# Exhibit C

# Final Report of the Chief Engineer

**Prepared pursuant to K.A.R. 5-4-1**

**Concerning a Claim of Water Right Impairment**

**In the Matter of**

**Water Right File No. 7,571**

**Owned and operated by**

**U.S. Fish and Wildlife Service**

July 15, 2016

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

This final report provides the results of DWR's impairment investigation requested by the U.S. Fish and Wildlife Service related to their water right for the Quivira Refuge, Water Right File No. 7,571.

The United States Fish & Wildlife Service (Service) holds Water Right File No. 7,571; a surface water right near the bottom of the Rattlesnake Creek for its Quivira National Wildlife Refuge. The Refuge's water right entitles it to take water from Rattlesnake Creek at three points of diversion at a combined maximum diversion rate not in excess of 300 cubic feet per second and a quantity not to exceed 14,632 acre-feet of water per calendar year for recreational use. The Refuge is located along the Central Flyway and consists of 7,000 acres of wetlands. The Refuge uses water primarily to provide habitat for several hundred species of birds and other animals, including several federally protected endangered species.

Over the last three decades, the Service has alleged that junior groundwater pumping above the Refuge has resulted in periods of significant water shortages at the Refuge. For more than 15 years, the Service worked with the Rattlesnake Partnership, seeking to bring about voluntary reductions in use to improve its supply. On April 8, 2013, the Service requested this impairment investigation.

DWR reviewed existing records and gathered additional information on the Refuge's infrastructure, historical use and shortages, and the pattern of water needs at the Refuge as part of this investigation. DWR used the GMD 5 groundwater model to determine the magnitude and timing of streamflow depletions due to upstream, junior groundwater pumping on water availability at the Refuge. Finally, DWR compared the streamflows that would have been available but for the effects of junior groundwater pumping with the seasonal needs of the Refuge to estimate the magnitude and frequency of impairment in the record reviewed.

A technical report on the investigation and data analyses is attached hereto.

Based on our impairment investigation, I make the following findings and conclusions.

## Findings

Upstream, junior groundwater pumping within the Basin is and has been significantly reducing water availability at the Refuge on the order of 30,000-60,000 acre-feet per year over the recent record (1995-2007). This does not mean that the Refuge is being impaired by 30,000-60,000 acre-feet per year, but rather that junior groundwater pumpers are taking that much out of the stream; water that would have otherwise flowed through or past the Refuge.

In comparing the seasonal needs of the Refuge, within the scope of its water right, with water that would have been available at the Refuge but for the effect of junior pumping, I find that the Refuge's water supply has been regularly and substantially impacted by junior groundwater pumping (see Figures 5-8 and Figure 9 of the report). Over the 34 years reviewed, shortages — when junior groundwater pumping prevented the Refuge from exercising its water right — were greater than 3,000 acre-feet in 18 years, particularly during periods of limited water supply.

As evidenced by various scenarios reviewed in the modeling report, while it will take years, reductions in groundwater pumping will restore streamflow at the Refuge.

DWR's analysis of water right data, water use data, and groundwater modeling analysis indicates that, due to the relatively small amount of pumping adjacent to the stream and the multi-year lag between pumping reductions and streamflow enhancement, real-time administration of junior groundwater pumping (i.e. curtailment only during periods of shortage) is unlikely to restore streamflow quickly enough to prevent impairment at the Refuge. Long-term reductions in upstream, junior groundwater pumping and/or the use of augmentation appear to be the only practical physical remedies to the impairment of the Refuge's water right.

My finding of impairment is based on historical simulations using the GMD 5 groundwater model and a retrospective analysis of the Service's needs. While I find this sufficient to conclude that impairment has occurred in the past and will occur in the future, the actual magnitude and timing of future impairment will depend on the specific circumstances. For instance, the Service has acknowledged that significant drought periods, and the resulting water shortages, are part of the natural hydrologic cycle, and DWR's impairment analysis does not directly factor in the Service's use of storage in Little Salt Marsh, which, in practice, may help to reduce some shortages to a limited degree.

Based on the historical analysis, and assuming that the basin's hydrology will not significantly change, for better or worse, in the next several decades, it appears that, to relieve the impairment of the Service's water right, groundwater reductions and/or augmentation will be needed to increase available streamflow at the Refuge by 3,000-5,000 acre-feet on a regular basis.

## Conclusion

Based on the results of this investigation, I conclude that upstream, junior groundwater pumping regularly and significantly impairs the Service's ability to use its Water Right File No. 7,571.

Further, I find this impairment is not substantially due to regional overall lowering of the water table, but is principally due to ongoing impacts of junior groundwater pumping and the associated reduction in outflows from the groundwater system to the stream system.

Pursuant to K.A.R. 5-4-1, this report is posted on the agency's website as of July 15, 2016: agriculture.ks.gov/quivira.

# Technical Report

**Prepared pursuant to K.A.R. 5-4-1**

**on a Claim of Water Right Impairment**
**In the Case of**

**Water Right File No. 7,571**
**owned and operated by**

**United States Department of the Interior**
**Fish & Wildlife Service**
**Quivira National Wildlife Refuge**

July, 2016

Division of Water Resources
Kansas Department of Agriculture

# i. Executive Summary

Quivira National Wildlife Refuge ("Refuge") is located in south-central Kansas and primarily gets its water supply from Rattlesnake Creek which runs into and through the Refuge. The Refuge is located midway along the Central Flyway and consists of about 7,000 acres of wetlands. The Refuge uses water primarily to grow feed crops and maintain wetlands at certain depths to provide habitat for several hundred species of birds and other animals, including several federally protected endangered species. The Refuge is owned and operated by the United States Fish & Wildlife Service (Service), a part of the United States Department of the Interior.

After nearly three decades of expressing concerns that junior groundwater appropriators upstream of the Refuge are depleting the streamflow in Rattlesnake Creek, and working with local water users and the groundwater management district to try to find solutions to their concerns, the Service lodged an impairment complaint with the Kansas Department of Agriculture Division of Water Resources (KDA-DWR) in an April 8, 2013, letter.

The Service owns Water Right File No. 7,571; which is senior in priority to about 95% of the water rights in the basin, and which entitles the Refuge to divert up to 14,632 acre-feet of surface water each year from Rattlesnake Creek, when water is available.

Results from KDA-DWR's simulations using a groundwater model commissioned by Big Bend Groundwater Management District #5 ("GMD5") and built by groundwater modeling consultants, show that junior groundwater pumping upstream of the refuge has significantly reduced streamflow available to the Refuge over the years.

Using the modeling results and the Service's operational guide, which lays out the Refuge's seasonal water needs, KDA-DWR finds that junior groundwater pumping in Rattlesnake Creek impaired the Refuge's water right, to varying degrees, in 26 of the 34 years 1974-2007. The results showed that the impairment was greater than 3,000 acre-feet in 18 of the 34 years. However, the results also showed that, because groundwater moves very slowly, shutting off junior groundwater pumping would take two or more years to significantly benefit streamflow.

Since there have been no substantial long-term changes to pumping levels or precipitation trends in the region of the basin closest to the Refuge, it is reasonable to conclude that the impacts to streamflow caused by pumping will continue into the foreseeable future.

## ii. Procedure, Content and Nature of this Report

This report was developed pursuant to the duties and responsibilities of the chief engineer and KDA-DWR set forth in the Kansas Water Appropriation Act, including but not limited to K.S.A. 82a-702, 82a-706, 82a-706b, 82a-707, and 82a-711a, and the procedures set forth in K.A.R. 5-4-1.

This technical report was developed to support the initial report of the chief engineer as described in 5-4-1(c)(2).

This report is intended to present the facts analyses performed to inform the chief engineer's finding on water right impairment. This report is not intended to evaluate or prescribe any particular remedy or resolution of any impairment observed.

# iii. Table of Contents

## iv. List of Figures



## v. List of Tables

# 1. Introduction and Background

After several decades of expressing concerns that junior groundwater pumpers were interfering with and harming the management operations of the Quivira National Wildlife Refuge (Refuge) by depleting the streamflow in Rattlesnake Creek which supplies the Refuge, in an April 8, 2013, letter, the United States Fish & Wildlife Service (Service) lodged an impairment complaint with the Kansas Department of Agriculture Division of Water Resources (KDA-DWR). This report summarizes KDA-DWR's resulting investigation. See Attachments 1 and 2.

In the late 1980s, the Service began to express concerns to KDA-DWR and Big Bend Groundwater Management District #5 (GMD5), that junior appropriators were reducing the flows in Rattlesnake Creek such that the Refuge was prevented from exercising its water right and its operations were being negatively impacted. In 1994, the Service entered into the Rattlesnake Creek Partnership (Partnership) with GMD5, KDA-DWR, and a group of local water users called the Water Protection Association of Central Kansas (WaterPACK) to find a way to address the Service's concerns. In 2000, the Partnership finalized a 12-year plan (Management Plan) to address USF&W's concerns and submitted the plan to the KDA-DWR's chief engineer who approved it. The Management Plan called for KDA-DWR to prepare and submit a report every four years on the progress made towards the plan's goals. Three four-year reviews of the Rattlesnake Creek Partnership Management Plan were prepared and are available at dwr.kda.ks.gov/impairment/RSC.Quivira/TechReport.Attachments/

Near the end of 2008, GMD5 began work on developing a hydrologic model of the district (GMD5 Model), including the Rattlesnake Creek Basin and the Refuge. KDA-DWR participated in the peer review of the model development. The GMD5 Model was completed in 2010.

In 2012, the last four-year review of the Management Plan was conducted by KDA-DWR and submitted to the Partnership for approval. KDA-DWR found that over the course of the Management Plan water savings from incentive-based programs and enhanced compliance and enforcement, yielded 2,804 acre-feet, just over 10% of the goal of 27,346 acre-feet of savings laid out by the Partnership. There was no significant reduction in irrigated acres and the amount of irrigation water applied per acre has remained generally constant when factoring in the effects of precipitation. GMD5 and WaterPACK did not accept KDA-DWR's 2012 review report.

After receiving the Service's 2013 impairment complaint, KDA-DWR began using the GMD5 Model to evaluate the historical impacts that junior appropriators have had on Rattlesnake Creek streamflow. Simulations using the GMD5 Model show that stream depletions (depletions to baseflow) caused by junior appropriators are on the order of approximately 30,000 acre-feet to 60,000 acre-feet per year for the period 1995-2007. This does not mean that the Refuge is being impaired by 30,000-60,000 acre-feet per year, but rather that junior groundwater pumpers are taking that much out of the stream; water that would have otherwise flowed through or past the Refuge.

A retrospective analysis added the streamflow depletions to the observed streamflow record gaged at Zenith to simulate how much streamflow would have been measured at the Zenith gage if there had been no pumping junior to the Service's right. Comparing the simulated "no junior pumping" record to the observed record and then evaluating how the seasonal needs of the Refuge within its water right would have been fulfilled in the simulated and observed cases shows that the Refuge's water right was impaired by upstream junior groundwater pumping in 26 of the 34 years of the simulation period 1974-2007. Further, the simulations also show that because of the relatively slow movement of groundwater, the time between when a pumping well is reduced or shut off and when the water that would have been streamflow but for the pumping is restored to the stream is on the order of two or more years, or even decades, depending on the well's distance from the stream.

## 2. Hydrogeologic Setting

The descriptions below are taken in large part from "A Computer Model for Water Management in the Rattlesnake Creek Basin, Kansas" (Kansas Geological Survey, The University of Kansas and Department of Civil Engineering, Kansas State University, 1997). Internal citations are omitted.

The Rattlesnake Creek basin is approximately 1,317 square miles in area and is located within the Great Bend Prairie of south-central Kansas. It is approximately 95 miles long and 18 miles wide with the long axis oriented in a southwest-to-northeast direction. Parts of Rice, Barton, Reno, Stafford, Pawnee, Edwards, Kiowa, Pratt, Ford, and Clark counties are included in the basin, with Stafford, Kiowa, and Edwards counties covering more than 82% of the watershed area.

The watershed is located in two physiographic regions. The upper 85% of the watershed is located in the Arkansas River lowlands (Great Bend Prairie region); it is a relatively flat alluvial plain characterized by sand-dune topography with moderate slopes and small hills separated by small basins. The upper 15% of the watershed belongs to the High Plains region, which is also a comparatively flat alluvial plain dissected by intermittent streams and exhibiting shallow depressions and gentle swells. Much of the sand-dune area of the watershed is covered by vegetation, and a large part of it is farmed; the watershed is primarily agricultural.

The watershed is drained by the Rattlesnake Creek, which is a meandering stream flowing from the High Plains region northeasterly into the Great Bend lowlands area where it empties into the Arkansas River. A number of smaller streams merge into the Rattlesnake Creek throughout its course from the highlands to the Arkansas River.

The primary source of recharge to the system is infiltration from precipitation, which varies spatially within the basin. Recharge varies with the soil type. The Rattlesnake Creek and its tributaries are a source of water to the ground-water system in the western parts of the watershed, where surface runoff into the stream eventually percolates into the subsurface. In the north-eastern parts of the watershed, the Rattlesnake Creek is essentially a gaining stream as recharge is discharged into the stream system from approximately Macksville downstream. The Quivira marsh in the lower reaches of the basin acts as a drainage outlet for the ground-water system.

Figure 1 illustrates the effect of groundwater pumping on streamflow.

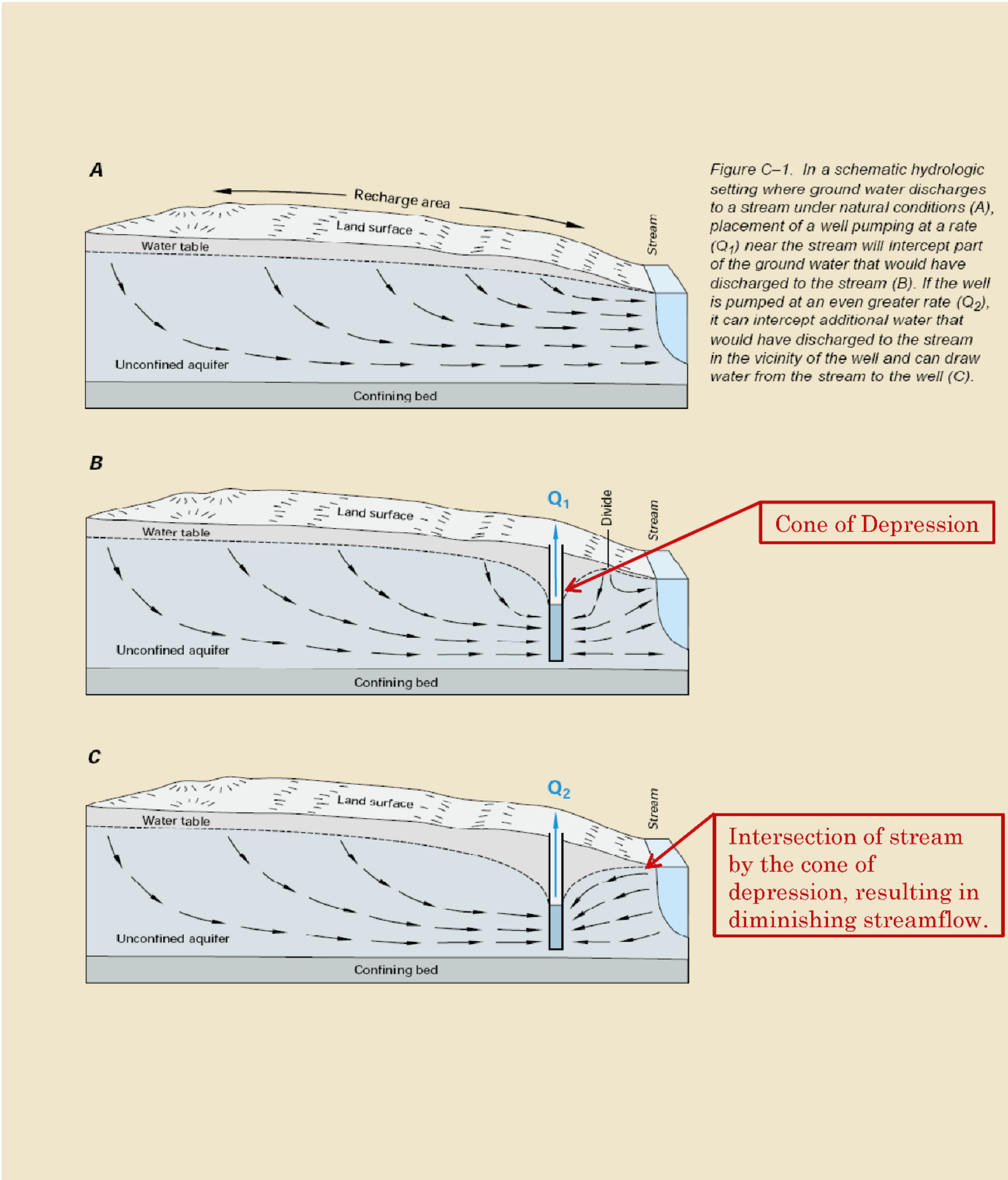


*Figure C–1. In a schematic hydrologic setting where ground water discharges to a stream under natural conditions (A), placement of a well pumping at a rate ($Q_1$) near the stream will intercept part of the ground water that would have discharged to the stream (B). If the well is pumped at an even greater rate ($Q_2$), it can intercept additional water that would have discharged to the stream in the vicinity of the well and can draw water from the stream to the well (C).*

Source: United States Geological Survey, Circular 1139, *Ground Water and Surface Water: A Single Resource* (1998), Figure C-1, p. 15 (Figure title and boxed annotations in red added).

*Figure 1 - Effect of Groundwater Pumping on Surface Water*

# 3. Water Use Summary

| Year of record | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of Water Rights * | | | | | | | | | | | | |
| Groundwater | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 | 1,680 |
| Surface Water | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Quivira (included in Surface | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Junior to Quivira | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 | 1,599 |
| Senior to Quivira | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| # of Water Rights Reporting Use | | | | | | | | | | | | |
| Groundwater | 1,374 | 1,371 | 1,367 | 1,368 | 1,379 | 1,378 | 1,376 | 1,375 | 1,376 | 1,377 | 1,381 | 1,381 |
| Surface Water | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Quivira (included in Surface | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Junior to Quivira | 1,304 | 1,301 | 1297 | 1298 | 1,309 | 1,308 | 1,306 | 1,305 | 1,306 | 1,307 | 1,311 | 1,311 |
| Senior to Quivira | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 |
| Water Use (AF) | | | | | | | | | | | | |
| Groundwater | 208,499 | 167,241 | 169,229 | 200,386 | 152,764 | 175,749 | 169,163 | 190,372 | 251,259 | 212,251 | 172,422 | 174,368 |
| Surface Water | 1,747 | 9,701 | 4,591 | 4,907 | 31 | 3,329 | 1,766 | 8,539 | 3,351 | 2,275 | 2,728 | 2,199 |
| Quivira (included in Surface | 1,727 | 9,679 | 4,559 | 4,875 | 0 | 3,323 | 1,760 | 8,526 | 3,320 | 2,249 | 2,712 | 2,178 |
| Total water use (AF) | 210,246 | 176,941 | 173,820 | 205,293 | 152,795 | 179,078 | 170,929 | 198,911 | 254,610 | 214,525 | 175,150 | 176,567 |
| Authorize Quantity (AF)* | | | | | | | | | | | | |
| Groundwater | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 | 252,258 |
| Surface | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 | 14,902 |
| Quivira (included in Surface | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 | 14,632 |
| Total | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 | 267,160 |
| % of Authorized Quantity Used* | | | | | | | | | | | | |
| Groundwater | 83% | 66% | 67% | 79% | 61% | 70% | 67% | 75% | 100% | 84% | 68% | 69% |
| Surface | 12% | 65% | 31% | 33% | 0% | 22% | 12% | 57% | 22% | 15% | 18% | 15% |
| Quivira (included in Surface | 12% | 66% | 31% | 33% | 0% | 23% | 12% | 58% | 23% | 15% | 19% | 15% |
| Total | 79% | 66% | 65% | 77% | 57% | 67% | 64% | 74% | 95% | 80% | 66% | 66% |
| # of Irrigated Acres | | | | | | | | | | | | |
| Groundwater | 160,692 | 161,606 | 157,722 | 160,660 | 158,168 | 160,400 | 160,129 | 160,867 | 161,316 | 160,274 | 158,510 | 158,765 |
| Surface | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 1 - Summary of Rattlesnake Creek Basin Water Rights*

Table 1 summarizes the basin's water rights and water use information over 2003-2014. Over 98% of the water use in the basin is from groundwater. The Refuge's surface water right accounts for 98% of all the surface water appropriated in the basin and is senior in priority to about 95% of all the water rights in the RSC Basin — groundwater and surface water.

The Water Right Information System database from which Table 1 was compiled does not contain records of the years in which water rights were dismissed. Water rights dismissed during 2003-2014, if any, are not represented in Table 1. The same is true for authorized quantity associated with dismissed rights.

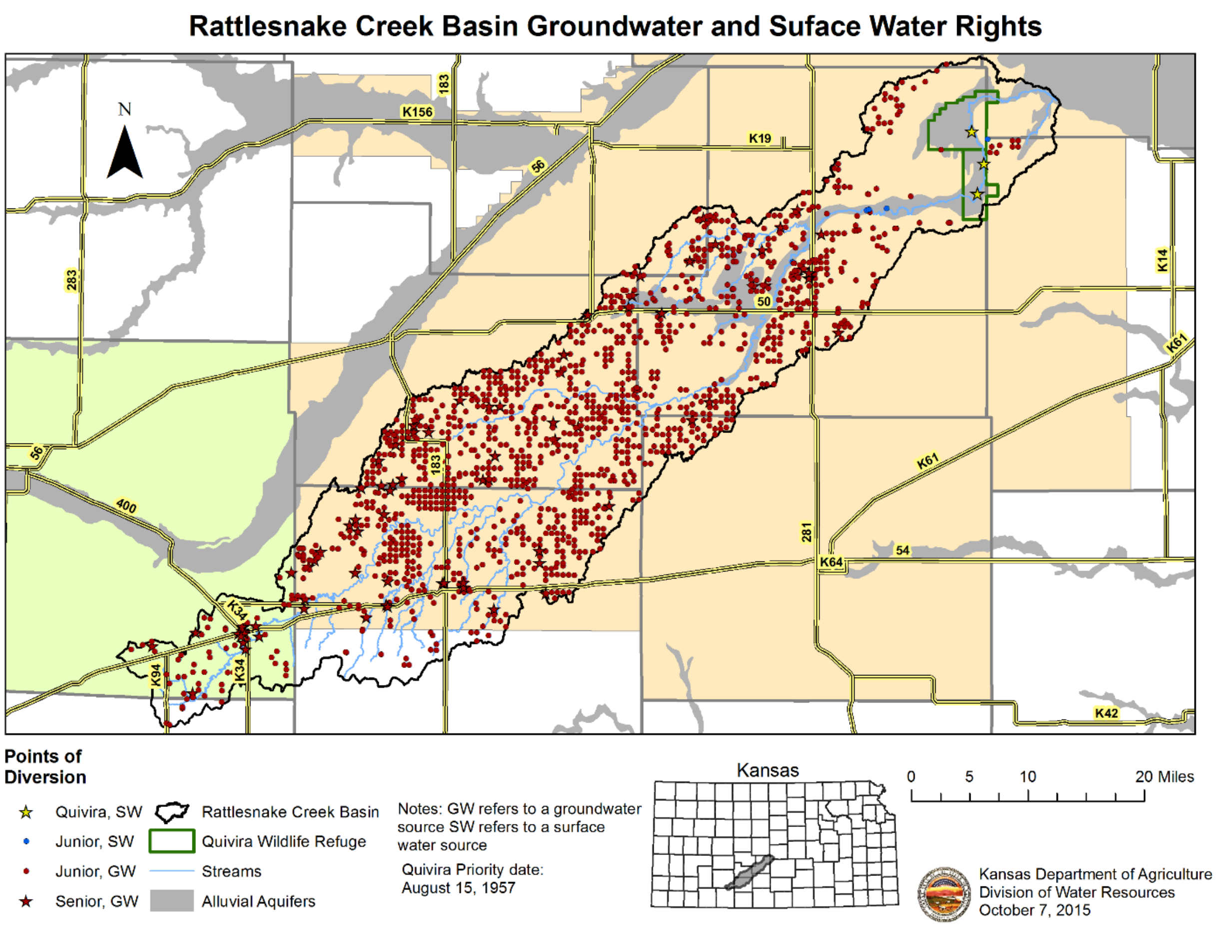


*Figure 2 - Rattlesnake Creek Basin map of water rights*

## 4. The Refuge's Water Right

The Refuge's Water Right File No. 7,571 was filed Aug. 15, 1957. The application requested 22,200 acre-feet at a diversion rate of 300 cubic feet per second. The Refuge's water right application was approved May 9, 1963, and specified a perfection date of Dec. 31, 1968. Citing ongoing construction and funding delays, on Nov. 29, 1968, the Service requested that the perfection period be extended to Dec. 31, 1973. This and the remaining documents referenced in this section are included in the electronic water right file available online at agriculture.ks.gov/quivira.

In a May 2, 1973, memorandum to the State Board of Agriculture, DWR Stafford Water Commissioner J. Maurice Street reported on a meeting held in St. John where an attorney representing the Service asserted that the Service held vested rights to some Rattlesnake Creek streamflow based in its acquisition of property from a gun club that had used water for recreational purposes prior to 1945.

In its July 17, 1973, letter, the Service described progress made in developing the Refuge and noted that the Refuge construction was 80% complete. The letter requested that the perfection period be extended to Dec. 31, 1978. In a March 20, 1974, letter the chief engineer noted that the Refuge was complete.

DWR notified the Service by March 20, 1974 letter that it considered the Refuge construction complete, that it had determined that the Refuge's 1971 water use report, along with the other documentation already compiled in the water right file was sufficient to fulfill the Notice and Proof requirements of K.S.A. 82a-714, and that the perfection period was extended to Dec. 31, 1978. The 1971 water use report showed that 10,063 acre-feet were used on the refuge.

Citing funding delays, the Refuge in its Dec. 22, 1978, letter requested the perfection period of its water right be extended to Dec. 31, 1983. DWR's receipt and approval of that request was not located in the paper file, nor was any subsequent request or approval for extending the perfection period to include the year of record 1987.

However, in order to catch up on a backlog of files pending certification, in August 1989, DWR implemented Administrative Policy 89-9 which, among other things, allowed for extensions of the perfection period for good cause shown for applications with a priority date on or before May 1, 1978. The perfection period of the Refuge's water right was extended to 1978 under the guidelines of this policy whose principles later became regulation K.A.R. 5-8-7 and are still in force today.

DWR's certification memorandum of Feb. 8, 1993, which is excerpted below, explains why 1987 was chosen as the year of record and notes that an extension would need to be granted by DWR. K.A.R. 5-8-7 allows the Chief Engineer to extend the perfection period of a water right if other records or information are available for a period after the original perfection period that would reasonably represent the application of water to beneficial use in accordance with the terms, conditions, and limitations of the permit. A USGS gage was installed at Zenith in 1973. The Refuge's diversion works were not fully functional until 1978. The 10-year perfection period after 1978 was extended until 1987. The USGS gage at Zenith established a good, verifiable water flow record which was used in part to help quantify the Refuge's water right.

On Oct. 31, 1986, the Service sent a letter to DWR claiming that Rattlesnake Creek streamflow was declining due to junior diverters, especially groundwater development. The Service was especially concerned about the increasing lack of streamflow in late summer and early fall when there is the greatest need for water on the refuge. In its letter, the Service also references K.S.A. 42-306 which says, "No person shall be permitted to take or appropriate the waters of any subterranean supply which naturally discharge into any superficial stream, to the prejudice of any prior appropriator of the water of such superficial channel."

DWR issued the draft certificate and its Feb. 8, 1993, Certification Memorandum, File 7571 laid out the chronology of events that led to finalizing the Refuge's water right and summarized the process:

> *File 7571 was approved in 1963. During the time period 1963 to 1972 many of the water use reports were estimated and during that time the diversion works were reported to be only 80% complete. An actual water measurement program may not have been in place prior to 1973. In 1973, a year of torrential rainfall, the diversion works and control structures at Quivira were destroyed. It was not until 1978 that the damage was finally repaired. The year 1978 was, therefore, the first year that the diversion works were complete and ready to divert and store water according to management plans. Assuming that the water requirements of the refuge are best represented by years after 1978, the year 1987 has been selected as the year of record. Using 1987 will require that an extension of time to perfect be granted to that year.*

*During 1987 the U.S. Fish and Wildlife Service reported that 10129.7 acre feet of water was diverted from the Rattlesnake Creek and that the refuge was "full all year." … the measurements do not reflect the amount stored and the subsequent evaporation in the Little Salt Marsh. Using an area of 950 acres in the Little Salt Marsh, and a capacity of 2260 acre feet, one would assume 2850 acre feet of evaporation during a calendar year (36 inches of net evaporation). The proposed certified quantity for file 7571 would then be the sum of the acre feet reported in 1987, the amount stored in the Little Salt Marsh: 10129.7 acre feet + 2260 acre feet + 2850 acre feet = 15240 acre feet. It is also proposed that all of the 15240 acre feet be shown as direct use and that the "quantity to be accumulated in reservoirs" as stated in the approval be dropped from the certificate.* (internal references omitted)

The Service's Nov. 12, 1993, letter raised several issues with DWR's draft certificate. The Service noted that the original application was for 22,000 acre feet of water and that hydrologic modeling performed by the Kansas Geological Survey (KGS Open File Report 93-7) estimated that by 1987, junior groundwater pumping — modeled at 70% of authorized — had depleted the streamflow in Rattlesnake Creek by at least 8,456 acre feet, some or all of which could have been used by the Refuge. As noted below, DWR has used the groundwater model developed by GMD5 to evaluate pumping impacts on Rattlesnake Creek streamflow. Figure 11 shows that the GMD5 model estimates that by 1987, junior groundwater pumping had depleted Rattlesnake Creek streamflow by about 38,000 acre-feet.

In a May 27, 1994, letter, Chief Engineer David Pope acknowledged the streamflow at the Refuge may have been reduced by groundwater pumping and that the Refuge may have been able to divert and beneficially use more water but for those reductions. However, DWR's position was that it was constrained by K.S.A. 82a-714 and K.A.R. 5-3-8 which, among other things, limits certification of a water right to no more than the amount actually diverted and used by the water user.

The Service and DWR exchanged several more letters over the next two years expressing their views on how the Refuge's water right should be certified. On April 10, 1996, DWR issued the final Certificate of Appropriation for File No. 7,571.

In a subsequent memorandum, KDA-DWR noted and recommended correcting a 45 acre-foot transposition error in the original certification memorandum. The corrected quantity was ultimately certified. See Attachment 3.

The Refuge's water right entitles it to take water from Rattlesnake Creek at three points of diversion at a combined maximum diversion rate not in excess of 300 cubic feet per second and a quantity not to exceed 14,632 acre-feet of water per calendar year for recreational use. This is the volume of water used in 1987 to operate the wetlands areas including filling Little Salt Marsh (1,865 acre-feet), evaporation from Little Salt Marsh (2,592 acre-feet), and filling the Refuge's management areas to meet wildlife feed crop demands (10,175 acre-feet). See Figure 3 below and Attachment 4.

Like all Kansas water rights, the Refuge's water right does not guarantee the availability of any certain amount of water, rather it entitles the Refuge to its authorized rate and quantity subject to prior and vested rights, and the natural availability of water. And, just like the water rights held by its irrigator neighbors, the Refuge's water right entitles it to divert the water at the times when it is most beneficial. Even though a quantity in excess of the Refuge's annual water right might pass by the Refuge's point of diversion in any given year, the test for whether the Refuge's water right has been diminished in value or utility — impaired — is whether the Refuge could have more fully exercised its water right if junior diverters had not taken the streamflow out of priority.

The owner of a water right can adjust the operation of his or her right once the right is perfected and certified, as long as the operation of the right stays within the terms, conditions, and limitations set forth in the certificate (use made of water, point of diversion, place of use, authorized quantity, etc.). The Refuge's water right was applied for, perfected, and has subsequently been exclusively used for recreational use, one of the authorized uses of water in Kansas. In the decades since it was established, the Refuge has adjusted the way it manages its habitat. Modifications to the operations of all water rights are to be expected as technology and best management practices change. For example, if someone perfected an irrigation water right on 160 acres of corn using a flood irrigation system in 1975, then modified their operation by installing a pivot, now watering 130 acres and growing wheat, that owner would not be required to reduce their property right as long as they stayed within the terms, conditions and limitations of the irrigation right. That water right owner would also have the right to go back to flood irrigating corn or another crop if they so choose to do. Likewise, a water right holder could perfect a stock watering right on 1500 head of cattle in a confined feeding operation. They could modify their operation by switching to 2000 head of hogs. No reduction would be required. They also could go back to 1500 head of cattle.

The Refuge water right was developed to manage approximately 7000 acres of wetlands within a refuge area of 22,135 acres (from 2014 CCP). In a letter dated November 12, 1993, the USFW stated that net evaporation based on DWR policy

84-1 using 36" of evaporation and a 6469.6 acres of marshes equates to 19,409 AF which does not include any water to fill the impoundments, which it estimated to be 13,246 AF. The Service recommended the certificate be issued for 20,021 AF year at 300 CFS. Based on managing approximately 7000 acres of wetlands, at 31 inches/year of net evaporation (average year, K.A.R 5-6-3), it would appear that the full authorized quantity could be used in most years, and substantially more than this in critical dry periods.

During both the perfection period and currently, the Refuge seeks to manage approximately 7000 acres in wetlands. As the use for the water and acres has remained the same, we see no evidence of expanded use.

## 5. The GMD5 Groundwater Model

In 2008, GMD5 commissioned Balleau Groundwater, Inc. to develop a numerical groundwater model of the district. The model was peer reviewed throughout its development by KDA-DWR and KDA-DWR's consulting expert, Steven P. Larson of S.S. Papadopoulos and Associates. The model was completed in 2010. The Model report and peer review report are available at dwr.kda.ks.gov/impairment/RSC.Quivira/TechReport.Attachments/.

The GMD5 model was built with seven layers, each layer representing a geologic formation at a range of depths below the surface of the ground. One of the principal reasons for using multiple layers in this model was so that the movement of water contamination plumes could be simulated and management strategies to contain those plumes could be evaluated. The complexity of the seven-layer model requires significant computer resources and time to run simulations.

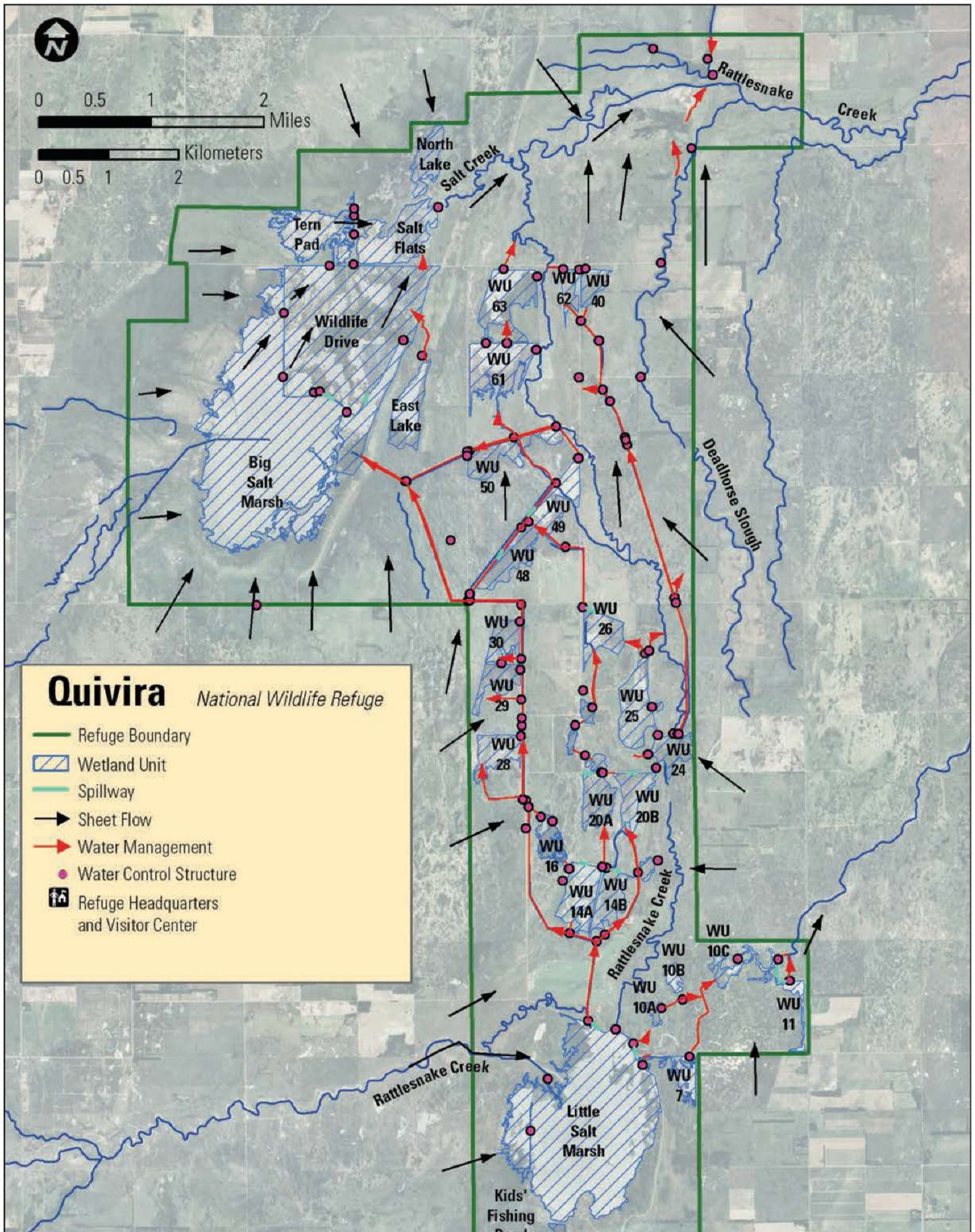


*Figure 3 - Refuge features*
*credit:US Fish & Wildlife Service*

To evaluate the effects of pumping on groundwater levels and the discharge of groundwater into the stream system, a one-layer model, if properly designed and calibrated, is sufficient. S.S. Papadopoulos and Associates simplified the GMD5 model by "collapsing" the original seven-layer model into a one-layer model so that it could be used to run scenarios in minutes instead of hours. The conversion from seven-layer model to one-layer model did lose the vertical resolution needed to simulate how contaminant plumes move up towards the surface of the earth and down away from it, but by effectively averaging the aquifer properties across the seven layers, the way that the horizontal movement of water beneath the ground is simulated was not significantly altered.

Beginning in 2014, KDA-DWR used the original seven-layer GMD5 model, and the simplified, one-layer modification of the model to simulate how the Rattlesnake Creek streamflow would respond to several alternative historical pumping scenarios. For instance, one scenario simulated the effect of no pumping anywhere in the basin junior to the Refuge's water right. Another scenario simulated no junior pumping in a corridor along the stream. The work was intended to increase familiarity with and understanding of the model, to show that the original seven-layer model and the simplified one-layer version of the model were functionally equivalent for these kinds of scenarios, and to show the Basin community how and when groundwater pumping affects RSC streamflow.

KDA-DWR presented results for nine alternative historical scenarios at a public meeting in St. John on November 4, 2014. The Appendix documents KDA-DWR's modeling work presented at the meeting. The following observations from this work were made at the meeting:

1. The seven-layer GMD 5 model and the one-layer simplified version of it are functionally equivalent for the purpose of evaluating groundwater pumping impacts to streamflow in Rattlesnake Creek.

2. The GMD5 model shows that junior groundwater pumpers have caused significant reductions to the amount of groundwater that discharges to Rattlesnake Creek. Basin-wide, the depletions are on the order of 30,000-60,000 acre-feet over the period 1995-2007.

3. Pumping reductions near the stream provide the most immediate benefit to Rattlesnake Creek stream flow. However, only about 8% of the junior pumping takes place within two miles of the stream, and only about 3% is within one mile of the stream. This nearby pumping accounts for about 16% (2 miles) and 6% (1 mile) of the impacts to streamflow, respectively [averaged over years 1998-2007 as fractions of impact of scenario 2, from Appendix, Table A3].

4. Depending on the distance from the stream, it takes two or more years for pumping reductions to manifest as increased streamflow in significant amounts and longer to fully recover.

In comments on the First Draft of the Initial Impairment Investigation Report, Balleau Groundwater, Inc. noted what they agreed was a minor issue with the way that DWR's model simulations started — from a "transient" instead of a more correct "steady state" condition. DWR has developed revised model runs accordingly and found discrepancy between the transient and steady-state runs diminished over the period from 1940 to 2008, and were negligible for the purposes of this impairment analysis. Therefore, DWR has not redone the rest of this analysis. Documentation of the resulting work is included as an addendum to the Modeling Appendix of this Second Draft of the report.

Further descriptions and results of these simulations are available at dwr.kda.ks.gov/impairment/RSC.Quivira/TechReport.Attachments/.

## 6. Determination of Junior Groundwater Pumping Impacts at the Refuge

One of the fundamental elements of an impairment investigation is the determination of the impacts that junior diversions have had, are having, and will likely have on senior water rights. The GMD5 Model was used to evaluate the historical effects of junior groundwater pumping on Rattlesnake Creek streamflow at the Refuge. The results of the modeling analysis were presented at a public meeting in St. John, Kan., on Nov. 4, 2014, and are documented in the Appendix. Below is a summary of the results that are most relevant to this investigation.

To evaluate the effects that junior pumpers upstream of the Refuge have had on the flows of Rattlesnake Creek at the Refuge, two simulations of the model were compared. In one simulation, pumping in the basin junior to the Refuge's water right was "turned off," or omitted from the simulation, and the amount and timing of groundwater that discharged from the aquifer to the stream was observed. This simulation was called "no junior pumping." The other simulation, called the "baseline," simulates the effects on streamflow caused by the actual recorded historical pumping. The "baseline" results were subtracted from the "no junior pumping" results and the effects of junior pumping on Rattlesnake Creek simulated streamflow over time were observed. These simulations show that there would have been significantly more water in Rattlesnake Creek, often at times when the Refuge could have made use of the additional water, if there had been no pumping junior to the Refuge's water right. See Figures 5-9 and Figures A8 and A9 in the Appendix.

KDA-DWR performed other simulations with the GMD5 Model to evaluate how Rattlesnake Creek would respond to targeted pumping reductions close to the stream. The simulations showed that, because of the characteristics of the hydraulic connections between the stream system and the groundwater system, and because of the relatively low volume of pumping in the stream corridor, even targeted reductions close to the stream would take on the order of two to three years to produce significant increases in streamflow. Though such reductions would eventually restore streamflow, they would be ineffective in providing timely, same-year, much less same-season, relief from shortages caused by junior pumping. For example, if the Refuge needed water in August of 2016, restricting upstream pumping by junior water rights in the spring of 2016 would provide limited benefit to the Refuge until the summer of 2018. See Figures A6 and A7 in the appendix on page 43.

## 7. Observations From Comparing Model Simulations and the Refuge's Operational Water Needs

The Service has documented its management strategies and quantified its goals for providing seasonal habitat in its Comprehensive Conservation Plan. At KDA-DWR's request, Service staff prepared a document explaining the water needs and management at the Refuge and specifying time periods and amounts of water needed within those time periods to accomplish the Refuge's mission within the scope of its water right. An excerpt of the Service's Comprehensive Conservation Plan describing the management goals for Refuge's wetlands and the subsequent documentation of the Refuge's water seasonal needs is in Attachment 5, Table 4. The historical averages from Table 1 of the Refuge's document were not used in this analysis as they represent the Service's use from the significantly depleted supply which has been the focus of the Service's complaints for decades and which led to this impairment investigation. As noted in the section of the report on the Service's water right, it is reasonable to expect that most of the Service's water right will be needed in each year, particularly during critical, dry periods. The Service's complete Comprehensive Conservation Plan is available here: [www.fws.gov/mountain-prairie/planning/ccp/ks/qvr/qvr.html.](www.fws.gov/mountain-prairie/planning/ccp/ks/qvr/qvr.html)

KDA-DWR compared the modeled impacts of junior pumping with the seasonal water needs defined by the Service to determine if there have been times when the Refuge was prevented from exercising its water right because streamflow was taken by junior pumpers. Comments to the initial report were concerned about use of a schedule based on 14,632 acre-feet per year without making allowances for evaporation and storage in Little Salt Marsh (LSM). The analysis compares the Service's schedule with flows at Zenith which is above LSM and thus could measure the water available to supply the storage and evaporation needs at LSM plus the diversion needs below it.

The analysis shows that junior groundwater pumping has prevented the Refuge from exercising its water right regularly in the past. Figures 6-7 show simulated seasonal streamflow that would have been in Rattlesnake Creek but for junior groundwater pumping and actual streamflow over time contrasted against the Refuge's seasonal water needs as defined by the Service in Attachment 5. The dark blue modeled pumping depletions are stacked on the light blue gaged streamflow to show how much streamflow would have been in Rattlesnake Creek but for junior pumping depletions. The green trace represents the Refuge's water needs, which is a repeating pattern over the time period illustrated. The red "impairment" trace shows where the dark blue modeled pumping depletions have intersected the green Refuge needs trace. The orange trace on the graphic shows the Refuge's reported historical diversions. The reported diversions are understated to varying degrees because they are measured after water from Rattlesnake Creek has been impounded and released from Little Salt Marsh, and therefore do not include evaporation from the Marsh, which would be counted as use. The surface area of the Little Salt Marsh is approximately 864 acres; 1,865 acre-feet of evaporation from the Marsh was assumed in the year of record for the certificate.

Note that the evaluation shows that the Refuge was impaired in 1987, the year of record for its water right certificate. The amount of simulated impairment is very small (220 acre feet); close to zero when compared to the amount of impairment simulated in other years, but it should be zero by definition. The small impairment simulated in 1987 is an artifact of imposing the Refuge's present operational plan on the historical record.

It is reasonable to assume that effects of the same magnitude seen in the year of record and caused by applying the Service's current operational plan to the historical record are present in all years in the simulation. No analysis was performed to compare differing management plans. Applying the Service's present operational plan on the historical record comes to within 1.5% of the seasonal and total water use in the year of record and indicates that the evolution of the Refuge's operations has not increased its water demand.

The historical impairment evaluation also does not explicitly take into account any mitigating effects that storage in Little Salt Marsh might have on the

Refuge's water needs. Figure 8, for instance, shows that in the two management periods May-June and July-September 1995, there is an abundance of water flowing at the Zenith gage. The expectation is that the Refuge would maximize their storage capabilities to the extent possible within the constraints of their primary mission to create and maintain habitat.

The historical impairment evaluation during dry periods such as 1990-1992 and 2001-2006 indicate that the pumping depletions to streamflow caused by junior groundwater pumping exceeded the actual measured streamflow, providing little to no opportunity to fill storage or fulfill the Refuge's water right. It is in these periods of pumping-induced shortages that the Refuge's water right was most severely impaired: 5730-8580 acre-feet in 1990-1992 and 4220-7930 acre-feet in 2001-2006. See Figure 10.

Unless groundwater pumping operations change significantly in the Rattlesnake Creek Basin, it is reasonable to assume that junior groundwater pumping will prevent the Refuge from exercising its water right regularly in the future.

Figure 4 below shows the method for determining the retrospective impairment illustrated in Figure 6-8.

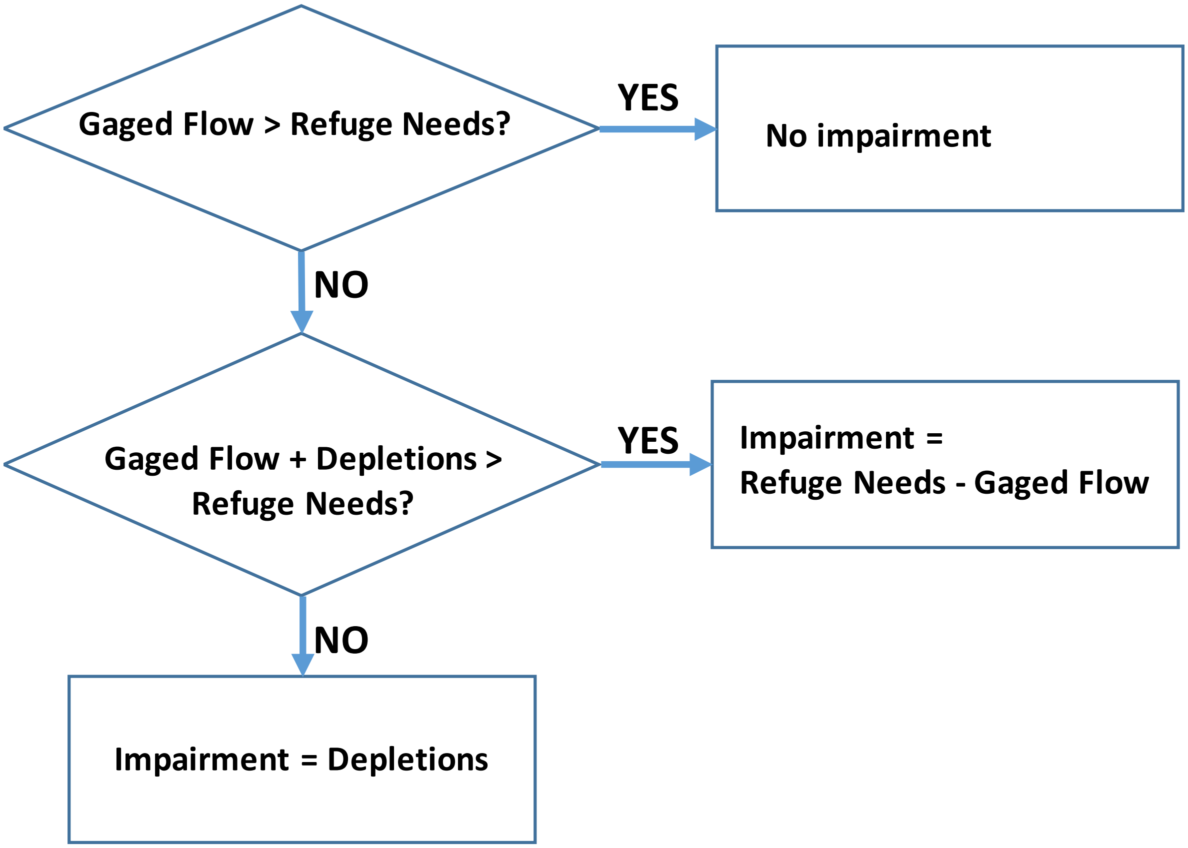


*Figure 4 - Method for determining historical simulated impairment to the Refuge's water right based on the USGS gage at Zenith*

| USFW Management Period | Year | Zenith Gaged Flow | Modeled Impacts to RSC | Refuge Reported Diversions | Refuge Needs | Amount short of needs |
|---|---|---|---|---|---|---|
| Jan/Feb | 2003 | 1860 | 7340 | 1180 | 1500 | 0 |
| Mar/Apr | 2003 | 4720 | 9640 | 320 | 3500 | 0 |
| May/Jun | 2003 | 2770 | 5690 | 0 | 2000 | 0 |
| Jul/Aug/Sep | 2003 | 650 | 4040 | 120 | 3500 | 2850 |
| Oct/Nov | 2003 | 840 | 4290 | 40 | 3600 | 2760 |
| Dec | 2003 | 540 | 2800 | 80 | 500 | 0 |
| Jan/Feb | 2004 | 1050 | 5140 | 970 | 1500 | 450 |
| Mar/Apr | 2004 | 2300 | 6270 | 2840 | 3500 | 1200 |
| May/Jun | 2004 | 1500 | 5430 | 370 | 2000 | 500 |
| Jul/Aug/Sep | 2004 | 2960 | 13070 | 4370 | 3500 | 540 |
| Oct/Nov | 2004 | 1690 | 7640 | 550 | 3600 | 1910 |
| Dec | 2004 | 1080 | 3220 | 580 | 500 | 0 |
| Jan/Feb | 2005 | 2490 | 7820 | 2130 | 1500 | 0 |
| Mar/Apr | 2005 | 2390 | 5630 | 130 | 3500 | 1110 |
| May/Jun | 2005 | 3000 | 7280 | 0 | 2000 | 0 |
| Jul/Aug/Sep | 2005 | 3620 | 8230 | 1660 | 3500 | 0 |
| Oct/Nov | 2005 | 900 | 5510 | 0 | 3600 | 2700 |
| Dec | 2005 | 740 | 2540 | 640 | 500 | 0 |
| Jan/Feb | 2006 | 1760 | 3710 | 1870 | 1500 | 0 |
| Mar/Apr | 2006 | 1940 | 4020 | 1240 | 3500 | 1560 |
| May/Jun | 2006 | 1060 | 4910 | 790 | 2000 | 940 |
| Jul/Aug/Sep | 2006 | 940 | 7970 | 750 | 3500 | 2560 |
| Oct/Nov | 2006 | 730 | 5150 | 220 | 3600 | 2870 |
| Dec | 2006 | 640 | 3650 | 0 | 500 | 0 |
| Jan/Feb | 2007 | 1670 | 7400 | 1690 | 1500 | 0 |
| Mar/Apr | 2007 | 10540 | 9530 | 1420 | 3500 | 0 |
| May/Jun | 2007 | 32510 | 14730 | 130 | 2000 | 0 |
| Jul/Aug/Sep | 2007 | 16420 | 14710 | 1720 | 3500 | 0 |
| Oct/Nov | 2007 | 2510 | 7580 | 1670 | 3600 | 1090 |
| Dec | 2007 | 3280 | 5240 | 830 | 500 | 0 |

*Table 2 - Gaged flow, Refuge needs, and calculated shortfall*

Table 2 above shows the recorded flow at the USGS gage at Zenith, the modeled groundwater pumping impacts to Rattlesnake Creek, the seasonal needs of the Refuge, and amounts, if any, that the pumping depletions impaired the Refuge's ability to execute its management plan. The table showing the entire simulation period from 1974-2007 is in Attachment 6.

The record shows that Rattlesnake Creek Basin experiences periodic dry cycles, when groundwater levels and streamflow decline, and wet periods when groundwater levels largely recover and streamflow is more plentiful. Figure 5 shows interpolated changes in water levels over the three review periods of the Rattlesnake Creek Management Plan. 2001-2004 was a dry period, but 2005-2008 saw widespread recovery to water levels. 2001-2012 shows declines in water levels on the order of 10 feet or more in the southwestern part of the basin, but in the northeastern part of the basin where the water table is shallower and more connected to the surface water system, declines are generally in the 0 ft. to -3 ft. range.

As demonstrated in the groundwater modeling work and the analysis above, water shortages to the Refuge are related to the impacts of junior groundwater pumping intercepting recharge which otherwise would show up as streamflow. These impacts are most pronounced during the dry periods.

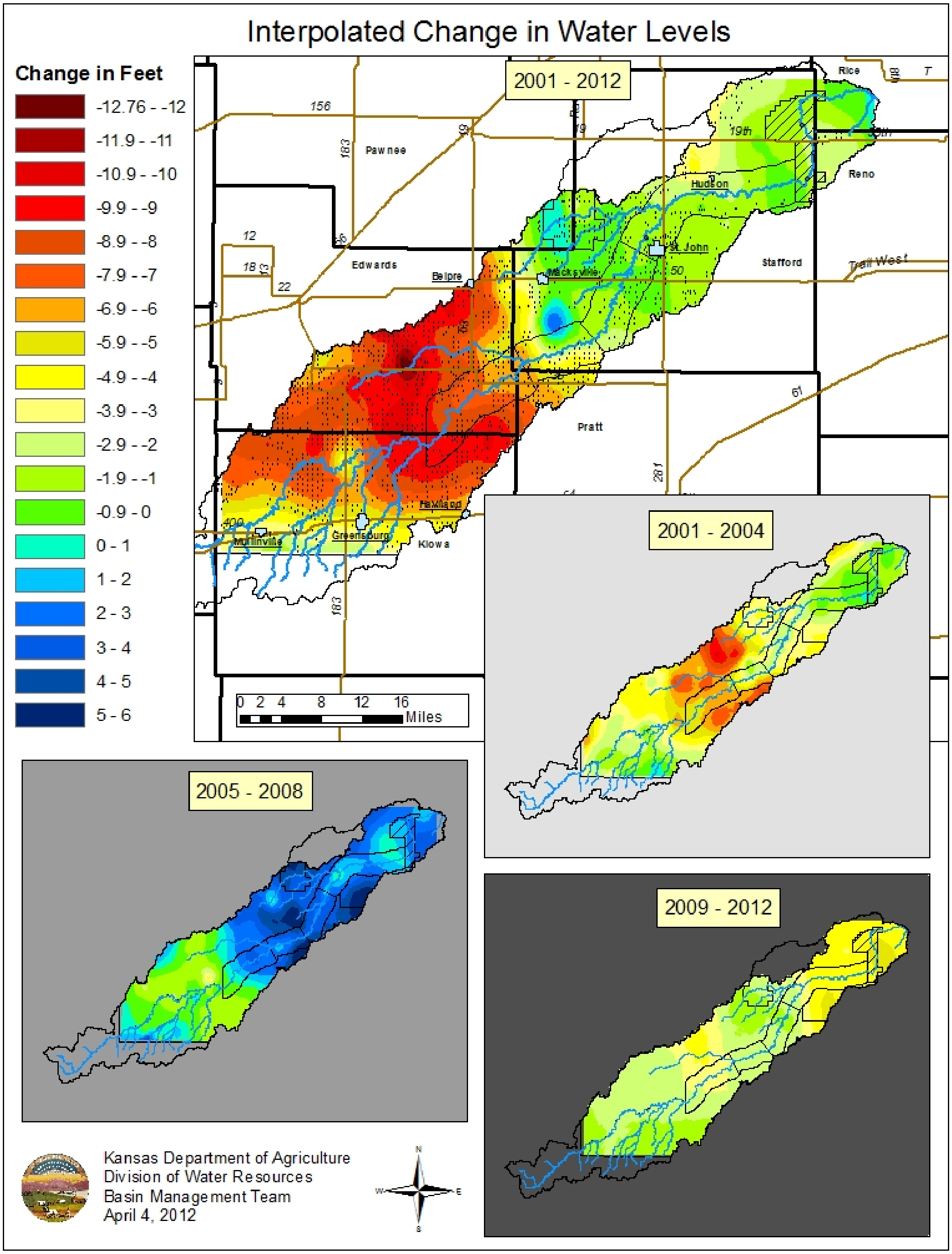


*Figure 5 - Interpolated Change in Water Levels in Rattlesnake Creek Basin*

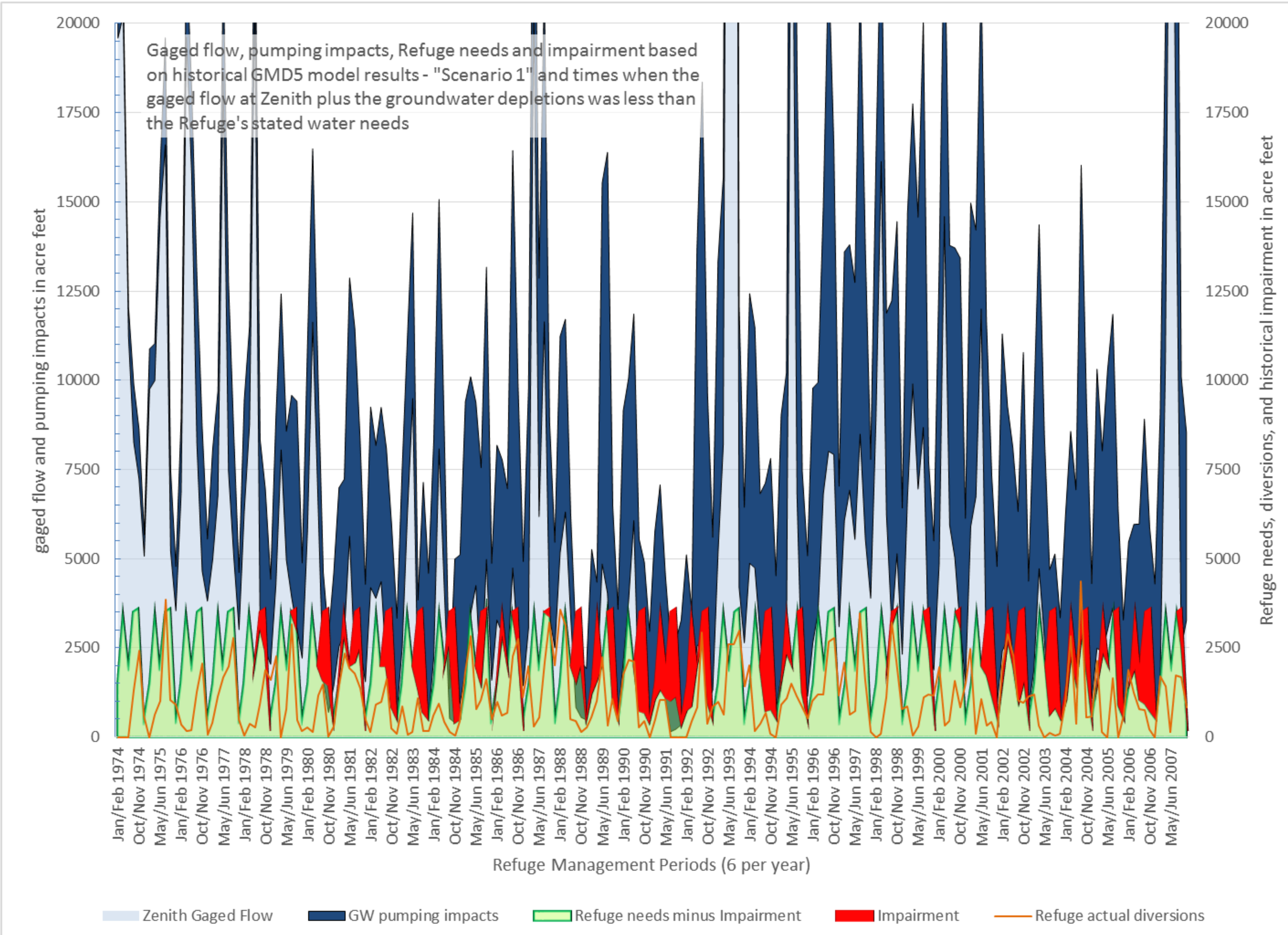


*Figure 6 - Simulated evaluation of impairment to the Refuge's water right 1974 - 2007*

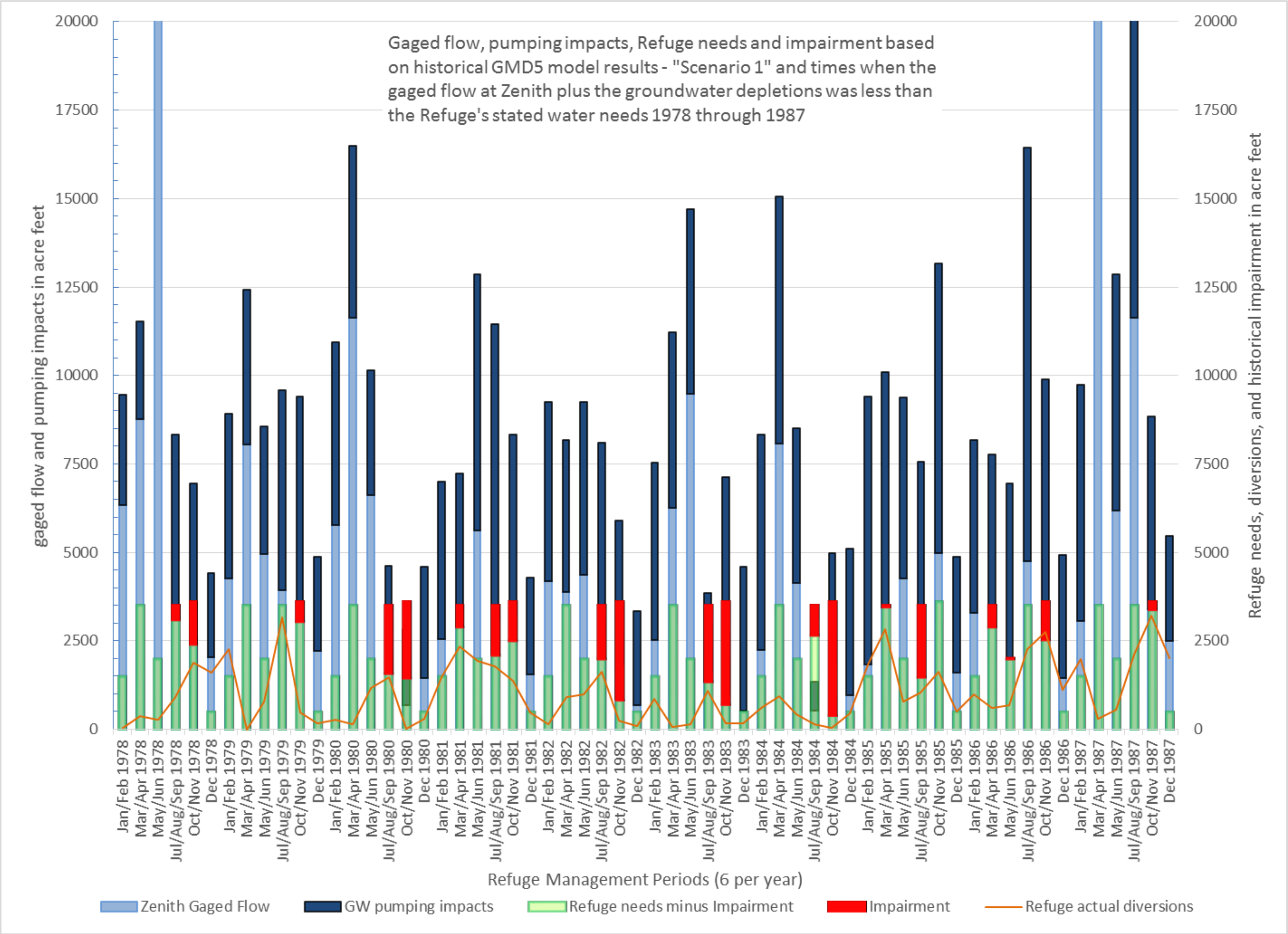


*Figure 7 - Simulated evaluation of impairment to the Refuge's water right 1978 - 1987*

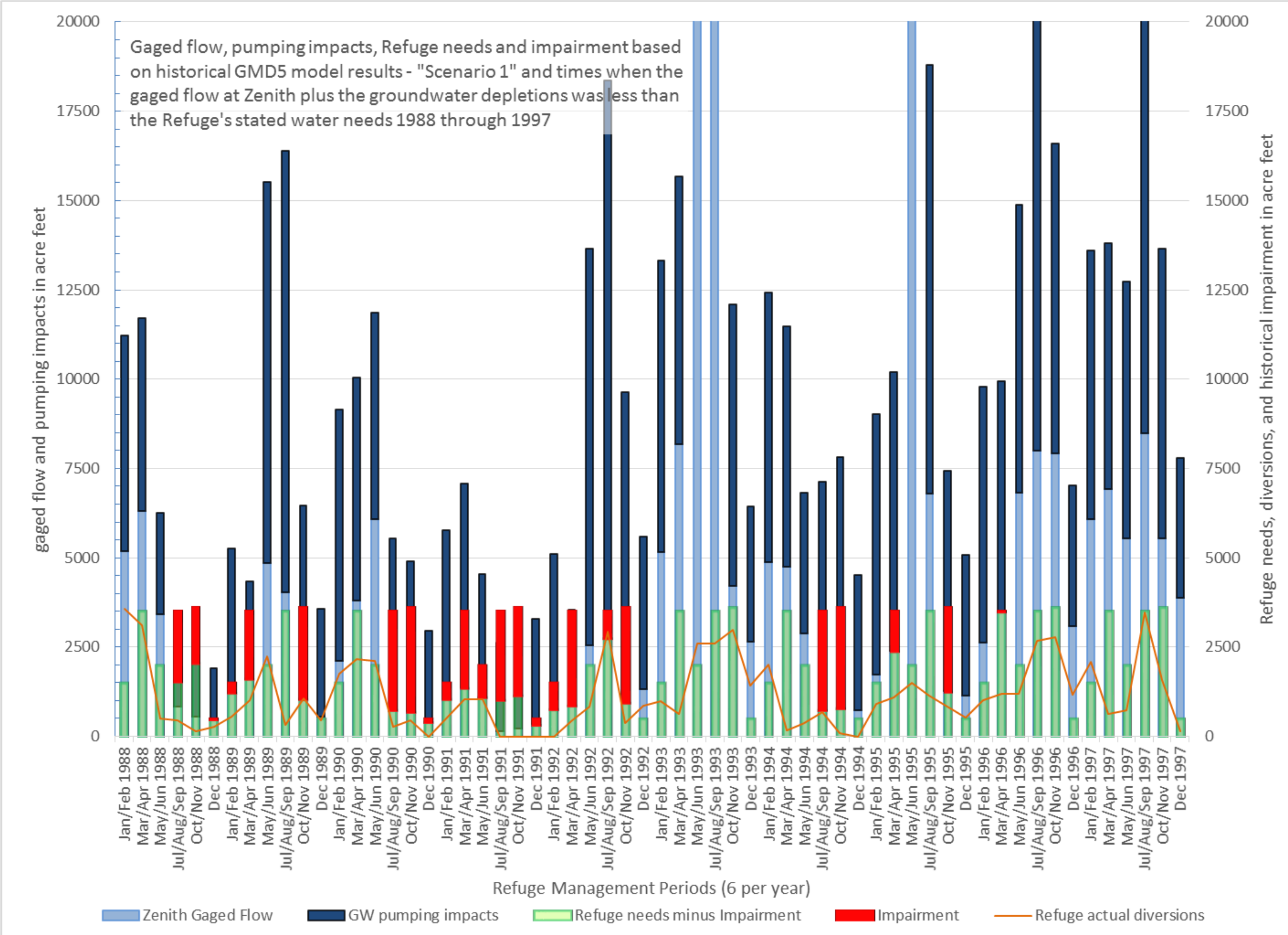


*Figure 8 - Simulated evaluation of impairment to the Refuge's water right 1988 - 1997*

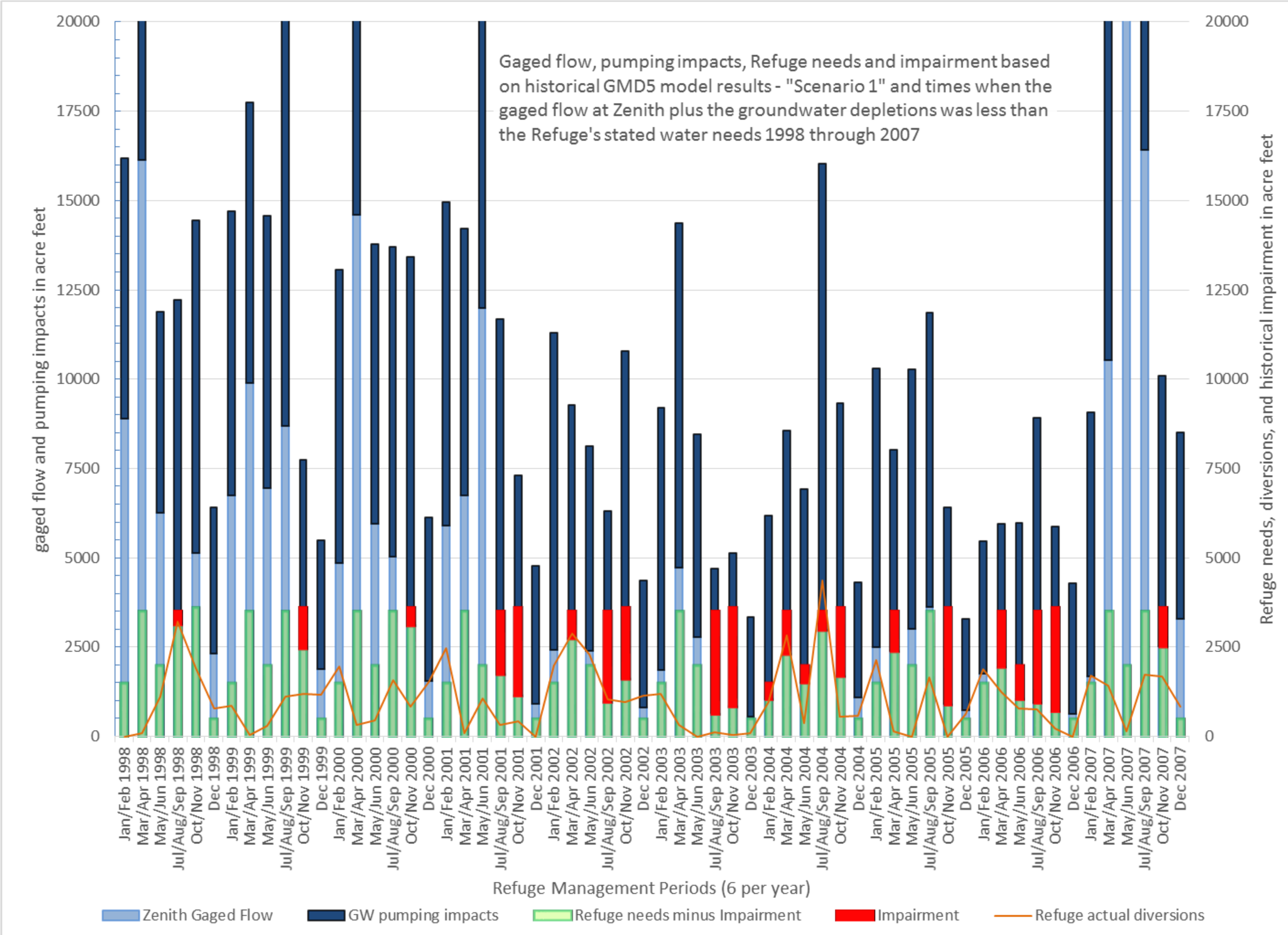


*Figure 9 - Simulated evaluation of impairment to the Refuge's water right 1998 - 2007*

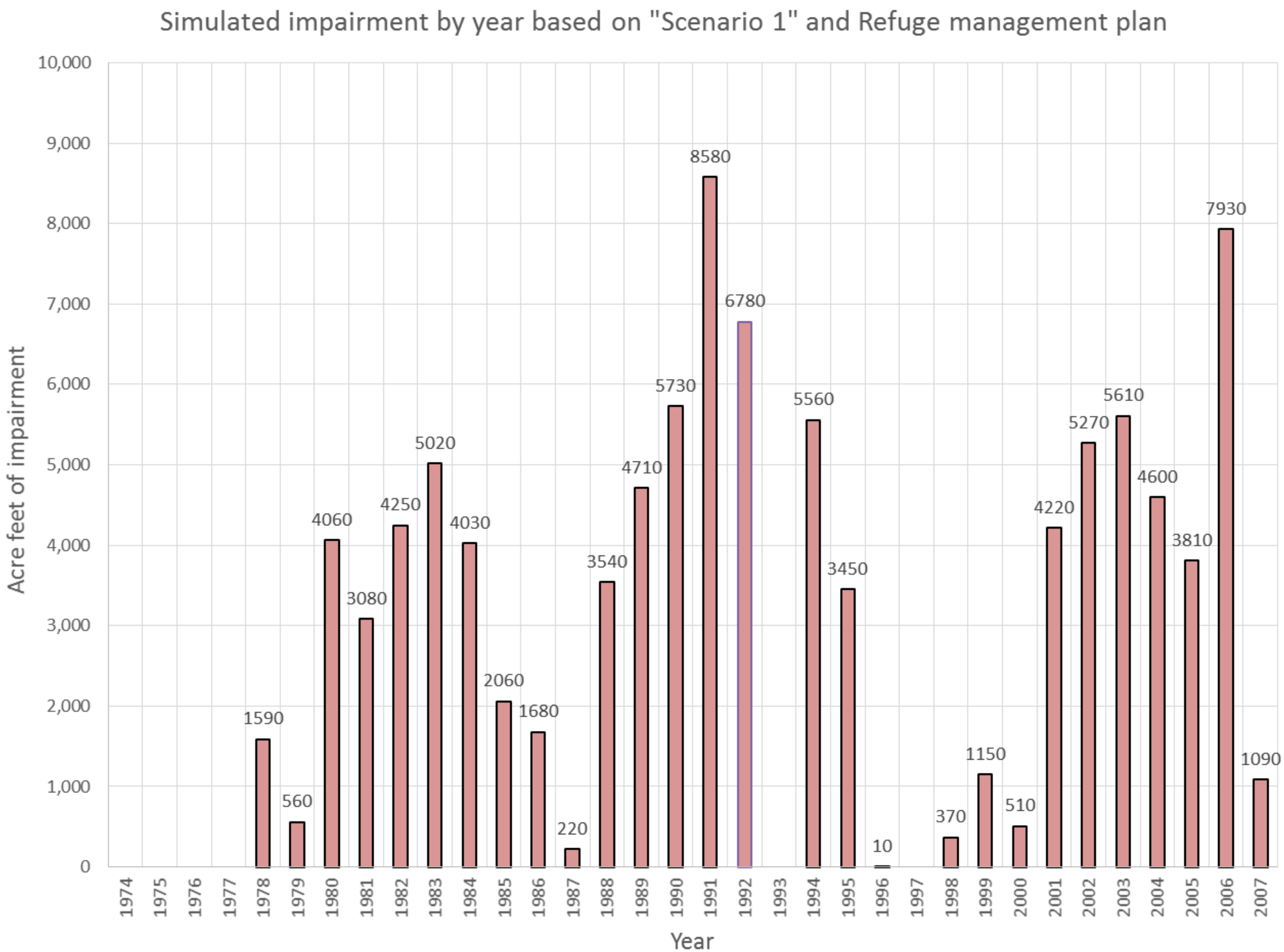


*Figure 10 - Simulated amount of impairment to the Refuge's water right by year*

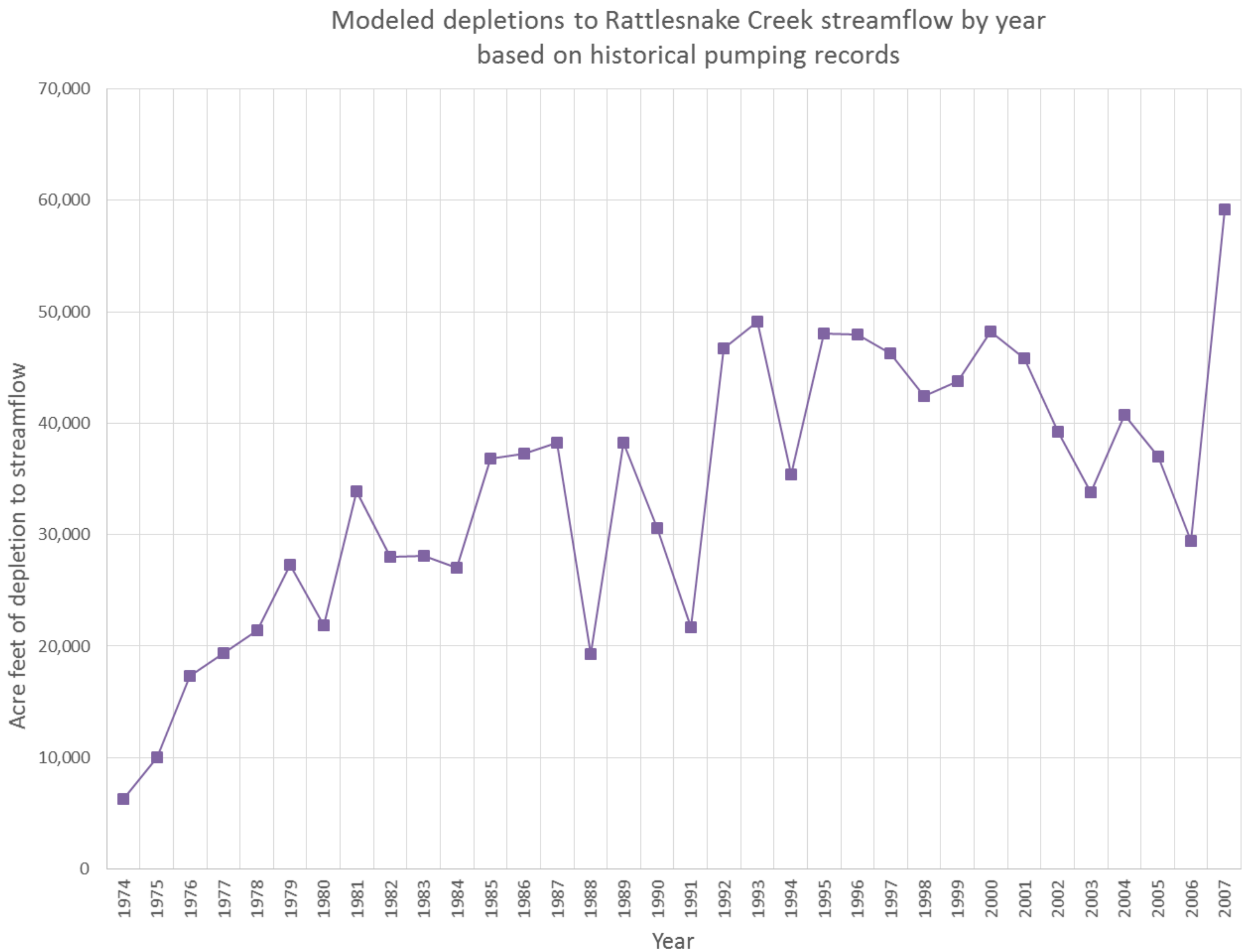


*Figure 11 - Modeled depletions to Rattlesnake Creek 1974 - 2007*

## 8. List of References

Kansas Statutes Annotated, Chapter 82a, Article 7
www.ksrevisor.org

Kansas Administrative Regulations, Chapter 5, Article 4
www.kssos.org

*Kansas Department of Agriculture – Division of Water Resources*, Rattlesnake Creek Third Four-Year Review of the Management Program 2009-2012, 2012

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Balleau, Peter W.; Romero, David M.; Silver, Steven E.; *Hydrologic Model of Big Bend Groundwater Management District No. 5 and Appendices*, 2010

Larson, S. P.; *Big Bend GMD5 Model Peer Review*, 2011

## 9. List of Attachments

Appendix: November 2015 GMD5 groundwater model scenarios developed by KDA-DWR

Attachment 1: March 5, 2013, letter from United States Fish & Wildlife Service to Kansas Department of Agriculture Division of Water Resources

Attachment 2: April 8, 2013, letter from United States Fish & Wildlife Service to Kansas Department of Agriculture Division of Water Resources

Attachment 3: Feb. 8, 1993, Certification Memorandum, File 7571; Kansas State Board of Agriculture

Attachment 4: April 9, 1996, Certificate of Appropriation for Beneficial Use of Water; Water Right File No. 7,571; Priority Date August 15, 1957; Kansas Department of Agriculture – Division of Water Resources

Attachment 5: Oct. 23, 2013, Excerpt from Comprehensive Conservation Plan, Quivira Nation Wildlife Refuge; Unites States Fish & Wildlife Service

Attachment 6: December 2015 GMD5 Model; KDA-DWR Scenario 1 analysis results table; KDA-DWR