,, All wells (recharge or production) in an Index Cell will be able to recover recharge credits if the permit modifications and pending applications are approved.
- Distributing AMCs equally across City production wells reasonably represents where groundwater has been left in storage as a result of utilizing LAR diversions as a source of supply.
- Distributing AMCs by Recharge Recovery Well (RRW) or by all wells does not change the quantity applied. Distribution to all wells will also provide the greatest degree of flexibility during periods of recharge credit recovery ensuring the opportunity to minimize any localized interference.

3. It is important to understand the basis for the selection of the initial and recurring losses:
   - A review of field data, previous accounting reports, and the multiple rounds of groundwater modeling completed within Attachment J of the proposal all indicate that an initial loss rate of five percent mirrors the current physical recharge accounting practice over a range of aquifer levels and conditions.
   - Gradational losses of one, three, and five percent moving from west to east across the wellfield reflect the direction of groundwater flow and migration losses of recharge credits from the basin storage area.
     1. Losses from the BSA on the west side of the EBWF are minimal where water slowly migrates from the west side of the EBWF to Index Cells in the center and eastern portions of the BSA.
     2. Losses from the BSA in the center of the wellfield are greater where larger volumes of water are injected resulting in a water level changes that create migration to down-gradient Index Cells and areas outside of the BSA.
     3. Losses from the BSA are highest on the east side of the wellfield, where water is lost to the Little Ark River and to the south outside of the BSA.
   - Figure 16 of the proposal illustrates a comparison of the actual physical recharge accounting process (the blue line) and the proposed AMC recharge accounting process using the five percent initial and one, three, and five percent gradational loss (the green line). As can be seen in the figure below, proposed AMC losses track very well with the physical recharge losses.
   - The difference in the total cumulative retention of credits in later years (73% for the physical accounting process compared to 85% utilizing the proposed AMC accounting) is due to full aquifer conditions and the substantial amount of recharge that has occurred at recharge basin RB-36.

Figure 16 - Current and Proposed Accounting Method Results Comparison



4. The constructed physical recharge capacity of ASR infrastructure and the capacity of the aquifer to accept recharge are different quantities:
   - At lowered water levels that facilitate physical recharge, the existing ASR system is capable of recharging 34.5 million gallons per day (MGD). Note that constructed physical recharge capacity exceeds the capacity of the Phase II ASR water treatment plant, which can produce up to 30 MGD of water for recharge.
   - Figure 14 located on page 3-12 of the proposal illustrates an example ASR Operations Plan reflective of elevated groundwater levels (2016), current ASR infrastructure, and water level conditions encountered during January of 2016.

- Based on 2016 elevated groundwater levels, the current sustainable physical recharge capacity is only 1.18 MGD.

5. Regarding the role of ASR recharge basins during consideration of physical recharge capacity and AMCs:
   - The City has excluded all Phase I recharge infrastructure from the permit modification proposal which includes recharge basin RB-2. The City believes that the highest value of water recharged at Phase I facilities will continue to be mitigating the movement of the Burrton chloride plume rather than developing recharge credits for later utilization during prolonged drought.
   - The permit modification proposal is intended to facilitate continued management of the aquifer at near full conditions. During near full aquifer conditions, the recharge water sent to RB-36 experiences significant losses. It is not in the best interest of the City or other aquifer users to focus physical recharge activities on locations where the water recharged is not effectively retained within the BSA for beneficial use, and for this reason RB-36 is not included in the calculation of physical recharge capacity.

6. The City has proposed utilizing an operations plan which relies upon static groundwater level measurements taken in January of each year:
   - The Kansas Geological Survey (KGS), United States Geological Survey (USGS), Division of water Resources (DWR) and Groundwater Management District no. 2 (GMD2) standard practice is to use January groundwater levels as the baseline representation of true aquifer storage conditions.
   - ASR physical recharge activities occur during and after significant periods of heavy precipitation which limits the correlation between physical recharge capacity and seasonal irrigation or municipal drawdown.
   - An annual ASR operations plan based on January groundwater levels provides clear, consistent, and manageable tracking of the relationship between physical ASR recharge capacity and groundwater elevations.

7. The physical recharge capacity of the ASR system is governed by several variables including a minimum feasible operating rate:
   - Please review page 3-7 of the proposal which indicates that the 5 MGD minimum for physical recharge capacity is considerate of the operational limits of the ASR system at lower flows which include pipeline residence times, well redevelopment frequency, pipeline flushing requirements, and water treatment plant startup and shutdown times.

8. The City offers the following to clarify the purpose of the examples that are provided in the proposal and to augment them as necessary:

- AMCs would be accumulated during periods when the recharge capacity of the aquifer and ASR system is less than the source water capture and process capacity of the ASR system.
- The examples on page 3-7 of the proposal were provided to illustrate a range of ASR water treatment plant operating rates, water level conditions, and physical recharge capacities.
- Please review section 3.5 of the permit modification proposal which contains the details of the operations plan and provides measurable assurance of the City's continued commitment to conducting physical recharge.
- Example 3 on page 3-7 was provided with the intent of including an instance where the ASR water treatment plant is running at 30 MGD under "Moderate Groundwater Levels" rather than "Lowered Groundwater Levels".
- To illustrate the City's commitment to conducting physical recharge during periods of lowered groundwater levels, the City would like to submit Example 4 below:

  Example 4 – Lowered Groundwater Levels with Available Recharge Capacity
  ASR Physical Recharge Capacity – 34.5 MGD
  ASR WTP Running at 30 MGD – 30 MGD to physical recharge facilities
  Max amount of ASR WTP water eligible for AMC – **0 MGD**

9. Regarding the conversion of existing production wells to recharge wells:
   - It is unreasonable to assume that the City should invest in conversion of additional conventional wells to recharge wells given that the City already has adequate infrastructure at existing recharge wells to conduct 34.5 MGD of recharge during lowered groundwater conditions.
   - The purpose of the proposed permit conditions is to facilitate management of the aquifer at near full conditions. During full aquifer conditions the City already has idle recharge well infrastructure due to lack of physical aquifer recharge capacity. Constructing additional idle recharge capacity would not provide a benefit to the City or other aquifer users
   - Future conversion of conventional wells to recharge wells will be based on the anticipated remaining lifespan of all existing wells and the projected benefits to the overall capacity of the ASR system.

10. For 2014 and 2015, a total of 1,132.19 acre-feet was diverted to town and could have been converted to AMCs. Any calculations related to years prior than 2014 would be highly speculative in nature.

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11. Currently the permits that cover the City's ASR program do not contain any limitation on the maximum number of recharge credits that can be accumulated. The City has voluntarily proposed a limitation on the combined total of physical recharge credits and AMCs based on the documented amount of aquifer storage available in 1993 during the original conception of the ASR project.

12. The City remains committed to maintaining the water quality of domestic wells within 660 feet of ASR physical recharge sites.
    - The City believes that a 660 feet distance is consistent with the original protections granted to domestic wells during development of the permit conditions for the ASR project.
    - No information has been presented indicating that ASR operations have caused any significant or detrimental changes in water quality that would warrant an extension of the 660 feet distance to the entire ASR Basin Storage Area.

13. The City remains committed to maintaining the water levels at domestic wells within 660 feet of ASR physical recharge sites.
    - The City believes that a 660 feet distance as is consistent with the protections previously granted to domestic wells during development of the permit conditions for the ASR project.
    - Note that the purpose of the proposed permit conditions is to facilitate improved management of the aquifer resulting in longer durations where the aquifer is at near full conditions.

14. The City agrees with the operating principle that native water rights should be utilized prior to recharge credits.

The City anticipates that you will continue to follow the process and schedule set out in your May 9, 2018 letter. Specifically utilization of an evidentiary hearing process following the schedule previously provided. That is:

- May 2018 – Update proposal and draft proposed approval documents.
- Early June 2018 – Pre-hearing conference, set public hearing date.
- June 2018 – Public informational meeting.
- Late July or early August 2018 – Public hearing including GMD2 bringing its recommendations.
- August 2018 – Close record.
- September/early October 2018 – Review record and decision.
- Potential review of record and decision by the Secretary of Agriculture.
- Potential review of record and decision by district court.

The City remains committed to dedicating the time and resources necessary to allow this schedule to be maintained and asks that you require the same of all other parties involved.

Sincerely,

Alan King
Director of Public Works & Utilities

CC: Robert Layton, City Manager, City of Wichita
Joseph T. Pajor, City of Wichita Public Works & Utilities
Don Henry, City of Wichita Public Works & Utilities
Brian Meier, Burns & McDonnell
Paul McCormick, Burns & McDonnell
Daniel Clement, Burns & McDonnell
Tim Boese, Groundwater Management District No. 2

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CITY COUNCIL PROCEEDINGS

OCTOBER 8, 2013

MINUTES OF THE MEETING OF THE CITY COUNCIL

Wichita, Kansas, October 8, 2013
Tuesday, 09:00 AM

The City Council met in regular session with Carl Brewer, Pete Meitzner, Jeff Longwell, James Clendenin, Jeff Blubaugh, Lavonta Williams, Janet Miller, Bob Layton City Manager, Gary Rebenstorf Director of Law, and Karen Sublett City Clerk.

Staff Members Present: None.

Mayor Brewer called the meeting to order at 9:05 a.m.

Approve the minutes of the regular meeting on October 1, 2013.

Carl Brewer moved to approve the minutes of the regular meeting on October 1, 2013.
Motion carried 7 to 0

AWARDS AND PROCLAMATIONS

Proclamations

Mayor Brewer read aloud the following Proclamations:

Friends of the Public Library
Disability Mentoring Day
Wichita Black Nurses Association Day

I. PUBLIC AGENDA

1. Mark Geitzen - Request for police protection at the Southwind Abortion facility.

(Not present)

2. Jan Harrison - Proposal to rename the Wichita Mid-Continent Airport in honor of Dwight D. Eisenhower.

Jan Harrison 1415 North Garland stated she presented a petition in favor of renaming the Wichita Airport calling it the Wichita Dwight D. Eisenhower International Airport with 1,573 signatures. Stated the City of Abilene and Senator Bob Dole said this name is fitting for the largest commercial airport in the state of Kansas. Stated we have a wonderful new terminal building that would benefit from a new name. Stated an airport gives hometown folks and all Kansans pride in their own city and state and provides an image to incorporate and marketing. Stated they believe that the name Eisenhower, a president ranked in the top 10 for effectiveness and popularity, says that we are a world class city and not a small town in the mis-named flyover country and results in a more memorable name. Stated a challenge faced by our airport is convincing flyers to favor our airport over others in the region.

Vice Mayor Meitzner asked staff to add this as an agenda item to appoint a naming advisory commitee.

Mayor Brewer thanked Ms. Harrison and stated that the Council asks for citizens to engage them in what they would like to see in the community. Stated the Council and staff should look at this and there has been discussions regarding the cost to do this and asked the City Manager to provide the Council with what it would cost.

Council Member Clendenin stated there was a vote taken last night at the Airport Board meeting based on costs and no one had the exact numbers and would like to have that information. Stated he would like the organic costs; costs that we are not otherwise going to be spending money on.

Pete Meitzner moved to bring an agenda item to appoint a naming committee.
Motion carried 7 to 0

II. CONSENT AGENDA (ITEMS 1 THROUGH 18)

Carl Brewer moved to approve consent agenda items 1 through 18 in accordance with the recommended actions shown thereon.
Motion carried 7 to 0

III. UNFINISHED COUNCIL BUSINESS

1. Drought Plan. (Deferred October 1, 2013)

Attachment: Agenda Report No. III-1

Attachment: Drought Plan

Attachment: Ordinance No. 49-585

Alan King Director of Public Works and Utilities reviewed the item.

Council Member Clendenin stated when developers are developing a development, we have mandatory requirements for vegetation. Stated if the City is in a drought three or four condition; asked staff if those rules will be relaxed.

Bob Layton City Manager stated they talked early during the drought planning about a review of the City's landscaping requirements and the Planning Department will be doing that. Stated the issues in terms of the watering and the requirements during a drought are addressed in this plan but the longer term policy issue in terms of what our landscaping requirements are, will eventually be addressed by the Council after going to the Planning Commission.

Council Member Clendenin asked if there are requirements for them to keep the property looking a certain way.

Alan King Director of Public Works and Utilities stated the City's requirements would be what was being enforced as far as water usage and recognizing that there could be some HOA requirements that have to have certain types of grass and certain types of appearances.

Bob Layton City Manager stated the restrictions will apply to everyone unless it is a business such as a car wash. Stated we are not going to prosecute someone for the way their property looks if they are only able to irrigate once a week.

Vice Mayor Meitzner asked staff if they solicited background information from Hays, Kansas.

Alan King Director of Public Works and Utilities stated they were one of the cities they talked to.

Vice Mayor Meitzner stated he spoke to a former Council Member from Hays, Kansas who said they have had these rebate programs and drought plans for 20 plus years and feels that the return and the long-term plan is to be commended in their community.

Council Member Miller stated our current rebate program still has money available in it and asked if we are going to continue it.

Alan King Director of Public Works and Utilities stated yes the rebate as it was advertised and promoted will last till the end of the year.

Council Member Miller asked if we are going to discontinue it after the end of the year. Stated it seems important to continue to encourage conservation all the time and not just when we are in a drought. Stated at some point she would like to have a discussion about continuing to offer those kinds of rebates on either an on-going basis or once or twice a year to keep that message out there.

Bob Layton City Manager stated that would take an amendment to the drought plan because right now the rebate program kicks in at stage one. Stated if we were to continue with normal conditions we would not have the rebate program under this drought plan.

Council Member Longwell stated this is a nice pro-active approach to working with water conservation but is not intended to be a cure all. Stated we still need to seek out a 50 year water supply, which is what the re-charge program was sold as nearly 10 years ago when it was brought before previous Council. Stated we are still looking at having good dialogue with some people about an opportunity to enhance our water supply and or efforts to getting to a 50 year water source. Stated this is just in addition to help us with conservation methods and being pro-active as we go forward anticipating that we will have future droughts.

Alan King Director of Public Works and Utilities stated that is correct, staff is presently working on an updated water resource plan that would consider bringing additional water resources on line and provide us with water supplies for a design drought. Stated it is still a policy matter from Council as to whether that is a two percent or a one percent design drought, but to bring some options before Council that shows what new water sources could be brought on and what the present value of those alternatives would be.

Council Member Williams asked if the rebate program is on line and can the citizens access that information.

Alan King Director of Public Works and Utilities stated it is on the City's website or they can call the Water Utility Department and the number is on their monthly water bills and staff can help direct them through the process.

Mayor Brewer inquired whether anyone from the audience wished to be heard.

1) Sybil Strum 326 North Walnut Street stated in her district she has seen businesses over-water but not the residents. Stated this is sort of a dictatorship and now the City staff is going to have to watch

over who is using too much water.

Carl Brewer moved to approve the drought plan and place the ordinance on first reading. Motion carried 7 to 0

Council Member Miller stated she would like for this to be brought back at some point closer to the end of the year to talk about possibly each year, the beginning of spring, to offer a rebate program.

IV. NEW COUNCIL BUSINESS

1. Public Hearing for West Bank Apartments TIF Project Plan. (District VI)

Attachment: Agenda Report No. IV-1

Attachment: Ordinance No. 49-586

Attachment: Ordinance No. 49-590

Attachment: Project Plan West Bank

Attachment: Development Agreement Final

(Council Member Blubaugh momentarily absent)

Allen Bell Urban Development Director reviewed the item.

(Council Member Longwell momentarily absent)

Vice Mayor Meitzner stated like other TIFs in our City, if there is eligibility to retire this TIF early, will that be part of this deal.

Allen Bell Urban Development Director stated it is not required that it be reflected in the development agreement because TIF revenues are the City's funds and it is more of a matter of the City's debt policy. Stated the City's debt management policy would cause them to accumulate the funds in a separate TIF fund and when there are efficient funds to redeem bonds early, they would start redeeming the bonds starting at the long end of the maturity schedule and thereby shorten the time the district would need to be in place. Stated once the bonds are paid off, then we would be able to cancel or terminate the district.

Council Member Blubaugh stated whenever we go from 2004 when this property was added to the East Bank Redevelopment District and then go back to 1995 tax value; how does this work?

Allen Bell Urban Development Director stated it is the way state law has it set up. Stated when a city adds property to an existing redevelopment district, as long as it goes through the process of holding hearings etc., then the land that is added, you use as the base year the value of that land (the entire district) at the time the district was first created. Stated it is the way that legislature crafted that provision in state law. Stated even though you add land years later in terms of doing the TIF calculations in which you have a base year valuation, you can use the original creation date for the base year.

(Council Member Williams momentarily absent)

Council Member Blubaugh asked how this comes into play when we have a property that did not have any valuation.

Agenda Item No. IV-4

City of Wichita
City Council Meeting
October 1, 2013

TO: Mayor and City Council

SUBJECT: Drought Plan

INITIATED BY: Department of Public Works & Utilities

AGENDA: New Business

Recommendation: Approve the plan and place the ordinance on first reading.

Background: The most recent drought began in early 2011 and ended with heavy rainfall in July and August. During that time, City staff presented options and data in numerous meetings with the City Council, District Advisory Boards, the Water Utilities Advisory Committee, and community groups. Developing a staged plan to respond to a future drought was a main theme from the input received.

On August 27, 2013, City staff presented a proposed drought plan that included phased implementation of water reduction strategies over four stages. Each stage would be triggered automatically by lake levels at Cheney Reservoir, one of the City's two water supply sources.

Analysis: Four drought stages are proposed. The actions included in each would be automatically triggered, based on a 12-month, smoothed average of the conservation pool level at Cheney Reservoir. The City Manager would be authorized to implement the approved actions.

- Stage 1 – Voluntary Conservation: Wichita would enter this early drought stage when the 12-month Cheney average moved below 90%. There would be no penalties or mandatory restrictions. However, the City would begin offering a rebate program to encourage conservation, while also engaging in a multi-faceted marketing campaign to raise drought awareness. A number of permanent conservation measures would continue for City of Wichita operations.

- Stage 2 – Mandatory Restrictions: Once the 12-month Cheney average was lower than 70%, Stage #2 would be triggered. Customers could then use water outdoors only one day a week, and hours would be restricted to the coolest part of the day (8pm – 10am). Violators would receive a warning, followed by penalties of $50 - $100. Businesses that generate economic activity directly from outdoor watering (golf courses, car washes, etc.) would be exempt. Most of the discretionary internal conservation measures would be enacted, though fountain schedules would remain unchanged.

- Stage 3 – Irrigation Bans: This severe drought stage would be triggered when Cheney's average level moves below 50%. All outdoor water usage would be prohibited, except for watering by the businesses exempted during Stage #2. Their exemption would still apply during Stage #3. Violators would receive a warning after their first infraction, and penalties ranging from $250 - $500 thereafter. The City would expedite repairs to all water main breaks and irrigation leaks and would reduce the operating hours at its public fountains.

- Stage 4 – Water Emergency: The final drought stage would be in effect after the Cheney average drops below 35%, necessitating an emergency climate for the water utility. No outdoor watering would be allowed, even from businesses that were formerly exempt from the drought bans. In addition, all customers would be required to decrease their indoor usage (base demand) by 15%. Major hospitals would be exempt from this base demand reduction, due to the critical life-saving operations they offer. Penalties would range from a warning to a $500 penalty, while a flow restrictor would be installed on water meters of customers who violate the policy three times. All of the City-owned fountains would be shut off.

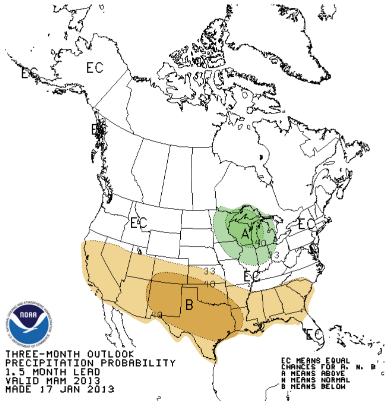
Financial Considerations: There is no current cost to adopting this plan. Should the region enter into a long-term drought that pushes into stages three or four, the utility would likely lose significant revenue. A precise amount is unknown, as it is dependent on how much water usage would be reduced, along with the rates that would be in place in the future.

Legal Considerations: The Law Department has reviewed and approved the ordinance as to form.

Recommendations/Actions: It is recommended that the City Council approve the drought plan and place the ordinance on first reading.

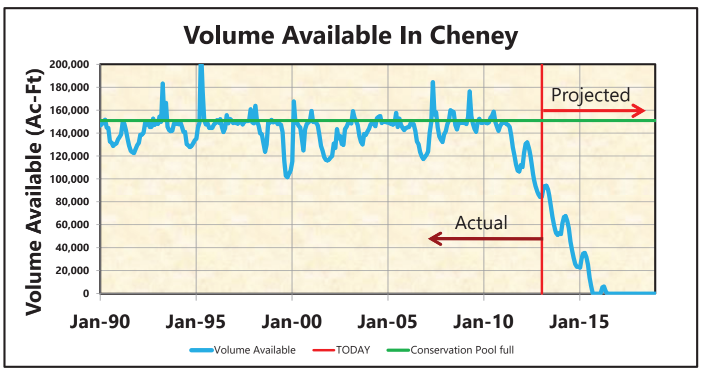
Attachments: Drought Plan and revised ordinance.

Spring Outlook

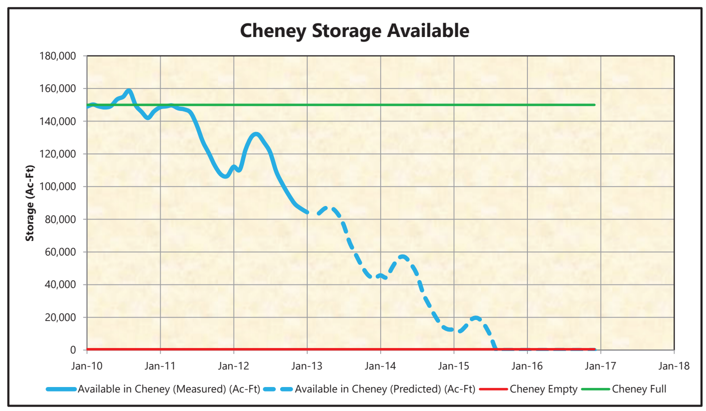


Cheney Reservoir

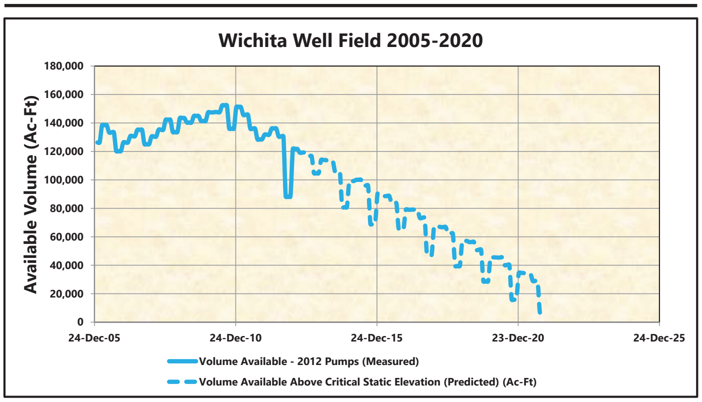
Cheney Lake 1990 – 2015



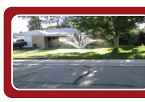
Cheney Lake 2011 -2015



Continue Existing Supply and Demand



Demand Reduction Strategies

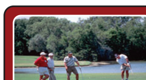


Option 1

Voluntary Water Restrictions

Option 2

50% Reduction in Outdoor Usage



Option 3

100% reduction in Outdoor Usage

Option 4

10% Reduction in Base Usage

Demand Reduction Strategies

Option 1: Voluntary Water Restrictions

Description: Residents would be encouraged to reduce overall water consumption through voluntary restriction, with an emphasis on outdoor usage. A public information campaign and media advertisements would commence.

Shortfall: None Water Saved: 334 Acre Feet

Supply Extension: 0.3 Months

Monthly Customer Billing Impact

Low-Use Customers		High- Use Customers	
Monthly Bill	Difference	Monthly Bill	Difference
$32.67	$0.00 (0.0%)	$151.00	$0.00 (0.0%)

Demand Reduction Strategies

Option 2: 50% Reduction in Outdoor Usage

Description: Would generally affect outdoor usage that does not generate economic activity, including lawn and garden watering and private pools. Golf courses, car washes, public pools, and other businesses reliant on outdoor water could operate but at higher costs.

Shortfall: $5,016,366 Water Saved: 7,093 Acre Feet

Supply Extension: 7 Months

Monthly Customer Billing Impact

Low-Use Customers		High- Use Customers	
Monthly Bill	Difference	Monthly Bill	Difference
$32.67	$0.00 (0.0%)	$321.59	$170.59 (113.0%)

Demand Reduction Strategies

Option 3: 100% Reduction in Outdoor Usage

Description: Major effects on the community. Would severely impact 12 golf courses, the Stryker Sports Complex, Botanica, car washes, and companies doing construction work. About 4,000 private and public pools would be impacted.

Shortfall: $17,245,330 Water Saved: 14,186 Acre Feet

Supply Extension: 21 Months

Monthly Customer Billing Impact

Low-Use Customers		High- Use Customers	
Monthly Bill	Difference	Monthly Bill	Difference
$41.64	$8.97 (27.5%)	$471.44	$320.44 (212.2%)

Demand Reduction Strategies

Option 4: 10% Reduction in Base Demand

Description: Deepest demand reduction strategy outlined. Would probably come after a reduction in outdoor usage. Strategy results in a 10% decrease in non-discretionary usage, mainly from indoor usage in homes and business operations.

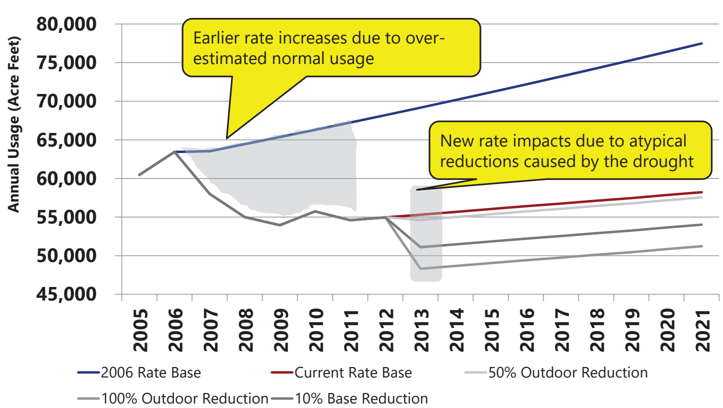
Shortfall: $12,328,274 Water Saved: 5,177 Acre Feet

Supply Extension: 5 Months

Monthly Customer Billing Impact

Low-Use Customers		High- Use Customers	
Monthly Bill	Difference	Monthly Bill	Difference
$52.94	$20.27 (62.0%)	$488.61	$337.61 (223.6%)

Reason for Rate Impacts



Rate Design

- Rates are effective instrument to reduce usage
- AWWA standards show that usage goes down 1%-3% for every 10% increase in rates

	Option 2	Option 3	Option 4
Fixed Charge	0%	77%	55%
Block 1 Increase	0%	0%	100%
Block 2 Increase	100%	300%	300%
Block 3 Increase	300%	300%	300%

How Drought Stages are Defined

The City of Wichita will use a 12-month average of the conservation pool level in Cheney Reservoir in order to determine the establishment and severity of a drought. The US Army Corps of Engineers provides hourly data on how full the conservation pool is. Cheney Reservoir is one of the City's two water sources and is the most susceptible to drought conditions. The 12-month average will smooth out seasonal variations to ensure that low points experienced in normal years do not move the City of Wichita into a drought response.

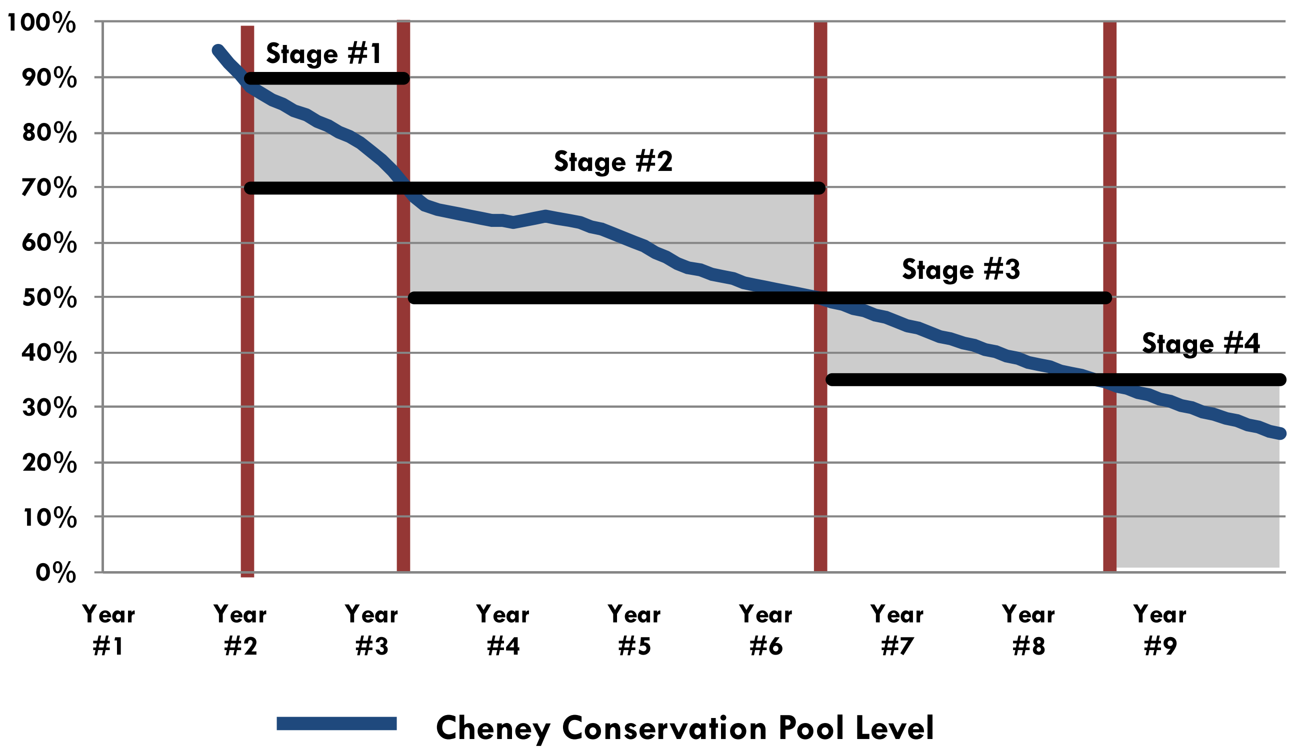
Trigger Points for Each Stage

Four stages of progressive measures will be instituted during a long-term drought in Wichita. The lake level triggers for each stage are included in the accompanying chart and table.

Cheney Conservation Pool: 12-Month Average		
	Top Level	Bottom Level
Normal Conditions	100%	90%
Stage #1	89%	70%
Stage #2	69%	50%
Stage #3	49%	35%
Stage #4	34%	0%

Wichita will need to experience a multi-year drought to enter any of these stages. Should the area experience a drought similar to the 2011-2012 conditions, there would be a full year before an enhanced drought response would be initiated. The City of Wichita would then progress through different stages until the drought ends.

Drought Stage Triggers



Appendix A
COMPARISON TO OTHER WICHITA STUDIES

Projections from 1993 in Comparison to 2013

The 1993 Water Supply Study[17] was similar to the 2013 Water Demand and Supply Assessment Study. Since the 1993 Study was similar, it provides a good comparison for the 2013 Study. Other studies since the 1993 used the methodology and assumptions of the 1993 Study, but included updated data based on known values.

The 1993 Study and the 2013 Study forecasted water demand, however, different methodologies were used and different assumptions were made. Here is a summary of the key assumptions and methodologies used and how they differ. Table A1.1 and Chart A1.1 show the comparison of projections for population, annual average day water demand, and peak day demand using the medium growth projections and the medium peak day factors.

- Population projection methodology
  - 1993 Study used linear regression methodology and compared to population projections by the US Department of Commerce-Bureau of Economic Analysis, 1985 Regional Projections and the Metropolitan Area Planning Department.
  - 2013 Study used Cohort Survival Methodology and compared annual population growth rate to that of the Center of Economic Development and Business Research at Wichita State University and the Metropolitan Area Planning Department.
  - 1993 Study assumed a 0.89% annual growth rate.
  - 2013 Study assumed a 0.62% annual growth rate.
- Service area
  - 1993 Study assumed 85% of Sedgwick County would be served by Wichita Water Utilities by 2030.
  - 2013 Study assumed the future service area would include only those municipalities and rural water districts currently served by Wichita Water Utilities.
- Water usage rates
  - 1993 Study was largely based on customer type usage rates.
  - 2013 Study is based on a per capita overall usage rate.
- Peak demand
  - 1993 Study developed 3 scenarios for different peak day factors.
    - High factor (2.14) was the highest peak day factor from 1960-1991.

- Medium factor (2.0) was the design value of the September 1992 draft of the Water System Master Plan.
- Low factor (1.8) was the average peak day factor from 1960-1991.

- 2013 Study developed 2 scenarios for different peak day factors.
  - High factor (2.07) was the highest peak day factor from 1990-2012.
  - Medium factor (1.83) was the average peak day factor from 1990-2012.
  - Low factor not used as it was not assumed to aid in planning for demand.

Table A1.1: 1993 Study Comparisons to 2013 Study

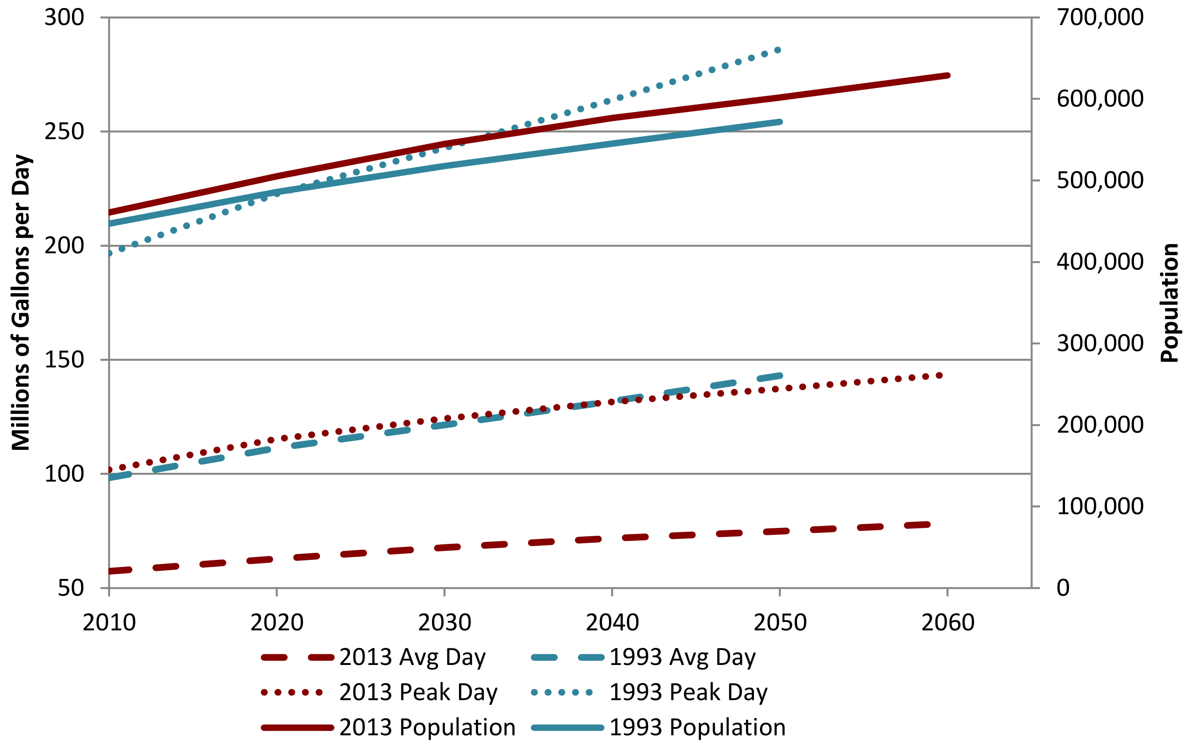
(medium growth and medium peak factor)

	Water Demand and Supply Assessment Study 2013			Water Supply Study 1993		
Year	Population	Avg Day Demand (MG)	Peak Day Demand (MG)	Population	Avg Day Demand (MG)	Peak Day Demand (MG)
1990		*58.4*	*109.5*	335,487		
2000		*59.6*	*114.1*	387,218	83.0	166.0
2010	*460,672*	*57.3*	*101.8*	447,058	98.3	196.6
2020	505,090	62.8	115.2	485,759	111.4	222.8
2030	544,913	67.8	124.3	517,604	121.4	242.8
2040	576,734	71.7	131.6	545,284	131.9	263.8
2050	601,935	74.9	137.3	571,784	143.0	286.0
2060	628,745	78.2	143.4			

Grey Shade is Actual

Chart A1.1: 1993 Study Comparisons to 2013 Study

(medium growth and medium peak factor)



Additional Projections for Comparison

Charts from intermediate studies between 1993 and 2013 are presented on the next three pages for review. By review, one can note that the historical conditions, trending method, and the selection of the point from which to project future conditions have an effect on the projection results.

Wichita Aquifer Storage and Recovery
Modified ASR Lower Index Levels and Aquifer Maintenance Credits: An Overview

Q and A:
Q: Why is the City pursuing these changes now?
Answer: ASR provides two benefits – drought resiliency and water quality protection. The changes are being proposed to provide operating flexibility that is needed to maintain the aquifer as high as possible – like the levels are now. Current permit conditions will cause the city to have to pump ASR Credits as fast as possible during dry spells in order to prevent as many credits as possible from becoming stranded below the current lower limits – the 1993 levels. This early pumping approach will result in lower aquifer levels into the future. Current permit conditions also cause the City to have to pump the aquifer down to make room for ASR injection. Otherwise, the City will not be able to accumulate the credits needed for future use during a one percent drought. This pumping down to inject approach will result in even lower aquifer levels. The change to allow for Aquifer Maintenance Credits – credits for ASR water that is treated and sent to town for immediate use – will make it possible to run ASR when aquifer levels are high and still bank credits. This will result in higher aquifer levels being maintained in perpetuity. Higher aquifer levels at the beginning of a drought means the impacts will be less severe, and fewer wells will dry up. Higher aquifer levels also slow down salt water intrusion into areas of the Equus Beds.

Q: Will these proposed changes dry up my domestic well?
Answer: No, in fact they are designed to do the exact opposite, protect the entire water supply for all users. The changes would provide ASR operating flexibility that would result in higher aquifer levels being maintained in perpetuity. Benefits include everyone's wells in the area would be protected. Salt water intrusion would be slowed down. And higher aquifer levels at the beginning of a drought would mean fewer wells would go dry during a severe drought.

Q: Does this mean the City will no longer have to recharge the aquifer in order to accumulate credits?
Answer: No. When operating ASR, the City will be required to inject ASR water into the aquifer when levels allow for effective recharge.

Q: Does this mean the city will be able to pump more water overall, or that the City will wind up owning all of the water in the aquifer, by accumulating Aquifer Maintenance Credits in addition to their Recharge Credits?
Answer: No. In fact, a cap will be placed on the total number of credits the city will be allowed to bank. The original "void" in the aquifer that ASR was meant to fill up was 120,000 acre-feet.

So, the total amount of ASR credits will be capped at 120,000 acre-feet. Currently, there is no regulatory cap on the amount of credits the City is allowed to accumulate.

Background:

The City of Wichita has been working to refocus their ASR project from a supplemental water supply source to a long-term drought protection project.

In refocusing the ASR project, the City of Wichita seeks to: 1) manage the project so that there is enough water in the aquifer for the City and for the well field neighbors during and immediately after a drought and 2) keep the aquifer as full as possible, as long as possible.

Wichita has two major sources of water, the Equus Beds aquifer and Cheney Reservoir. During the drought of 2011-12, the City observed dropping water levels in both Cheney and the aquifer during. The City became concerned that current ASR permit limits might prevent them from accessing their recharge credits due to the lowering water table. They also decided to start using Cheney move aggressively to avoid evaporation loss.

The City now takes most of its water from Cheney, using about 20% from the aquifer. As a result, the aquifer has recovered to near pre-development conditions. This is better for everyone but undermines the ASR project under current rules.

When flows in the Little Arkansas River are high enough, and there is room in the aquifer, the ASR project treats the surface water and injects it into the portion of the Equus Beds aquifer designated as the "Basin Storage Area" for future use. It is different water than what would naturally be found in the aquifer. The basin storage area is basically a reservoir to store this water.

Losses from this underground reservoir are in the form of leakage out of the Basin Storage Area instead of the evaporation which occurs in surface water reservoirs. We look at the Basin Storage Area as the "box" the City can operate ASR in, and the box started with roughly 120,000 acre feet of storage capacity.

Two main reasons for changing the Wichita ASR terms and conditions are to:

1) adjust the minimum index cell levels (bottom of the box) so the City can access their recharge credits during long-term drought.

2) Allow the City build credits for its ASR operations when the aquifer is full via Aquifer Maintenance Credits (AMC).

Currently, in order to create recharge credits, there has to be space in the box in which to inject water. When the box is full (10 feet from surface), ASR cannot inject water into wells.

To develop needed ASR credits for the inevitable drought, the City could, with their existing water rights, divert non-ASR water from the Basin Storage Area wells thereby creating a hole in the aquifer, then inject surface water, and create recharge credits. But this is an inefficient way to operate; pumping water out to put water right back in. This approach results in lower aquifer levels overall. Realizing this, the City proposes to modify existing terms and conditions to allow for more operational flexibility and the ability to maintain higher aquifer levels overall.

The AMC is a credit for what the City could have done. **It works like this: the City diverts and treats excess surface water. If there is space in the aquifer, the City will inject the water and generate a traditional ASR credit. However, if there is no space in the aquifer, the City will divert route the water to town and get an AMC.**

This does not require them to pump a hole to refill. As a result, higher aquifer levels would be maintained in perpetuity. Thus, this approach works to help slow salt water intrusion into the Equus Beds and protects all aquifer users against the impacts of severe drought. As a result, other users wells in the area would be less likely to go dry with this approach.

Permit conditions we are currently working on include:
1) Maximum credit accumulation on the order of 120,000 AF which equals 10% of the total storage in the well field area.
2) Ensuring other area native rights are protected from impairment by requiring the City to use pumping rotation and timing if conflicts occur. 3) Sequence of priority pumping.

The City currently owns 40,000 AF of senior native rights in the aquifer. The City is planning for an 8-year drought during which recharge credits will be withdrawn over the duration of the drought during years when demand exceeds the City's annual base rights of 40,000 AF.

The City will pump their 40,000 AF of native rights first and draw from their recharge credits as needed. The 40,000 AF renews each calendar year. The recharge credits do not renew, they go away when they are either pumped or when they seep out of the Basin Storage Area.

The modeling shows worst case, at the end of an 8-year, 1% drought, the aquifer remains on average over 80% full. That is with all current pumping. This includes domestic, municipal, irrigation and the other beneficial uses operating in the well field.

It is important to understand the City has the ability to manage through a one percent drought by utilizing all of its existing resources and is prepared to proceed under the current ASR operating terms and conditions.

However, in the spirit of sound resource management, the City desires to shift to a more outcome-based approach that would benefit all aquifer users when it comes to operating ASR. **To that point, the City is proposing to modify current ASR terms and conditions. The modifications are designed to provide the needed flexibility to operate ASR in such a way that results in higher aquifer levels overall.**

<u>Higher aquifer levels provide a two pronged benefit to all users:</u>

1) Higher water levels help preserve water quality by slowing down the inevitable movement of salt water into areas of the Equus Beds.

2) Higher aquifer levels at the beginning of a drought help to lessen the severity of impacts caused by drought. This means other user's water wells would be less likely to go dry during a drought.

These are the reasons why the City believes the proposed modifications are in the best interest of not only the City of Wichita and all of its customers, but for the benefit of all aquifer users.

Chapter 1: Introduction

The "Wichita Project Equus Beds Division Authorization Act of 2005" (Public Law 109-299) authorizes the Secretary of the Interior to help the City of Wichita, Kansas, in funding and implementing the *Aquifer Storage Recharge and Recovery Component* of the City's *Integrated Local Water Supply Plan* (ILWSP). The purpose of the ILWSP is to provide municipal and industrial (M&I) water to the City and surrounding region through the year 2050. The Aquifer Storage Recharge and Recovery Project (ASR) would pump water from the Little Arkansas River into the region's Equus Beds Aquifer for storage and later re-use. When completed, the ASR would become the "Equus Beds Division" of the U.S. Bureau of Reclamation's Wichita Project. Operation, maintenance, replacement, and liability of the new division would be the responsibility of the City.

P.L. 109-299 requires Reclamation to use, to the extent possible, the City's plans, designs, and analyses. The Federal funding cap would be 25% of total costs, or $30 million (indexed to January 2003), whichever is less. The full scale ASR system, costing over $500 million, would recharge the Equus Beds Aquifer with up to 100 million gallons of water per day (MGD).

This environmental impact statement (EIS) is required by the *National Environmental Policy Act* (NEPA). The Federal funding provided through Reclamation is a Federal action subject to NEPA. Alternatives are discussed in Chapter 2. The environment of the affected area is described in Chapter 3, and the impacts of the alternatives analyzed in Chapter 4. A list of agencies and interested groups consulted or coordinated with during the study is provided in Chapter 5.

Purpose and Need

One purpose of the project is to provide a safe and reliable source of drinking water for the City by preventing the continuing decline of water levels in the Equus Beds Aquifer. Federal funding is needed to help implement the ASR and defray costs.

Approximately 32% of the City's water supply comes from the aquifer The Equus Beds also supplies irrigation and livestock water throughout the region. There are approximately 1,650 non-domestic water wells withdrawing about 157,000 acre-feet (51.2 billion gallons) of water per year from the aquifer. Use of the Equus Beds for both municipal and agricultural needs over the last 60 years has exceeded recharge. This has caused a drop in the water table of up to 50 feet in some locations. About 50% of the water used annually goes to agriculture, 34% to cities, 15% to industry and 1% to other users (GMD2 1995).

A **second purpose** of the project is to protect water quality in the aquifer. The decline in the Equus Beds water table has allowed water with higher salt content to seep into the aquifer. Saltwater encroachment has become a problem because as freshwater levels drop, more saltwater infiltrates from the Arkansas River and other sources. This change in "gradient" between fresh and saltwater allows poorer quality water into the aquifer. Continuing saltwater encroachment could degrade water quality to the point where the water would require much more treatment to make it drinkable. In addition, the use of saline water for irrigation would damage crops, reduce soil productivity, and cause more salt to be available for re-infiltration through the soil. The ASR would help maintain a safe gradient between fresh and saltwater sections, protecting the aquifer from saltwater encroachment.

The **ASR is needed** because population and resulting water demands of Wichita and surrounding areas are projected to increase significantly by the year 2050. The City currently has the capacity to meet average daily water demands until 2016 (Burns & McDonnell 2003). With the ASR, the City would have the capacity to meet average daily needs of 112 MGD in 2050. The project would also:

- Store surface water underground to prevent evaporation and reduce other losses
- Reduce the gradient between fresh and saltwater sections within the aquifer to protect water quality
- Capture surface water for storage during periods of high stream flow, and
- Protect stored water from short term, seasonal, annual or long term climate change.

Reclamation has the further purpose to ensure that Federal funds would be spent in such a manner as to protect the environment. Reclamation has the responsibility to review and publicly document the environmental consequences of the project before a Federal action is taken.

season pasture and riparian[1] woodlands. The Local Well Field covers only about 10 acres and lies completely inside the Wichita city limits.

Small areas and rights-of-way needed for permanent structures, including the surface water intake, pipeline, recharge basin, SWTP, overhead electric lines, SCADA towers, wells and roadways would cause minor impacts on future land use. Most of the construction would involve pipelines, which would impact land use only temporarily. Approximately 12 miles of the new pipeline would be installed along existing pipeline right-of-way. About 29 acres would be permanently impacted by construction of the SWTP and another 200 acres changed by installation of well heads, roads, and a recharge basin.

Mitigation – Land Use

To the maximum extent practicable, all construction would replace existing structures, occur on already-disturbed land next to existing structures, or along existing roads and rights-of-way. Care would be taken to minimize the foot print whenever construction is required in riparian or other sensitive areas. Roads and rights-of-way would run parallel to or along the edges of, rather than through riparian zones, prime farmland and other sensitive ecosystems whenever possible. For these reasons, no mitigation would be necessary for changes in land use. Approximately 266 acres including about 65 acres of prime farmland would be permanently disturbed. The farmlands disturbed would not be available for crop production. Lands would be physically altered by the project and dedicated to roads, well sites, and recharge basins.

Water Resources

Key concerns about water are related to changes to the levels of water in the Little Arkansas, Arkansas, and Ninnescah rivers, Equus Beds aquifer, and Cheney Reservoir. These changes are in turn related to concerns about water quantities (including water rights) and quality, aquatic resources, wildlife, and other topics addressed in this EIS. To have an understanding how the project would affect water resources a hydrology model was developed and used to estimate the changes. Model results were used in estimating the effects on biological resources.

Modeling Hydrology

The Reservoir Network (RESNET) computer model was used to evaluate potential hydrologic impacts of Wichita's ILWSP (including the ASR.) Modeling required data from all aspects of the ILWSP, as impacts to surface and ground water in the area would not be mutually exclusive. Model details are found in Appendix A, but the following general data sets were used:

[1] *Riparian* – pertaining to the banks of a river or stream, and the plant and animal communities found there

- Historical mean daily stream discharge at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir
- Available storage, natural recharge and other parameters for the Equus Beds aquifer
- Wichita's current and projected water demands
- Agricultural irrigation demands in the Equus Beds Well Field area minimum Kansas desirable stream flow requirements
- Supply capability and other operating parameters for all current and potential water supply sources, and
- The preferred allocation order for each water supply source.

RESNET then performed a daily simulation of reservoirs and streams as a circulating network. Impacts to ground waters were simulated. A daily water balance was calculated for ILWSP over an 85-year period (for water years 1923 – 2007.)

Three alternatives were modeled, based on date, water demand, and comparison of a project compared to no project, as follows:

- **Current** – This alternative used year 2000 average-day demand data to simulate current City water requirements, based on ASR construction through Phase I
- **No Project** – Same as "Current," except average-day raw-water demands were projected through the year 2050
- **ILWSP 100** – This alternative projected average-day demands and included development of the following components, projected through the year 2050, including:
    - The capture of 60 MGD of induced filtration surface water and 40 MGD of direct diversion surface water from the Little Arkansas River (ASR)
    - Redevelopment of the Bentley Reserve Well Field, and
    - Expansion of the Local Well Field.

The model considered both municipal and agricultural demands on the aquifer.[2] RESNET simulated aquifer operations in the same way it would a surface water reservoir. A USGS MODFLOW groundwater flow model was used to create a table used by RESNET to relate aquifer elevation, aquifer storage deficit, and aquifer gains and losses to the Arkansas and Little Arkansas rivers. Table 4-2 lists total gains and losses for the Equus Beds as a function of water table level. The table is a product of simulated stream flux derived from the groundwater flow model and a review of the distribution of recent baseflow gains

[2] Details on the development of water demands can be found in section 1.5 of Appendix A

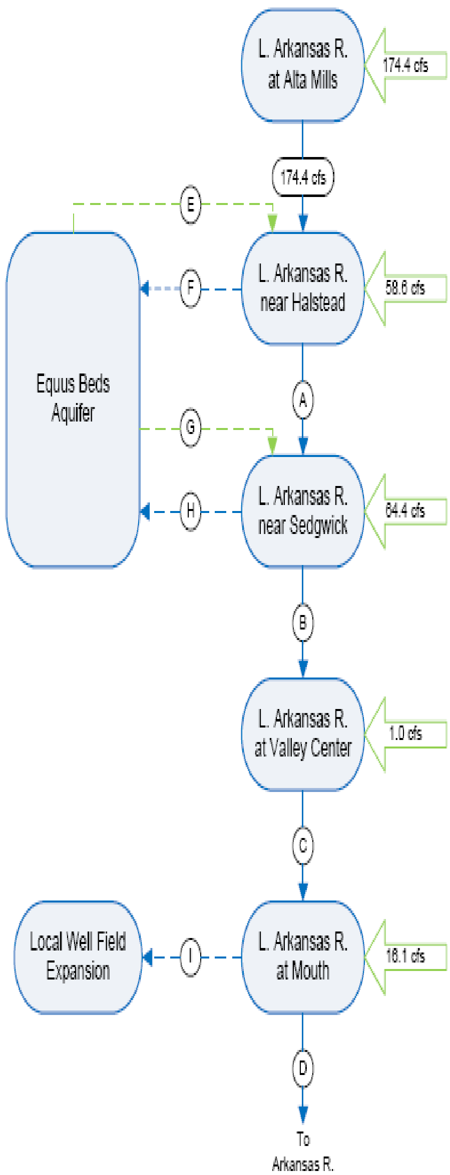
in the Arkansas and Little Arkansas rivers next to the project area. The final two columns in Table 4-2 show the resulting distribution of aquifer losses. Results indicate that the aquifer contributes water to both rivers once elevations reach 1,389 feet (storage deficit of 63,500 acre-feet.) Aquifer gains and losses were simulated to the Arkansas River near Maize, Little Arkansas River near Halstead, and the Little Arkansas River near Sedgwick.

Table 4-2 Equus Beds Storage Deficit Gains-Loss Data

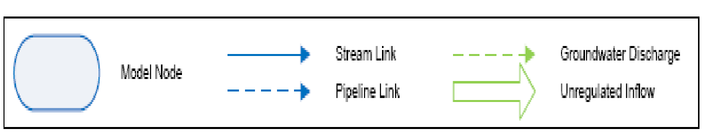
Index Well 886 Elevation (ft. NGVD[3])	Storage Deficit (acre-ft.)	Net Equus Beds Loss Rates (cfs)	
		To Arkansas River	To Little Arkansas River
1,342	429,700	-116.6	6.6
1,360	289,400	-72.8	10.8
1,366	242,700	-58.3	12.3
1,370	211,500	-50.5	12.5
1,375	172,600	-38.7	13.7
1,380	133,600	-24.1	15.1
1,385	94,700	-11.1	17.1
1,389	63,500	0.6	19.4
1,390	55,700	4.1	20.0
1,395	16,800	20.6	23.4
1,396	9,000	24.8	24.2
1,402	0	41.8	28.2

[3] NGVD = National Geodetic Vertical Datum

Water Balance for Little Arkansas River



Schematic Location	Description	Average Flow for Alternative (cfs)		
		Current	No Project	ILWSP
A	Flow in Little Arkansas River below Halstead	238.5	236.8	222.9
B	Flow in Little Arkansas River below Sedgwick	310.9	306.7	278.1
C	Flow in Little Arkansas River below Valley Center	311.9	307.7	279.2
D	Flow in Little Arkansas River at Mouth	328.0	323.8	258.1
E	Groundwater discharge from Equus Beds to Little Arkansas River above Halstead	5.4	3.7	6.0
F	Recharge to Equus Beds from diversion wells along Little Arkansas River	0.0	0.0	16.3
G	Groundwater discharge from Equus Beds to Little Arkansas River between Halstead and Sedgwick	8.0	5.5	9.1
H	Total recharge from Little Arkansas River to Equus Beds through diversion wells between Halstead and Sedgwick and surface intake near Sedgwick	0.0	0.0	18.2
I	Diversions from Little Arkansas River to Local Well Field expansion	0.0	0.0	39.2



Notes:

- Current alternative assumes no project with approximate current water demands (70.4 million gallons per day [MGD] average).
- No-project alternative is same as Current except with projected year 2050 demands (111.6 MGD average).
- ILWSP alternative assumed year 2050 water demands with 100-MGD diversion system from Little Arkansas River for recharge of Equus Beds aquifer.
- All stated values are average flows, in cubic feet per second, over the entire 85-year simulation period (10/1/1922-9/30/2007).
- Flows may not balance exactly because of rounding.

Figure 4-1 Water Balance for the Little Arkansas River

Surface Water Resources

Principal streams in the project area include the Arkansas, Little Arkansas, Ninnescah and the North Fork of the Ninnescah rivers. Both the Little Arkansas and Ninnescah are tributaries of the Arkansas River. Cheney Reservoir lies on the North Fork of the Ninnescah and stores water for the support of fish and wildlife, recreation, and drinking water supply.

Zebra mussels (*Dreissena polymorpha*), originally thought to originate in the Black or Caspian seas of Europe, are confirmed invaders of Cheney Reservoir (Jeffrey Tompkins, pers. comm. 5/30/2008) as well as El Dorado and Marion reservoirs. These fingernail-sized, rapidly reproducing mollusks have created serious, economically devastating problems in water supply systems around the country by clogging up intakes, filters, pumps, etc. There are no known effective predators of this species in America, and no known means of extermination. This leaves expensive chemical application along with labor-intensive manual removal of infestations in water systems as the only, temporary treatment options. The presence of this species could impact the City's future reliance on public water supplies from the reservoir.

Cyanobacteria (*Anabaena*) blooms occasionally cause severe taste and odor problems in Cheney Reservoir. The USGS monitors environmental variables, such as light, temperature, conductivity, and turbidity to predict blooms, which can impact use of reservoir water for drinking water.

Minimum desirable stream flows (MDS) established by the Kansas Department of Health and Environment (KDHE) for locations within on the Little Arkansas River are found in Table 3-2. Minimum allowable flows were established primarily for the purpose of protecting irrigation water rights, but also to protect vegetation, fish and wildlife. The Kansas Department of Wildlife and Parks (KDWP) prefers higher flows, especially during spawning seasons, to protect aquatic life (60 cfs from May through June, 34 cfs during the remaining months.) No minimum desirable stream flow standards have been formally established for the protection of spawning aquatic species (Eric Johnson, personal communication, May 19, 2008). Impacts to "Surface Water Resources" are specified below under "Surface Water Levels" and "Surface Water Quality."

Surface Water Levels

Impacts to water surface elevations and flow depths would closely mirror changes in flow. Therefore, flow and elevation are considered together in this section.

Little Arkansas River

Halstead

The project should result in approximately 3 cfs increase in median flow at Halstead for ten months each year by 2050. However, median flows from May through June (typically high flow months) should decrease up to 12 cfs. Should the project not be completed, median flows would be expected to range from about 26 cfs in October to a high of 90 cfs in June. This compares to

Figure 4-2 Little Arkansas River near Halstead

28-78 cfs with the project. Average daily flows at Halstead (in Harvey County) above 1,000 cfs would still occur approximately 4% of the time, and average daily flows above 300 cfs would occur about 10% of the time, in comparison to 11% without the project. Changes in the flow regime due to diversion would be more apparent during flows between 80 and 200 cfs (Figure 4-3.)

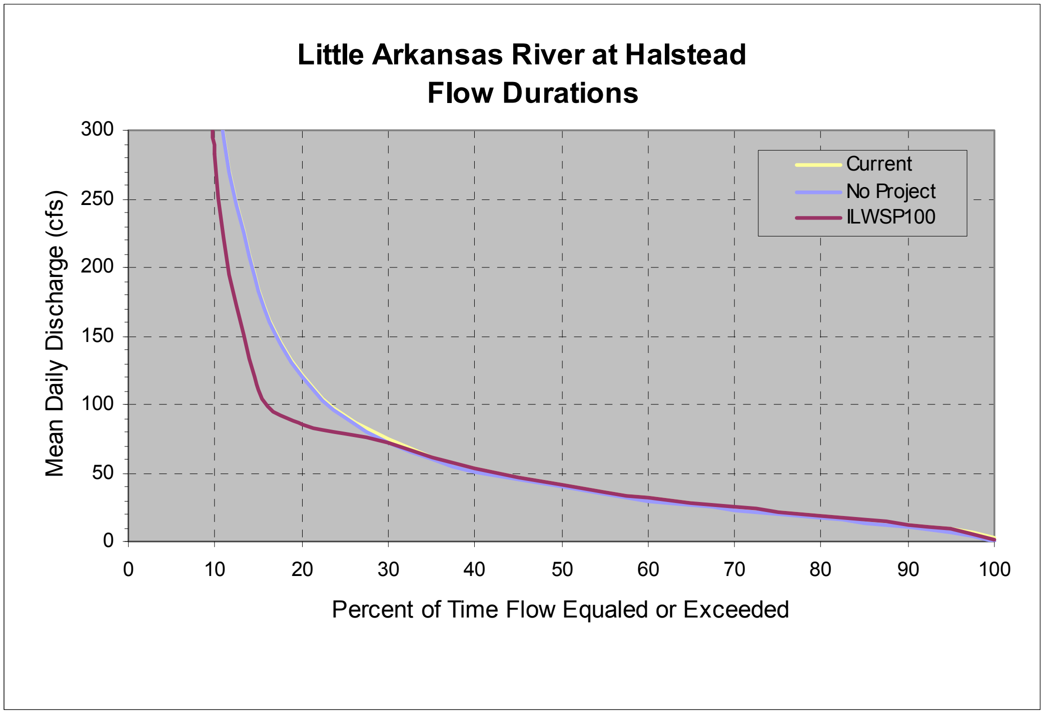


Figure 4-3 Flow durations for the Little Arkansas River at Halstead

Sedgwick

Median flows at Sedgwick should increase about 2-6 cfs from July through April, but decrease by 15-35 cfs during May and June. Monthly median flows for these two months are currently about 94 and 117 cfs, respectively. Based on these results, median monthly flows would continue to exceed the lower limit recommendations from KDHE and KDWP. Greater median flows during low-flow periods should benefit both riparian and aquatic habitat, including vegetation, fish, and wildlife. The predicted increase would be due to additional groundwater recharge of the stream resulting from rising aquifer levels. Water would be diverted from the river more frequently and at higher rates during May and June when flows are typically the highest. Changes in the flow regime due to diversion would be more apparent during flows between 80 and 300 cfs (Figure 4-4.)

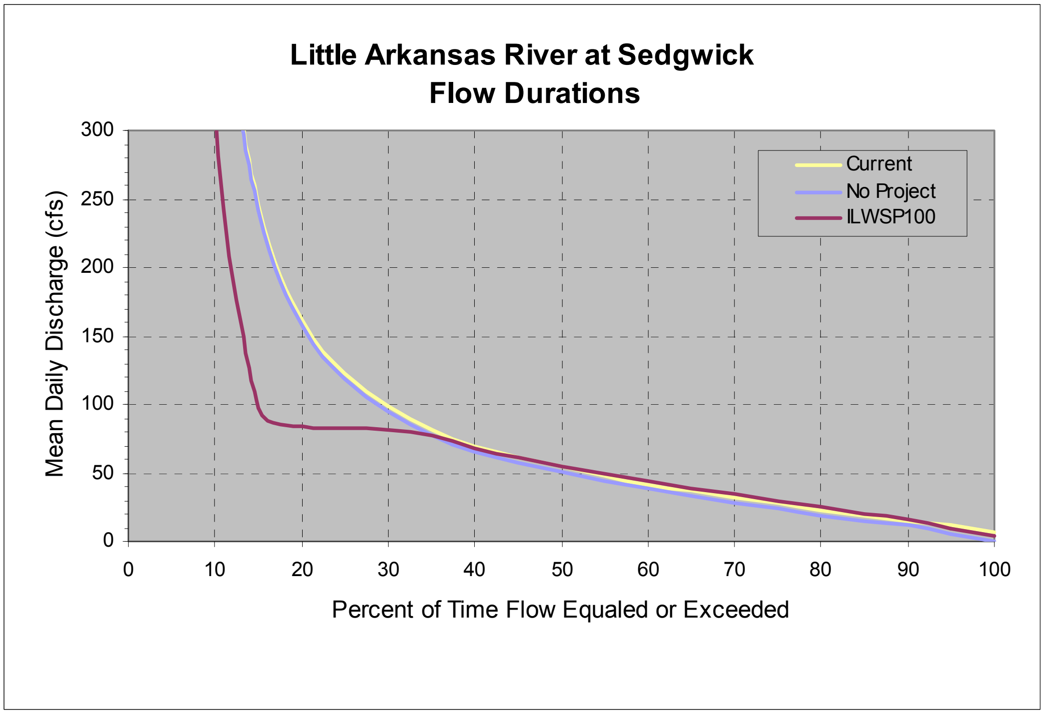


Figure 4-4 Flow durations for the Little Arkansas River at Sedgwick

Table 4-3 Number of Days per Year when Base Flows were exceeded (2005 Permit Requirements)*

	Year										
Little Arkansas River @	1995	1996	1997	1998	1999	2000	2001	2001	2003	2004	2005
Halstead	114	130	270	199	349	228	168	99	151	151	144
Sedgwick	210	180	318	301	365	290	226	143	218	258	239

** Based on USGS recorded flows*

Valley Center

The project should result in median flow increases of 6-7 cfs at Valley Center (in Sedgwick County) during all months except May and June. Flows would decrease by about 16-36 cfs during this two-month period. Average daily flows over 1,000 cfs would still occur approximately 5% of the time, and average daily flows above 300 cfs would continue approximately 10% of the time. Since these larger, high energy flows would change little and high energy flows have the most influence on stream morphology,[4] load transport,[5] and often on aquatic species reproduction, impacts to these natural processes should be minimal. Kansas established a year-round MDS of 20 cfs at this location. All simulated median monthly flows with the project would exceed the MDS (Figure 4-5). Project implementation would increase the probability of stream flows exceeding the Kansas MDS (78-92%), as compared to conditions without the project (68-92%.) The KDWP has no official, current MDS recommendations for protection of habitat but has indicated in the past that it would prefer minimum flow values at this site of 60 cfs in April, May, and June, when many species reproduce. The agency recommends minimum flows of 34 cfs for the remaining months. Again, project implementation should result in greater frequency in meeting KDWP flow recommendations (56-77% with project compared to 51-74% without project.)

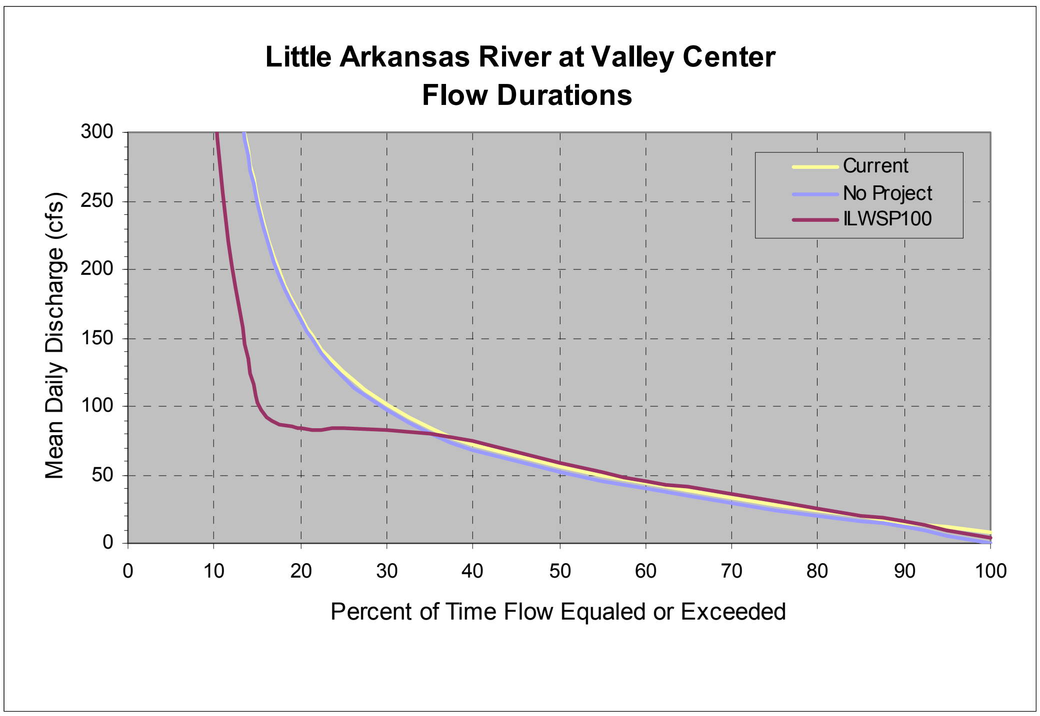


Figure 4-5 Flow durations for the Little Arkansas River at Valley Center

Project-related increases in *base flow* in the Little Arkansas at Valley Center should eventually raise flow elevations in the river about 0.05 feet during most months. Slight declines in elevation from April through June would be likely (as stated above) when diversions would be highest. These greater diversions for aquifer recharge could lower water levels by as much as 0.2 feet about 25% of the time. Data on the number of days per year (1995-2005) when base flow was exceeded are provided in Table 4-3. Modeled monthly base flow summaries are charted in Appendix A.

4 Stream morphology is the field of science dealing with changes of stream form and cross-section due to sedimentation and erosion processes

5 High energy flows can pick up and carry much more sediment, debris and other particles than lower energy flows

No diversions would occur during low flows and changes to flow during moderate periods would impact aquatic ecosystems less than changes during high or low “outlier” flows. Negative impacts resulting from surface diversions would be partially offset by the benefits of increased *base flow*. Changes in the flow regime due to diversion would be more apparent during flows between 80 and 300 cfs (Figure 4-5.)

Little Arkansas at Mouth

The most pronounced flow changes would occur just upstream of the confluence of the Little Arkansas with the Arkansas River in Wichita. The Expanded Local Well Field (not part of the project) could divert up to 45 MGD (70 cfs) from the Little Arkansas River in this area. Again, no diversions would occur when river flows fall below 20 cfs, the MDS established by KDHE. However, pumping from

Figure 4-6 Little Arkansas flows into the Arkansas River at Wichita

the Expanded Local Well Field and from upstream would typically cause monthly, median flows at the mouth to drop to about 20 cfs. Water would be diverted from collector (infiltration) wells approximately 90% of the time, or for all flows above the MDS. Median monthly flows currently range from about 17-106 cfs. Simulated daily flow durations indicate that discharge to the Arkansas River from this location would decrease markedly about 80% of the time. The Expanded Local Well Field lies between the Arkansas and Little Arkansas rivers, near their confluence in an urban, extensively developed area. Natural habitat within the City has been reduced by floodway diversions, low-head dams, bulkheads, and other channel modifications. Most of the river banks through downtown have been rip-rapped, built upon, or otherwise modified by man

(Figure 4-6.) There is a low-head dam at the mouth of the Little Arkansas, a second dam about 500 meters upstream, and additional dams constructed upstream from there. As a result, water flows from pool to pool and water elevation in this short stream segment would be maintained, despite the drop in average flow. Likewise, periodic high and flood flows would not be expected to decrease in frequency. These flows would effectively maintain the scour and build effects needed to maintain sandbars and other riverine habitat. As a result, changes resulting from the project should not cumulatively impact natural habitats.

During periods of maximum diversion, flows and water levels would drop, but the amount of drop would be limited by the MDS (Figure 4-7.) Project facilities would continue to be developed through the year 2050 (Phase IV), which would assure incremental change in streamflow. Extended implementation would also result in incremental increases in *base flow* as the aquifer level increases. The rate at which the Equus Beds is recharged would depend on climatic conditions and the rate at which construction is completed.

Mitigation – Little Arkansas River, Surface Water Levels
Regaining the natural operating balance between the aquifer and the Little Arkansas River is one of the primary objectives of the project. Overall median flows would decrease, as more water would be diverted from the river when flows reach or exceed moderate levels. However, *base flows* would be protected and likely increased. Significant flow reductions would occur only in the short, pooled reach near the mouth of the stream, primarily during periods of moderate flow. Low-head dams and other modifications to both stream and banks have resulted in an urban, rather than a natural environment near the confluence. Additional mitigation for any changes in water surface level or flow is not necessary in this locale.

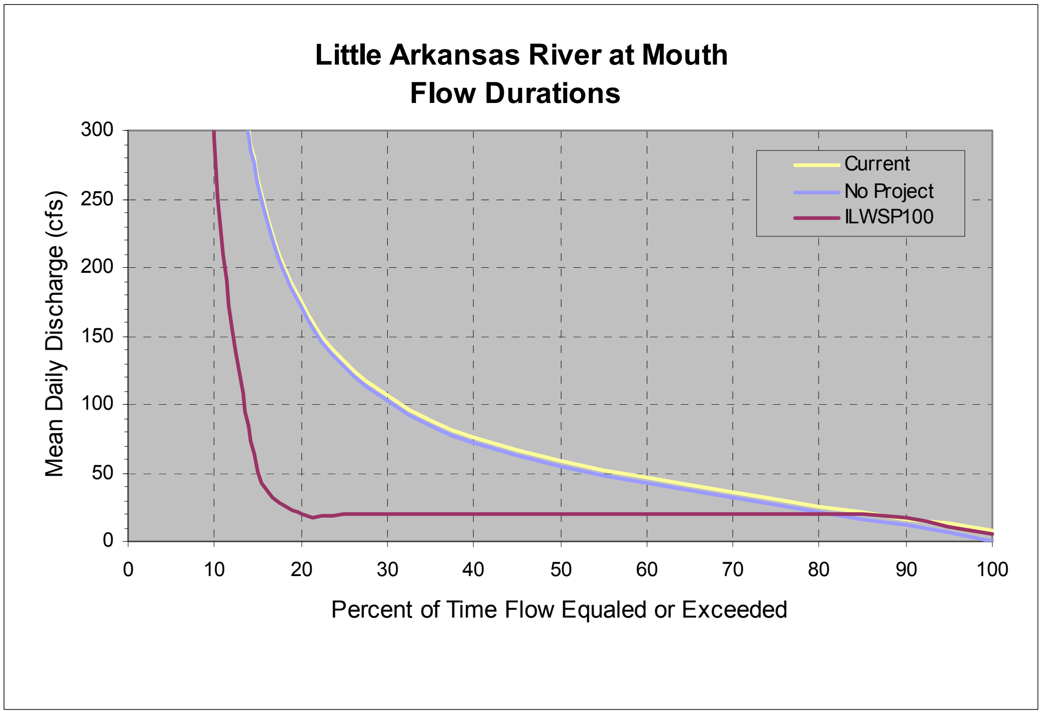


Figure 4-7 Flow durations for the Little Arkansas River at the mouth

Arkansas River

Wichita

The nearest USGS gauging station in the Arkansas River downstream from the Little Arkansas and the project area is approximately 3.7 miles below the confluence with the Little Arkansas. Flows at this site are influenced by groundwater discharges to the Little Arkansas and by withdrawals from both the Arkansas River upstream and from the Little Arkansas. These discharges and diversions include:

- Induced infiltration from the Arkansas River resulting from redevelopment of the Bentley Reserve Well Field
- Induced infiltration from the Little Arkansas River resulting from operation of the expanded Local Well Field
- Diversions from the Little Arkansas for recharge of the Equus Beds aquifer (the Aquifer Storage and Recharge Phases of the ILWSP)
- Changes in the amount of groundwater discharge from the Equus Beds to the Little Arkansas and Arkansas rivers
- Upstream irrigation and water rights withdrawals from the Little Arkansas and Arkansas rivers.

Figure 4-8 Arkansas River downstream from confluence with Little Arkansas

Median monthly flows below the confluence with the Little Arkansas River currently range from about 206 to 765 cfs. During these typically higher flows, impacts from diversions upstream or in the Little Arkansas would be largely buffered. The net or overall effect would be reduced. Simulated flow duration curves indicate that during low flow periods, project flows would be slightly higher than those predicted without the project. Conversely, the project would result in slightly reduced flows during higher flow periods. Overall, water surface elevations with the project would be expected to vary less than 0.1 feet from those without the project (Figure 4-9.) Modeled monthly base flow summaries are charted Appendix A. Flows in the Arkansas River near the mouth of the Little Arkansas should be minor, as the Little Arkansas contributes only a small part of the total river flow. Impacts to sediment load transport and channel morphology would also be considered minor, as these processes occur primarily during high and flood flows. The percent of time that flows exceed 1500 cfs should drop slightly, from about 14% to 13%, with the project.

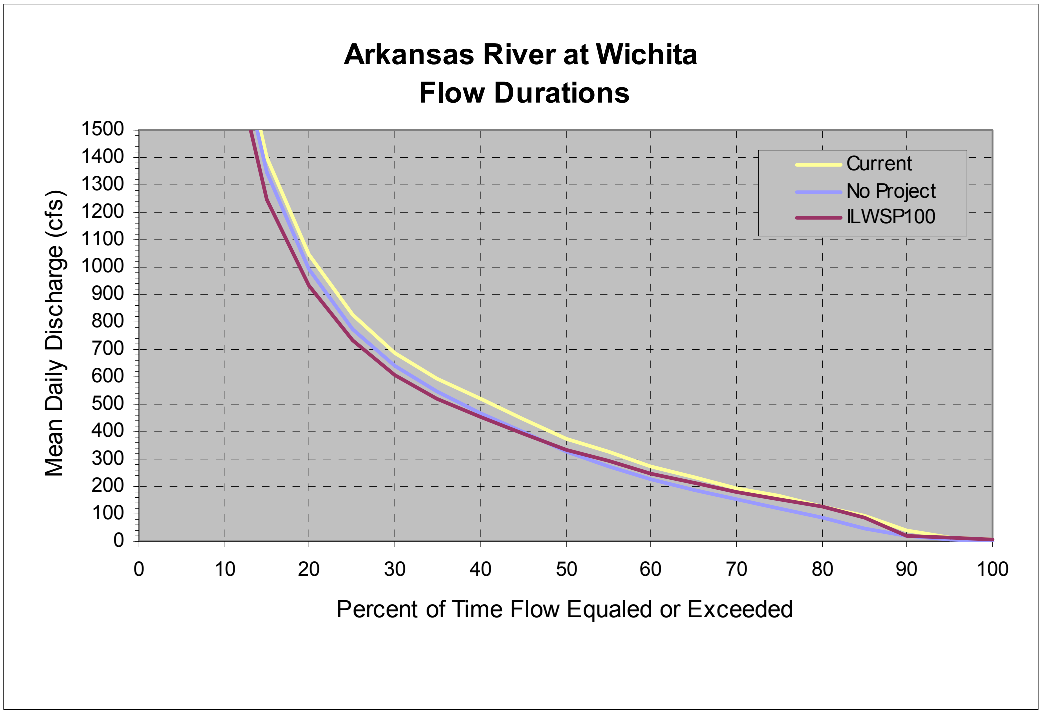


Figure 4-9 Flow durations for the Arkansas River at Wichita

Arkansas City

The USGS station on the Arkansas River at Arkansas City lies about 24 miles downstream from the confluence with the Ninnescah, near the Kansas-Oklahoma state line. Discharge at this site would reflect net downstream impacts from the ILWSP (including the project) as it lies below both the confluence of the Arkansas with the Little Arkansas and with the Ninnescah. Due to distance downstream and relatively small predicted changes to overall flow, no adverse impacts on water resources are expected. Simulated median monthly flows suggest that peak flows in June could be 36 cfs less with the project than without it. That would be equal to about a 2% reduction in median flow. Annual median flows would drop by only about 1.2 cfs or about 0.15% (Figure 4-10).

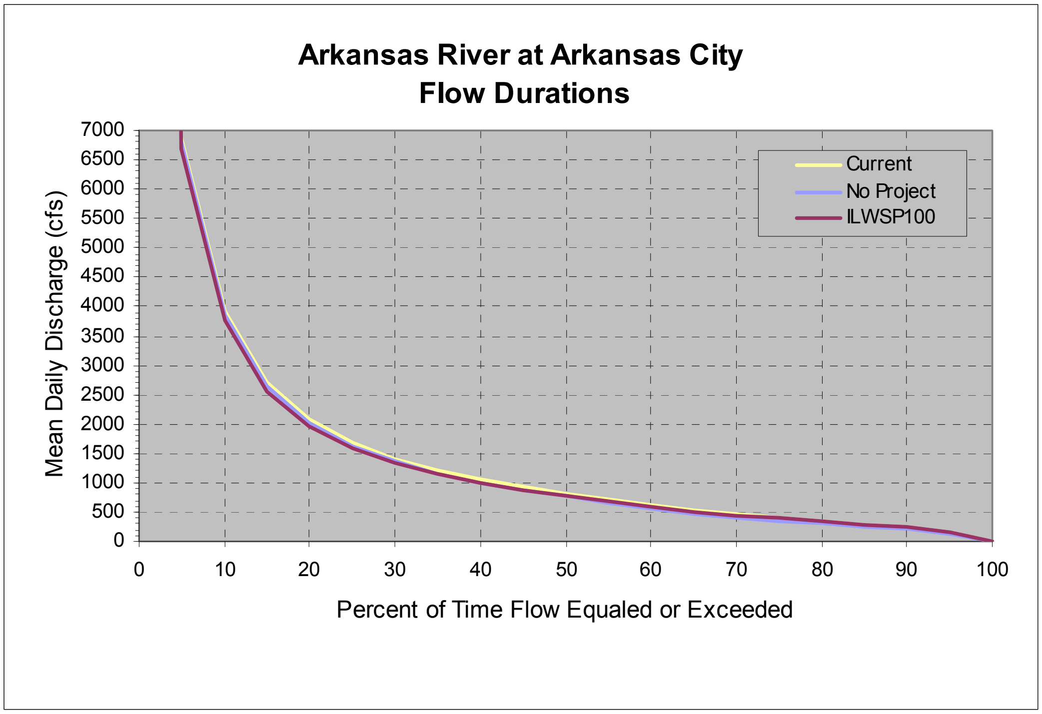


Figure 4-10 Simulated flow durations on the Arkansas River at Arkansas City

Mitigation – Arkansas River, Surface Water Levels

Changes in flow in the Arkansas River downstream from the project area considered to be inconsequential. As a result, net impacts to the river and ecosystem should be insignificant. No mitigation is necessary.

Cheney Reservoir

The project should result in more City reliance upon water from the Equus Beds and less dependence upon water from Cheney Reservoir. Increased use of the Local and Bentley Reserve Well fields (through the ILWSP) would also reduce the City's reliance on the reservoir. RESNET modeling predicts that increased use of Equus Beds water would result in a 1.5 to 3 foot overall increase in pool elevation at Cheney (Figure 4-11.) Should the project not be completed, municipal demands on Cheney during drought periods could deplete the usable water supply.

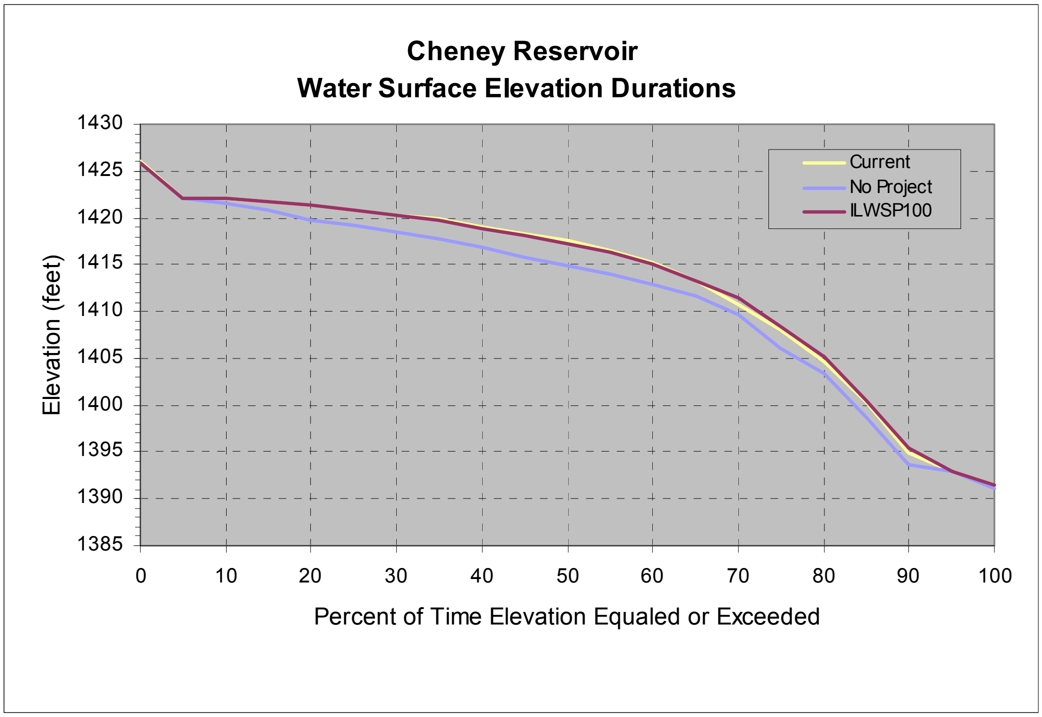


Figure 4-11 Surface water elevations for Cheney Reservoir

Mitigation – Cheney Reservoir, Surface Water Levels
No mitigation should be necessary.

North Fork of the Ninnescah River

There are no minimum release requirements for Cheney Reservoir. Releases generally occur only after significant runoff events and when the conservation pool is full (elevation 1421.6 feet.). Releases and spills from the reservoir into the North Fork would likely decrease without the project, as Wichita would be forced to take more water from conservation storage. The project should result in lower municipal demand on the reservoir, and thus higher average water levels. This could result in an increase in the number and volume of water releases from the dam (Figures 4-11 and 4-12), resulting in similarly modest, higher average flows in the river. Higher water levels should benefit water rights holders, and both aquatic and riparian communities downstream.

Mitigation – North Fork of the Ninnescah River, Surface Water Levels
No mitigation is necessary.

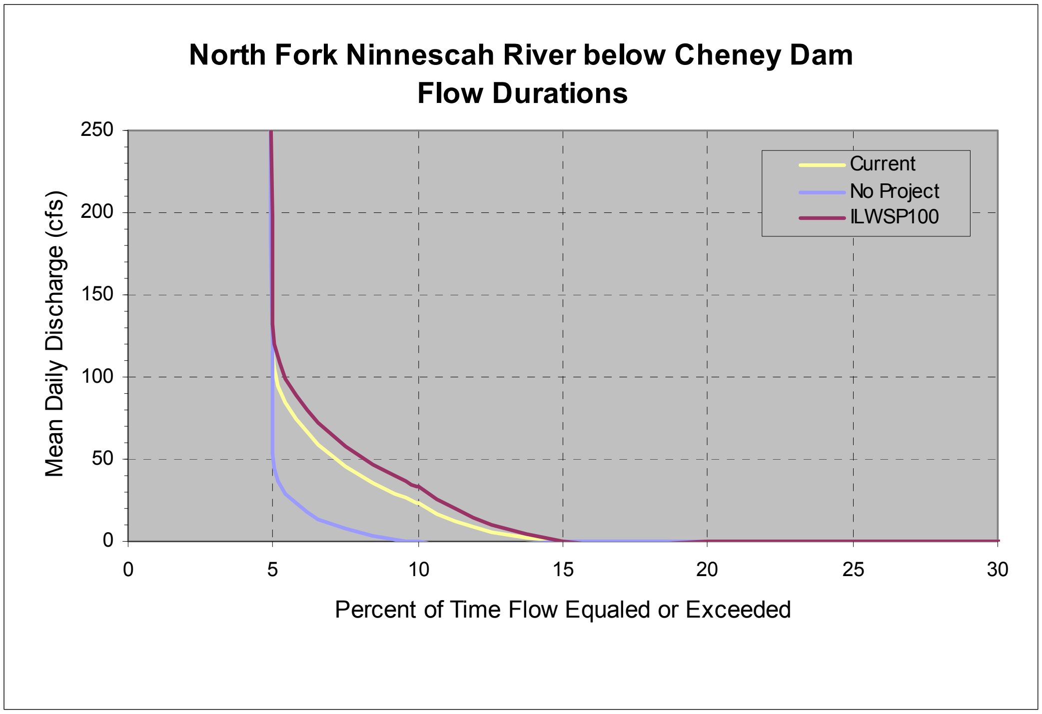


Figure 4-12 Flow durations for North Fork Ninnescah below Cheney Dam

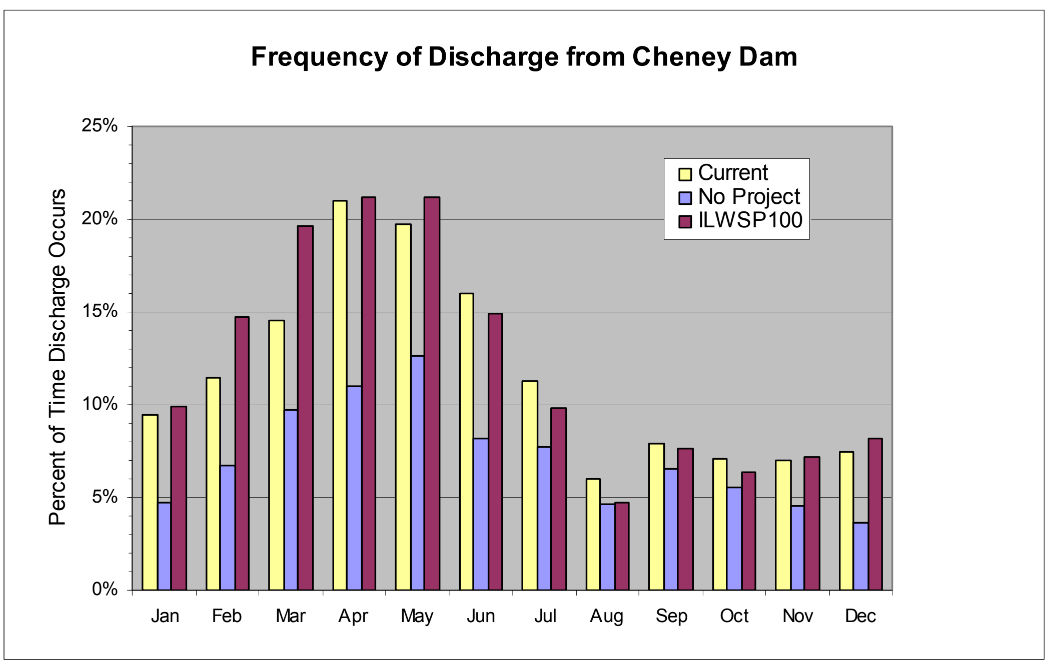


Figure 4-13 Discharge frequency from Cheney Dam

Ninnescah River near Peck

Simulated project impacts to the Ninnescah River below its confluence with the North Fork would be insignificant compared to total stream discharge. Spills from Cheney Reservoir make up only a tiny part of total streamflow. The project could result in overall flow increases of about 9 cfs in comparison to no project (Figure 4-14)

The established MDSs at this location based on month are:

- 100 cfs from November through May
- 70 cfs in June
- 30 cfs from July through September, and
- 50 cfs in October.

The percentage of time that MDS values could be met would vary slightly, whether or not the project is implemented.

Mitigation – Ninnescah River near Peck, Surface Water Levels
No mitigation is necessary.

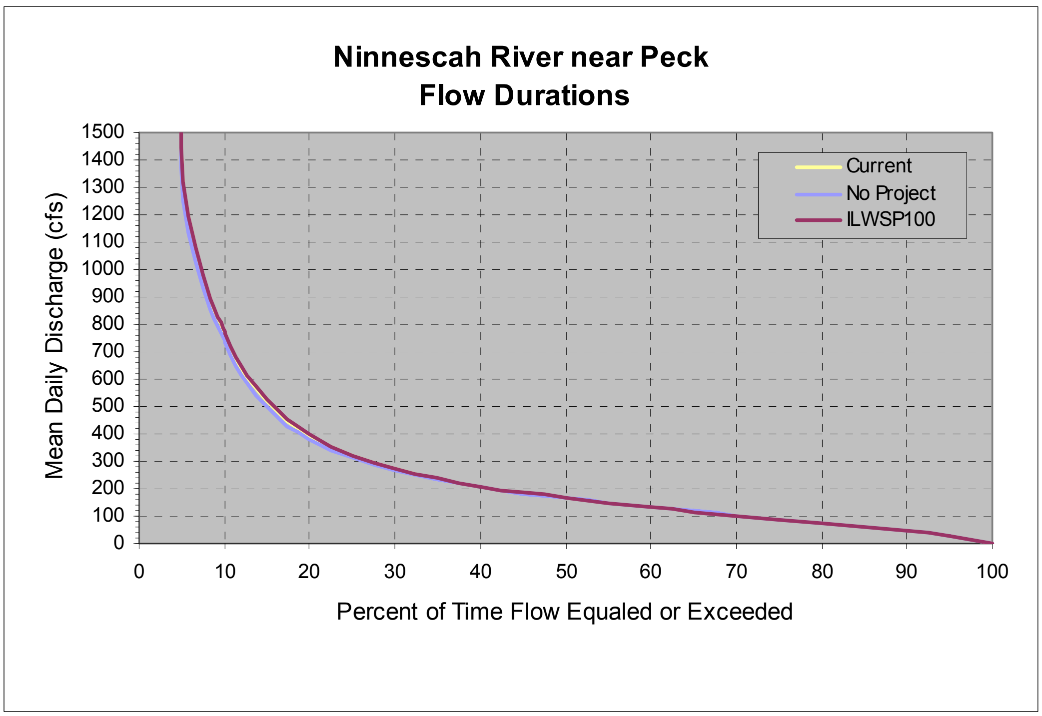


Figure 4-14 Flow durations in the Ninnescah River near Peck

Surface Water Quality

A variety of factors influence water quality in and around the project area, including season, amount of sunlight or shade, flow rate, water depth, precipitation, temperature, aquatic/riparian community health, and agricultural, industrial and domestic activities. Given these factors, surface water quality can vary considerably with both time and location. The project would impact some of these contributing factors, water depth and flow rate, for example, but this impact should be minimal. In addition, eventual higher quality groundwater discharges contributing to *base flow* should improve water quality in the Little Arkansas, which discharges to the Arkansas River.

Little Arkansas River

KDHE includes Little Arkansas River segments 1 (headwaters[6]) and 14 (upstream of the confluence with the Arkansas in Wichita) on its list of streams with water quality impairments. The constituents of concern for segment 14 (project area) include chlordane, dissolved oxygen, oxygen demand, nutrients, and sediments (KDHE 2001). Atrazine levels in water may be elevated during the spring and summer when most herbicides are applied. Identification of seasonal trends is important because high stream flows have a substantial effect on chemical loads (Christensen *et al*. 2000). Chemical concentrations are often reduced during periods of high flow, which are generally more common during certain months.

In general, the Little Arkansas is a "gaining" stream within the project area, as indicated by higher water levels in the surrounding aquifer than in the stream (Myers *et al.* 1996; Aucott *et al.* 1998). Gaining streams are partially replenished from groundwater sources. A relatively large amount of local annual precipitation (approximately 20%) recharges the Equus Beds aquifer and moves down gradient. Percolation through sands and soils removes some contaminants, resulting in higher quality water in the aquifer than on the surface. Groundwater not intercepted by pumping ultimately discharges to the Little Arkansas and lower reaches of the Arkansas River. The single exception along the Little Arkansas is near Halstead, where a small dam causes higher surface water elevations upstream than in the aquifer, resulting in a reverse flow (the stream recharges the aquifer.)

The quality of water in the aquifer can often exceed that of the river. Seasonal environmental fluctuations, changes in human or livestock activities, flow rates and groundwater levels can directly impact surface waters. Therefore, surface water quality can be beneficially impacted by groundwater discharges. Injecting pre-treated water into the aquifer, or allowing it to infiltrate through sands from recharge basins should increase aquifer storage. It should also raise water table levels, limit salt water intrusion, and help enhance water quality. In addition, pre-treating water to reduce atrazine has been shown to effectively reduce concentrations to near-baseline levels (Ziegler et al. 1999). Simply diverting water through a diversion well located next to the stream removed about 75% of the atrazine, probably through sorption to aquifer sediment (Schmidt *et al.* 2007). This filtration process also removed or reduced the concentration of other potential contaminants (that is*,* chlorides, suspended solids, bacteria, etc.) Some suspended solids filter out as water flows through the stream bottom to bank storage wells. These solids tend to re-suspend in the stream during high flows,

[6] Headwaters refer to waters located near the origin or beginning of a stream

which temporarily increases suspended solids concentrations in the water column. Suspended sediments are scoured from the bottom during high flow events anyway, so little additional impact would be expected.

The overall effect would be increased gain of higher quality water in the Little Arkansas from Equus Beds discharges. Provided that polluting influences remain the same, long-term improvements in Little Arkansas River water quality would be expected.

Mitigation – Little Arkansas River, Water Quality
The project is intended to improve long-term water quality in the Little Arkansas River. No mitigation is necessary.

Arkansas River

Water quality impacts to the Arkansas River should result primarily from changes in the quantity and quality of water received from the Little Arkansas. While diversions from the Little Arkansas would occur only when flows are above *base flow*, these diversions would nevertheless reduce the quantity of better quality water available for dilution of the salty Arkansas River. This impact would be somewhat reduced once the aquifer elevation exceeds 1389 ft. Flow simulations indicate that the Equus Beds would then start contributing to *base flow* in the Arkansas as well as the Little Arkansas. Water entering the stream from the aquifer would be of generally higher quality, but of insufficient quantity to substantially improve mainstem water quality.

Long-term impacts to the Arkansas River downstream of the confluence with the Little Arkansas should result in an overall average decrease in flow of about 2%. Improvements in the quality of Little Arkansas discharges and to Arkansas River recharge from a rising aquifer should partially mitigate this minor reduction in flow. Total dissolved solids (TDS), total suspended sediment (TSS), and chloride concentrations would likely increase slightly in the mainstem. Such increases would be expected to be insignificant.

Mitigation – Arkansas River, Water Quality
Predicted changes in water quality in the Arkansas River are less discernable in comparison to the water quality improvements expected in the Equus Beds and Little Arkansas River. No changes in designated stream uses would result, as salinity of the Arkansas River is periodically too high for use as an irrigation or drinking water source. No mitigation is necessary.

Cheney Reservoir

Cheney Reservoir lies on the North Fork of the Ninnescah River, which is outside the immediate project area. No direct impact on reservoir water quality would be expected. As aquifer levels rise and groundwater quality improves, more drinking water should be diverted from the Equus Beds aquifer and less from the reservoir, resulting in higher reservoir water levels (provided there are no significant changes in local climate or other surface water uses.) Rising water levels would be expected to have neutral to positive effects on water quality.

Mitigation – Cheney Reservoir, Water Quality
Water quality impacts of higher water levels in Cheney Reservoir are not known at this time, but should not cause any degradation of water quality. Mitigation is not necessary.

North Fork of the Ninnescah River

Increased releases from Cheney Reservoir due to the project should provide a net, positive benefit to water quality in the North Fork of the Ninnescah River and to nearby riparian zones. Increased flows should increase dissolved oxygen levels for support of fish and wildlife and provide additional water to water rights holders.

Mitigation – North Fork of the Ninnescah River, Water Quality
No mitigation is necessary.

Surface Water Rights

Little Arkansas River

The City would not divert water from the Little Arkansas River unless flow exceeds MDS requirements (20 cfs during winter (non-irrigation season and 57 cfs (irrigation season) at Halstead. Trigger rights at the Sedgwick river intake have not yet been determined by the KDWR.) No additional water rights would be needed. There should be no impact to existing water rights.

Mitigation – Little Arkansas River, Surface Water Rights
No mitigation is necessary.

Arkansas River

Flows in the Arkansas River downstream from the confluence with the Little Arkansas would decrease slightly with the project, especially during periods of moderate to high flow. The KDA lists only 1 water rights permit (industrial) within the City on the Arkansas below the confluence with the Little Arkansas. State records indicate that this diversion is not currently active (KGS 2008). The next diversion point is located more than 11 miles downstream, near the city of Derby.

Mitigation – Arkansas River, Surface Water Rights
The modest decrease in flow during high energy river flows, when plenty of water is available, would not impact existing surface water rights. No mitigation is necessary.

Cheney Reservoir

The project should make more water available for withdrawal from the Equus Beds. This should ultimately result in less reliance by the City upon waters diverted from Cheney Reservoir. Reservoir water rights holders would benefit.

Mitigation – Surface Water Rights in Cheney Reservoir
No mitigation is necessary.

North Fork of the Ninnescah River

The project would mean decreased City dependence upon water diverted from Cheney Reservoir. As a result, more water should be available for release from Cheney Dam, benefiting downstream water rights holders.

Mitigation – North Fork of the Ninnescah River, Surface Water Rights
No mitigation is necessary.

Groundwater Resources

The Equus Beds is an important source of municipal, industrial, irrigation, domestic and livestock water. There are 1,620 non-domestic wells withdrawing an average of 157,000 acre-feet (51.2 billion gallons) of water from the aquifer each year. Industrial use comprises approximately 15% of the total, while irrigation takes another 50% and municipalities use 34%. All other uses account for about 1% (GMD2 1995). The Kansas legislature created GMD2 in 1972 to manage and protect the heavily used aquifer. Once representatives were selected and the district boundaries approved in 1974, management of the Equus Beds was based on two fundamental principles: 1) the Aquifer Safe-Yield Principle, which limits withdrawals to annual recharge, and 2) the Groundwater Quality Principle, which seeks to maintain naturally occurring water quality.

Groundwater Levels

The City, irrigators, and others would continue to rely on the Equus Beds as a prime water source, with or without the project. Should the project not be developed, water levels in the aquifer would continue to drop and water quality would degrade as more high-chloride Arkansas River water seeps into the aquifer.

In general, the project would increase the volume of water stored within the Equus Beds. Increasing storage would result in a corresponding increase in aquifer elevation. The rate at which the Equus Beds could be recharged after a drought would improve dramatically. Due to changing climatic conditions, it is not possible to accurately estimate the time needed to replenish current storage deficits; however, the 100 MGD ASR (60/40) Preferred and No Action Alternatives should result in an estimated net recharge rate of 12,700 acre-feet/year (Burns &McDonnell 2003.) With a current deficit of 250,000 acre-feet, initial replenishment should take an estimated 21 years, given the current information on precipitation, temperature, and water use. Once the aquifer were replenished, modeling suggests that water storage could be maintained within 100,000 acre-feet of pre-aquifer development conditions.

The USGS studied groundwater level impacts at artificial recharge sites near Halstead and Sedgwick during 1997-98 (Ziegler *et al.* 1999). River levels near Halstead were nearly always higher than water levels in the adjacent aquifer, due to a downstream, low-head dam. This indicated that, contrary to other segments of the Little Arkansas, the segment running through Halstead tends to recharge the aquifer. In addition, approximately 307 million gallons of water were artificially recharged through a well at the Halstead site. Water levels in shallow monitoring wells showed little or no change, while water levels in deep wells rose during extended periods of artificial recharge. Water levels receded once artificial recharge stopped, most likely due to distribution of locally recharged water throughout a wider area within the aquifer. Regardless, these notable changes in water level in the deep wells verified that artificial recharge rates were sufficient to benefit the aquifer.

Only approximately 37 million gallons of water were artificially recharged at the Sedgwick site. The entire recharge was done through recharge basins rather than through recharge recovery wells. All four monitoring wells showed increases in water levels while recharge was occurring, but when recharge ceased, water levels dropped within two months.

The volume of water recharged at either site during the study was inadequate to accurately predict long-term water level impacts. The spread of recharge waters throughout the aquifer over time and distance (moving away from the recharge point) likely limited the ability to monitor long-term effects over such a short time period. However, RESNET modeling indicates that raising the water table would increase hydraulic gradients from the aquifer to the Little Arkansas River. This would result in an increase in river *base flows*. Raising the water table would also result in a general reduction of hydraulic gradients from the Arkansas River to the aquifer, resulting in decreased infiltration of river water with higher chloride concentrations. RESNET predicts an overall, potential decrease of about 50 cfs by 2050, should the project be fully implemented. In addition, once aquifer levels reach 1389 feet, the aquifer could begin recharging the Arkansas, though volumes would be too small to impact water quality in the river. Discharge from the aquifer to the smaller Little Arkansas would be expected to increase by 4 cfs or greater.

Mitigation – Groundwater Levels

One of the primary purposes of the project is to increase water levels in the aquifer to more natural levels. This should help protect against saltwater intrusion and increase groundwater gains to both the Little Arkansas and Arkansas rivers. More ground water would become available for agricultural, municipal and industrial use. No mitigation for rising groundwater levels is necessary.

Groundwater Quality

Water quality in the aquifer varies considerably, depending upon which geologic formation the water comes from. Water tends to become more mineralized with depth (Burns & McDonnell 2003). Total dissolved solids (TDS) content ranges from 300 mg/l to 2,700 mg/l. Oil field brine (saltwater) contamination has made some groundwater unsuitable for use in parts of western Harvey County. This water quality degradation is attributable, in part, to historic poor management of brines from salt-mining and oilfield production prior to enactment of laws and regulations designed to prevent mismanagement of waste. Chloride concentrations in contaminated areas range from 500 mg/l to 8,000 mg/l. Before saltwater contamination, chloride concentrations were less than 150 mg/l (GMD2 1995). The EPA Secondary Maximum Contaminant Level (SMCL) is 250 mg/l.

The project should provide some water quality relief in both shallow and deeper areas. This would be accomplished by:

1) injecting relatively high quality water from the Little Arkansas River during high flows
2) reducing the hydraulic gradient between the Arkansas River and the aquifer, thereby reducing infiltration rates of high chloride water, and
3) inserting freshwater between salty and higher quality water areas.

Salinity increase in the aquifer is undesirable and is a key water management issue. Adding freshwater is expected to dilute high chloride waters and help impede the rate of water quality degradation by changing the hydraulic gradient.

The USGS collected more than 4,000 water samples from the Little Arkansas River, diverted source water, and monitoring wells near the recharge areas between 1995 and 2000. Researchers found four possible contaminants to be of concern (COCs.) COCs, are defined as contaminants with concentrations greater than 20% of drinking water standards (Ziegler *et al*. 2001). COCs in the Equus Beds include chloride, arsenic, total coliform bacteria, and atrazine. Data indicate that mixing shallow groundwater near the stream with surface water dilutes overall concentrations of atrazine. Powder Activated Carbon (PAC) could be used to remove additional amounts during primary herbicide application season (May through June.) The City would monitor atrazine levels to ensure that water is treated for the contaminant when necessary.

The USGS used chloride as a tracer during artificial recharge studies from 1995 through 2004. Researchers noted that Total Organic Carbon (TOC) concentrations from shallow monitoring wells alongside the Little Arkansas River near Halstead were diluted by 20% compared to water collected directly from the river. Diverting stream water through a diversion well at Halstead removed approximately 75% of the atrazine and diluted other chemical concentrations as well (Schmidt *et al.* 2007). Clay, organic matter, and other particles in the soil

appeared to filter out many constituents. These results demonstrated potentially effective bank water collection and filtration which could enhance water quality protection of the alluvial aquifer.
Schmidt, *et al.* (2007) examined the geochemical effects of induced stream-water recharge on the Equus Beds during a pilot demonstration project from April 1995 through May 2002. The authors concluded that water level declines in the aquifer may accelerate migration of saltwater from the Burrton oil field and the Arkansas River. Data indicated that water levels and chemistry in the shallow part of the aquifer next to the Little Arkansas River were constantly recharged. As a result, groundwater chemistry was similar to that of the Little Arkansas River. Data suggest that artificial recharge from the Little Arkansas during high flow would not only augment the City's underground water supply, it would replenish the aquifer with fresh rather than saltwater (Appendix A).

Water samples from the Halstead recharge site showed physicochemical impacts from artificial recharge. Chloride concentrations (median concentration of 60 mg/l) in diverted source water at the Halstead site were lower than in samples of fresh water. The USGS attributes this to the fact that diversion water was collected during high flow periods when chloride concentrations were lower. Chloride concentrations in shallow monitoring wells approximated chloride concentrations in recharge water shortly after recharge. Once recharge ceased, chloride levels rebounded to greater than pre-recharge concentrations.

The quality of pre-treated surface water diverted at the Sedgwick site was also improved over the quality of raw river water (Ziegler *et al.* 1999). Diverted surface water was treated before pumping into recharge basins (no recharge recovery wells were used at Sedgwick) and most physical properties – like turbidity and suspended solids – improved substantially. A polymer was used to remove turbidity before recharge. Concentrations of constituents like dissolved solids, bacteria, and organic compounds were lower in treated recharge water than in the river. Median chloride concentration in the treated diversion water was 62 mg/l, well below EPA's SMCL.

Given these findings, USGS researchers point out that the volume and period of artificial recharge (especially at the Sedgwick site) have been inadequate to determine long-term water quality impacts. About 744 million gallons of water had been artificially recharged at Halstead by January 2001. Approximately 136 million gallons had been recharged near Sedgwick. Artificial recharge during the Equus Beds Groundwater Demonstration project was equivalent to less than 3% of the water pumped for municipal use (USGS 2008). Some increases in chloride and atrazine concentrations in well water were noted during the trial, though concentrations remained considerably less than standards established by the EPA.

Mitigation – Groundwater Quality
One of the intended purposes of the project is to protect and enhance groundwater quality. Water quality monitoring would continue and mitigation measures; that

is, additional treatment to reduce atrazine, turbidity, chloride or bacteria levels (chlorination followed by dechlorination) would be instituted, as needed.

Groundwater Rights

Area groundwater rights are significantly over-allocated in relation to groundwater recharge values. Prior to 1990, estimated safe groundwater yield per year was 50,240 acre-feet, based on recharge estimates of 6 inches/year. The USGS subsequently revised estimated recharge rates to 3.2 inches/year (Hansen 1991). The more recent estimate supports an actual safe yield of 29,900 acre-feet/year. The City's water rights for the Equus Beds Well Field alone allow use of 40,000 acre-feet (78 MGD) per year.

Groundwater Management District No. 2 was created in 1974 to manage the aquifer's falling water table. This resulted in the closure of most areas in the City's well field to development of additional water rights. Regardless, a total of approximately 120,000 acre-feet/year of water rights had already been allocated in the 175 square mile Equus Beds area by 2003. Should the project be implemented, the amount of water in storage and available for recovery would be reviewed and certified annually by GMD2. The City has obtained additional water rights for withdrawals from the Bentley Reserve and Expanded Local well fields (Table 4-4). However, poor water quality in the Bentley Reserve Well Field already limits agricultural use.

Table 4-4 Projected Water Recovery and Diversion Rates

Area	Annual Quantity (ac-ft)	Max. Diversion Rate (MGD)
Bentley Reserve Well Field	5,000	10
Expanded Local Well Field	35,000	45
Source Water Diversion (Surface)	100,000	100
Storage Recovery Rights	Depends upon volume stored	126

The project would benefit current water rights holders in two ways: 1) higher groundwater levels would reduce pumping costs, and 2) reduced migration of high chloride water from the Arkansas River and the Burrton oil field would help protect groundwater quality.

Mitigation – Groundwater Rights

The project would help protect existing groundwater rights by increasing water storage and improving water quality in the Equus Beds. The KDWR and GMD2 are developing regulations and permitting requirements to ensure that existing water rights would not be negatively impacted. No further mitigation would be necessary.

Air Quality

The Wichita/Sedgwick County area has been designated as "In Attainment" for air toxins and criteria pollutants since 1989 (USEPA 2008). Air pollutant criteria are provided in Table 4-4. The project would add only minor sources of air pollutants and contaminants. Well-head pumps and other equipment would be electrically powered, placing additional modest demands on electric utilities. Backup generators would be used only when utilities fail. As a result, neither the "Prevention of Significant Deterioration" (PSD) increments nor significant impact levels for criteria pollutants would be exceeded in the long-term. Fugitive dust (PM_{10}) from excavations or vehicle traffic over dirt roads could exceed PSD levels during construction. Likewise, short-term emissions from construction equipment could increase NO_X (nitrogen dioxide produced by high temperature combustion), CO (carbon monoxide) and SO_2 levels. Actual increases would depend upon the type and amount of construction equipment being used, but pollutants would only result in short-term impacts to ambient air quality.

Table 4-5 Air Pollutant Criteria

Pollutant	Averaging Period	Significance Criteria ($\mu g/m^3$)	Secondary[a] Criteria
SO_2[b]	Annual	20	
	24-hour	91	
	3-hour	512	1300 $\mu g/m^3$
PM_{10}[c]	Annual	17	
	24-hour	30	150 $\mu g/m^3$
$PM_{2.5}$[d]	Annual		15 $\mu g/m^3$
	24-hour		35 $\mu g/m^3$
NO_2[e]	Annual	25	0.053 ppm[f]

Source: www.epa.gov/air/criteria.html

[a] Secondary criteria were established by the EPA to protect public welfare
[b] Sulfur dioxide
[c] Particulate matter less than 10 micrometers in diameter
[d] Particulate matter less than 2.5 micrometers in diameter
[e] Nitrogen dioxide
[f] ppm = parts per million by volume

Mitigation – Air Quality

No mitigation is necessary.

River Intake

THE STATE OF KANSAS

KANSAS DEPARTMENT OF AGRICULTURE
[redacted]
Joshua Svaty, Acting Secretary of Agriculture

DIVISION OF WATER RESOURCES
David W. Barfield, Chief Engineer

APPROVAL OF APPLICATION
and
PERMIT TO PROCEED

(This Is Not a Certificate of Appropriation)

This is to certify that I have examined Application,**File No. 46,627** of the applicant

City of Wichita
Water & Sewer Department
455 North Main
Wichita, Kansas 67202

for a permit to appropriate water for beneficial use, together with the maps, plans and other submitted data, and that the application is hereby approved and the applicant is hereby authorized, subject to vested rights and prior appropriations, to proceed with the construction of the proposed diversion works (except those dams and stream obstructions regulated by K.S.A. 82a-301 through 305a, as amended), and to proceed with all steps necessary for the application of the water to the approved and proposed beneficial use and otherwise perfect the proposed appropriation subject to the following terms, conditions and limitations:

1. That the priority date assigned to such application is **November 13, 2006.**

2. That the water sought to be appropriated shall be used for both Artificial Recharge in the basin storage area previously identified in Phase I of the aquifer storage and recovery (ASR) project and for

Municipal Use within the City of Wichita and immediate vicinity; within the City of Andover and immediate vicinity, within the City of Bel Aire and immediate vicinity, within the City of Benton and immediate vicinity, within the City of Derby and immediate vicinity; within the City of Kechi and immediate vicinity; within the City of Park City and immediate vicinity; within the City of Rose Hill and immediate vicinity; within the City of Valley Center and immediate vicinity; within the City of Bentley and immediate vicinity, within the boundaries of Rural Water District No. 1, Sedgwick County; within the boundaries of Rural Water District No. 2, Sedgwick County; within the boundaries of Rural Water District No. 3, Sedgwick County; and within the boundaries of Rural Water District No. 8, Butler County; within a tract of land in Sedgwick County, Kansas, beginning at the Southeast corner of Section 25, Township 28 South, Range 2 East, then West a distance of 22 miles to the Southwest corner of Section 28, Township 28 South, Range 2 West, then North a distance of 16 miles to the Northwest corner of Section 9, Township 26 South, Range 2 West, then East a distance of 22 miles to the Northeast corner of Section 12, Township 26 South, Range 2 East, then directly Southa distance of 16 miles to the point of beginning.

3. That the authorized source from which the appropriation shall be made is surface water from the Little Arkansas River, to be withdrawn by means of one (1) water intake structure located in the Northeast Quarter of the Northwest Quarter of the Northwest Quarter (NE¼ NW¼ NW¼) of Section 9, more particularly described as being near a point 4,960 feet North and 4,020 feet West of the Southeast corner of said section, in Township 25 South, Range 1 West, Sedgwick County, Kansas, located substantially as shown on the topographic map accompanying the application.

4. That the water intake structure has been assigned Division of Water Resources Structures Permit No. CSG-0289.

5. That the appropriation sought shall be limited to a maximum diversion rate not in excess of **41,667 gallons per minute (92.84 c.f.s.)** and to a quantity not to exceed **14,738.24 million gallons** (45,230 acre-feet) of water for any calendar year.

6. That installation of works for diversion of water shall be completed on or before **December 31, 2011**, or within any authorized extension thereof. The applicant shall notify the Chief Engineer and pay the statutorily required field inspection fee, which is currently $400.00, when construction of the works has been completed. Failure to timely submit the notice and the fee will result in revocation of the permit. Any request for an extension of time shall be submitted prior to the expiration of the deadline and shall be accompanied by the required statutory fee, which is currently $100.00.

7. That the proposed appropriation shall be perfected by the actual application of water to the proposed beneficial use on or before **December 31, 2029**, or any authorized extension thereof. Any request for an extension of time shall be submitted prior to the expiration of the deadline and shall be accompanied by the required statutory fee, which is currently $100.00.

8. That the applicant shall not be deemed to have acquired a water appropriation for a quantity in excess of the amount approved herein nor in excess of the amount found by the Chief Engineer to have been actually legally been used for the approved purpose during one calendar year subsequent to approval of the application and within the time specified for perfection or any authorized extension thereof.

9. That the use of water herein authorized shall not be made so as to impair any use under existing water rights nor prejudicially and unreasonably affect the public interest.

10. That the right of the appropriator shall relate to a specific quantity of water and such right must allow for a reasonable raising or lowering of the static water level and for the reasonable increase or decrease of the streamflow at the appropriator's point of diversion.

11. That this permit does not constitute authority under K.S.A. 82a-301 through 305a to construct any dam or other obstruction; nor does it grant any right-of-way, or authorize entry upon or injury to, public or private property.

12. That all diversion works constructed under the authority of this permit into which any type of chemical or other foreign substance will be injected into the water pumped from the diversion works shall be equipped with an in-line, automatic quick-closing, check valve capable of preventing pollution of the source of the water supply. The type of valve installed shall meet specifications adopted by the Chief Engineer and shall be maintained in a satisfactory operating condition.

13. That an acceptable water flow meter shall be installed and maintained on the diversion works authorized by this permit in accordance with the Kansas Administrative Regulation 5-22-4. This water flow meter shall be used to provide an accurate quantity of water diverted as required for the annual water use report, and such additional reports required in the Order to which this permit is attached (including the meter reading at the beginning and end of the report year).

14. That the applicant shall maintain accurate and complete records from which the quantity of water diverted during each calendar year for municipal use and artificial recharge may be readily determined, and the applicant shall file an annual water use report with the Chief Engineer by March 1 following the end of each calendar year. Each authorized beneficial use of water shall be separately reported on the annual water use report. Failure to file the annual water use report by the due date shall cause the applicant to be subject to a civil penalty.

15. That no water user shall engage in nor allow the waste of any water diverted under the authority of this permit.

16. That failure without cause to comply with provisions of the permit and its terms, conditions and limitations will result in the forfeiture of the priority date, revocation of the permit and dismissal of the application.

17. That the right to appropriate water under authority of this permit is subject to any minimum desirable streamflow requirements identified and established pursuant to K.S.A. 82a-703c for the source of supply to which this water right applies.

18. That diversion of natural flows shall not take place unless there is water available to satisfy all demands by senior water rights and permits.

19. That the stream flow shall not be stopped at the first riffle below the point of diversion while diversion is taking place under the authority of this permit.

20. That the surface water intake structure authorized herein shall be operated only when flows in the Little Arkansas River at the U.S. Geological Survey stream gage No. 07144200 located west of Valley Center, Kansas exceed baseflow, and in order to ensure protection of senior water rights, shall not cause the streamflow at said Gage to fall below **30 cubic feet per second (c.f.s.).**

21. That the surface water intake structure shall be constructed and maintained to allow only withdrawal of surface water.

22. That the injection of any surface water into the Equus Beds Aquifer is authorized by the Kansas Department of Health and Environment.

23. That the rate of diversion and quantity of water approved under this permit for municipal use, is further limited to the rate of diversion and quantity of water which when combined with the rate of diversion and quantity of water authorized for artificial recharge use under this permit will provide a maximum diversion rate not in excess of **41,667 gallons per minute (92.84 c.f.s.)** and to a quantity not to exceed **14,738.24 million gallons** (45,230 acre-feet) of water for any calendar year.

24. That the Chief Engineer specifically retains jurisdiction in this matter with authority to make such reasonable reductions in the approved rate of diversion and quantity authorized to be perfected, and such changes in other terms, conditions, and limitations set forth in this approval and permit to proceedas may be deemed to be in the public interest.

That this approval of application is further subject to the terms, conditions, and limitations of the Order approving the Phase II ASR Project to which this permit is attached.

Review of this permit is subject to the provisions of the Petition for Review of Order, set forth in the Chief Engineer's accompanying Findings and Order.

Dated at Topeka, Kansas, this 18th day of September, 2009.

DIVISION OF WATER RESOURCES * DAVID W. BARFIELD CHIEF ENGINEER * KANSAS DEPARTMENT OF AGRICULTURE

David W. Barfield, P.E.
Chief Engineer
Division of Water Resources
Kansas Department of Agriculture

State of Kansas)
) SS
County of Shawnee)

The foregoing instrument was acknowledged before me this 18th day of September, 2009, by David W. Barfield, P.E., Chief Engineer, Division of Water Resources, Kansas Department of Agriculture.

OFFICIAL SEAL SHERYL P. FERGEL MY COMMISSION EXPIRES January 5, 2010

Notary Public

1. Physical recharge activities will continue to occur during periods when aquifer conditions facilitate adequate physical recharge capacity defined by an annual ASR Operations Plan.
2. The rate of accrual of all recharge credits cannot exceed the constructed physical diversion capacity of the ASR system including direct surface water diversions and future bank storage wells, and will be limited to the rate and quantity authorized by Water Right No. 46627.
3. ASR Phase I RRW's are not eligible to receive AMCs, only physical recharge at Phase I RRW's or recharge basins will result in the development of an ASR recharge credit.
4. The estimated aquifer storage volume in the CWSA during initial implementation of the ILWSP by the City and during the conceptual development of the ASR program is estimated at 120,000 AF (see Attachment H, page 13) therefore the combined total quantity of AMCs and physical recharge credits cannot exceed 120,000 AF. The proposed 120,000 AF limit on the combined total quantity of AMCs and physical recharge credits represents an estimated 11.7% of total available aquifer storage within the CWSA
5. The fundamental differences between the processes used to generate physical recharge credits and AMCs will require an alternative or modified accounting process for AMCs.
6. AMCs would be accumulated based on the metered quantity of water diverted from the Little Arkansas River via direct surface water diversions or water captured via bank storage wells and sent directly to the City.
7. A straight-forward spreadsheet accounting process will be adopted similar to other existing water management conservation programs in the State.
    a. A uniform and equal annual distribution throughout the EBWF to all authorized City points of diversion within the EBWF based on the annual quantity of water diverted from the Little Arkansas River sent directly to the Wichita MWTP.
    b. Uniform distribution of AMCs to all authorized City points of diversion within the wellfield reasonably reflects historic wellfield operations at locations where groundwater has effectively been left in storage within the aquifer due to the development and utilization of Little Arkansas River flows.
    c. After distribution and assignment of AMC quantities by point of diversion, an acceptable AMC accounting process will track the quantity of AMCs stored within each Index Cell.

3.5 ASR Physical Recharge & ASR Operations Plan

To illustrate the City's commitment to conducting physical recharge activities during periods when the aquifer permits physical recharge capacity, the City is proposing the use of an annual ASR Operations

CITY OF WICHITA

Department of Public Works & Utilities

May 22, 2018

David Barfield
Chief Engineer
Kansas Department of Agriculture
Division of Water Resources
1320 Research Park Drive
Manhattan, Kansas 66502

RE: City of Wichita Aquifer Storage and Recovery (ASR) Permit Modification Proposal

Dear Mr. Barfield:

On March 12, 2018, the City of Wichita (City) submitted "ASR Permit Modification Proposal Revised Minimum Index Levels & Aquifer Maintenance Credits" for your consideration. Prior to and following that submission the City conducted an informal engagement process with interested parties. Information received prior to the submission of the document helped inform the proposed conditions under which certain changes could be made to allow the City's ASR project to better provide drought resilience for the City's utility customers. This letter provides additional clarifications to our proposal based on the remainder of the informal engagement process.

With this submittal, the City considers the informal engagement to be completed and that it is time for the formal process you have recommended to begin. Time is of the essence to the City as we seek to improve the position of the largest water utility in the state to weather a drought.

1. The source water considered eligible for Aquifer Maintenance Credits (AMCs) would be the metered water from the ASR processes required prior to transmission to City's Main Water Treatment Plant.

2. As to the distribution of AMCs, the City offers the following additional information/perspective:

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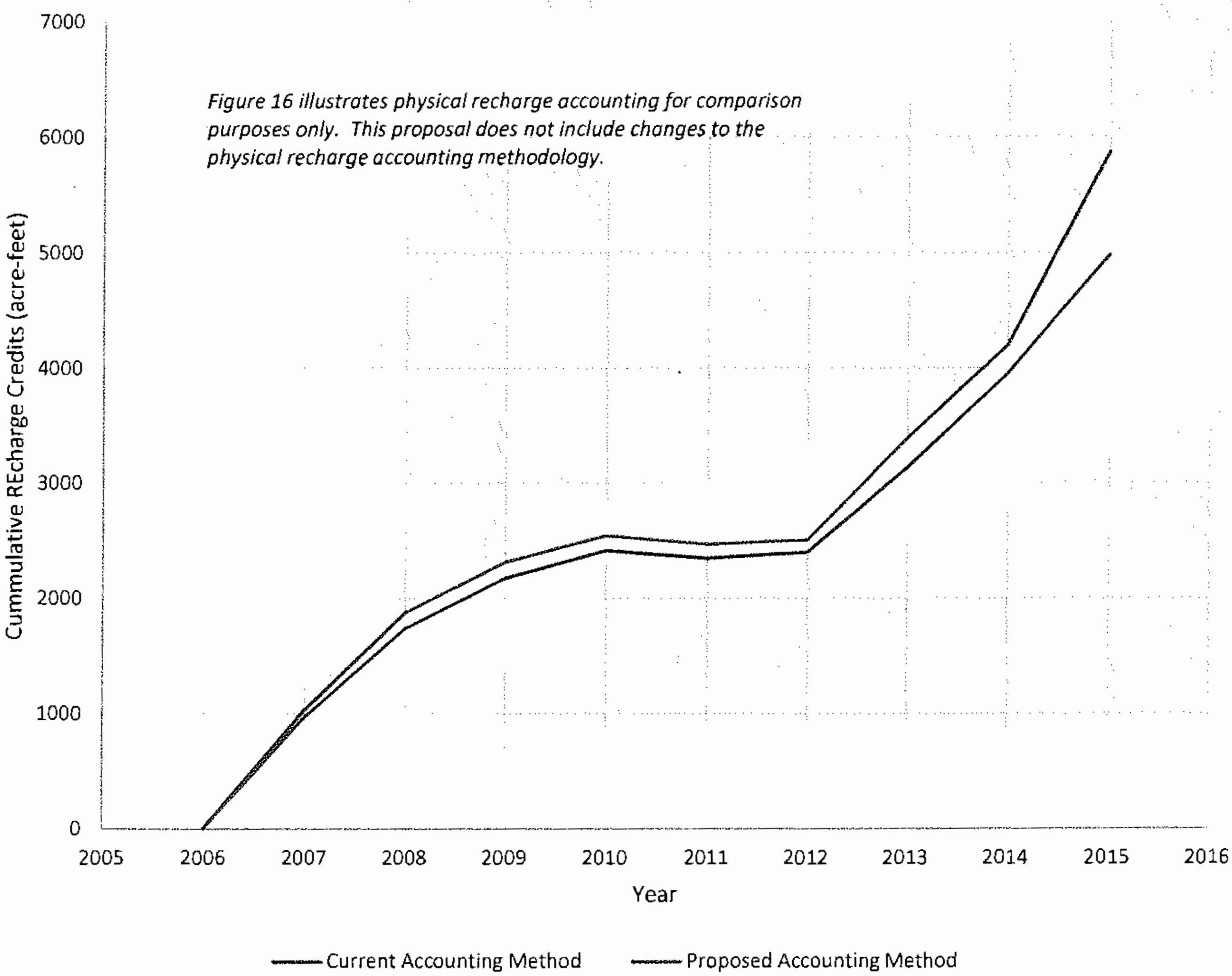
- Recharge credits are accumulated within Index Cells, not by well/s.,, All wells (recharge or production) in an Index Cell will be able to recover recharge credits if the permit modifications and pending applications are approved.
- Distributing AMCs equally across City production wells reasonably represents where groundwater has been left in storage as a result of utilizing LAR diversions as a source of supply.
- Distributing AMCs by Recharge Recovery Well (RRW) or by all wells does not change the quantity applied. Distribution to all wells will also provide the greatest degree of flexibility during periods of recharge credit recovery ensuring the opportunity to minimize any localized interference.

3. It is important to understand the basis for the selection of the initial and recurring losses:
   - A review of field data, previous accounting reports, and the multiple rounds of groundwater modeling completed within Attachment J of the proposal all indicate that an initial loss rate of five percent mirrors the current physical recharge accounting practice over a range of aquifer levels and conditions.
   - Gradational losses of one, three, and five percent moving from west to east across the wellfield reflect the direction of groundwater flow and migration losses of recharge credits from the basin storage area.
     i. Losses from the BSA on the west side of the EBWF are minimal where water slowly migrates from the west side of the EBWF to Index Cells in the center and eastern portions of the BSA.
     ii. Losses from the BSA in the center of the wellfield are greater where larger volumes of water are injected resulting in a water level changes that create migration to down-gradient Index Cells and areas outside of the BSA.
     iii. Losses from the BSA are highest on the east side of the wellfield, where water is lost to the Little Ark River and to the south outside of the BSA.
   - Figure 16 of the proposal illustrates a comparison of the actual physical recharge accounting process (the blue line) and the proposed AMC recharge accounting process using the five percent initial and one, three, and five percent gradational loss (the green line). As can be seen in the figure below, proposed AMC losses track very well with the physical recharge losses.
   - The difference in the total cumulative retention of credits in later years (73% for the physical accounting process compared to 85% utilizing the proposed AMC accounting) is due to full aquifer conditions and the substantial amount of recharge that has occurred at recharge basin RB-36.

Figure 16 - Current and Proposed Accounting Method Results Comparison



4. The constructed physical recharge capacity of ASR infrastructure and the capacity of the aquifer to accept recharge are different quantities:
   - At lowered water levels that facilitate physical recharge, the existing ASR system is capable of recharging 34.5 million gallons per day (MGD). Note that constructed physical recharge capacity exceeds the capacity of the Phase II ASR water treatment plant, which can produce up to 30 MGD of water for recharge.
   - Figure 14 located on page 3-12 of the proposal illustrates an example ASR Operations Plan reflective of elevated groundwater levels (2016), current ASR infrastructure, and water level conditions encountered during January of 2016.

- Based on 2016 elevated groundwater levels, the current sustainable physical recharge capacity is only 1.18 MGD.

5. Regarding the role of ASR recharge basins during consideration of physical recharge capacity and AMCs:
   - The City has excluded all Phase I recharge infrastructure from the permit modification proposal which includes recharge basin RB-2. The City believes that the highest value of water recharged at Phase I facilities will continue to be mitigating the movement of the Burrton chloride plume rather than developing recharge credits for later utilization during prolonged drought.
   - The permit modification proposal is intended to facilitate continued management of the aquifer at near full conditions. During near full aquifer conditions, the recharge water sent to RB-36 experiences significant losses. It is not in the best interest of the City or other aquifer users to focus physical recharge activities on locations where the water recharged is not effectively retained within the BSA for beneficial use, and for this reason RB-36 is not included in the calculation of physical recharge capacity.

6. The City has proposed utilizing an operations plan which relies upon static groundwater level measurements taken in January of each year:
   - The Kansas Geological Survey (KGS), United States Geological Survey (USGS), Division of water Resources (DWR) and Groundwater Management District no. 2 (GMD2) standard practice is to use January groundwater levels as the baseline representation of true aquifer storage conditions.
   - ASR physical recharge activities occur during and after significant periods of heavy precipitation which limits the correlation between physical recharge capacity and seasonal irrigation or municipal drawdown.
   - An annual ASR operations plan based on January groundwater levels provides clear, consistent, and manageable tracking of the relationship between physical ASR recharge capacity and groundwater elevations.

7. The physical recharge capacity of the ASR system is governed by several variables including a minimum feasible operating rate:
   - Please review page 3-7 of the proposal which indicates that the 5 MGD minimum for physical recharge capacity is considerate of the operational limits of the ASR system at lower flows which include pipeline residence times, well redevelopment frequency, pipeline flushing requirements, and water treatment plant startup and shutdown times.

8. The City offers the following to clarify the purpose of the examples that are provided in the proposal and to augment them as necessary:

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- AMCs would be accumulated during periods when the recharge capacity of the aquifer and ASR system is less than the source water capture and process capacity of the ASR system.
- The examples on page 3-7 of the proposal were provided to illustrate a range of ASR water treatment plant operating rates, water level conditions, and physical recharge capacities.
- Please review section 3.5 of the permit modification proposal which contains the details of the operations plan and provides measurable assurance of the City's continued commitment to conducting physical recharge.
- Example 3 on page 3-7 was provided with the intent of including an instance where the ASR water treatment plant is running at 30 MGD under "Moderate Groundwater Levels" rather than "Lowered Groundwater Levels".
- To illustrate the City's commitment to conducting physical recharge during periods of lowered groundwater levels, the City would like to submit Example 4 below:

  Example 4 – Lowered Groundwater Levels with Available Recharge Capacity

  ASR Physical Recharge Capacity – 34.5 MGD
  ASR WTP Running at 30 MGD – 30 MGD to physical recharge facilities
  Max amount of ASR WTP water eligible for AMC – **0 MGD**

9. Regarding the conversion of existing production wells to recharge wells:
   - It is unreasonable to assume that the City should invest in conversion of additional conventional wells to recharge wells given that the City already has adequate infrastructure at existing recharge wells to conduct 34.5 MGD of recharge during lowered groundwater conditions.
   - The purpose of the proposed permit conditions is to facilitate management of the aquifer at near full conditions. During full aquifer conditions the City already has idle recharge well infrastructure due to lack of physical aquifer recharge capacity. Constructing additional idle recharge capacity would not provide a benefit to the City or other aquifer users
   - Future conversion of conventional wells to recharge wells will be based on the anticipated remaining lifespan of all existing wells and the projected benefits to the overall capacity of the ASR system.

10. For 2014 and 2015, a total of 1,132.19 acre-feet was diverted to town and could have been converted to AMCs. Any calculations related to years prior than 2014 would be highly speculative in nature.

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11. Currently the permits that cover the City's ASR program do not contain any limitation on the maximum number of recharge credits that can be accumulated. The City has voluntarily proposed a limitation on the combined total of physical recharge credits and AMCs based on the documented amount of aquifer storage available in 1993 during the original conception of the ASR project.

12. The City remains committed to maintaining the water quality of domestic wells within 660 feet of ASR physical recharge sites.
    - The City believes that a 660 feet distance is consistent with the original protections granted to domestic wells during development of the permit conditions for the ASR project.
    - No information has been presented indicating that ASR operations have caused any significant or detrimental changes in water quality that would warrant an extension of the 660 feet distance to the entire ASR Basin Storage Area.

13. The City remains committed to maintaining the water levels at domestic wells within 660 feet of ASR physical recharge sites.
    - The City believes that a 660 feet distance as is consistent with the protections previously granted to domestic wells during development of the permit conditions for the ASR project.
    - Note that the purpose of the proposed permit conditions is to facilitate improved management of the aquifer resulting in longer durations where the aquifer is at near full conditions.

14. The City agrees with the operating principle that native water rights should be utilized prior to recharge credits.

The City anticipates that you will continue to follow the process and schedule set out in your May 9, 2018 letter. Specifically utilization of an evidentiary hearing process following the schedule previously provided. That is:

- May 2018 – Update proposal and draft proposed approval documents.
- Early June 2018 – Pre-hearing conference, set public hearing date.
- June 2018 – Public informational meeting.
- Late July or early August 2018 – Public hearing including GMD2 bringing its recommendations.
- August 2018 – Close record.
- September/early October 2018 – Review record and decision.
- Potential review of record and decision by the Secretary of Agriculture.
- Potential review of record and decision by district court.

The City remains committed to dedicating the time and resources necessary to allow this schedule to be maintained and asks that you require the same of all other parties involved.

Sincerely,

Alan King
Director of Public Works & Utilities

CC: Robert Layton, City Manager, City of Wichita
Joseph T. Pajor, City of Wichita Public Works & Utilities
Don Henry, City of Wichita Public Works & Utilities
Brian Meier, Burns & McDonnell
Paul McCormick, Burns & McDonnell
Daniel Clement, Burns & McDonnell
Tim Boese, Groundwater Management District No. 2

Summary and Conclusions

The *Equus* Beds aquifer is a primary water-supply source for the city of Wichita, Kansas. Water level declines because of municipal and agricultural pumping and periodic drought conditions have led to concern about the adequacy of the aquifer as a future water supply for Wichita. Chloride migration toward Wichita's central well field is another concern. Sources of chloride include oil-field brines that leaked from surface disposal pits and injection wells in the Burrton oil field area, municipal wastewater facility discharges, and mineralized water from the underlying Wellington Formation, and the high chloride waters from the Arkansas River to the southwest of the well field. In order to increase the volume of water stored in the aquifer and to protect the water quality from the chloride threats, in 2006 the city of Wichita began construction of the *Equus* Beds Aquifer Storage and Recovery project, to artificially recharge excess surface water flow from the Little Arkansas River into the aquifer for later recovery and to form a hydraulic barrier to retard movement of chloride in a brine plume near Burrton, Kansas.

In 2009, the USGS, in cooperation with the city of Wichita and as part of the *Equus* Beds Aquifer Storage and Recovery project, began a study to determine groundwater flow in the area between the Arkansas and Little Arkansas Rivers, which includes the Wichita well field and chloride transport from the Arkansas River and the Burrton oil field to the Wichita well field. A groundwater-flow model was developed using MODFLOW. Chloride transport was simulated for the *Equus* Beds aquifer using SEAWAT, a computer program that combines the groundwater-flow model MODFLOW-2000 and the solute-transport model MT3DMS. Chloride transport in the *Equus* Beds aquifer was simulated between the Arkansas and Little Arkansas Rivers near the Wichita well field. The chloride-transport model was used to simulate the period from 1990 through 2008 and the effects of five well pumping scenarios and one artificial recharge scenario. The chloride distribution in the aquifer for the beginning of 1990 was interpolated from groundwater samples from around that time, and the chloride concentrations in rivers for the study period were interpolated from surface water samples.

The SEAWAT model was used to compare chloride transport and groundwater flow between the existing-pumping and artificial-recharge scenario, four hypothetical well-pumping scenarios, and one hypothetical artificial-recharge scenario. The scenarios tested were (1) the existing 1990 through 2008 pumping and artificial recharge conditions, to serve as a baseline scenario for comparison with others; (2) no pumping in the model area, to demonstrate the chloride movement without the influence of well pumping; (3) double Wichita municipal pumping from the Wichita well field with existing irrigation pumping; (4) existing Wichita municipal pumping with no irrigation pumping in the model area; (5) double Wichita municipal pumping in the Wichita well field and no irrigation pumping in the model area; and (6) increasing artificial recharge to the Phase 1 Artificial Storage and Recovery project sites by 2,300 acre-ft per year.

In the existing pumping scenario, in the area between the Arkansas River and the southern boundary of the well field, the simulated chloride front moved north at an average rate of approximately 660 ft/yr in the shallow layer (layer 1), 780 ft/yr in the middle layer (layer 2), and 660 ft/yr in the deep layer (layer 3). The simulated chloride front moved toward the Wichita well field from the Burrton area at an approximate rate of 400 ft/yr in the shallow layer, 150 ft/yr in the middle layer, and 310 ft/yr in the deep layer.

In the no pumping scenario, chloride from the Arkansas River and the Burrton plume moved toward the Wichita well field. The chloride front from the Arkansas River near the southern part of the well field moved north toward the well field at an approximate average rate of 500 ft/yr in layer 1 (160 ft/yr slower than in the baseline scenario), 570 ft/yr in layer 2 (210 ft/yr slower than in the baseline scenario), and 510 ft/yr in layer 3 (150 ft/yr slower than in the baseline scenario). The simulated chloride front in the Burrton plume moved southeast toward the well field at a rate of approximately 520 ft/yr in layer 1 (120 ft/yr faster than in the baseline scenario), 70 ft/yr in layer 2 (80 ft/yr slower than in the baseline), and 190 ft/yr in layer 3 (120 ft/yr slower than in the baseline scenario).

In the double Wichita municipal pumping, existing irrigation pumping scenario, chloride from the Arkansas River and from the Burrton plume moved toward the Wichita well field. The simulated chloride front from the Arkansas near the southern part of the well field moved north toward and into the well field at an approximate rate of 810 ft/yr in layer 1 (150 ft/yr faster than in the baseline scenario), 870 ft/yr in layer 2 (90 ft/yr faster than in the baseline scenario), and 740 ft/yr in layer 3 (80 ft/yr faster than in the baseline scenario). The simulated chloride front in the main body of the Burrton plume moved southeast towards the well field at a rate of approximately 350 ft/yr in layer 1 (50 ft/yr slower than in the baseline scenario), 210 ft/yr in layer 2 (60 ft/yr faster than in the baseline scenario), and 440 ft/yr in layer 3 (130 ft/yr faster than in the baseline scenario).

In the existing Wichita municipal pumping and no irrigation pumping scenario, chloride from the Arkansas River near the southern part of the well field and from the Burrton plume moved toward the Wichita well field. The simulated chloride front from the Arkansas River moved north at an approximate rate of 590 ft/yr in layer 1 (70 ft/yr slower than in the baseline scenario), 710 ft/yr in layer 2 (70 ft/yr slower than in the baseline scenario), and 620 ft/yr in layer 3 (40 ft/yr slower than in the baseline scenario). The simulated chloride front of the main body of the Burrton plume moved southeast toward the well field at a rate of approximately 510 ft/yr in layer 1 (110 ft/yr faster than in the baseline scenario), 100 ft/yr in layer 2 (50 ft/yr slower than in the baseline scenario), and 260 ft/yr in layer 3 (50 ft/yr slower than in the baseline scenario).

In the double Wichita municipal pumping and no irrigation pumping scenario, chloride from the Arkansas River and the Burrton plume moved toward the well field. The simulated chloride front from the Arkansas River near the southern part of the well field moved north toward and into the well field at an average rate of approximately 770 ft/yr in layer 1 (110 ft/yr faster than in the baseline scenario), 850 ft/yr in layer 2 (70 ft/yr faster than in the baseline scenario), and 710 ft/yr in layer 3 (50 ft/yr faster than in baseline scenario). The simulated chloride front of the main body of the Burrton plume moved southeast at an average rate of approximately 500 ft/yr in layer 1 (100 ft/yr faster than in the baseline scenario), 150 ft/yr in layer 2 (the same as the rate estimate in the baseline scenario), and 400 ft/yr in layer 3 (90 ft/yr faster than in the baseline scenario).

In the increased Phase 1 artificial recharge scenario, the chloride transport from the Arkansas River near the southern part of the well field was similar to that of the baseline scenario. The simulated chloride front moved at the same rate in the increased Phase 1 artificial recharge scenario as in the baseline scenario. In the Burrton area, the simulated chloride front moved southeast toward the well field at an approximate average rate of 430 ft/yr in layer 1 (30 ft/yr faster than in the baseline scenario), 140 ft/yr in layer 2 (10 ft/yr slower than in the baseline scenario), and 270 ft/yr in layer 3 (60 ft/yr slower than in the baseline scenario). The eastward movement of the Burrton plume was slowed by the additional artificial recharge at the Phase 1 sites.

The average of simulated water levels from the end of the 2008 stress period in index monitoring wells in the Basin Storage Area was calculated for each scenario. Compared to the baseline scenario, the no pumping scenario was 5.05 feet higher, the double Wichita pumping with existing irrigation scenario was 4.72 feet lower, the no irrigation pumping with existing Wichita municipal pumping scenario was 2.49 feet higher, the double Wichita municipal pumping with no irrigation scenario was 1.53 feet lower, and the increased Phase 1 artificial recharge scenario was 0.48 feet higher.

The groundwater flow was simulated with a preexisting groundwater-flow model, which was not altered to calibrate the solute-transport model to observed chloride-concentration data. Therefore, in some parts of the model area, simulated and observed chloride concentration data match poorly. Most notably, chloride from the Arkansas River southwest of the well field moved northeast at a higher rate than the data indicate, and the simulated chloride front entered the most southern part of the well field in all scenarios simulated. Compared to the observed location of the chloride front interpreted from data collected in 2011, in the Arkansas River area the simulated chloride front moved from the river toward the well field about twice the rate of the chloride front interpreted from observed concentrations in layer 1 and about four times the rate of the chloride front interpreted from observed concentrations in layer 3. Achieving a better agreement between simulated and observed chloride data in the chloride-transport model may require changes to the groundwater-flow model. Future updates and recalibrations of the groundwater-flow and chloride-transport model will allow for changes in the groundwater-flow model parameters, including hydraulic conductivity, riverbed properties, and effective porosity, to accommodate the chloride-transport model in places where the chloride-transport model fit indicates problems with the groundwater flow.

Results of the modeling scenarios indicate that the Burrton chloride plume will continue moving toward the well field regardless of pumping in the area and that one alternative is to increase pumping from within the plume area to reverse the flow gradients and remove the plume. The modeling scenarios also indicate that the eastward movement of the Burrton plume could be slowed by additional artificial recharge at the Phase 1 sites. Decreasing pumping along the Arkansas River or increasing water levels in the aquifer near the river may retard the movement of chloride and may prevent further encroachment into the southern part of the well field area.

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Burns and McDonnell Engineering Consultants, 2009, Aquifer Storage and Recovery Project 2008 Accounting Report: Kansas City, Mo., Burns and McDonnell Engineering Consultants, [prepared for the Wichita Water and Sewer Department], [variously paged].

Burrton Task Force, 1984, Proposed Burrton Intensive Groundwater Use Control Area: prepared for the Kansas State Board of Agriculture, Division of Water Resources, 103 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods, book 1, chap. A1, 151 p. (Also available at *http://pubs.er.usgs.gov/publication/ofr02293*.)

aquifer and simulated effects of well pumping and artificial recharge on groundwater flow and chloride transport near the city of Wichita, Kansas, 1990 through 2008

Request No. 12: Memos, studies, reports, and/or documents regarding actual or potential impairment to other water users in the BSA as a result of the City withdrawing 120,000 AF in Alternative Maintenance Credits.

Counsel objects to the request as vague due to the vague reference to "other documents," and based on false premises due to the faulty use of the undefined term "Alternative Maintenance Credits" and Interveners' complete lack of understanding as to the character, application and function of the 120,000 AF limit.

/s/ Brian K. McLeod
Brian K. McLeod, SC # 14026

Subject to and without waiving the foregoing objection, no applicable documents are known to exist. The 120,000 acre-foot limit is a proposed new limit on accrual of AMCs and Physical Recharge Credits combined, and not a proposal to withdraw a net 120,000 acre feet of water from the aquifer, and consequently neither such a withdrawal nor the impact on chloride migration was modeled as part of the City's proposal because such an event is not contemplated by the City's proposal.

Request No. 13: Memos, studies, reports, and/or documents regarding actual or potential impairment to other water users in the BSA as a result of the proposed minimum index levels during the modeled 1% drought or the City's use of its current 40,000 AF appropriation.

Counsel objects to the request as vague due to the vague reference to "other documents," and further objects to the portion directed at the City's use of its current appropriation as irrelevant.

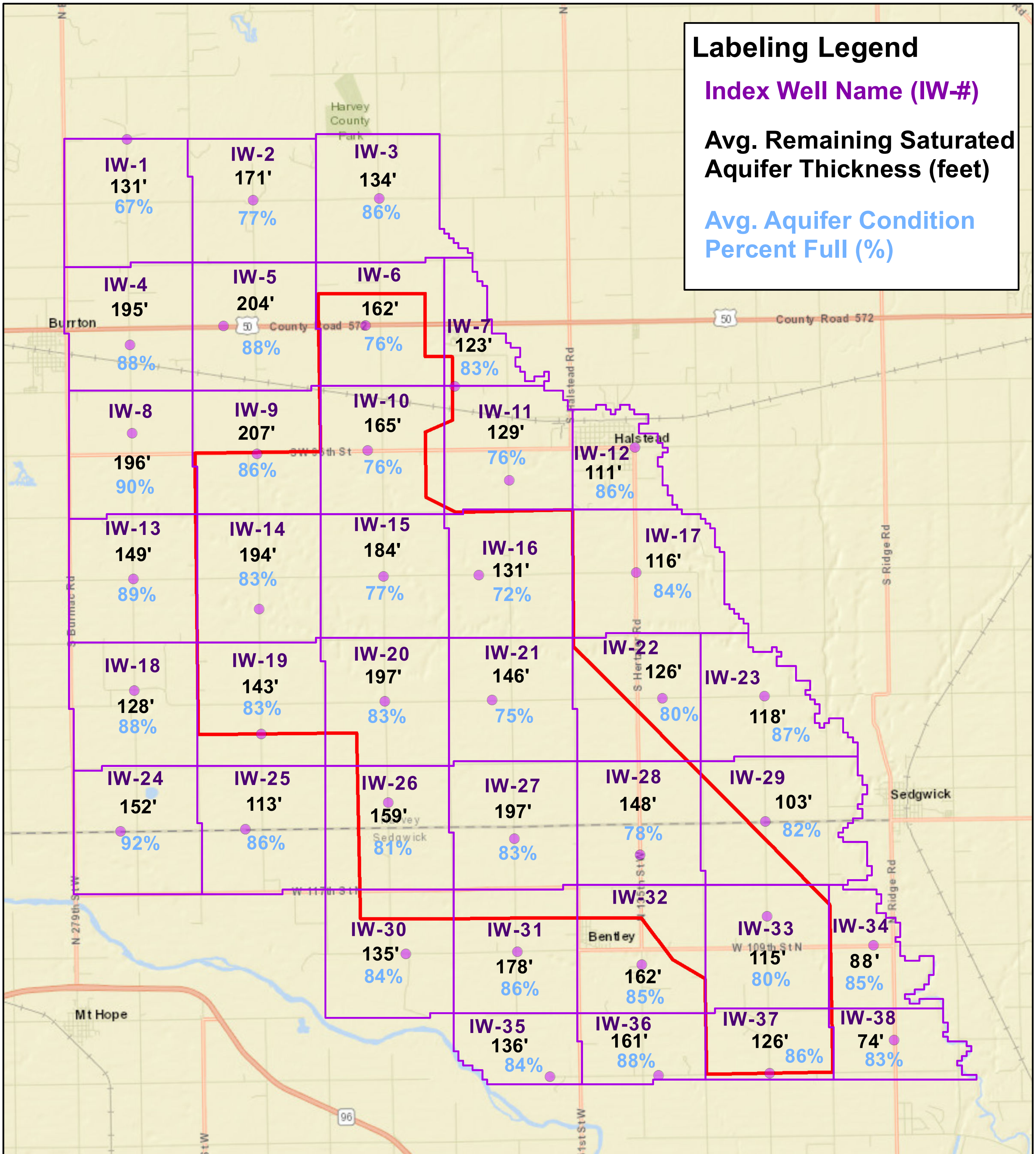
/s/ Brian K. McLeod
Brian K. McLeod, SC # 14026

Subject to and without waiving the foregoing objection, no applicable documents are known to exist. However, groundwater modeling data prepared during development of the Proposal represent the operation of known wells. Review of modeled performance of non-City wells in the vicinity of the Wichita wellfield was undertaken during modeling. Water levels at such wells were evaluated to verify that the wells continued to pump even during periods of modeled low water levels. Impairment was not indicated during the modeled 1% drought with increased pumping associated with recovery of Credits, as there were no observed instances were wells were shut down due to low water levels. Modeling data have been provided in the subdirectory Model in the City of Wichita's Responses to Production Requests of Equus Beds Groundwater Management District No. 2.

Request No. 14: Model results demonstrating the impact on other water rights and/or domestic water users in the BSA if the water levels drop (a) below the 1993 levels and (b) to the proposed minimum index levels.

a) Applicable modeling data have been provided in the subdirectory Model in the City of Wichita's Responses to Production Requests of Equus Beds Groundwater Management District No. 2. Review of potential impacts to non-City wells during the modeled drought conditions was performed as described in the response to Request No. 13.

b) There are no model results demonstrating impacts if the water levels drop to the proposed minimum index levels. The proposed minimum index levels include an additional contingency added pursuant to GMD2 requests, as shown in Table 2-10 of the Proposal. Review of potential impacts to non-City wells during the



Legend

- ASR Index Cells (Numbered)
- USGS Central Wellfield Study Area
- ASR Index Well Locations

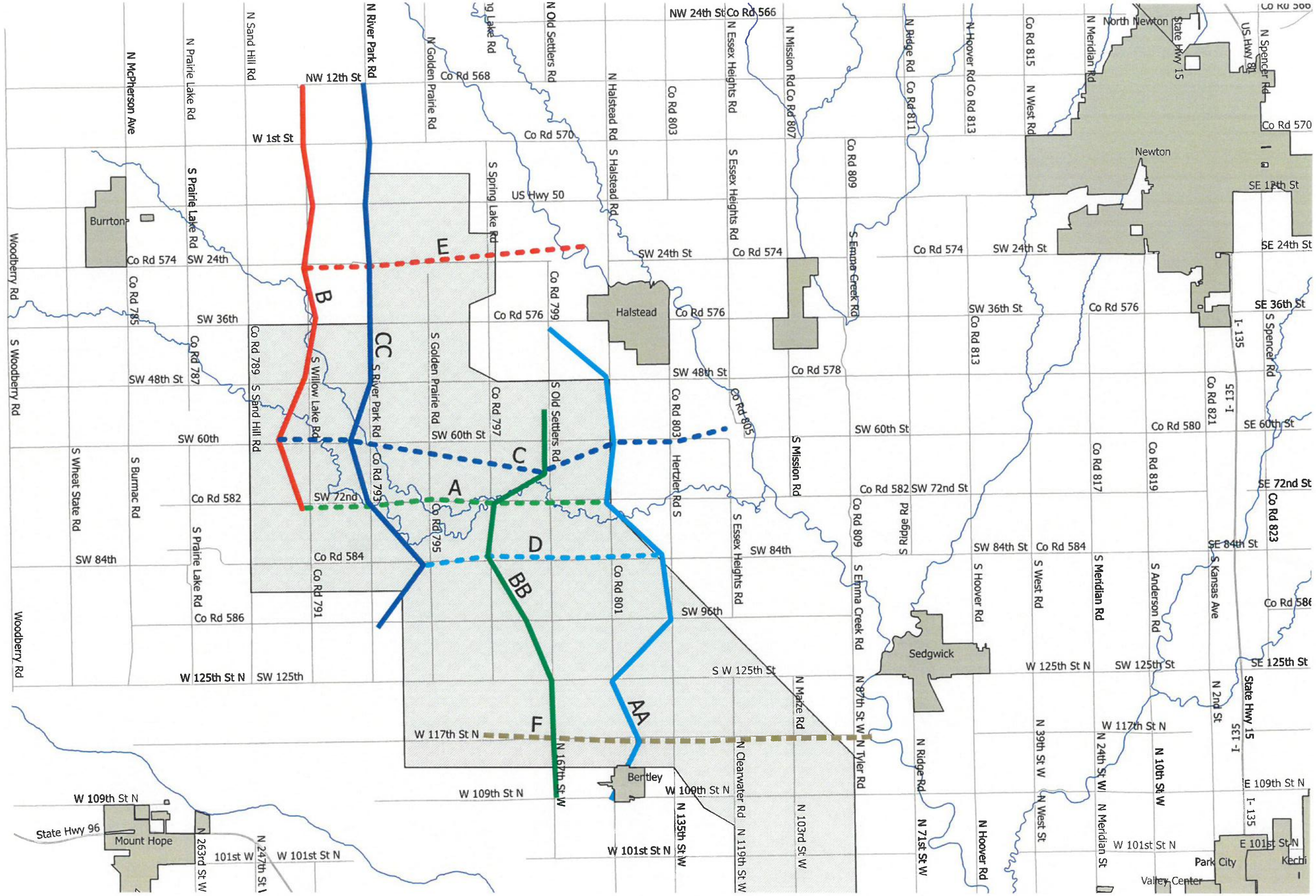
N

1:130,000

0 0.5 1 2
Miles

Figure 11

Average Aquifer Conditions by Index Cell at Modified ASR Minimum Index Level Elevations



A
AA
B
BB
C
CC
D
E
F
Burrton
Halstead
Sedgwick
Newton
North Newton
Bentley
Mount Hope
Park City
Valley Center
Kechi
N McPherson Ave
N Prairie Lake Rd
N Sand Hill Rd
N River Park Rd
N Golden Prairie Rd
N Old Settlers Rd
N Halstead Rd
NW 24th St Co Rd 566
N Essex Heights Rd
N Mission Rd Co Rd 807
N Ridge Rd Co Rd 811
N Hoover Rd Co Rd 813
Co Rd 815
N West Rd
N Meridian Rd
State Hwy 15
US Hwy 81
N Spencer Rd
NW 12th St
W 1st St
Co Rd 568
Co Rd 570
US Hwy 50
S Spring Lake Rd
S Halstead Rd
S Essex Heights Rd
Co Rd 803
Co Rd 809
S Prairie Lake Rd
Co Rd 574
SW 24th St
SW 36th
SW 36th St
Co Rd 785
Co Rd 787
SW 48th St
Co Rd 789
S Sand Hill Rd
S Willow Lake Rd
S River Park Rd
S Golden Prairie Rd
Co Rd 797
S Old Settlers Rd
Co Rd 799
Co Rd 576
Co Rd 578
Co Rd 805
SW 60th
SW 60th St
Co Rd 580
SE 60th St
Co Rd 582
SW 72nd
Co Rd 793
Co Rd 795
Hertzler Rd S
S Mission Rd
S Emma Creek Rd
Co Rd 582 SW 72nd St
SE 72nd St
Co Rd 823
S Wheat State Rd
S Burmac Rd
SW 84th
Co Rd 584
Co Rd 791
Co Rd 586
Co Rd 801
SW 96th
SW 84th St
S Ridge Rd
S Hoover Rd
S West Rd
S Meridian Rd
Co Rd 817
S Anderson Rd
Co Rd 819
S Kansas Ave
Co Rd 821
SE 84th St
I-135
SE 12th St
SE 24th St
SE 36th St
S Spencer Rd
Woodberry Rd
S Woodberry Rd
W 125th St N
SW 125th
S W 125th St
W 125th St N
SW 125th St
SE 125th St
W 117th St N
N Maize Rd
N 87th St W
N Tyler Rd
N 167th St W
N Clearwater Rd
N 119th St W
N 103rd St W
N 135th St W
W 109th St N
W 101st St N
N 71st St W
N Hoover Rd
N 39th St W
N West St
N 24th St W
N Meridian St
N 10th St W
N 2nd St
E 109th St N
E 101st St N
State Hwy 96
N 263rd St W
101st W
N 247th St W

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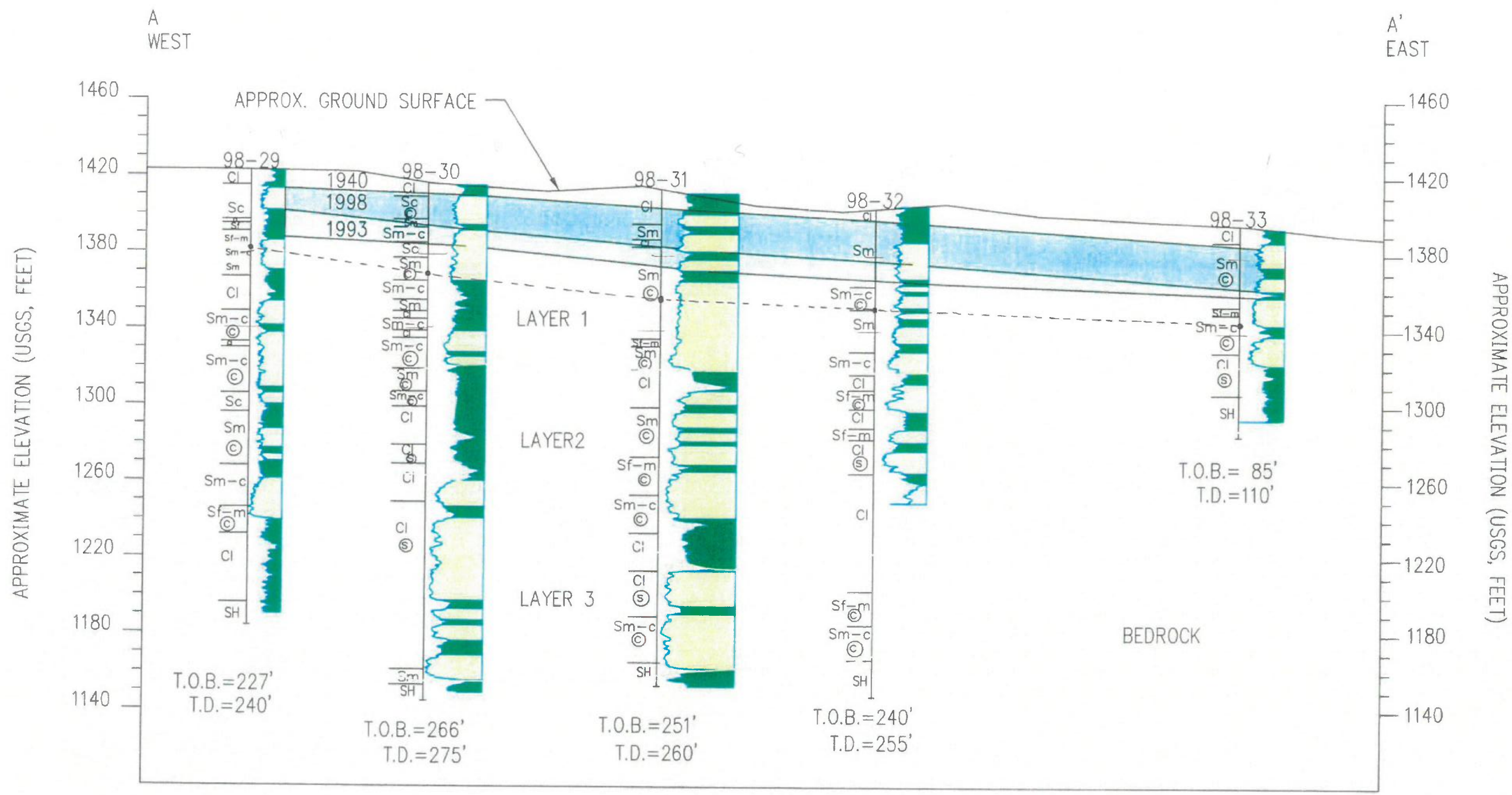


CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm

GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940 **1940 WATER LEVEL ELEVATION**

1993 **1993 WATER LEVEL ELEVATION**

1998 **1998 WATER LEVEL ELEVATION**

DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

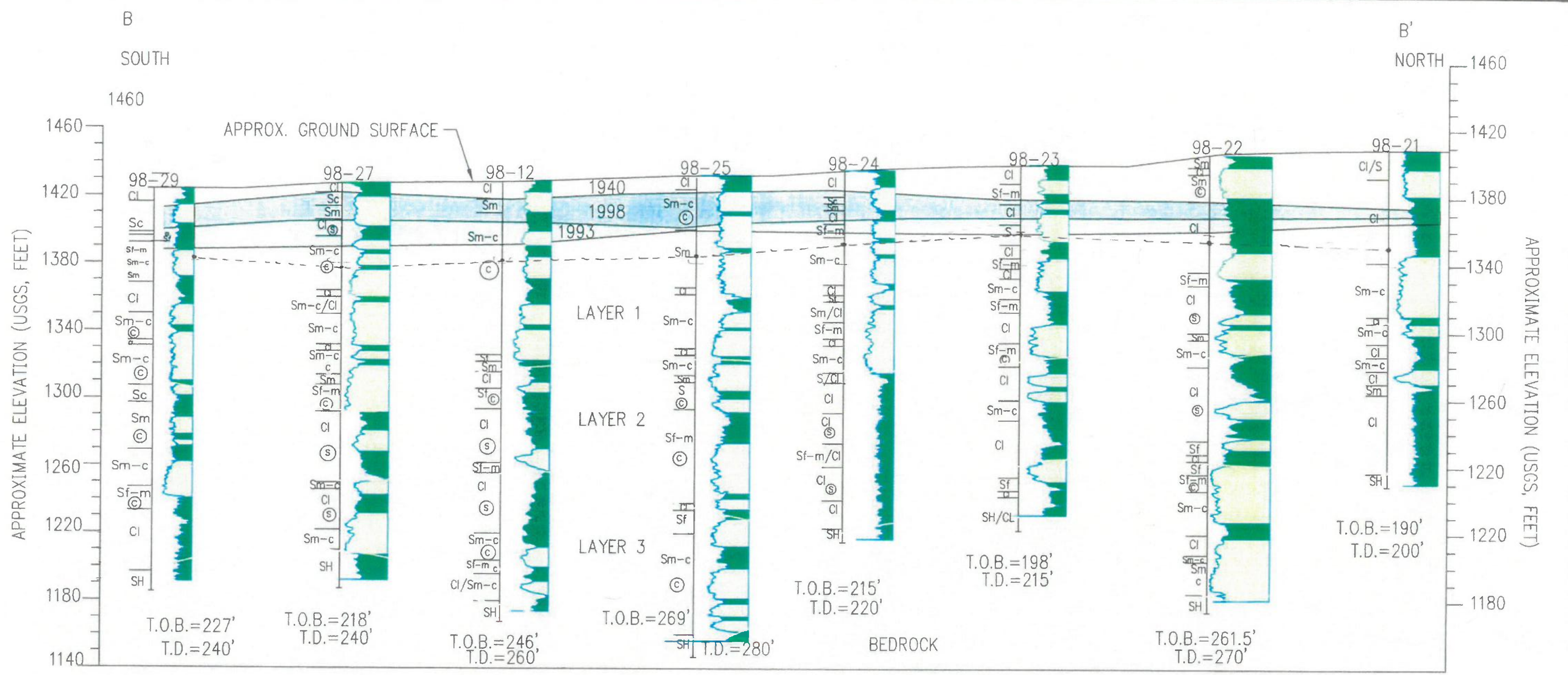
T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
(C)	TRACE OF CLAY
(S)	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 3000 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-8
WICHITA EQUUS BEDS
RECHARGE PROJECT
CROSS-SECTION A-A'



CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl

GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940 **1940 WATER LEVEL ELEVATION**

1993 **1993 WATER LEVEL ELEVATION**

1998 **1998 WATER LEVEL ELEVATION**

DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
(C)	TRACE OF CLAY
(S)	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 3000 FEET

VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-9

WICHITA EQUUS BEDS RECHARGE PROJECT CROSS-SECTION B-B'

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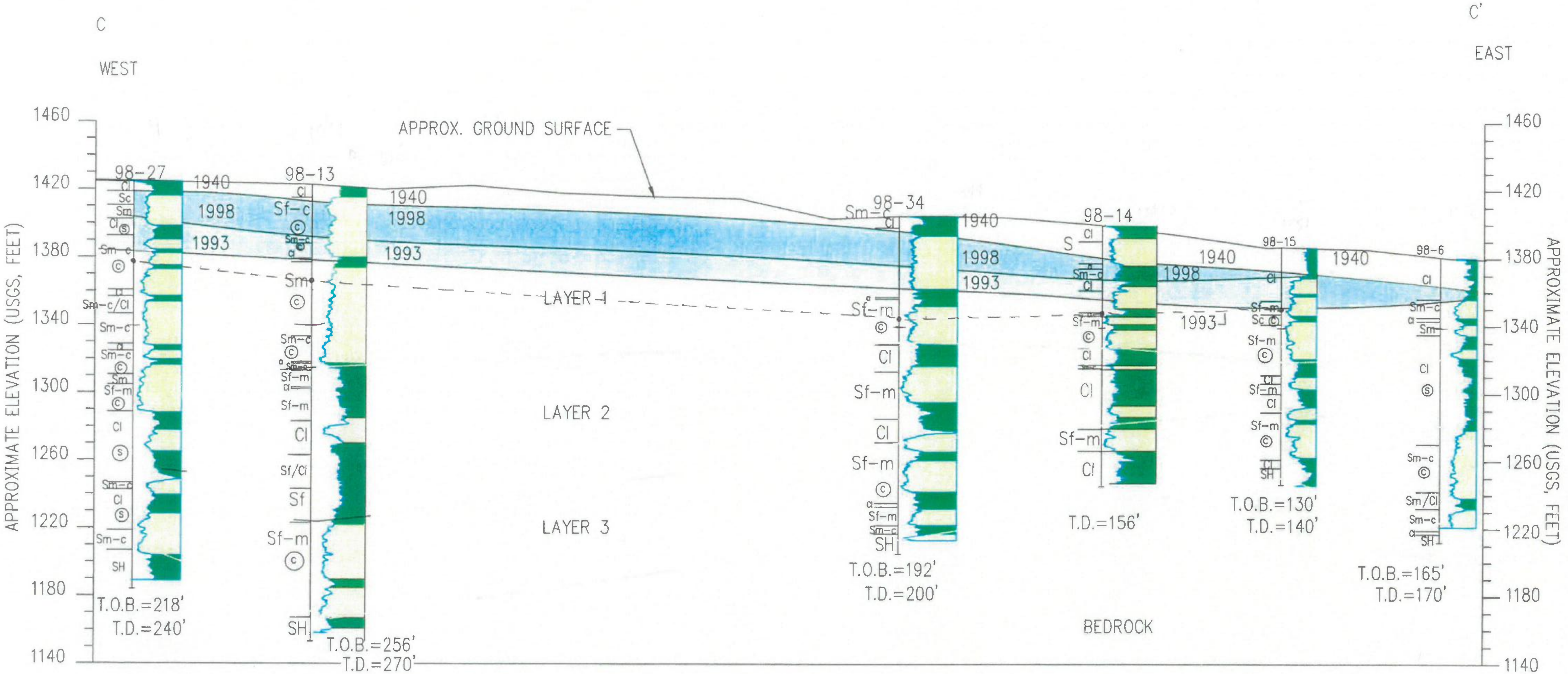

CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl
GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940	**1940 WATER LEVEL ELEVATION**
1993	**1993 WATER LEVEL ELEVATION**
1998	**1998 WATER LEVEL ELEVATION**
	DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
(C)	TRACE OF CLAY
(S)	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 3000 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-10
WICHITA EQUUS BEDS
RECHARGE PROJECT
CROSS-SECTION C-C'

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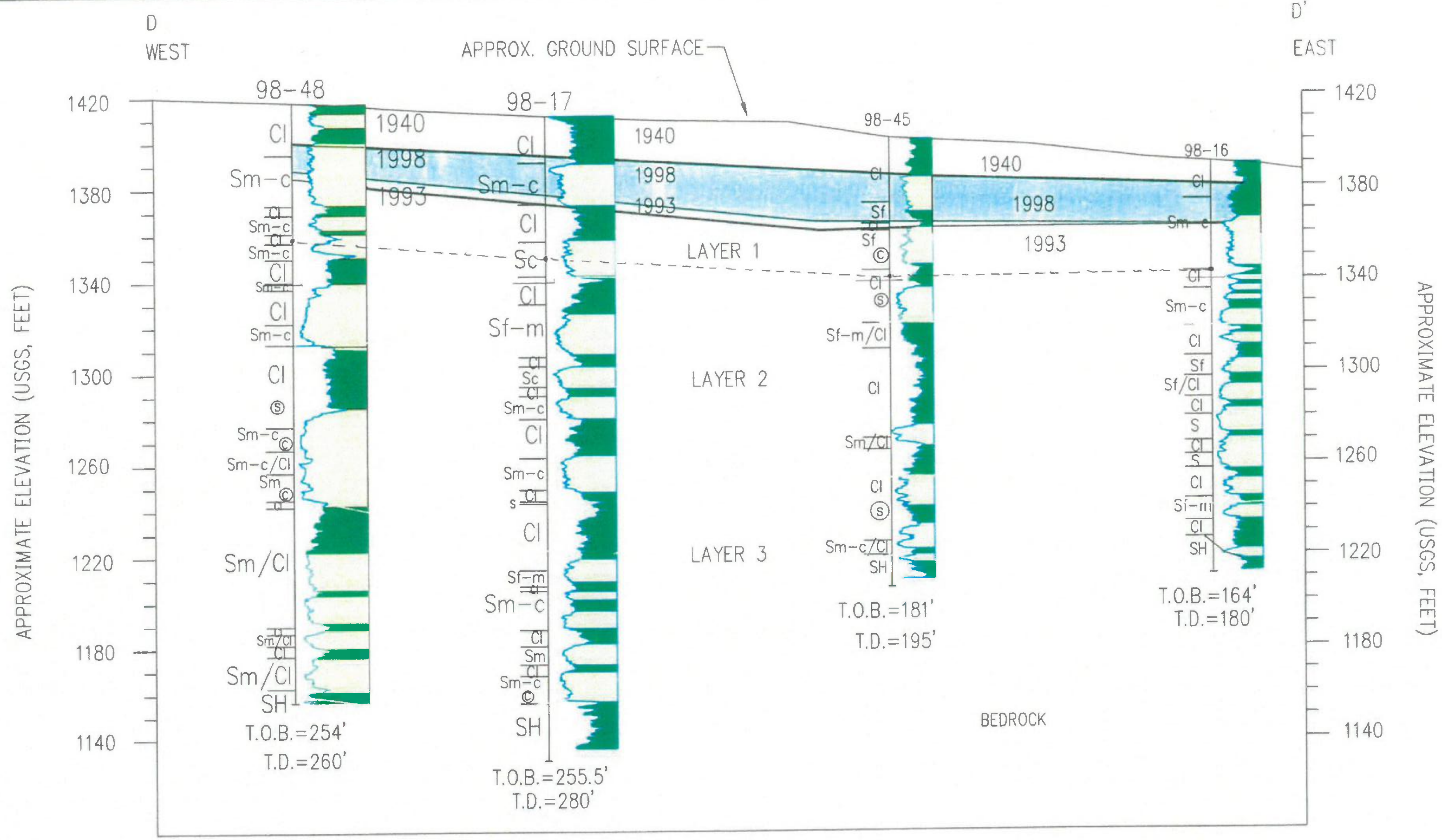

CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl
GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940	**1940 WATER LEVEL ELEVATION**
1993	**1993 WATER LEVEL ELEVATION**
1998	**1998 WATER LEVEL ELEVATION**
(box)	**DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998**

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
(C)	TRACE OF CLAY
(S)	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALF 1 IN = 2500 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-11
WICHITA EQUUS BEDS
RECHARGE PROJECT
CROSS-SECTION D-D'

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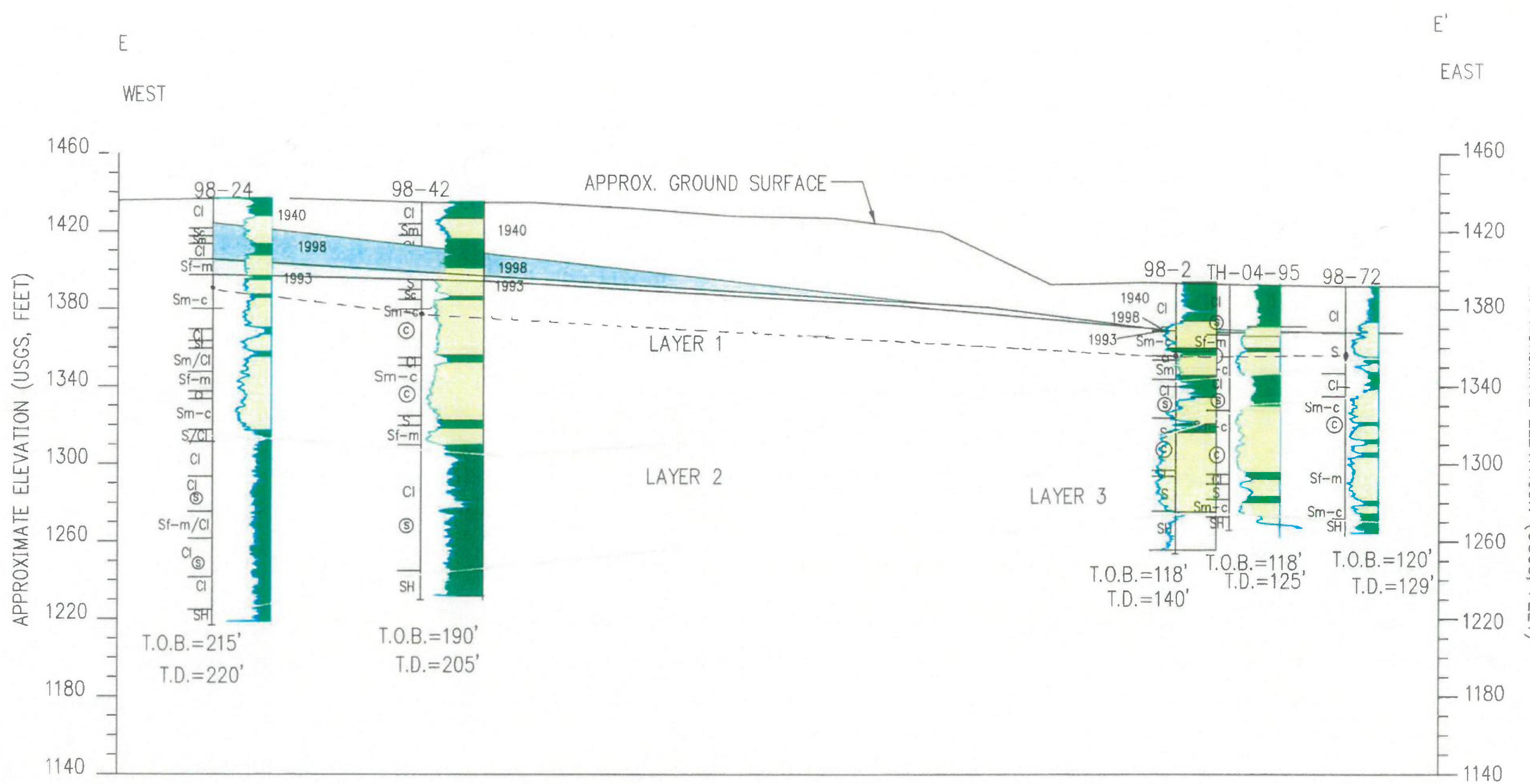

CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm, Cl; GAMMA LOG RESPONSE — SAND, CLAY, SAND, CLAY

1940	**1940 WATER LEVEL ELEVATION**
1993	**1993 WATER LEVEL ELEVATION**
1998	**1998 WATER LEVEL ELEVATION**
(shaded)	**DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998**

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
(C)	TRACE OF CLAY
(S)	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 3000 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-12
WICHITA EQUUS BEDS
RECHARGE PROJECT
CROSS-SECTION E-E'

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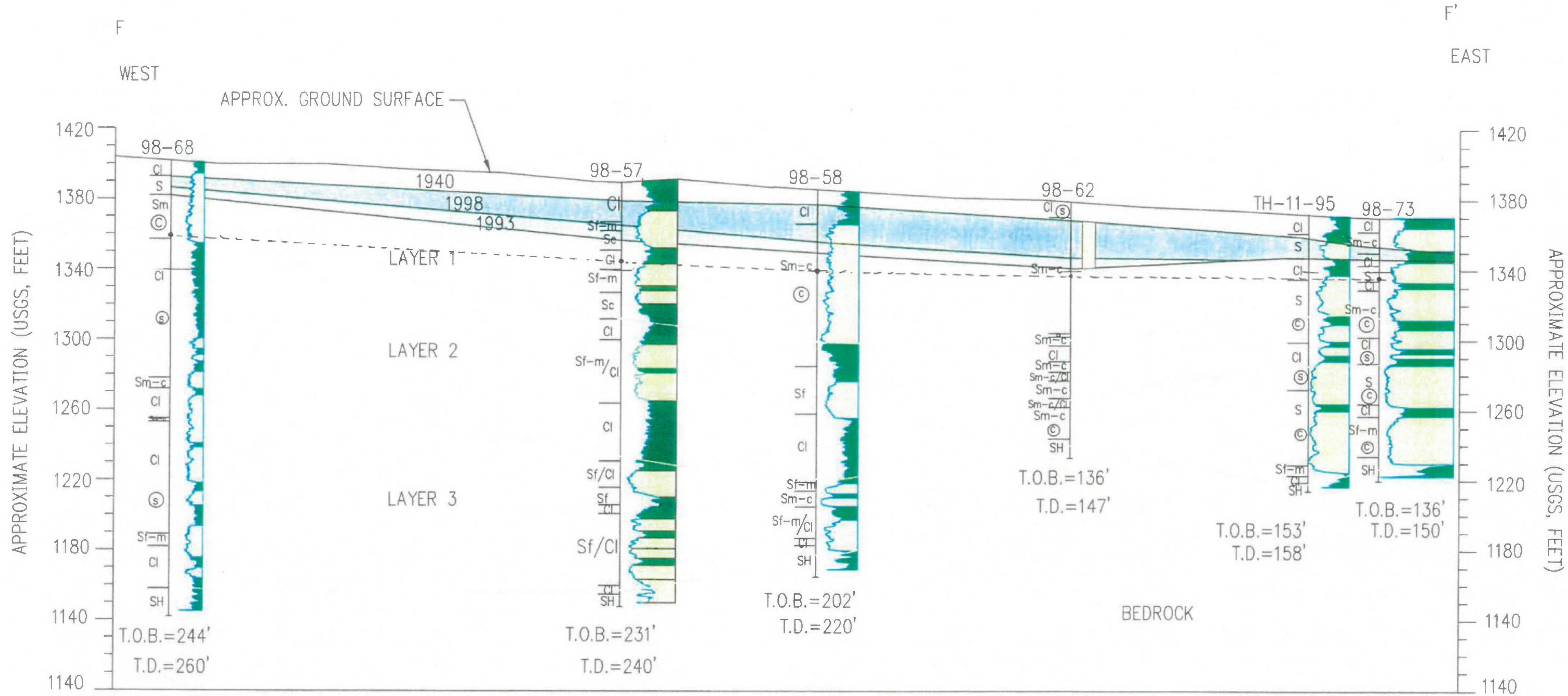

CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl
GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940 **1940 WATER LEVEL ELEVATION**
1993 **1993 WATER LEVEL ELEVATION**
1998 **1998 WATER LEVEL ELEVATION**
DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
(C)	TRACE OF CLAY
(S)	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 3000 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-13
WICHITA EQUUS BEDS RECHARGE PROJECT
CROSS-SECTION F-F'

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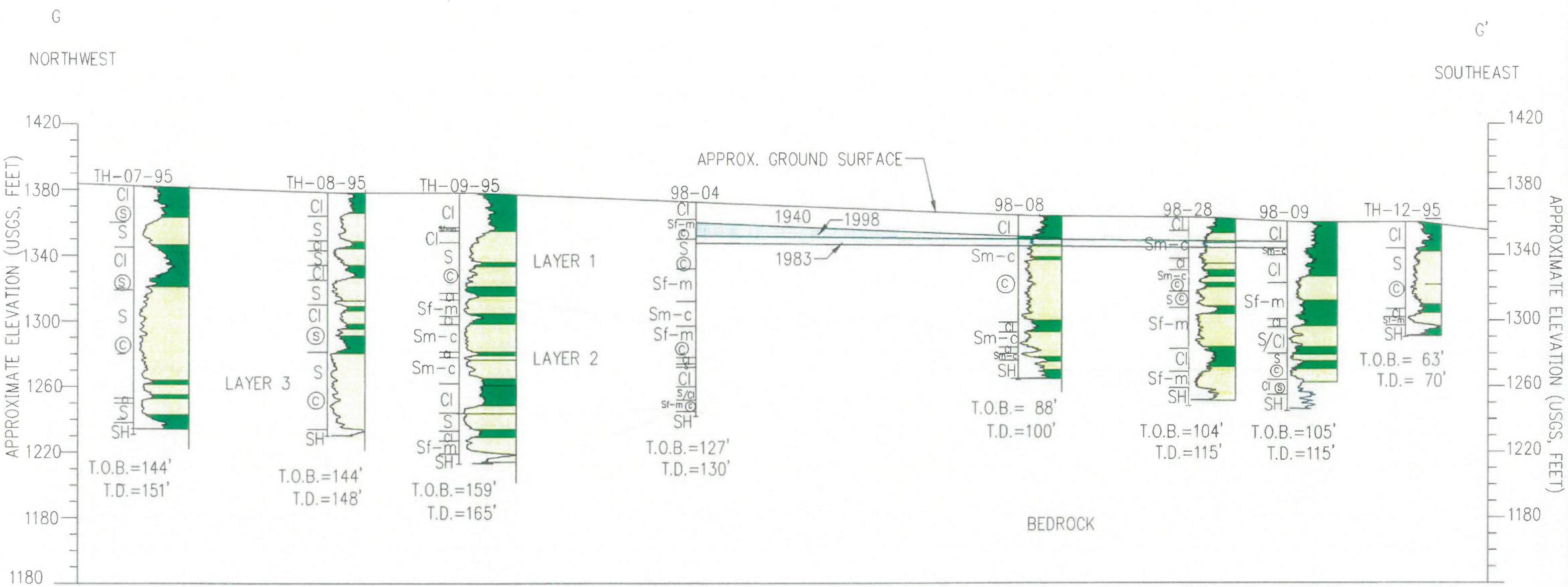


CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl — SAND / CLAY

GAMMA LOG RESPONSE — SAND / CLAY

1940 — **1940 WATER LEVEL ELEVATION**

1993 — **1993 WATER LEVEL ELEVATION**

1998 — **1998 WATER LEVEL ELEVATION**

DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

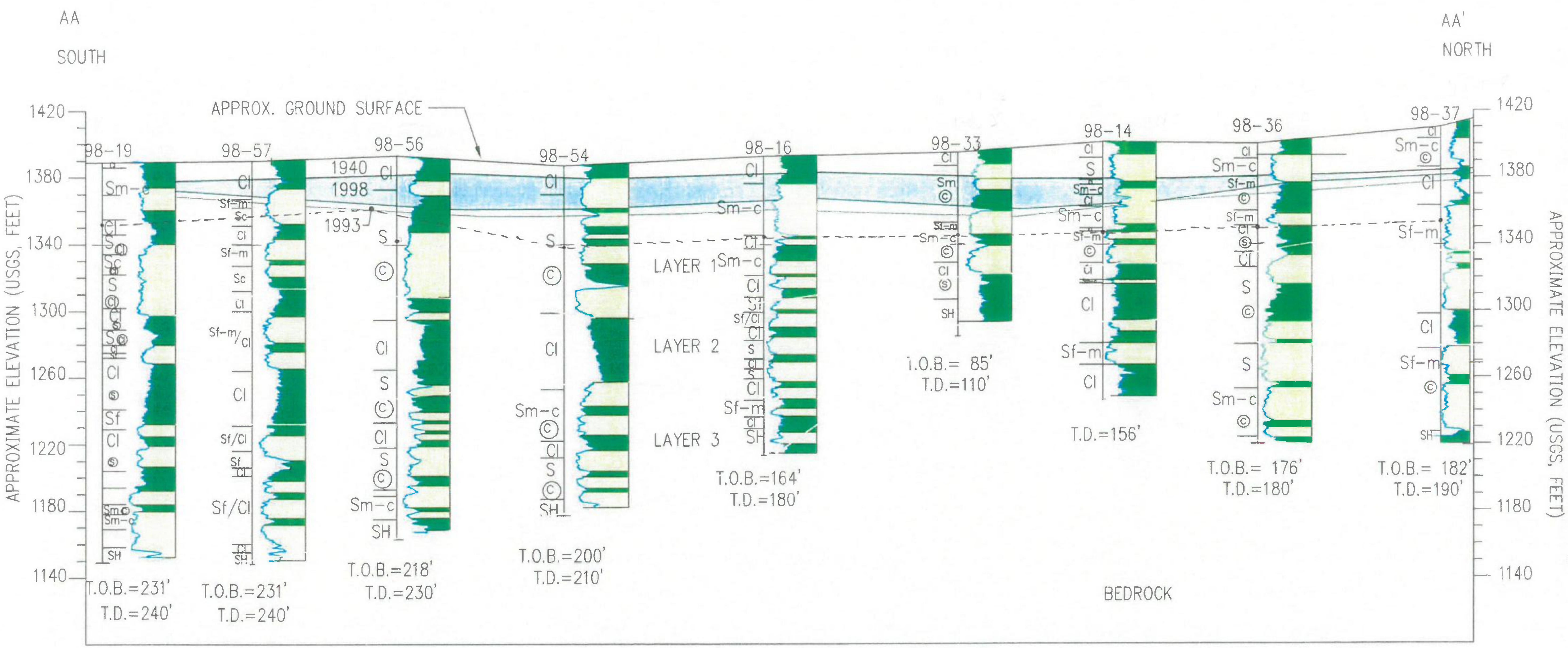
T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
Ⓒ	TRACE OF CLAY
Ⓢ	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 3000 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-14
WICHITA EQUUS BEDS
RECHARGE PROJECT
CROSS-SECTION G-G'
RIVER



CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl
GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940 — **1940 WATER LEVEL ELEVATION**
1993 — **1993 WATER LEVEL ELEVATION**
1998 — **1998 WATER LEVEL ELEVATION**
DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
Ⓒ	TRACE OF CLAY
Ⓢ	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

SCALE 1 IN = 3600 FEET
VERTICAL EXAGGERATION: 60

Burns & McDonnell

Figure VII-15
WICHITA EQUUS BEDS
RECHARGE PROJECT
CROSS-SECTION AA-AA'

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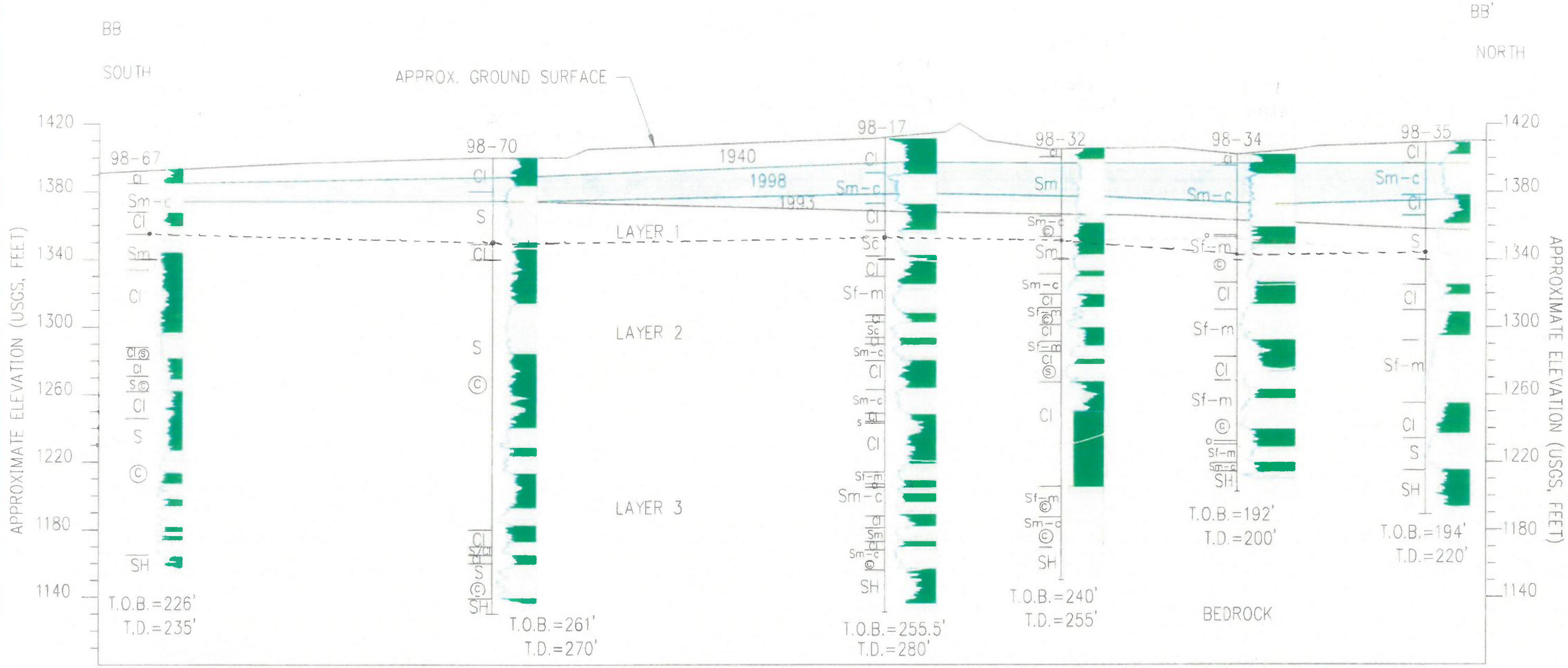


CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm — SAND / CLAY

GAMMA LOG RESPONSE — SAND / CLAY

1940 — **1940 WATER LEVEL ELEVATION**

1993 — **1993 WATER LEVEL ELEVATION**

1998 — **1998 WATER LEVEL ELEVATION**

DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

T.O.B	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
Ⓒ	TRACE OF CLAY
Ⓢ	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

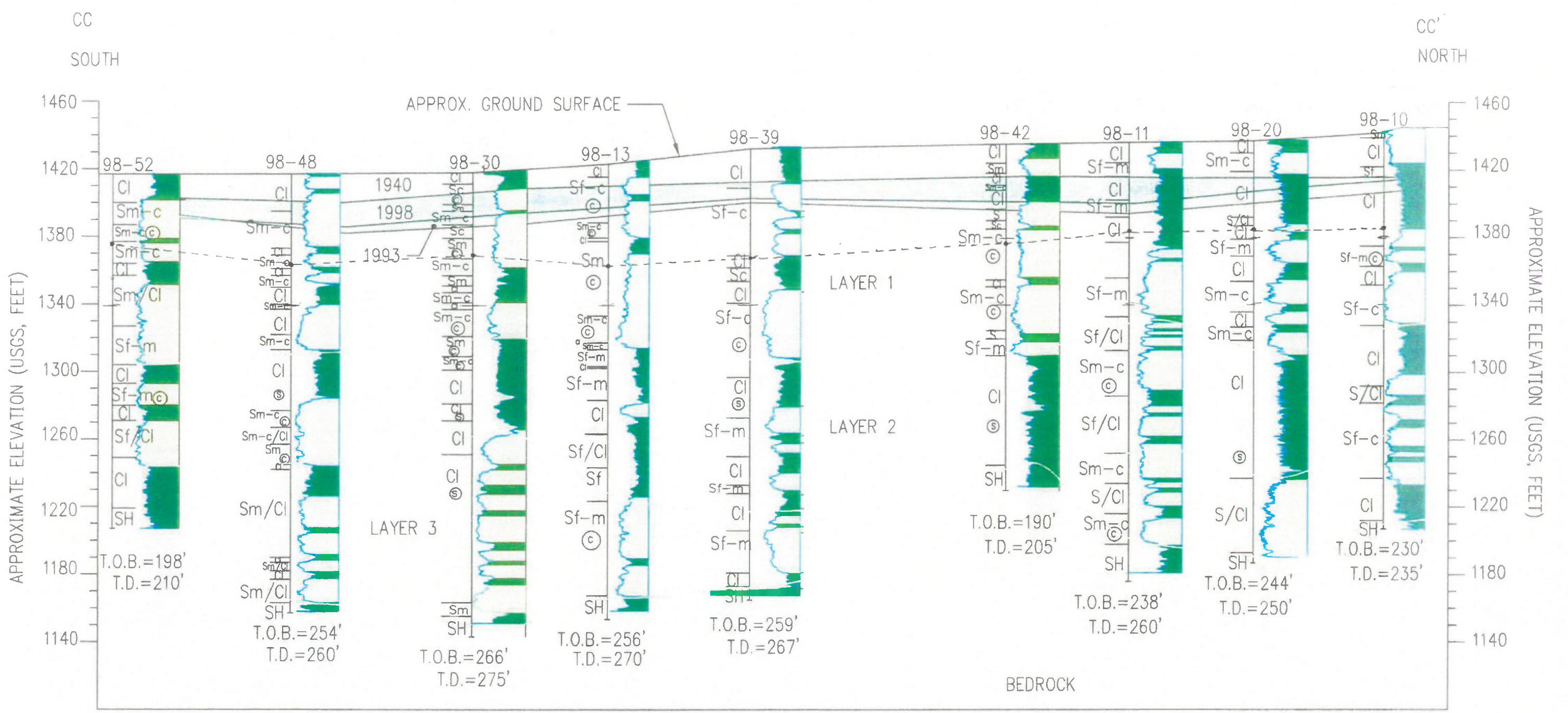
SCALE 1 IN = 3000 FEET
VERTICAL EXAGGERATION: 50

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-16

WICHITA EQUUS BEDS RECHARGE PROJECT CROSS-SECTION BB-BB'



CROSS-SECTION INDEX

DRILLING LOG INFORMATION — Sm / Cl
GAMMA LOG RESPONSE — SAND / CLAY / SAND / CLAY

1940 **1940 WATER LEVEL ELEVATION**
1993 **1993 WATER LEVEL ELEVATION**
1998 **1998 WATER LEVEL ELEVATION**
DIFFERENCE IN WATER ELEVATION FROM 1940-1998, AND 1993-1998

LEGEND

T.O.B.	TOP OF BEDROCK
Cl	CLAY
Sf	FINE SAND (MED., m COARSE, c)
Sf-m	FINE TO MEDIUM SAND
Sm-C	MED. TO COARSE SAND
Ⓒ	TRACE OF CLAY
Ⓢ	TRACE OF SAND
T.D.	TOTAL DEPTH
SH	SHALE

SCALE 1 IN = 4200 FEET
VERTICAL EXAGGERATION: 70

NOTE: ELEVATION ESTIMATED FROM 7.5' USGS QUADRANGLE MAPS.

Burns & McDonnell

Figure VII-17
WICHITA EQUUS BEDS RECHARGE PROJECT
CROSS-SECTION CC-CC'

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