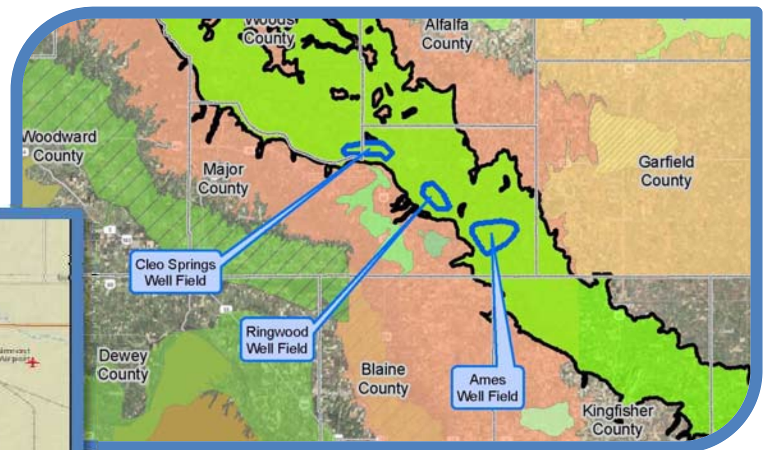
# FINAL REPORT

## CITY OF ENID
# EXECUTIVE SUMMARY
## SURFACE WATER SUPPLY STUDY
## GROUNDWATER SUPPLY STUDY





## January 2014

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# FINAL

# EXECUTIVE SUMMARY

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# EXECUTIVE SUMMARY/CITY OF ENID WATER SUPPLY STUDY

## BACKGROUND

The City of Enid (City) has concerns over the long-term viability of the current water supply (groundwater), which has prompted the City to evaluate alternative water sources. The goals and objectives of this study are to evaluate the feasibility of additional groundwater sources and three proposed reservoirs. The development of the study resulted from the *2009 Water System Master Plan* recommending further evaluation of available water resources. Current key characteristics of the water situation in the City are presented below:

- Conservation measures have reduced the annual water usage
- Resuming reuse of treated sewage effluent by Koch Nitrogen Plant removes 1461 million gallons per year (MGY), or 4 million gallons per day (MGD) from the current demand in 2014
- Addition of a new Canola Plant demand of 163 MGY (0.45 MGD) in 2016 and 42 MGY (0.11 MGD) in 2020
- Continue to expect a gradual increase in demand in future years
- Current well field supply based upon sustainable recharge rates

Enid is located in the northwestern quadrant of Oklahoma in Garfield County. The City has a population of approximately 50,000 (2010 data). It is home to Vance Air Force Base (AFB) and a number of diversified industrial companies.

## CURRENT WATER SUPPLY CONDITIONS

Based on the *2009 Water System Master Plan*, the City receives its entire water supply from 116 active wells within five well fields that tap three separate aquifers as depicted in Figure ES-1. A summary of the well fields and productivity is provided in Table ES-1.

FIGURE ES-1: EXISTING WATER SUPPLY

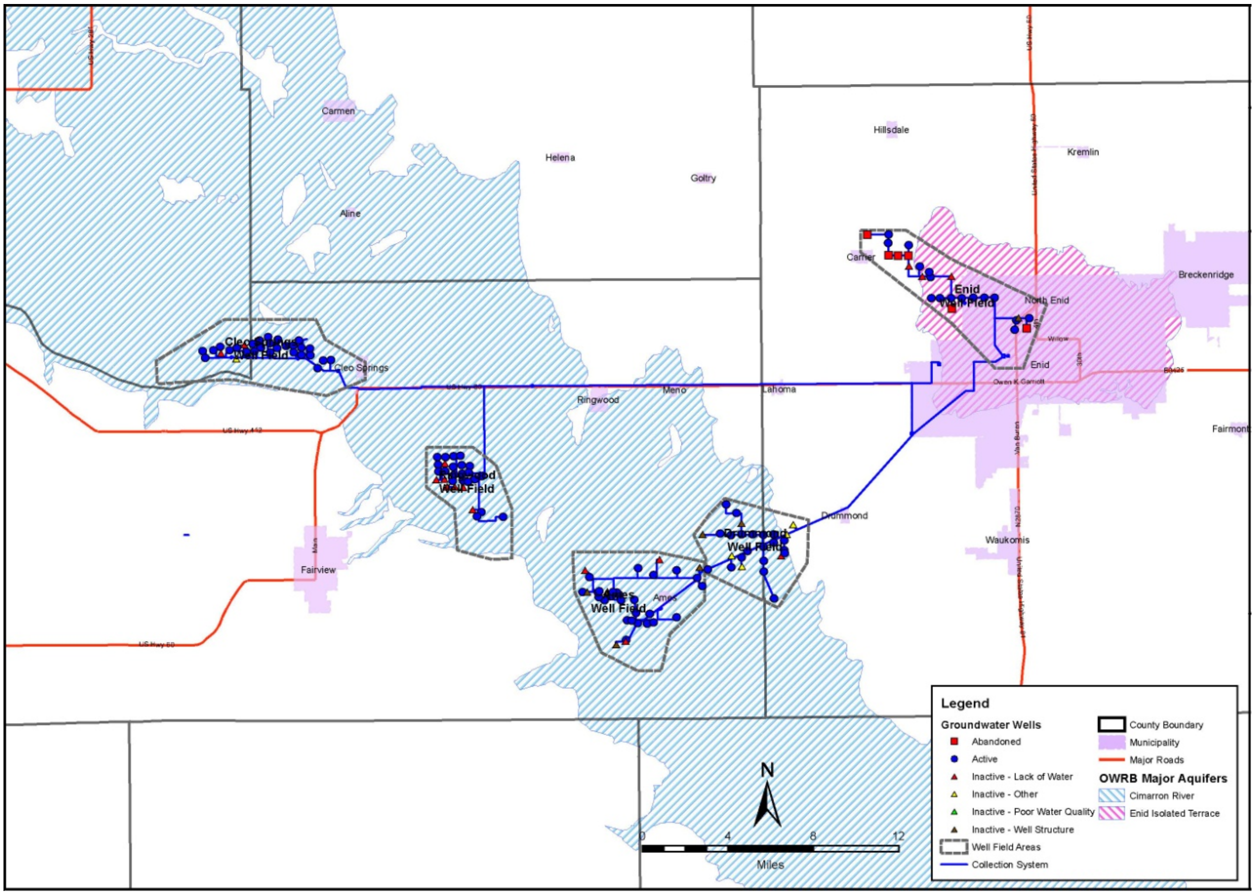


TABLE ES-1: SUMMARY OF CITY WELLS AND PRODUCTIVITY

| Well Field | Number of Active Wells | Reported Average Use and Peak Capacity | | Aquifers |
|---|---|---|---|---|
| | | 2000-2005 Average | 2000 Peak | |
| Ames | 26 | 1.53 MGD | 2.9 MGD | Cimarron River Terrace |
| Cleo Springs | 28 | 2.77 MGD | 4.0 MGD | Cimarron River Terrace |
| Drummond | 20 | 2.25 MGD | 3.3 MGD | Cedar Hills Sandstone |
| Enid | 21 | 0.95 MGD | 1.2 MGD | Enid Isolated Terrace |
| Ringwood | 21 | 1.24 MGD | 2.8 MGD | Cimarron River Terrace |
| TOTAL | 116 | 8.74 MGD | 14.2 MGD | |

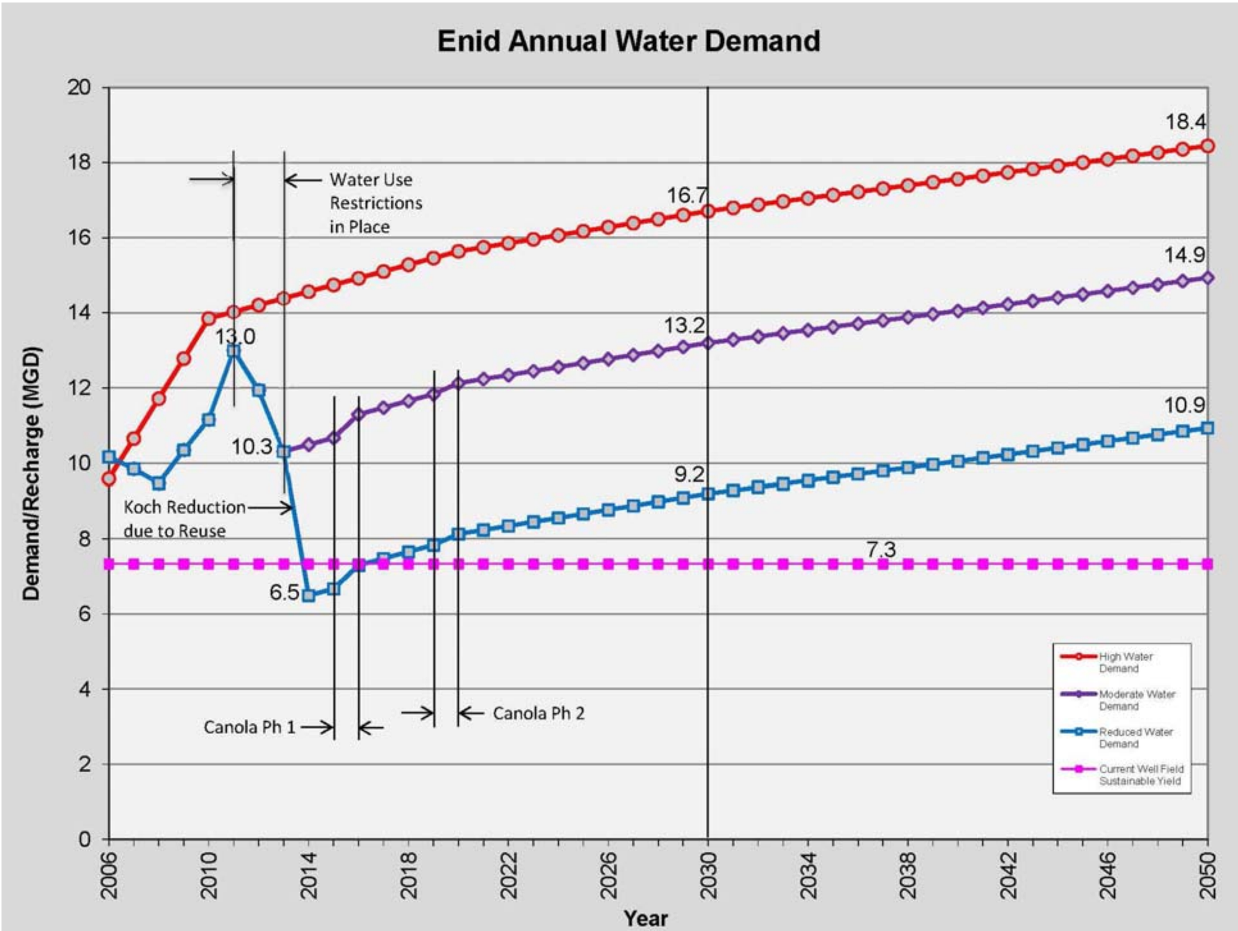
These well fields supplied the City's reported average demand of approximately 9 MGD. At one time, the wells were reportedly capable of supplying enough water to meet peak demands of 21 MGD. The City is concerned that the peak supply capability has been reduced in recent years. Based on projected growth and according to the Water System Master Plan, the average demand for the City will increase to 18 MGD by the year 2050, and the associated peak demands will be approximately 33 MGD. Currently, the quality of water supplied from the well fields complies with Federal and State drinking water standards, and the only treatments currently utilized by the City are fluoridation and chlorination.

Historically, capacities of individual wells and well fields in aggregate have declined due primarily to deteriorating mechanical conditions in wells, and also due in some areas to decreases in saturated thickness of the aquifers in well field areas (i.e., water-level declines). Additionally, water-quality degradation, primarily related to increasing concentrations of total dissolved solids (TDS) and nitrates, has caused reductions in availability and has caused the City to closely monitor and operate well fields so that water quality remains in compliance with the Safe Drinking Water Act for the State of Oklahoma's Public Water Supply program. Based on evaluations in the Water System Master Plan, some of the well fields are likely being produced at rates that exceed optimal pumping, while others may not be utilized enough. Some wells cannot be operated during drought periods, and some well fields are operated on an alternating basis due to potential water level interference between pumping wells. Additionally, due to the relatively shallow depths, limited aerial extent of the aquifers tapped by City wells, and perceived relatively small direct recharge rates, there are concerns that the aquifers are being "mined", at least within well field areas. Due to these concerns, the estimate used in this study for the sustainable production from the current well fields is 7.3 MGD. Therefore, detailed and expert studies are needed to assess the prospects for optimizing production from the City's current wells fields, and for economically expanding well fields in order to obtain sufficient, reliable, good-quality and cost-effective water supplies to meet the City's needs through 2050.

Figure ES-2 presents the annual water requirements for the City projected through 2050, graphed against the estimated sustainable production from the existing well fields. Information is presented for current, reduced, moderate, and high water demand. Specific milestones within this timeline reflect the following:

| Average Water Demand | 2013 | 2030 | 2050 |
|---|---|---|---|
| • Current | 7.3 MGD | | |
| • Reduced | 6.5 MGD | 9.2 MGD | 10.9 MGD |
| • Moderate | 10.3 MGD | 13.2 MGD | 14,9 MGD |
| • High | 13.0 MGD | 16.7 MGD | 18.4 MGD |

FIGURE ES-2: CURRENT WATER USAGE




## RESULTS OF WATER SUPPLY STUDY

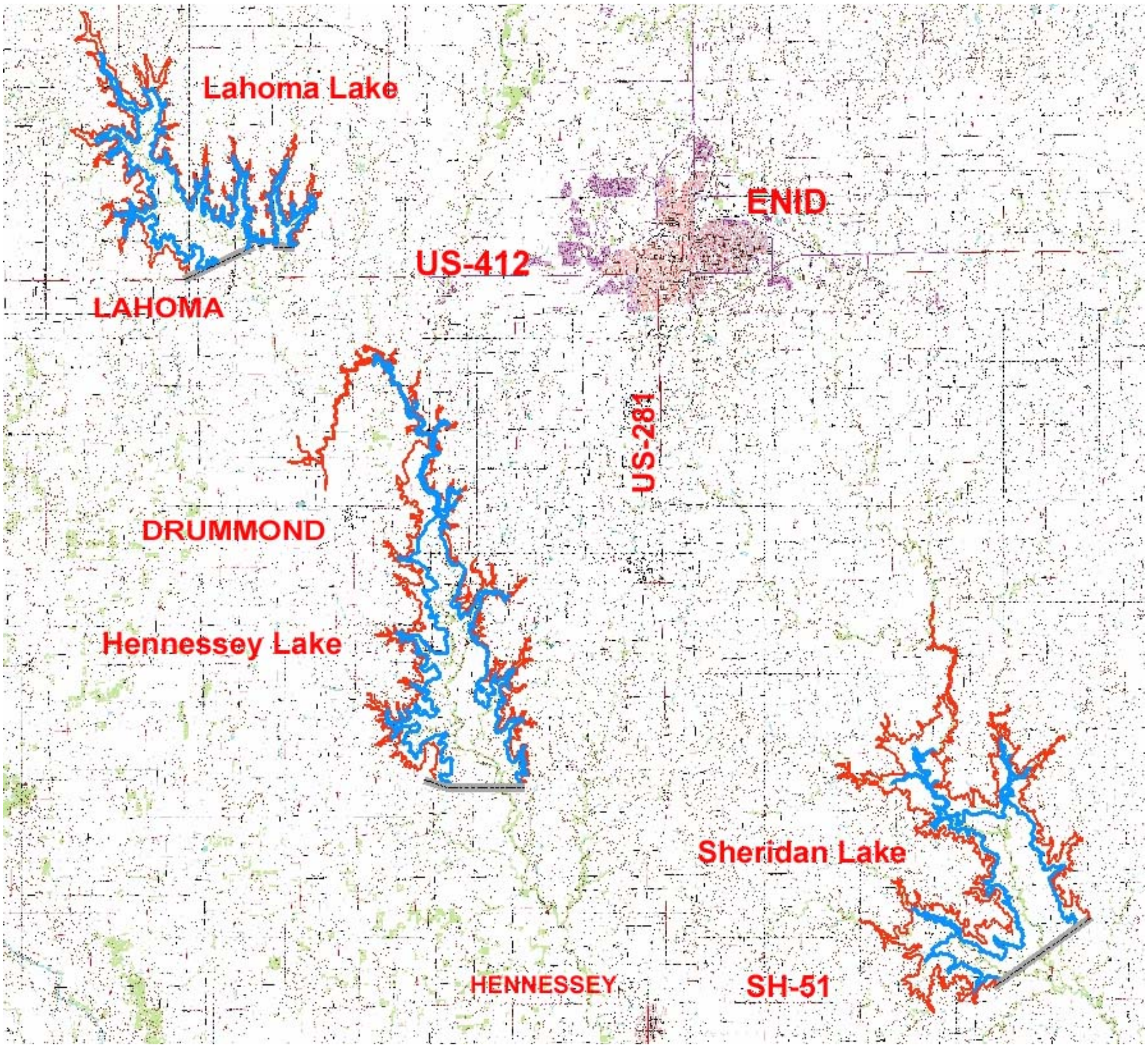
The information provided below summarizes the results of the surface water and groundwater analyses that were undertaken.

### SURFACE WATER

The study was designed to evaluate the potential development of three water supply reservoirs in the vicinity of Enid, Oklahoma (see Figure ES-3). The Study evaluated the following potential surface water supply reservoirs:

- Hennessey Reservoir
- Sheridan Reservoir
- Lahoma Reservoir

FIGURE ES-3: PROPOSED SURFACE WATER LOCATIONS




The three reservoir sites are characterized below. As shown, Hennessey Lake and Sheridan Lake reflect the highest dependable yield. Hennessey Lake has been selected as the best reservoir site.

TABLE ES-2: CHARACTERISTICS OF RESERVOIR SITES

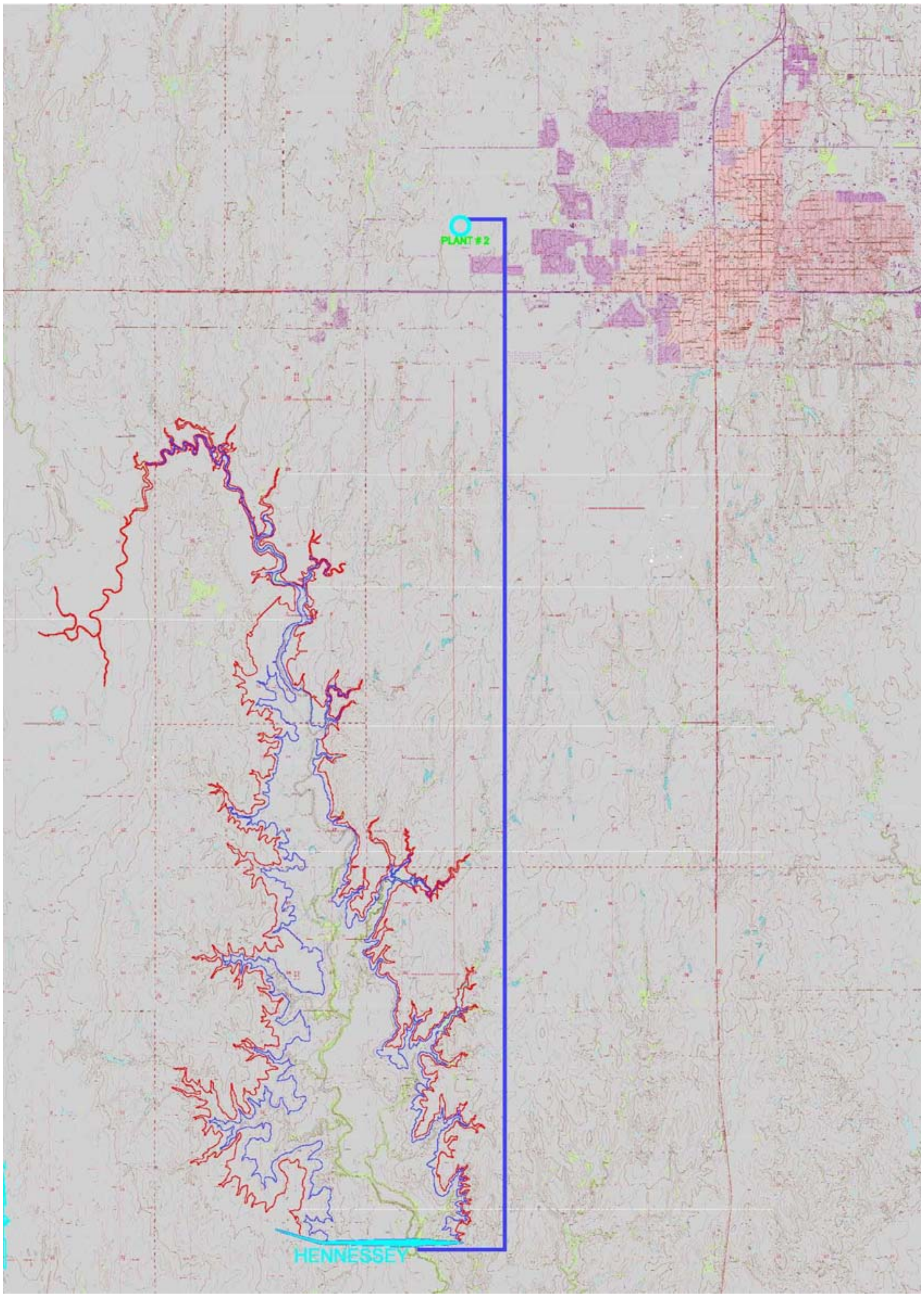
| Characteristic | Lahoma | Hennessey | Sheridan |
|---|---|---|---|
| Drainage Basin ($mi^2$) | 124 | 312 | 290 |
| Dependable Yield (MGD) | 12.6 (Still Need Well Fields) | 22.9 | 25.0 |
| Surface Area (Conservation Pool, ac) | 3,871 | 6,665 | 4,510 |
| Average Depth (Conservation Pool, ft) | 14.6 | 17.5 | 13.4 |
| Water Quality (will need further analysis) Desirable TDS Max. = 500 | High TDS @ 820, Fe, Mn | High TDS @ 980, Fe, Mn | High TDS @ 960, Fe, Mn (potentially high As and Nitrate) |
| Water Treatment Needs | Reverse Osmosis for TDS removal | Reverse Osmosis for TDS removal | Reverse Osmosis for TDS removal |
| Oil & Gas Activities | 88 wells on or within one-half mile | 275 wells on or within one-half mile | 365 wells on or within one-half mile |
| Highways/Railroads | No | Railroad | No |
| Transmission Lines | No | No | Yes |
| Proximity to Enid center (road miles to dam) | 11 | 18 | 29 |

Figure ES-4 identifies the proposed route in moving water from Hennessey Lake to the City for eventual treatment. There are definite concerns with any proposed reservoir in the Enid area because of climatic conditions. Filling lakes in the region is a concern. To the west/northwest is a reservoir site identified by the US Army Corps of Engineers in the 1960s/1970s that was developed/constructed, but because of a number of factors never filled and became an unviable facility.

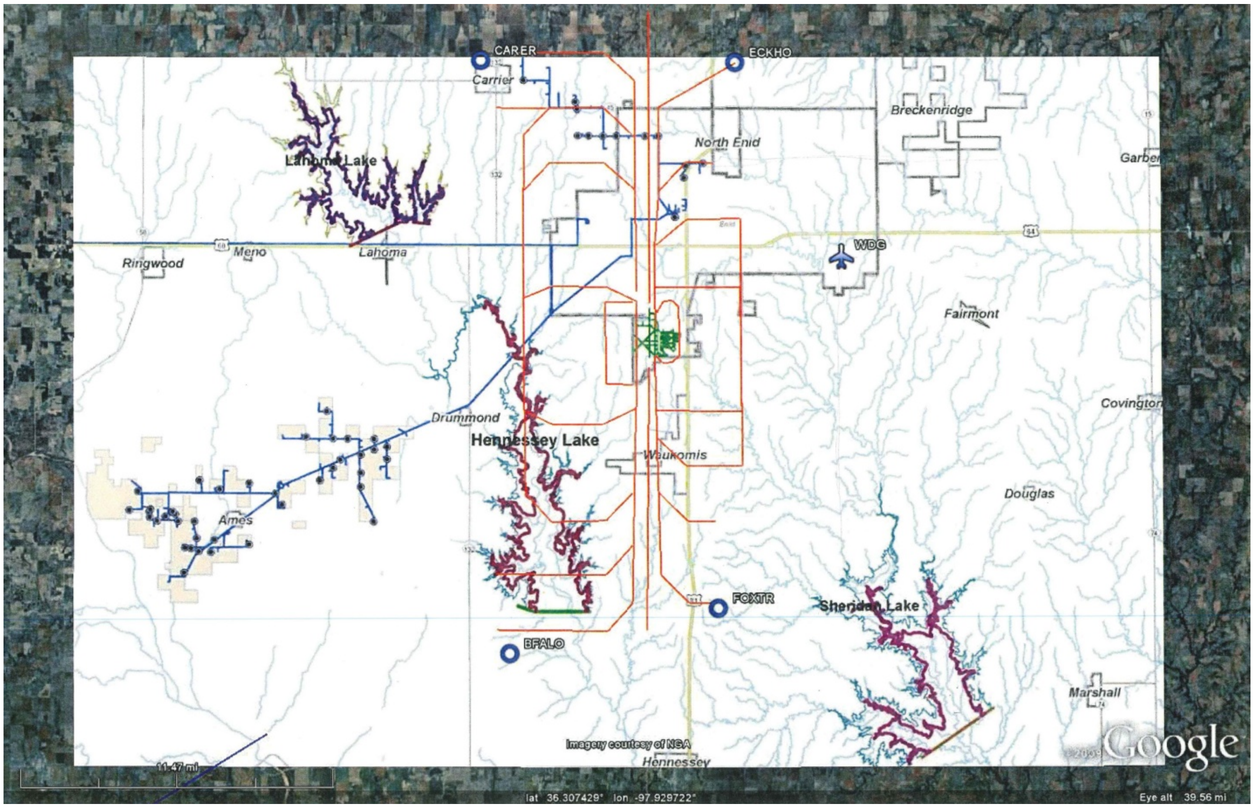
There are other concerns regarding Hennessey involving Vance AFB. The leadership at Vance has expressed concerns regarding the attractiveness of the reservoir to waterfowl and the increased population of birds in the area.

This scenario creates potentially increased safety hazards for flying missions in the area and is a cause for concern. Figure ES-5 illustrates the current flight patterns associated with Vance AFB and their location relative to the three reservoir sites.

ES-4: WATER TRANSFER FROM HENNESSEY TO THE CITY



ES-5: VANCE AFB FLIGHT PATTERNS AFFECTING HENNESSEY LAKE




In the original Water System Master Plan, Kaw Lake, located in northeastern Oklahoma, was identified as a potential surface water alternative. During the early stages of the study Kaw Lake was not considered because of more interest in developing a reservoir completely dedicated to Enid, but as the study progressed, it became apparent that Kaw Lake required increased consideration. As a result, the information from master plan was updated for this study.

Figure ES-6 illustrates the proposed pipeline route from Kaw Lake to Enid. This route is about 57.3 miles in distance. The project would require the following facilities:

- Intake and pump station at Kaw Lake
- Pipeline
- Intermediate pump station and potential storage
- New water treatment plant in Enid

Figure ES-7 provides more detail on the intermediate facilities required. Two potential storage options are identified in addition to a needed pump station.

FIGURE ES-6: PROPOSED PIPELINE ROUTE FROM KAW LAKE

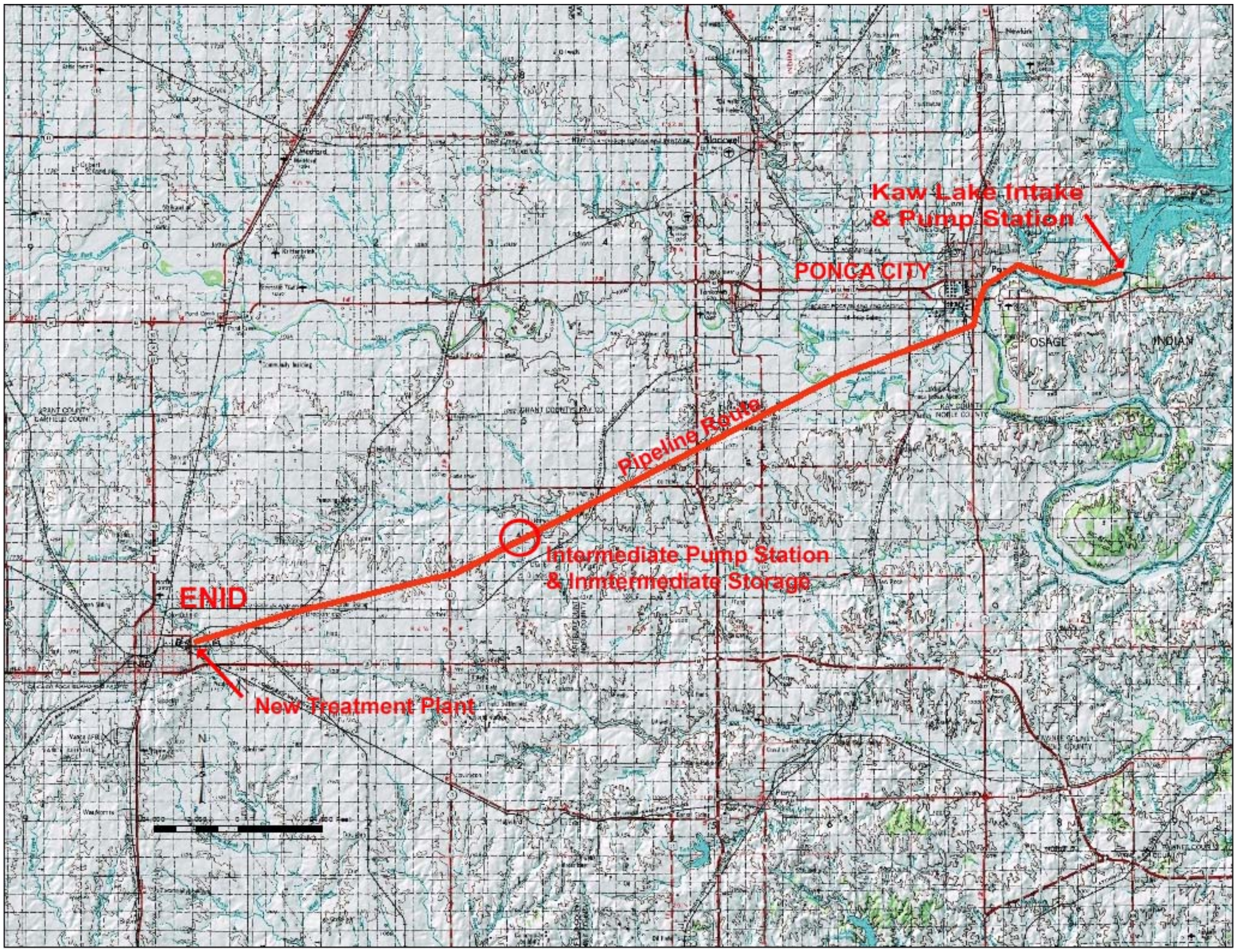


FIGURE ES-7: INTERMEDIATE STORAGE FACILITIES IDENTIFIED FOR THE KAW LAKE ALTERNATIVE

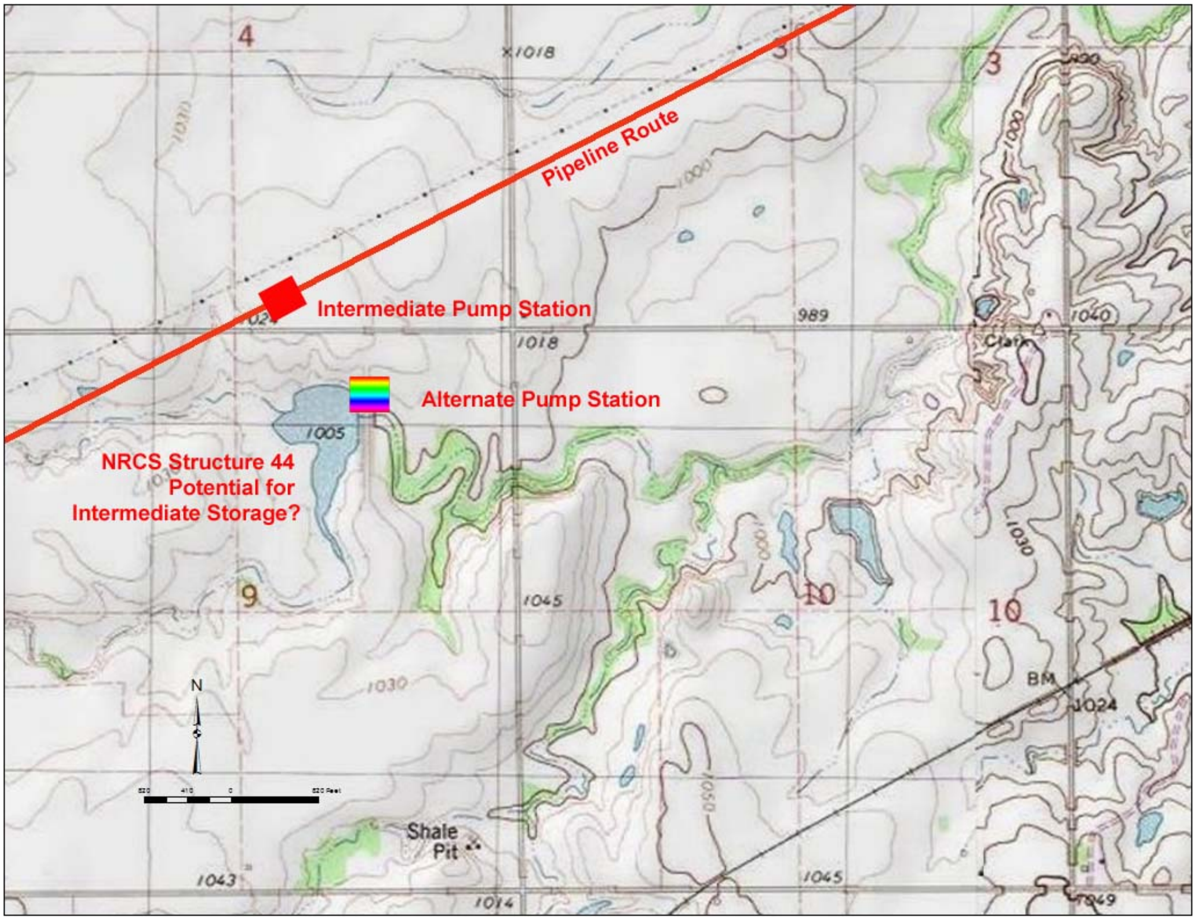



Table ES-3 summarizes various options for pipeline sizing for Kaw Lake water conveyance and the affects of size on peak flow and the proposed treatment plant. As shown, logically, the larger the pipeline size, more water can be provided to the City, with a peak of 24 MGD with a 48” pipeline. The greater the flow, a larger water treatment plant can be provided with each increase in pipeline size.

TABLE ES-3: ALTERNATIVE PIPELINE SIZES, FLOW CHARACTERISTICS, AND TREATMENT PLANT PRODUCTION DATA FOR THE KAW LAKE OPTION

| Characteristic | 24” Pipeline | 36” Pipeline | 48” Pipeline |
|---|---|---|---|
| Peak Flow | 15.5 MGD<br>6,665 MGY | 20 MGD<br>7,320 MGY | 24 MGD<br>8,770 MGY |
| Average Plant Production | 7.75MGD<br>2,826 MGY | 10 MGD<br>3,648 MGY | 12 MGD<br>4,373 MGY |

## GROUNDWATER

Continuing reliance on groundwater is a very viable option for the City. Two options are considered including:

- Option 1: Expand Well Field with Significant Infrastructure Renovation & Expansion
- Option 2: Expand Existing Well Field without Significant Infrastructure First, then Expand Well Field Requiring Significant Infrastructure in the Future

For both options, new well locations and new well fields are proposed relating to the following needs/caveats:

- This study provided geophysical testing to provide additional data for the Cimarron River Terrace Aquifer
- An older aquifer model was updated with the results of the testing
- Several promising locations for expansion of the well fields were determined
- Significant expansion and renovation of the City’s well field collection system will be required to bring significant amounts of water into the City’s system
- Test wells will be required to confirm hydraulic characteristics
- Acquisition of additional water rights will be required to significantly increase the amount of available groundwater

FIGURE ES-8: POTENTIAL GROUNDWATER EXPANSION AREA

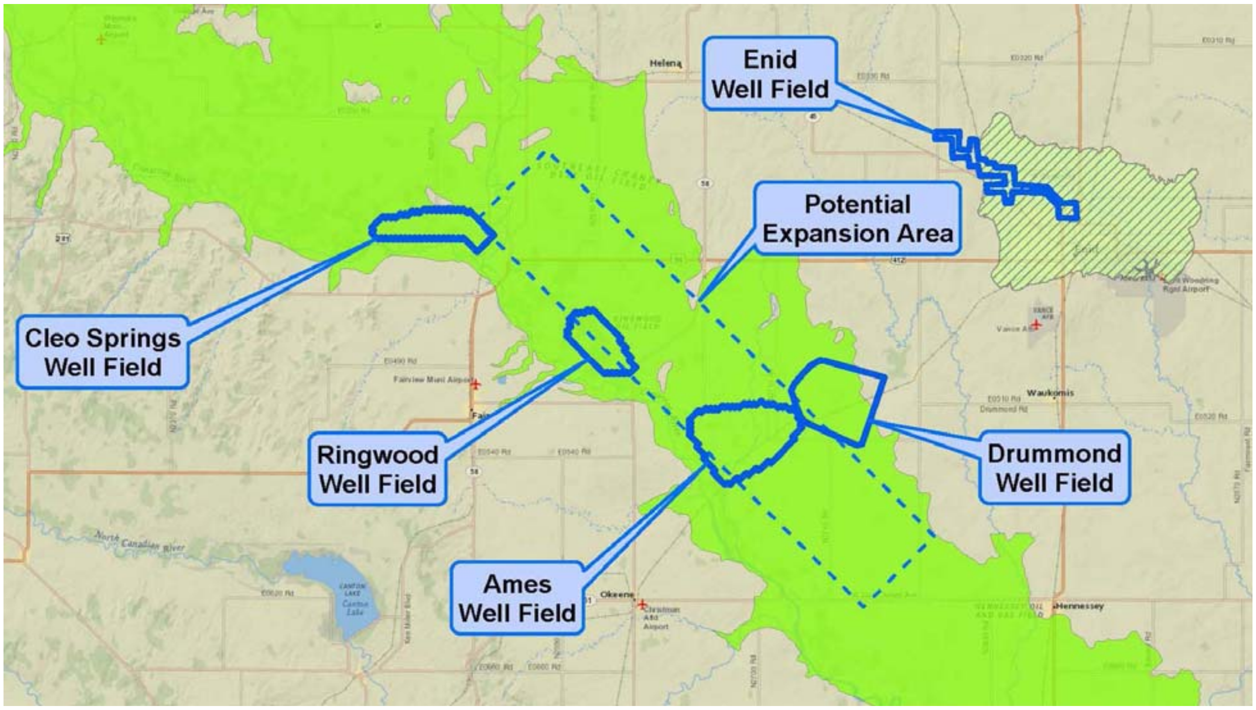



Table ES-4 summarizes a proposed program for continued use of groundwater. Two aquifers are combined for each scenario and the program reflects phasing, required water treatment, and required pumping facilities.

TABLE ES-4: PROPOSED PROGRAM FOR FURTHER DEVELOPMENT OF AQUIFERS AND INFRASTRUCTURE

| Characteristic | Ames & Drummond Area | Cleo Springs & Ringwood Area |
|---|---|---|
| Aquifer Characteristics | Best saturated thickness in Cimarron Terrace Aquifer | Expand in areas similar to Cleo Springs & Ringwood Wellfields |
| Phasing | New pipeline and plant required before utilizing "first drop" of water from aquifer | Can connect to Cleo Springs pipeline with limited cost |
| Water Treatment | Treat 7.35 MGD for Nitrate Removal | Treat 7.35 MGD for Nitrate Removal |
| Pumping Plant(s) | One pumping station with 1.0 MG ground storage tank | Two pumping stations, each with 1.0 MG ground storage tanks |

## COST ANALYSIS AND WATER AVAILABILITY

The overall project reflects a need for 18.4 MGD average demand in the year 2050. The cost for the various surface water and groundwater alternatives are provided below in Figures ES-9 through ES-12. The costs include construction, operations (electricity and maintenance), and inflation adjustments for the future.

### HENNESSEY LAKE OPTION

Construction of a new reservoir will require a substantial amount of up-front activity, including the preparation of an Environmental Impact Statement (EIS). The EIS will need to be coordinated with, and approved by, the U.S. Army Corps of Engineers (Corps). In recent reservoir proposals (the closest being in north Texas), the Corps has required a third-party to perform some of the environmental analysis and to receive public comment. This study is using a six year period for a short preliminary design phase followed by the EIS preparation and acceptance. The costs shown in Figure ES-9 for the first six years of the project include the engineering and environmental studies.

When the EIS is accepted, the project will proceed into final design and land acquisition. This study uses a two year period for these activities. For land acquisition, this means a fairly aggressive approach that will most likely result in condemnations of property. Additionally, an easement will need to be obtained for the pipeline from the dam to the new treatment plant. The cost line is appreciably steeper during this period as money is expended on these purchases.

A three year construction period follows next, which also gives time for clearing of improvements from the acquired properties. This clearing also includes the plugging of oil and gas wells, as well as potential re-plugging of abandoned oil and gas wells. Pipeline and other utility relocations will also occur during this period. On a per year basis, this will be the most expensive time period as is reflected by the steepness of the cost curve on Figure ES-9.

A treatment plant will also be required, assumed to be located at existing Plant No. 2. The City of Enid has a significant investment in the existing water supply system. The pipeline from the new dam location to Plant No. 2, and the treatment units at the plant, are sized based upon the assumption that the City will continue to use the existing well field infrastructure.

Once the dam is constructed and the reservoir area cleared, filling can begin. It is difficult to determine how long it will take to fill a large reservoir, as we cannot predict the weather patterns during this period. This study uses a three year period before enough water is held by the reservoir to begin using it for water supply. For the basis of this study, the year 2027 was chosen as the year that the City will be partly supplied with water from the reservoir.

To reach the year 2027, this study assumes that the City will need to augment the existing well fields with additional wells. A total of 36 new wells are included in the cost estimate, with the first 25 slated to come on line before 2019. There will be additional costs (beyond those shown in this estimate) if the existing pipeline from the Ames pumping station to the City will need to be replaced in-lieu-of the repairs included in the estimate. The existing well field will remain in operation.

Table ES-5 details the activities by time period and shows the cumulative current cost (the estimated cost as if all work could be performed today). These costs include operations and maintenance expense from the time a particular item (well, treatment plant, etc.) is placed in service. The current construction cost estimate is $324,100,000 in 2013 dollars. An inflation rate of 2.5% was used to project the cost of each activity into the appropriate future year. The cumulative costs of the future value are shown in the last column of Table ES-5.

FIGURE ES-9: COST AND WATER AVAILABILITY FOR HENNESSEY LAKE OPTION

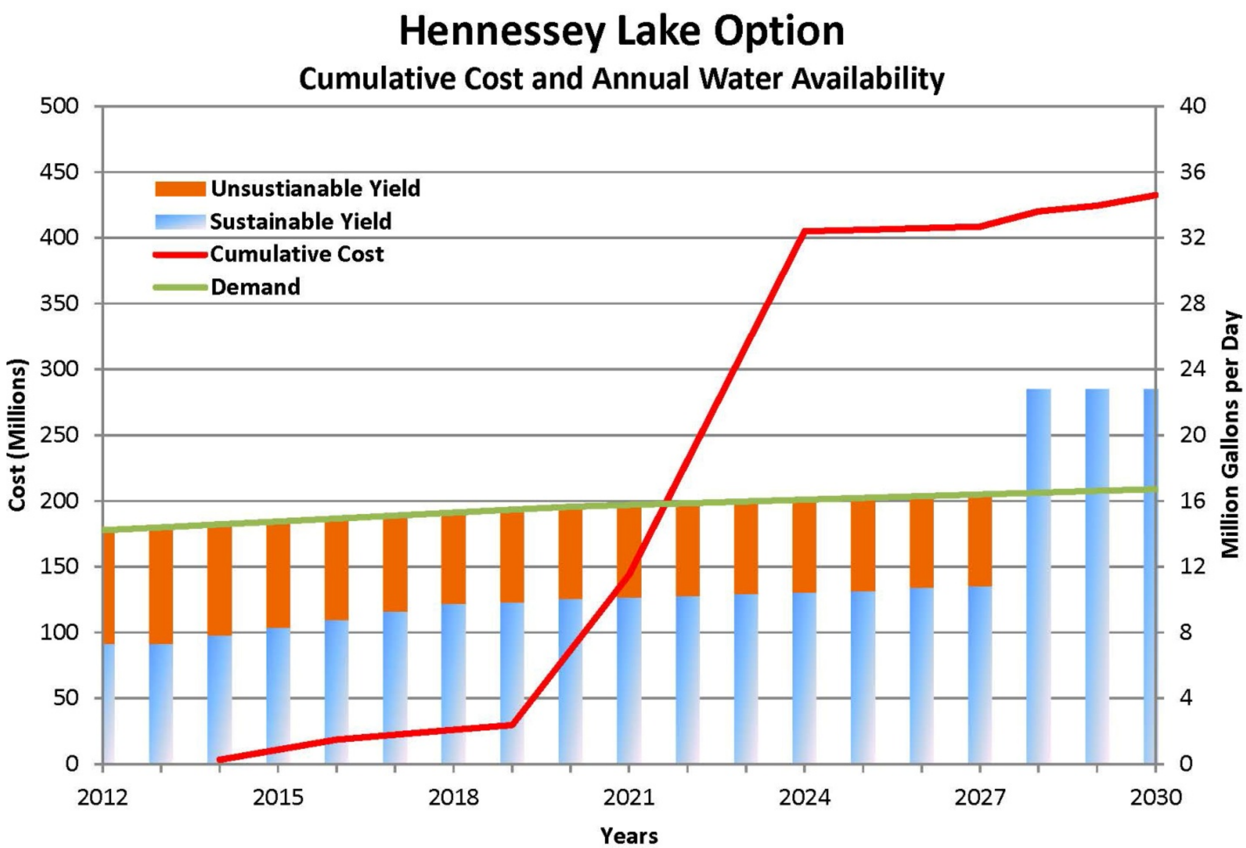



TABLE ES-5: HENNESSEY LAKE ACTIVITIES AND COSTS

| Years | Activity | Cumulative Costs | |
|---|---|---|---|
| | | 2013 Value | Future Value |
| 2014 | Begin<br>Preliminary engineering<br>Permitting & mitigation<br>Adding wells (5/yr) | $3,100,000 | $3,200,000 |
| 2015 to 2019 | Begin<br>O & M for new wells<br>Continue<br>Adding wells (26 total)<br>Complete<br>Preliminary engineering<br>Permitting & mitigation | $27,700,000 | $29,500,000 |

| Years | Activity | Cumulative Costs | |
|---|---|---|---|
| | | 2013 Value | Future Value |
| 2020 to 2021 | Begin<br>Clearing lake bed<br>Continue<br>Adding wells (match incremental demand)<br>O & M for new wells<br>Complete<br>Engineering<br>Easement acquisition<br>Land acquisition | $123,700,000 | $143,600,000 |
| 2022 to 2024 | Continue<br>Adding wells (match incr. demand)<br>O & M for new wells<br>Complete<br>Dam<br>Pipeline to treatment plant<br>Intake and pump station<br>Treatment plant<br>Clearing lake bed | $332,900,000 | $404,900,000 |
| 2025 to 2027 | Begin<br>Filling reservoir<br>Continue<br>O & M for all improvements<br>Complete<br>Adding wells | $335,400,000 | $408,400,000 |
| 2028 | Begin<br>Treating lake water<br>Continue<br>O & M for all improvements | $343,400,000 | $420,000,000 |
| 2029 to 2030 | Continue<br>O & M for all improvements | $351,200,000 | $432,400,000 |

## KAW PIPELINE OPTION

The City of Enid no longer has a storage allocation at Kaw Lake, nor does the City have water rights in the Arkansas River basin. Although all of the water rights for Kaw Lake are nominally assigned, the Oklahoma Water Resources Board (OWRB) has stated that a new application, backed by a plan to use the water in the near-term, would be favorably considered.

Use of Kaw Lake water would require the City to once again enter into a storage contract with the Corps and obtain the needed water rights from OWRB. Only the City of Stillwater has an intake through the Kaw Lake dam, so a new intake structure would need to be constructed. Easements would need to be obtained for a pipeline extending from the Kaw Lake dam to the east side of Enid. This study uses a cross country line that would not follow highway or section line roads, thus minimizing the length of pipe.

A 48" pipeline has been used for the cost estimates. The estimates also include an intermediate pumping station, for use if an intermediate storage location can be identified. A treatment plant, assumed to be located on the east side of Enid, would be required to treat surface water.

The intake structure, pipeline, pumping station and treatment plant could be in-place by the year 2019. As before, to reach the year 2019, this study assumes that the City will need to augment the existing well fields with additional wells. A total of 25 new wells are included in the cost estimate, all slated to come on line before 2019. There will be additional costs (beyond those shown in this estimate) if the existing pipeline from the Ames pumping station to the City will need to be replaced in-lieu-of the repairs included in the estimate. The existing well field will continue in operation. An economic evaluation would need to be made to determine if the existing well field will provide the base demand or the peaking demand.

Table ES-6 details the activities by time period and shows the cumulative current cost (the estimated cost as if all work could be performed today). These costs include operations and maintenance expense from the time a particular item (well, treatment plant, etc.) is placed in service. The current construction cost estimate is $198,700,000 in 2013 dollars. An inflation rate of 2.5% was used to project the cost of each activity into the appropriate future year. The cumulative costs of the future value are shown in the last column of Table ES-6.

FIGURE ES-10: COST AND WATER AVAILABILITY FOR KAW PIPELINE

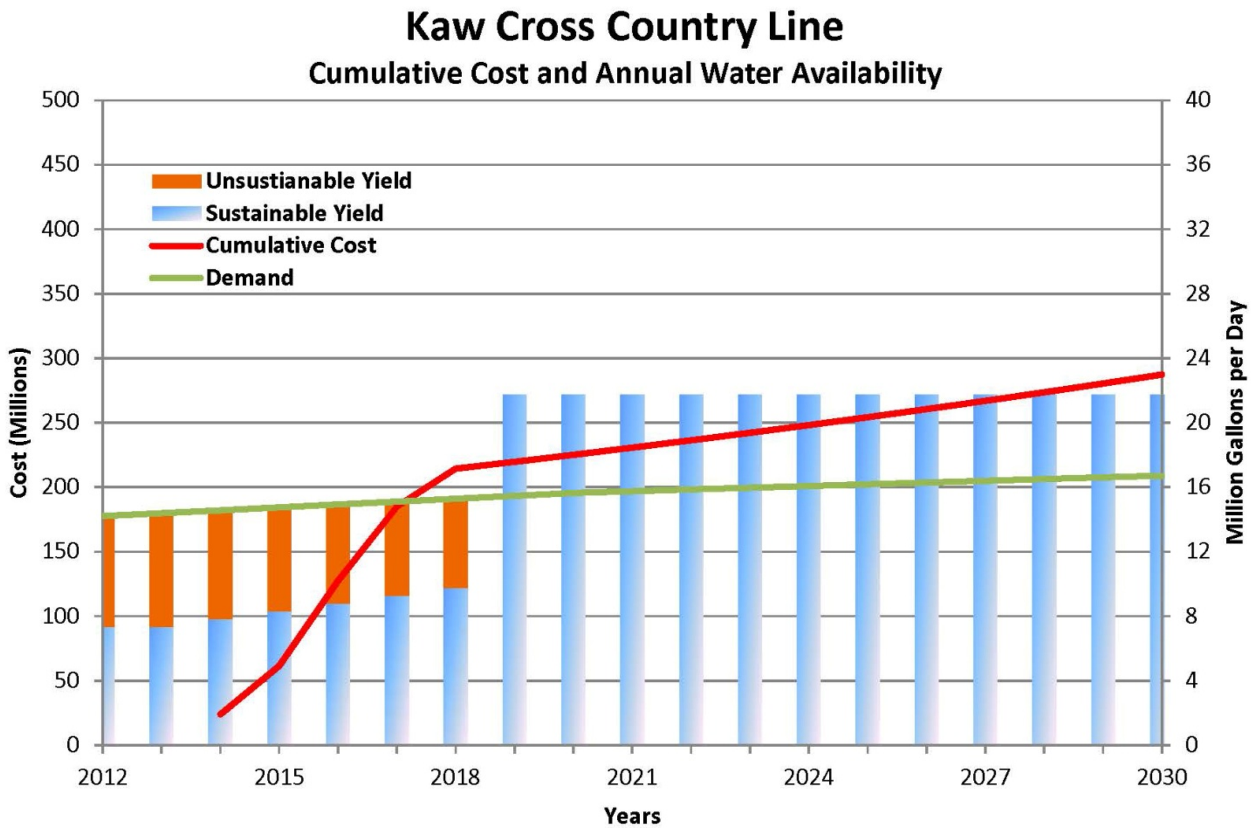



TABLE ES-6: KAW LAKE PIPELINE ACTIVITIES AND COSTS

| Years | Activity | Cumulative Costs | |
|---|---|---|---|
| | | 2013 Value | Future Value |
| 2014 | Begin<br>Engineering<br>Permitting & mitigation<br>Storage cost<br>Adding wells (5/yr)<br>Complete<br>Water rights | $23,400,000 | $23,900,000 |

| Years | Activity | Cumulative Costs | |
|---|---|---|---|
| | | 2013 Value | Future Value |
| 2015 | Begin<br>Easement acquisition<br>Kaw Lake pipeline<br>Pump stations<br>Water treatment plant<br>O & M for new wells<br>Continue<br>Storage cost<br>Adding wells (5/yr)<br>Complete<br>Engineering<br>Permitting & mitigation | $59,100,000 | $61,300,000 |
| 2016 to 2017 | Continue<br>Kaw Lake pipeline<br>Pump stations<br>Water treatment plant<br>Adding wells (5/yr)<br>O & M for new wells<br>Complete<br>Storage cost | $176,800,000 | $184,900,000 |
| 2018 | Begin<br>Pumping & treating lake water<br>O & M for lake<br>Continue<br>O & M for new wells<br>Complete<br>Kaw Lake pipeline<br>Pump stations<br>Treatment plant<br>Wells (25 total) | $204,500,000 | $214,400,000 |
| 2019 to 2030 | Continue<br>O & M for all improvements | $259,100,000 | $287,200,000 |

## NEW WELL FIELD OPTION

If the City of Enid decides to continue to use ground water for 100% of the City's supply, the number of wells needs to be significantly increased. The variability of the Cimarron Terrace Aquifer makes it very difficult to determine how many new wells are required as the location of available water rights is not known. For this study, an average new well is assumed to supply only 150 gpm during peak flow. This same well is also assumed to produce an average flow of 67.5 gpm, or 97,200 gallons per day (0.0972 MGD). This is on the low end of expected well capability, so it should represent a conservative value. To reach the projected demand of 18.4 MGD, 115 new wells will be required.

The location of the new well fields will determine how much of the existing infrastructure can be utilized. This cost estimate assumes that new well field collection lines will connect to a common trunk line, which will in turn connect to the existing main pipelines.

Obtaining a significant amount of additional water rights will be the key to this option. Although the wells can be added to the system one at a time, which is an advantage of this option, the general location of those wells needs to be known to maximize the efficiency of the collection system. Therefore, this study assumes that all additional water rights are obtained prior to year 2018, although well additions continue throughout the analyzed period.

Unlike the other options, this study has found that the pipeline from the Ames pumping station to the City will need to be replaced with a larger pipeline. In addition, a cost estimate is included for improvements to the Ames Plant. Depending upon where the water rights are obtained, this cost may actually be used to construct a new pumping plant.

Table ES-7 details the activities by time period and shows the cumulative current cost (the estimated cost as if all work could be performed today). These costs include operations and maintenance expense from the time each new well is placed in service. The current construction cost estimate is $153,300,000, including a large area of new water rights. An inflation rate of 2.5% was used to project the cost of each activity into the appropriate future year. The cumulative costs of the future value are shown in the last column of Table ES-7. As wells are added continuously, Table ES-7 continues to year 2050. Figure ES-12 shows the continuation of Figure ES-11 to year 2050 as well.

FIGURE ES-11: COST AND WATER AVAILABILITY FOR WELLS ONLY OPTION TO 2030

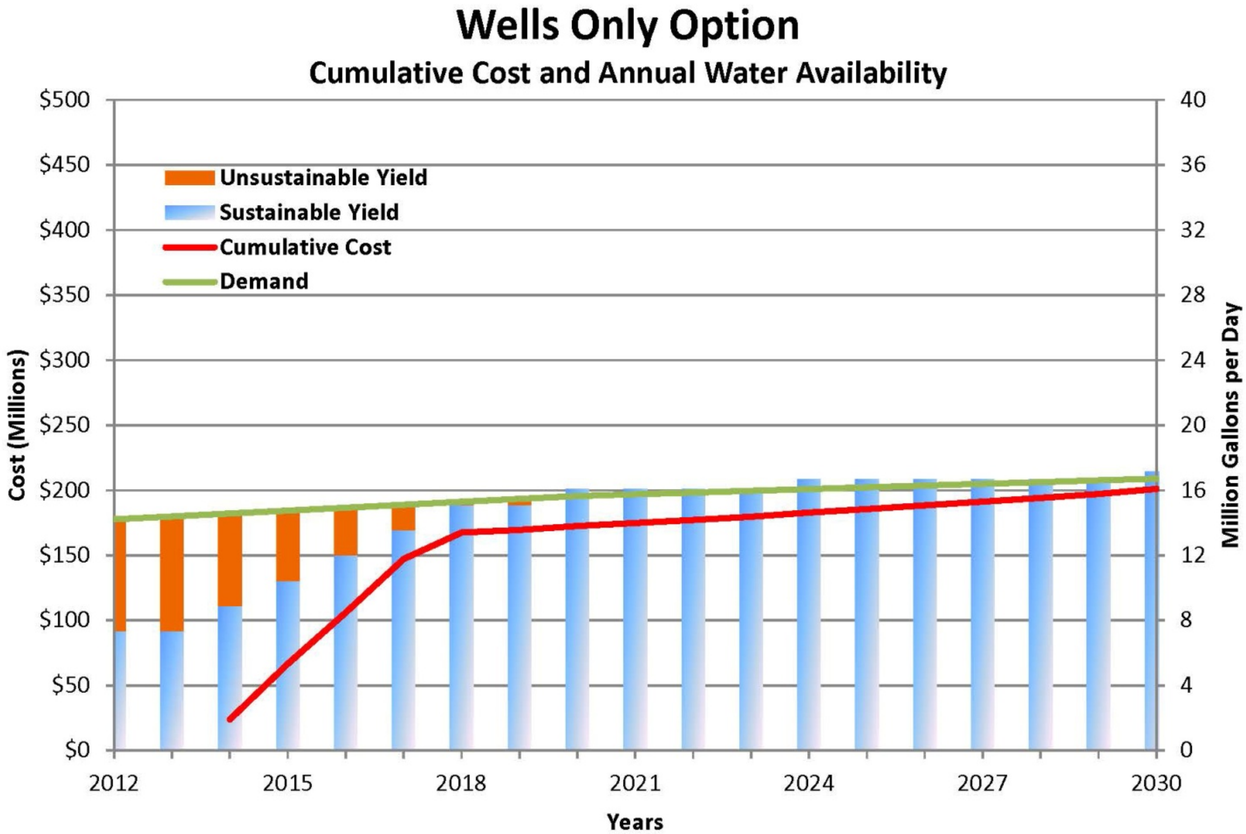


FIGURE ES-12: COST AND WATER AVAILABILITY FOR WELLS ONLY OPTION TO 2050

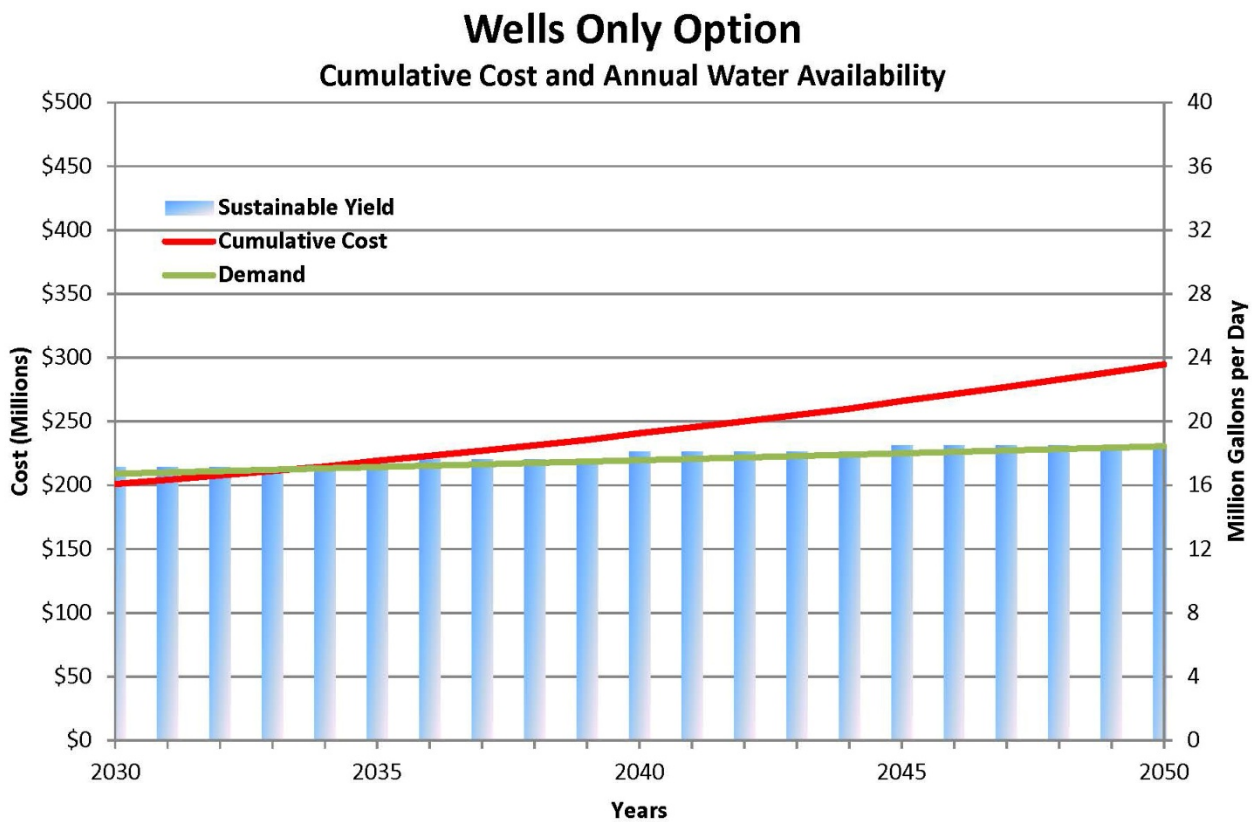


TABLE ES-7: NEW WELL FIELD ACTIVITIES AND COSTS

| Years | Activity | Cumulative Costs | |
|---|---|---|---|
| | | 2013 Value | Future Value |
| 2014 | Begin<br>Engineering & mitigation<br>Easement acquisition<br>Water rights<br>New well field pipelines<br>Adding wells (16/yr)<br>O & M for new wells | $23,100,000 | $23,700,000 |
| 2015 to 2017 | Begin<br>Ames pipeline<br>Ames Plant improvements<br>Continue<br>New well field pipelines<br>Adding wells (16/yr)<br>O & M for new wells<br>Complete<br>Preliminary engineering<br>Permitting & mitigation | $138,700,000 | $147,200,000 |
| 2018 | Continue<br>New well field pipelines<br>Adding wells (16/yr)<br>O & M for new wells<br>Complete<br>Ames pipeline<br>Ames Plant improvements | $156,900,000 | $167,400,000 |
| 2019 to 2030 | Continue<br>New well field pipelines<br>Adding wells (match incr. demand)<br>O & M for new wells | $182,000,000 | $200,900,000 |
| 2031 to 2050 | Continue<br>New well field pipelines<br>Adding wells (match incr. demand)<br>O & M for new wells | $228,800,000 | $294,700,000 |

## PROJECT SUMMARY/RECOMMENDATIONS

Table ES-8 summarizes the total costs (based upon costs which have been inflated from 2013 estimates to the year in which the money is expended) of each of three alternatives. For each of these alternatives, the corresponding increase in water rates (per 1000 gallons) is shown. This is the additional rate required based upon the financing assumptions discussed in each report. The assumption behind this increase is that rate payers will pay all of the debt service for construction as well as the additional operations and maintenance costs incurred. The average additional rate is shown for the years 2014 through 2030. Extending beyond 2030, the rates can be inferred from the trend shown in years 2025 through 2030. These rates should be considered very preliminary in nature due to the large number of assumptions that needed to be made in the calculations.

Based upon a long-term analysis of groundwater levels in the City's well fields, it appears the existing groundwater supply system is providing water at rates that are not sustainable in the long-term. One common recommendation for all options is to increase the number of wells currently used to alleviate the continued drop in groundwater levels. This is particularly important if a new reservoir is to be constructed.

Continuing to supply water from well fields only is the least expensive of the three options. However, this option assumes that enough water rights can be obtained in areas underlain by a competent aquifer. The Cimarron River Terrace Aquifer is highly variable in saturated thickness, magnifying the issue of aquifer competence. This option also assumes that some competing groundwater demands (primarily agricultural and energy) are removed from areas near the new well field expansion. If enough competing demands cannot be removed, the groundwater will flow from areas controlled by the City into adjacent areas that are pumping at higher-than-sustainable rates.

Construction of Hennessey Reservoir would allow the City to eventually phase out the use of groundwater. However, this option has the highest initial cost which places stress on the water rate structure well into future years. The only way to minimize the rates is to find additional customers for the water, thus dropping the unit cost for Enid citizens. The Lahoma Reservoir option (not detailed in this executive summary) has a lower cost basis, but continues the City's long-term reliance on groundwater as the Lahoma Reservoir will not have enough yield to act as a sole source. The Lahoma Reservoir is very near to the City's well fields. Thus, both the Lahoma Reservoir and the well fields rely upon essentially the same rainfall for filling the reservoir and recharging the aquifer. As the recent drought has highlighted, surface water reservoirs in western Oklahoma are considerably affected by drought. Any new reservoir will require an extended period of time prior to having enough water in the reservoir to begin supplying water. This study used a 14-year period from the time design begins on a reservoir until the reservoir is full enough to begin pumping and treating water. Two of the variables in this timeline, the environmental process and the time required to fill, are very difficult to project.

This study did not originally include obtaining water from Kaw Reservoir. However, as the study progressed, it became very apparent that using Kaw as a water source should still be considered. Kaw Reservoir, coupled with continued (but decreased) use of the City's well fields, has several advantages. Because Kaw Reservoir is on the Arkansas River, there is the opportunity to take advantage of different rainfall events. Additionally, Kaw Reservoir performed comparatively well during the recent period of drought. For the period of February 2011 to December 2013, the lowest Kaw Reservoir water elevation was only 1.11 feet below the normal pool, this during a period in which western Oklahoma lakes suffered much greater water level declines. Finally, maintaining a diversity of supply options allows the City to provide adequate water when operations are disrupted by maintenance issues.

This study recommends two actions that the City needs to take soon:

1. Greatly increase the level of effort towards pursuit of additional groundwater resources. No matter which long-term option is chosen, either additional wells or modifications to existing wells are needed.

2. Obtain firm commitments from the U.S. Army Corps of Engineers and the Oklahoma Water Resources Board as to the availability and cost of Kaw Reservoir water. This study included discussions with Corps and OWRB personnel, but commitments need to be obtained from higher levels.

TABLE ES-8: COST ANALYSIS

| YEAR | DEMAND (MGD) | DEMAND (1000 GAL/YEAR) | KAW CROSS COUNTRY LINE | | HENNESSEY LAKE | | WELLS ONLY | |
|---|---|---|---|---|---|---|---|---|
| | | | CUMULATIVE COSTS | RATE INCREASE PER 1000 GAL | CUMULATIVE COSTS | RATE INCREASE PER 1000 GAL | CUMULATIVE COSTS | RATE INCREASE PER 1000 GAL |
| 2012 | 11.94 | 4,358,100 | | | | | | |
| 2013 | 10.82 | 3,949,300 | | | | | | |
| 2014 | 7 | 2,555,000 | $23,900,000 | $0.59 | $3,200,000 | $0.08 | $23,700,000 | $0.59 |
| 2015 | 7.17 | 2,617,050 | $61,300,000 | $1.49 | $10,700,000 | $0.26 | $66,557,642 | $1.61 |
| 2016 | 7.8 | 2,847,000 | $127,300,000 | $2.84 | $18,400,000 | $0.41 | $105,848,183 | $2.36 |
| 2017 | 7.98 | 2,912,700 | $184,900,000 | $4.03 | $22,100,000 | $0.48 | $147,200,000 | $3.21 |
| 2018 | 8.16 | 2,978,400 | $214,400,000 | $4.57 | $26,000,000 | $0.55 | $167,400,000 | $3.57 |
| 2019 | 8.34 | 3,044,100 | $219,700,000 | $4.58 | $29,500,000 | $0.62 | $169,348,099 | $3.53 |
| 2020 | 8.63 | 3,149,950 | $225,100,000 | $4.54 | $86,600,000 | $1.75 | $172,470,804 | $3.48 |
| 2021 | 8.74 | 3,190,100 | $230,600,000 | $4.59 | $143,600,000 | $2.86 | $174,773,367 | $3.48 |
| 2022 | 8.85 | 3,230,250 | $236,300,000 | $4.65 | $230,600,000 | $4.53 | $177,133,493 | $3.48 |
| 2023 | 8.95 | 3,266,750 | $242,100,000 | $4.71 | $317,800,000 | $6.18 | $179,552,622 | $3.49 |
| 2024 | 9.06 | 3,306,900 | $248,100,000 | $4.76 | $404,900,000 | $7.78 | $182,777,902 | $3.51 |
| 2025 | 9.17 | 3,347,050 | $254,200,000 | $4.82 | $406,000,000 | $7.70 | $185,488,939 | $3.52 |
| 2026 | 9.28 | 3,387,200 | $260,500,000 | $4.88 | $407,200,000 | $7.63 | $188,267,753 | $3.53 |
| 2027 | 9.38 | 3,423,700 | $266,900,000 | $4.95 | $408,400,000 | $7.57 | $191,116,037 | $3.54 |
| 2028 | 9.49 | 3,463,850 | $273,500,000 | $5.01 | $420,000,000 | $7.70 | $194,035,528 | $3.56 |
| 2029 | 9.6 | 3,504,000 | $280,300,000 | $5.08 | $424,300,000 | $7.69 | $197,028,006 | $3.57 |
| 2030 | 9.7 | 3,540,500 | $287,200,000 | $5.15 | $432,400,000 | $7.76 | $200,900,000 | $3.60 |
| AVERAGE RATE INCREASES | | | | $4.19 | | $4.21 | | $3.16 |