MEMORANDUM

FREESE AND NICHOLS

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TO: Bruce Turner, Luminant

FROM: Jon S. Albright

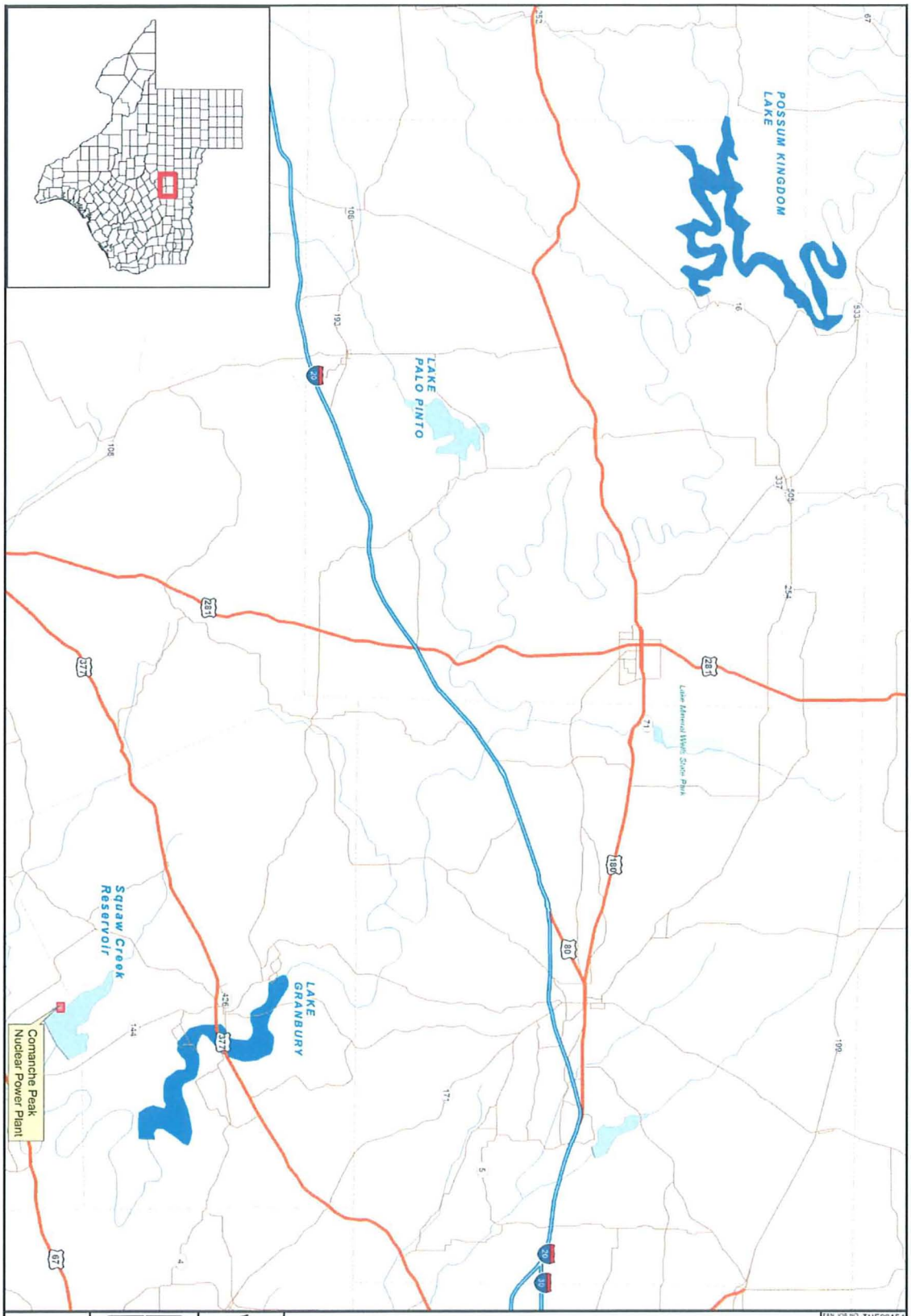
SUBJECT: Supplemental Information for NRC Request

DATE: December 15, 2009

1. Freese and Nichols, Inc. (FNI) believes that Scenarios A and C from the October 10, 2008 *Lake Granbury Dissolved Minerals Study* using 2020 conditions can be used to compare conditions with and without the proposed Units 3 and 4 at the Comanche Peak Nuclear Power Plant (Comanche Peak). Even though the Dissolved Minerals Study focused on water quality impacts, the year 2020 hydrologic modeling should give a reasonable assessment of the operation of Lakes Possum Kingdom and Granbury around the time that Units 3 and 4 come on-line. Scenario A only has the demands for the existing Units 1 and 2 at Comanche Peak. Scenario C is identical to Scenario A but adds the demands for the proposed Units 3 and 4 with treatment of the blowdown to stream standards. (Scenario B is the same as Scenario C except without treatment of the blowdown to reduce TDS loading.) Figure 1 is a location map showing the area of interest.

Demands for Units 3 and 4

2. The demands for Units 3 and 4 in the *Lake Granbury Dissolved Minerals Study* was 90,152 acre-feet per year with a consumptive demand of 53,827 acre-feet per year, with 36,325 acre-feet per year returned to Lake Granbury as blowdown. (In Scenario C, the total consumptive demand and blowdown volume varies somewhat from month to month with different levels of treatment to remove dissolved solids from the blowdown.) The demand and consumptive amounts were provided by Luminant. According to Luminant, the demand of 90,152 acre-feet per year is based on a statistical analysis of historical air temperature conditions at the site. These historical temperatures were divided into 13 bins and an estimate of water needs for each bin was extrapolated using turbine performance curves. The 90,152 acre-feet per year demand level is indicative of typical annual demands expected for the new units. Other studies



FIGURE

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W S N E

Lake Granbury and Lake Possum Kingdom
Vicinity Map

FAN JOB NO.	TUE06154
DATE	June 2008
SCALE	1:331,000
DESIGNED	JSA
DRAFTED	BME

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have used different demand levels as the design for the new units has been refined over time. For example, the amendment to the Brazos G Regional Water Plan used a demand of 103,717 acre-feet per year with a consumptive demand of 61,617 acre-feet per year, with 42,100 acre-feet per year returned as blowdown. This demand level is based on operation during high summer ambient temperatures, applied year around. For this memorandum, Scenario C was rerun with the 103,717 acre-feet of demand to examine the sensitivity of lake levels and flows to demand under 2020 conditions.

Modeling Assumptions

3. Table 1 is a summary of the assumptions used in the modeling of Scenarios A and C. Additional description of the modeling scenarios can be found in the *Lake Granbury Dissolved Minerals Study*. The modeling assumptions are based on historical operation of Lakes Possum Kingdom and Granbury. In our opinion these policies are a reasonable way to operate the reservoir system. The Brazos River Authority is currently re-evaluating its operating policies, and future operating policies may be different than those presented in this study.

4. The Lake Granbury Dissolved Minerals Study used a RiverWare model of the Brazos River from Lake Possum Kingdom to the Brazos River near Glen Rose stream gage (USGS 08091000), including Lake Granbury. Figure 2 shows the objects in the RiverWare model. The Glen Rose gage is located 4.1 stream miles upstream of the confluence of the Brazos and Paluxy Rivers[1]. The modeling to date does not extend to the Paluxy confluence. The RiverWare model uses monthly hydrology covering the historical period from 1940 to 2007. Attachment 1 contains more information regarding the model.

RiverWare Modeling Results

5. Figure 3 compares the simulated elevations in Lake Granbury for Scenarios A and C under 2020 conditions. Scenario A is shown in blue. Scenario C includes demands at both 90,152 (shown in green) and 103,717 acre-feet per year (shown in red). Figure 4 shows the exceedence frequency of the elevations in the same reservoir. Attachment 2 contains tables with the data used to create these graphs. Without the demands for the new units (Scenario A), the reservoir is full about 57 percent of the time. With the new units (Scenario C), Lake Granbury is full about 48 percent of the time at the 90,152 acre-feet per year demand level and about 46 percent of the

[1] U.S. Geological Survey: Water Resources Data Texas Volume 1, Water Year 1996.

Table 1
Summary of 2020 Modeling Assumptions

Item	Description
Water Supply for Units 1 and 2	48,300 acre-feet per year from Lake Granbury. Luminant is assumed to take the full amount each year and none of this water is returned to Lake Granbury. The actual operation of Squaw Creek Reservoir and Units 1 and 2 are not explicitly modeled.
Demands for Units 3 and 4 **(Scenario C only)**	90,152 acre-feet per year typical demand and 103,717 acre-feet per year high temperature demand. Water comes from Lake Granbury, with approximately 40 percent returned to Lake Granbury as blowdown. The actual amount of blowdown varies somewhat from month to month depending on level of treatment.
Possum Kingdom local demands	12,867 acre-feet per year directly from the reservoir
Other Lake Granbury local demands	36,828 acre-feet per year directly from the reservoir.
Downstream demands from Possum Kingdom/Granbury system	Brazos River Authority demands - 10,000 acre-feet per year released downstream during normal conditions, 50,000 acre-feet per year released downstream during drought. Releases for downstream rights were extracted from the Brazos River Basin Water Availability Model. Attachment 1 contains more information on this model.
Reservoir storage	Adjusted for expected sediment accumulation in 2020. Lake Granbury at conservation - 117,109 acre-feet with 7,737 surface acres. Lake Possum Kingdom at conservation – 495,052 acre-feet with 16,314 surface acres.
Possum Kingdom release rules*	If the reservoir is full, set to the amount needed to reach conservation storage at the end of the timestep. Hydropower releases above elevation 990 feet based on historical operation of the reservoir. Below elevation 990 feet FERC minimum flow releases. If Possum Kingdom has more than 250,000 acre-feet in storage, sufficient water is released downstream to keep Lake Granbury with 80,000 acre-feet in storage. Includes hydropower and FERC releases. If Lake Granbury is more than 2.5 feet down, a portion of the local and downstream demand from Lake Granbury is released from Possum Kingdom based on the percentage of total storage in each reservoir. Includes hydropower and FERC releases.
Lake Granbury release rules*	If the reservoir is full, set to the amount needed to reach conservation storage at the end of the timestep. Set to expected downstream demands for the Brazos River Authority and senior water rights. 28 cfs minimum release at all times.

* Additional information on release rules can be found in the April 17, 2009 Memorandum to Bruce Turner, Luminant, *Description of RiverWare Files*

Figure 2
Objects in RiverWare Model

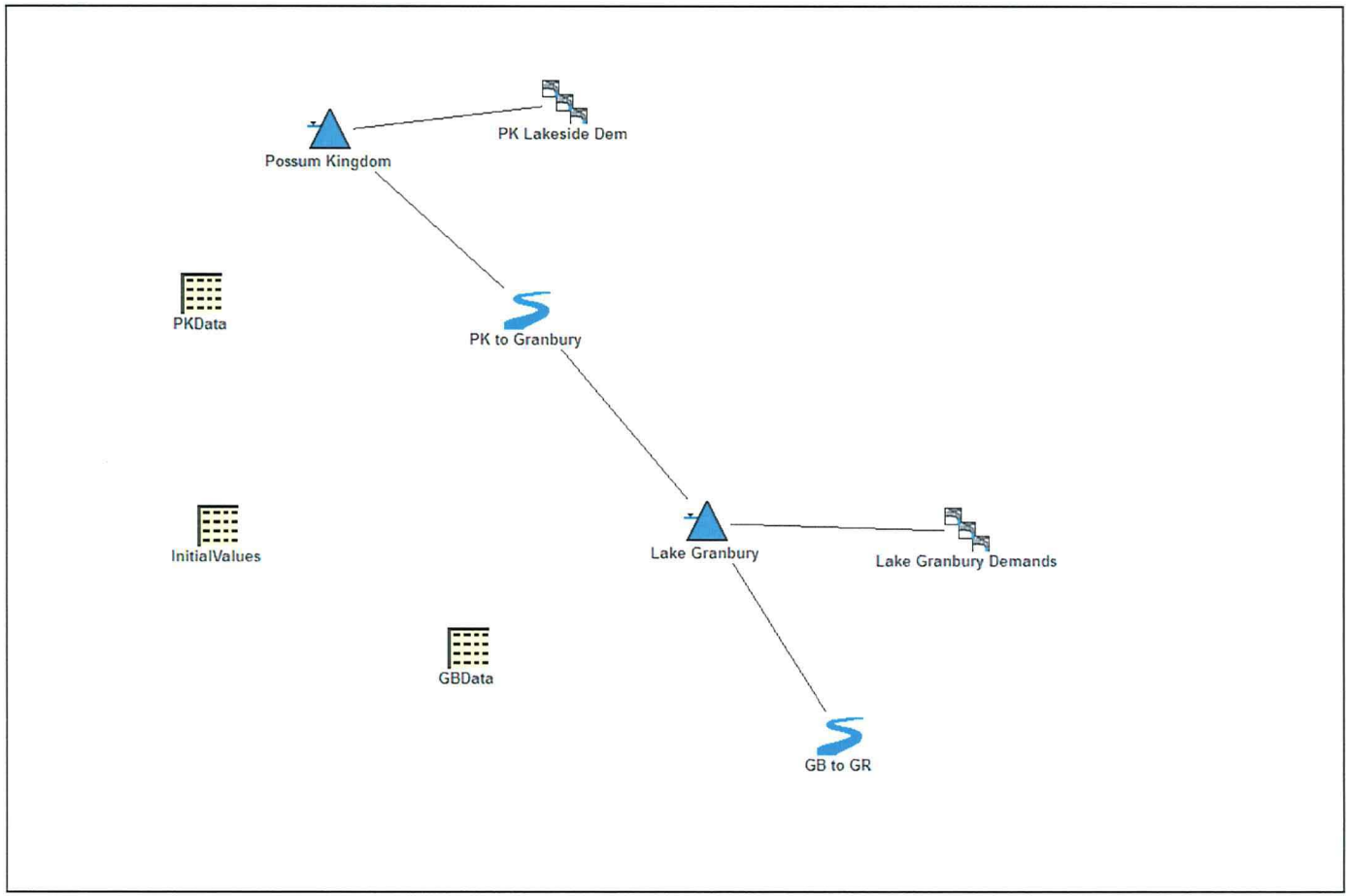


Figure 3
Simulated Lake Granbury Elevations
Scenarios A and C – 2020 Conditions

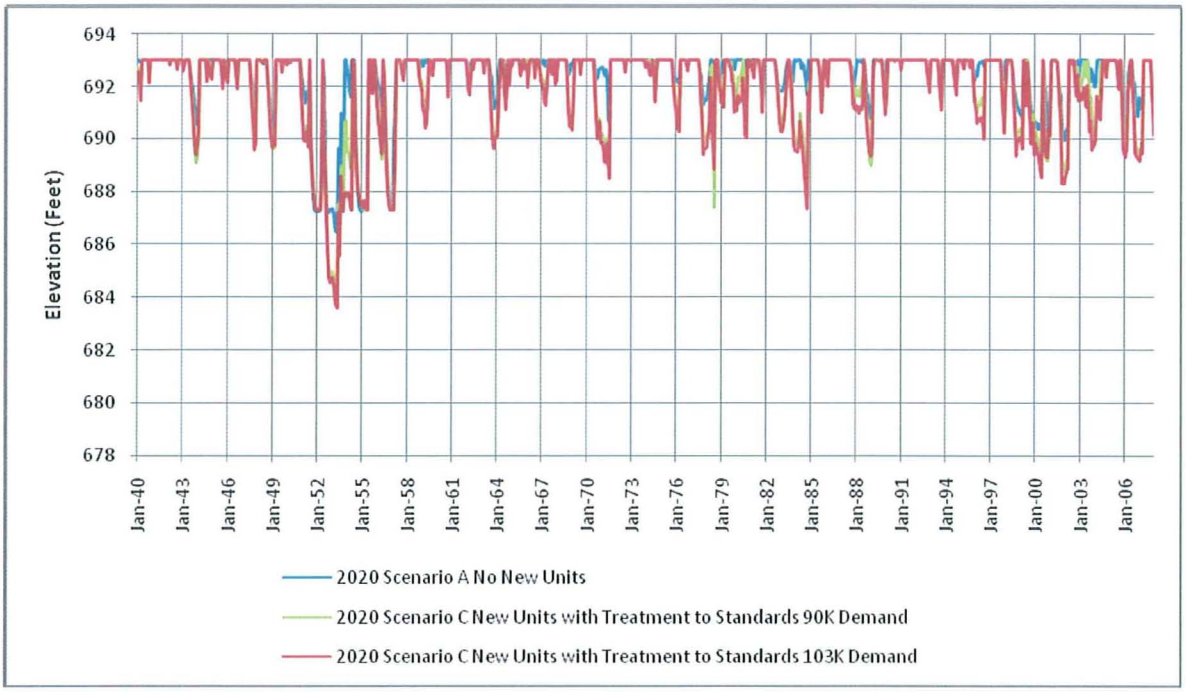
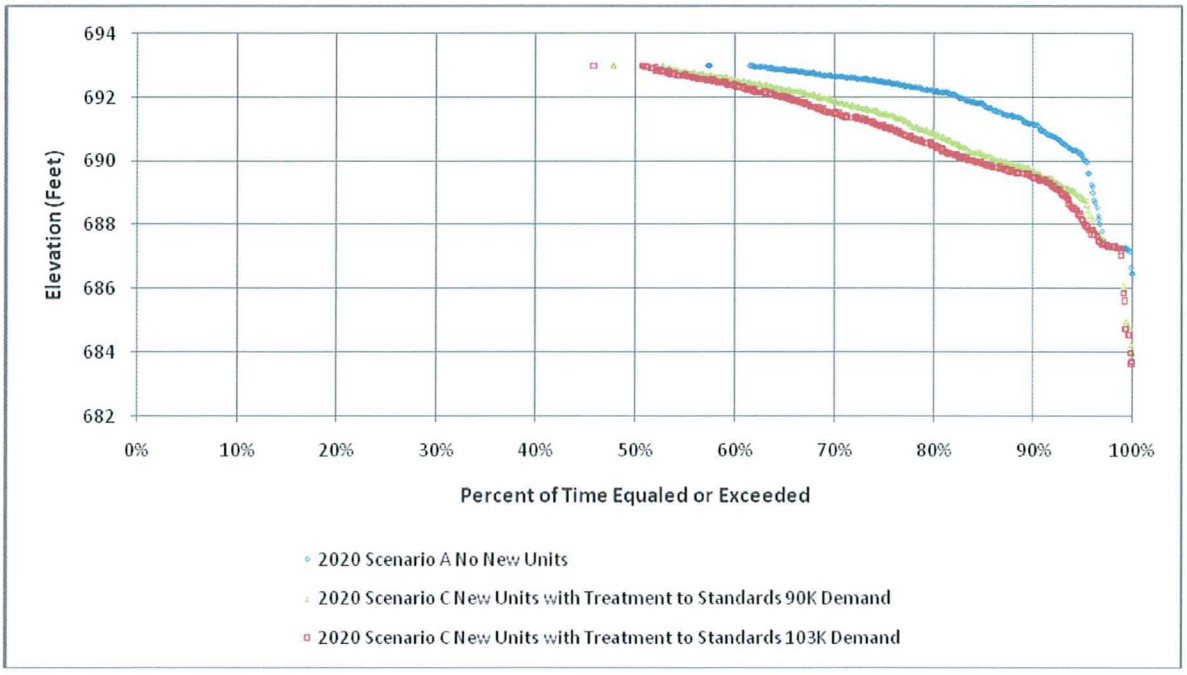


Figure 4
Exceedence Frequencies of Simulated Lake Granbury Elevations
Scenarios A and C – 2020 Conditions



time at the 103,717 acre-feet per year demand level. With the new units the reservoir is somewhat lower during dry periods. The reservoir is about 2.5 feet lower at its lowest point in March 1953 at the 90,152 acre-feet per year demand level and about 2.9 feet lower at the 103,717 acre-feet per year demand level. On average, with Units 3 and 4 (Scenario C) the reservoir is 0.4 feet lower at the 90,152 acre-feet per year demand level and 0.6 feet lower at the 103,717 acre-feet per year demand level.

6. Figures 5 and 6 show the simulated elevations and exceedence frequency for Lake Possum Kingdom, respectively. Attachment 2 contains tables with the data used to create these graphs. Without the new units (Scenario A), Possum Kingdom is expected to be full about 34 percent of the time. With the new units, the reservoir is full about 27 percent of the time at the 90,152 demand level and 26 percent of the time at the 103,717 acre-feet per year demand level. At the reservoir's lowest point in April 1953, with units 3 and 4 the reservoir is 12.6 feet lower at the 90,152 acre-feet per year demand level and 14.8 feet lower at the 103,717 acre-feet per year demand level. On average, in Scenario C the reservoir is 1.3 feet lower at the 90,152 acre-feet per year demand level and 1.5 feet lower at the 103,717 acre-feet per year demand level.

7. Figure 7 shows the modeled annual outflow from Lake Possum Kingdom. Figure 8 shows the exceedence frequency of the monthly outflows from the same reservoir. These values are plotted on a logarithmic scale because of the wide range of values. Figure 9 shows the monthly median outflow from the reservoir. Figures 10, 11 and 12 show the same data for the inflows to Lake Granbury. Attachment 2 contains tables with the data used to create these graphs. These graphs do not show as much difference in flows in this reach as would be expected from the changes in elevation shown in Figures 5 and 6. There are two explanations for this. First, releases from Possum Kingdom when the reservoir is relatively full are similar in both scenarios. Second, the larger spills from Lake Possum Kingdom in Scenario A sometimes mask the increased outflow during dry periods in Scenario C. For example, during the period from July 1951 to April 1953 about 246,000 acre-feet was passed downstream in Scenario A. In Scenario C at the 90,152 acre-feet per year demand level, 338,000 acre-feet was passed downstream during the same period, an increase of 92,000 acre-feet. However, when the reservoir refills in October 1953, in Scenario A 145,000 acre-feet of water spills from Possum Kingdom. In the same month in Scenario C at the 90,152 acre-feet per year demand level, only 37,000 acre-feet spills from the reservoir, a change of 108,000 acre-feet. Even though the outflows are

distributed differently in the two scenarios, over a long period of time the volume of the outflows is similar.

8. Figure 13 shows the annual outflow from Lake Granbury. Figure 14 shows the exceedence frequency of the monthly outflows and Figure 15 shows the monthly medians of the outflows. Figures 16, 17 and 18 show the same data at the Glen Rose gage. Attachment 2 contains tables with the data used to create these graphs. The outflows from Lake Granbury are similar for larger and smaller outflows. As the volume of the outflows decreases, the difference between Scenarios A and C becomes more pronounced, with generally lower outflows in Scenario C (with Units 3 and 4). At the lowest end of the flow range flows are governed by the constant minimum release of 28 cfs. The outflows from the reservoir are similar at both the 90,152 and 103,177 acre-feet per year demands.

9. The modeling shows that the increased demands for Units 3 and 4 will cause both Lake Granbury and Lake Possum Kingdom to be lower during drier periods. At the 90,152 acre-feet per year demand level, which is the typical demand expected from the new units, the maximum change is 12.6 feet in Possum Kingdom and 2.5 feet in Lake Granbury during the period of most severe drawdown. On average, elevations in Possum Kingdom will be 1.3 feet lower and elevations in Lake Granbury will be 0.4 feet lower with Units 3 and 4. All but the highest and lowest outflows from Lake Granbury will be reduced as well. With Units 3 and 4, the outflows from Possum Kingdom would increase during dry periods, and spills from Possum Kingdom at the end of these periods would be smaller. However, over time the outflows from Possum Kingdom would be the similar with and without Units 3 and 4.

10. Previous studies have used other slightly higher demand rates. Using a conservatively high demand of 103,717 acre-feet per year, elevations in Lake Granbury could be somewhat lower. Possum Kingdom elevations, flows from Possum Kingdom to Lake Granbury, and outflows from Lake Granbury would be minimally impacted.

Figure 5
Simulated Lake Possum Kingdom Elevations
Scenarios A and C – 2020 Conditions

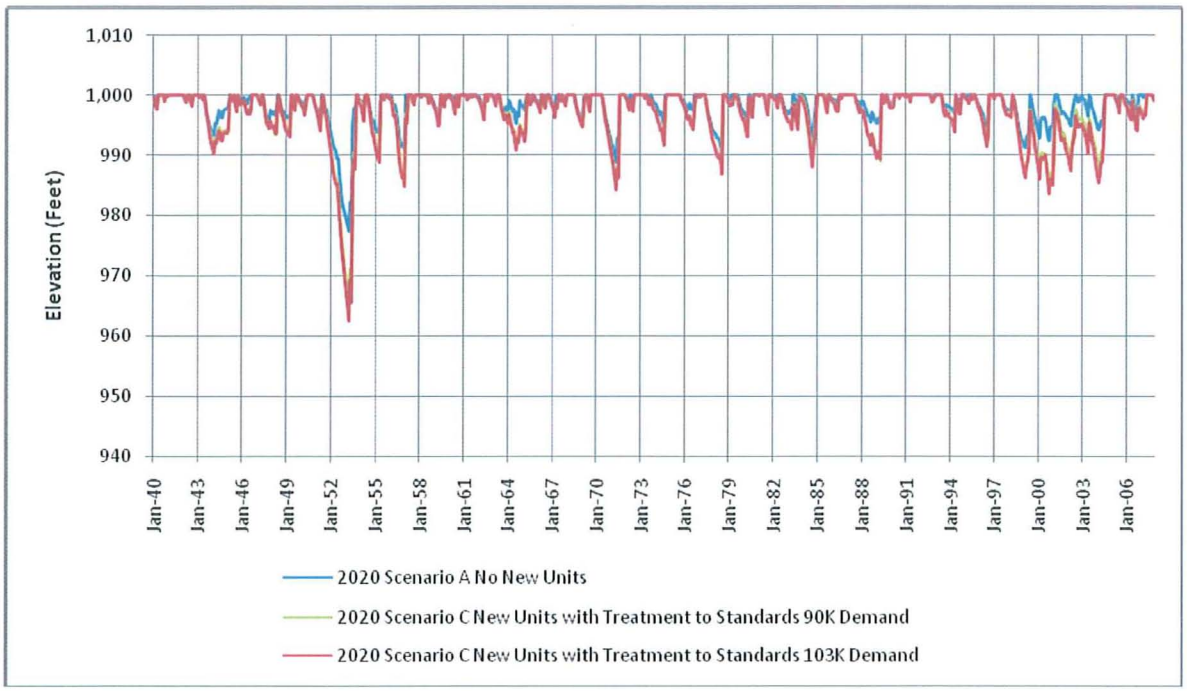


Figure 6
Exceedence Frequencies of Simulated Lake Possum Kingdom Elevations
Scenarios A and C – 2020 Conditions

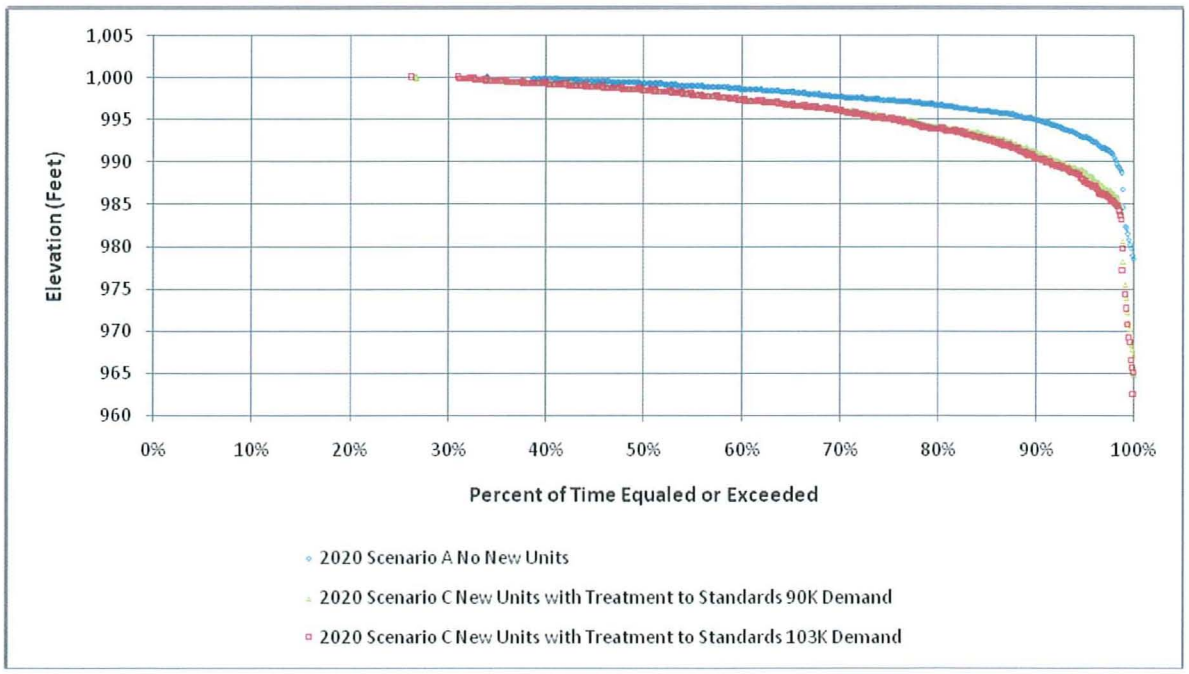


Figure 7
Simulated Annual Outflow from Lake Possum Kingdom
Scenarios A and C – 2020 Conditions

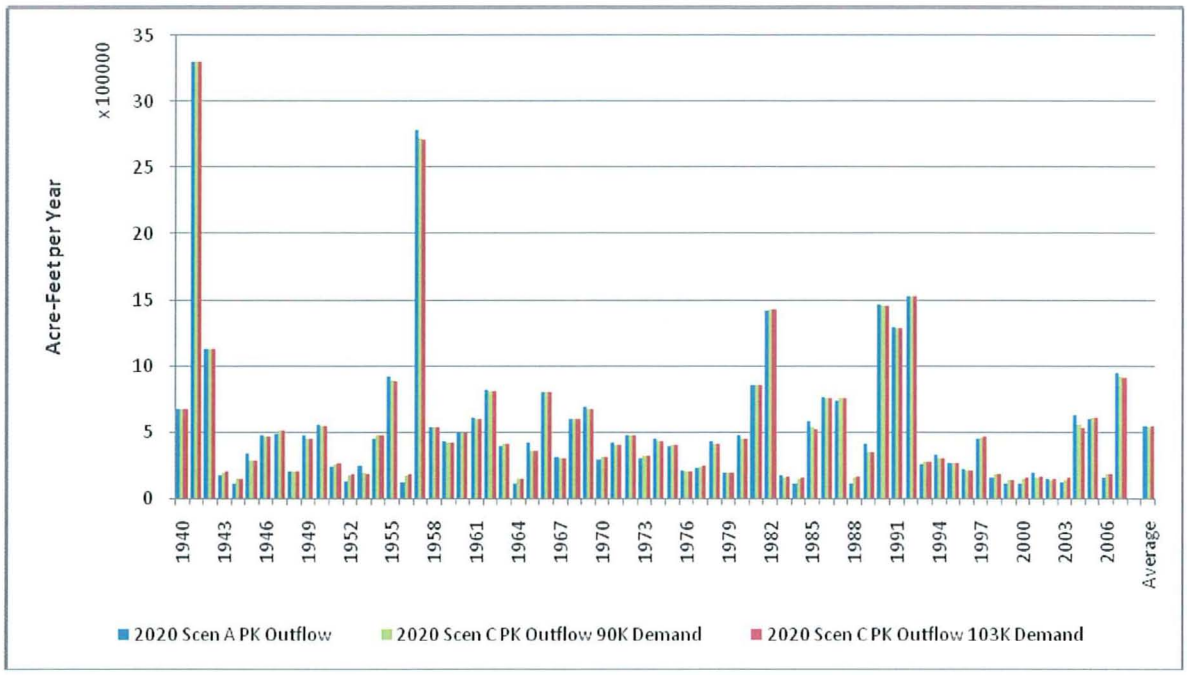


Figure 8
Exceedence Frequencies of Monthly Simulated Outflow from Lake Possum Kingdom
Scenarios A and C – 2020 Conditions

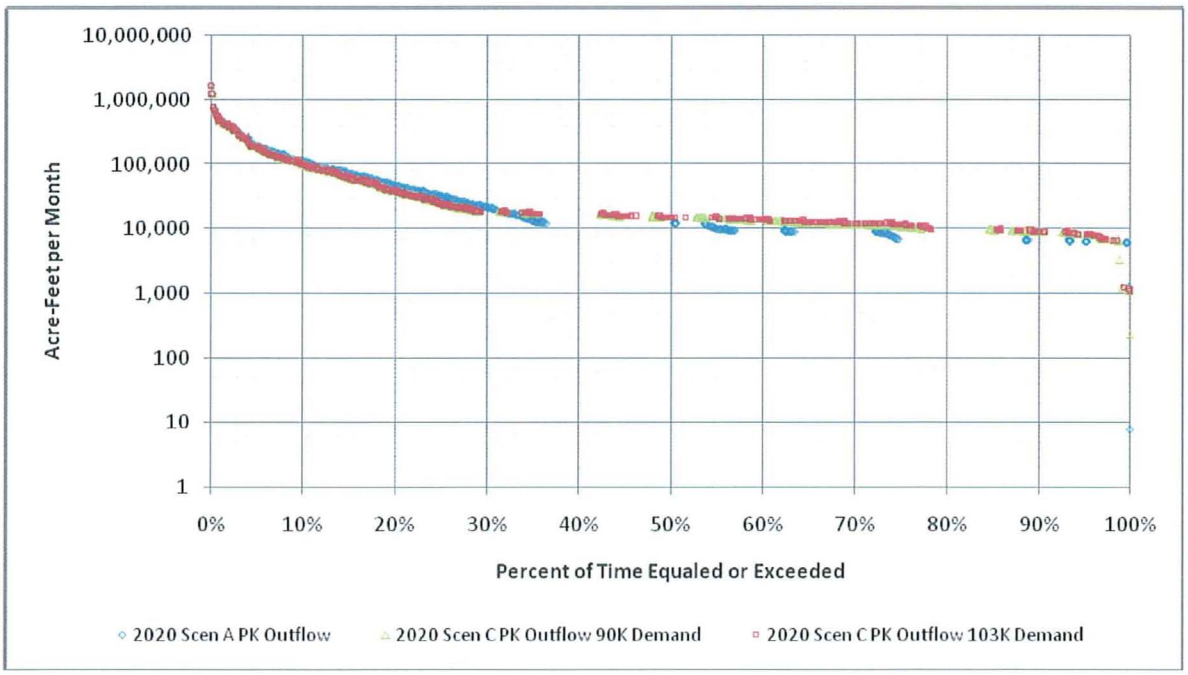


Figure 9
Monthly Median Simulated Outflow from Possum Kingdom
Scenarios A and C – 2020 Conditions

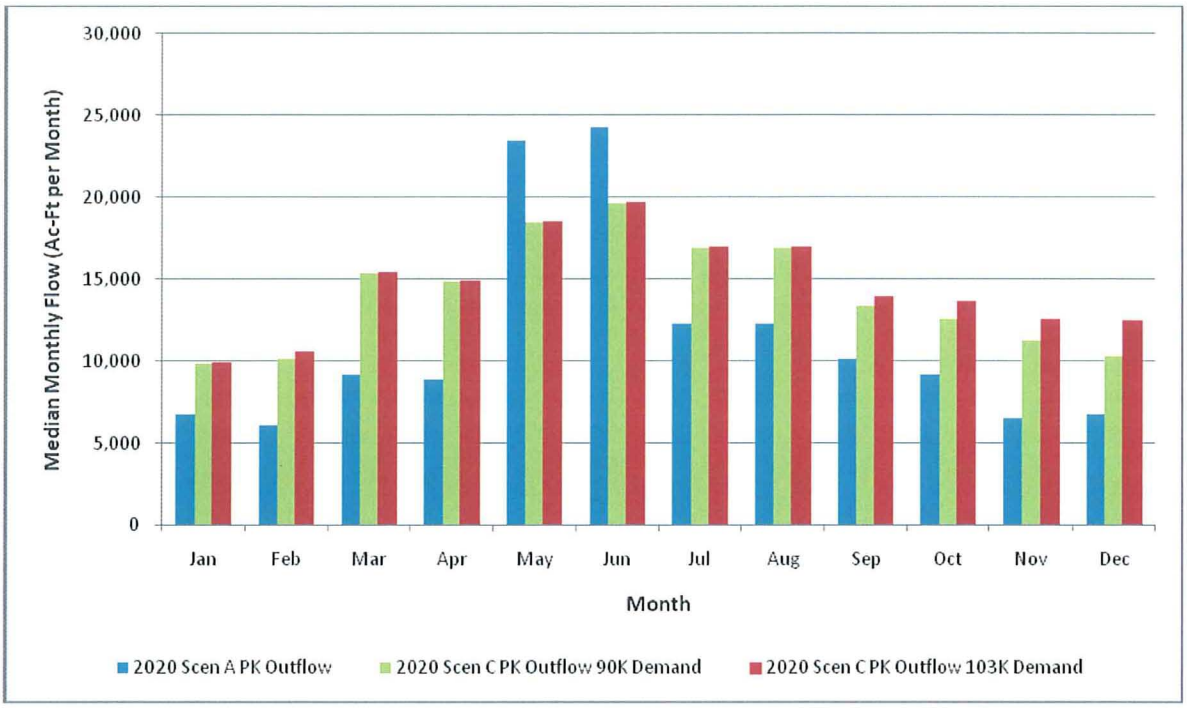


Figure 10
Simulated Annual Inflow to Lake Granbury
Scenarios A and C – 2020 Conditions

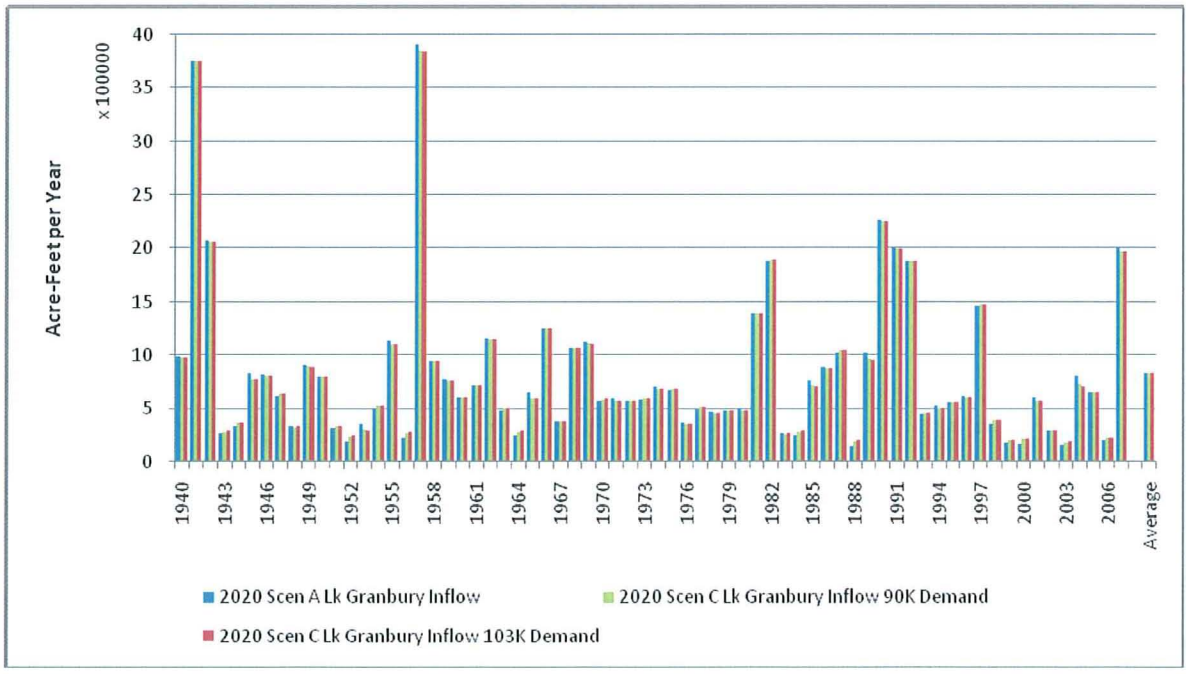


Figure 11
Exceedence Frequencies of Monthly Simulated Inflow to Lake Granbury
Scenarios A and C – 2020 Conditions

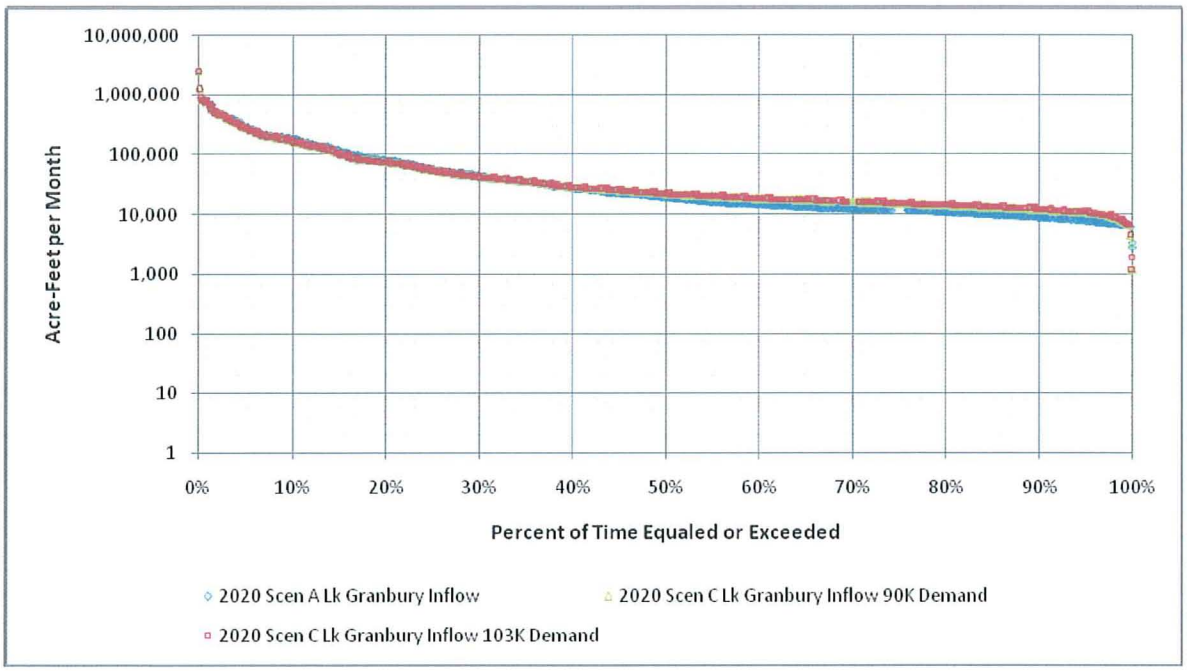


Figure 12
Monthly Median Simulated Inflow to Lake Granbury
Scenarios A and C – 2020 Conditions

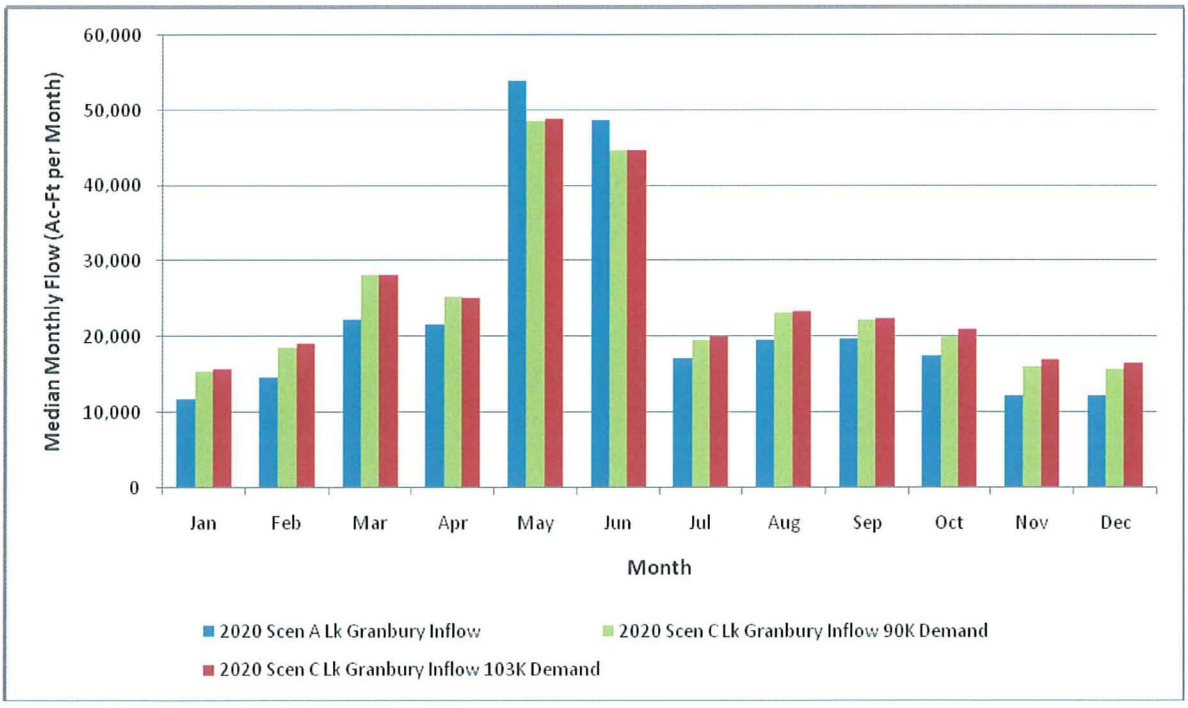


Figure 13
Simulated Annual Outflow from Lake Granbury
Scenarios A and C – 2020 Conditions

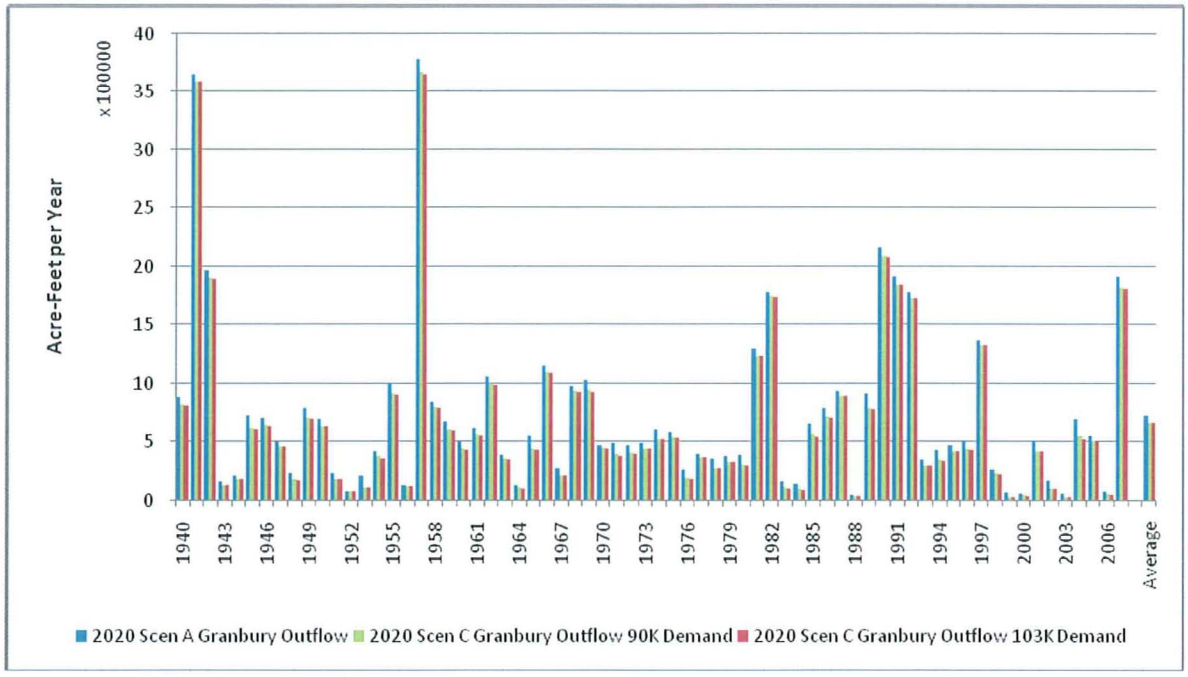


Figure 14
Exceedence Frequencies of Monthly Simulated Outflow from Lake Granbury
Scenarios A and C – 2020 Conditions

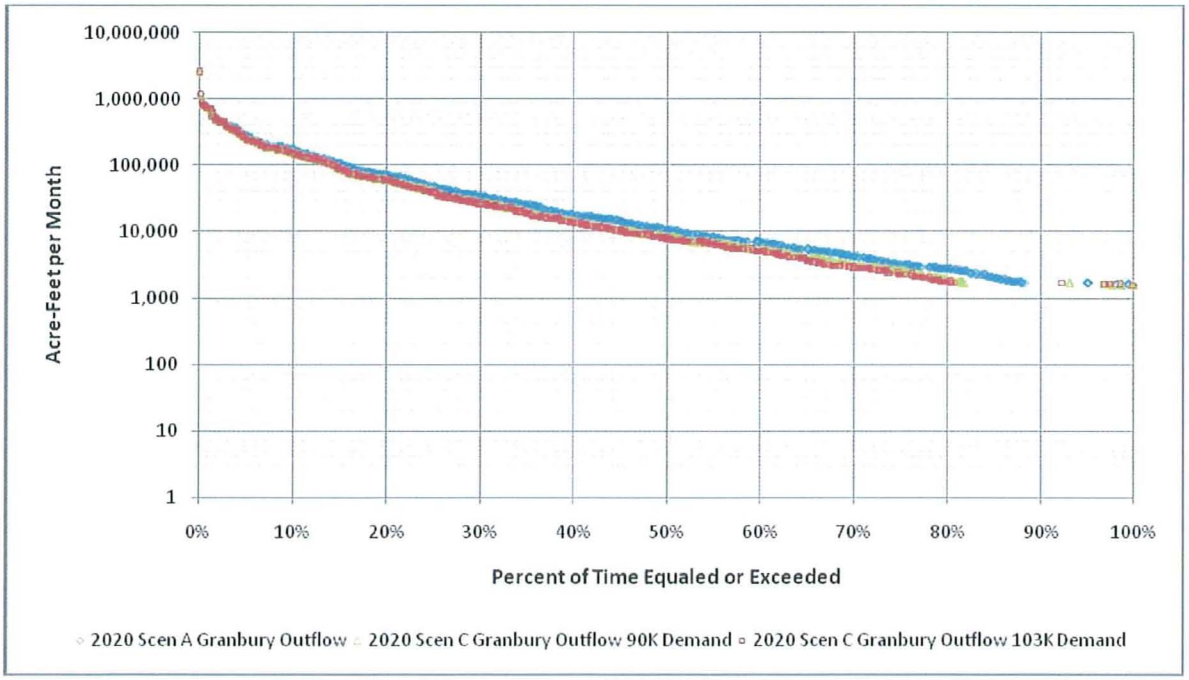


Figure 15
Monthly Median Simulated Lake Granbury Outflows
Scenarios A and C – 2020 Conditions

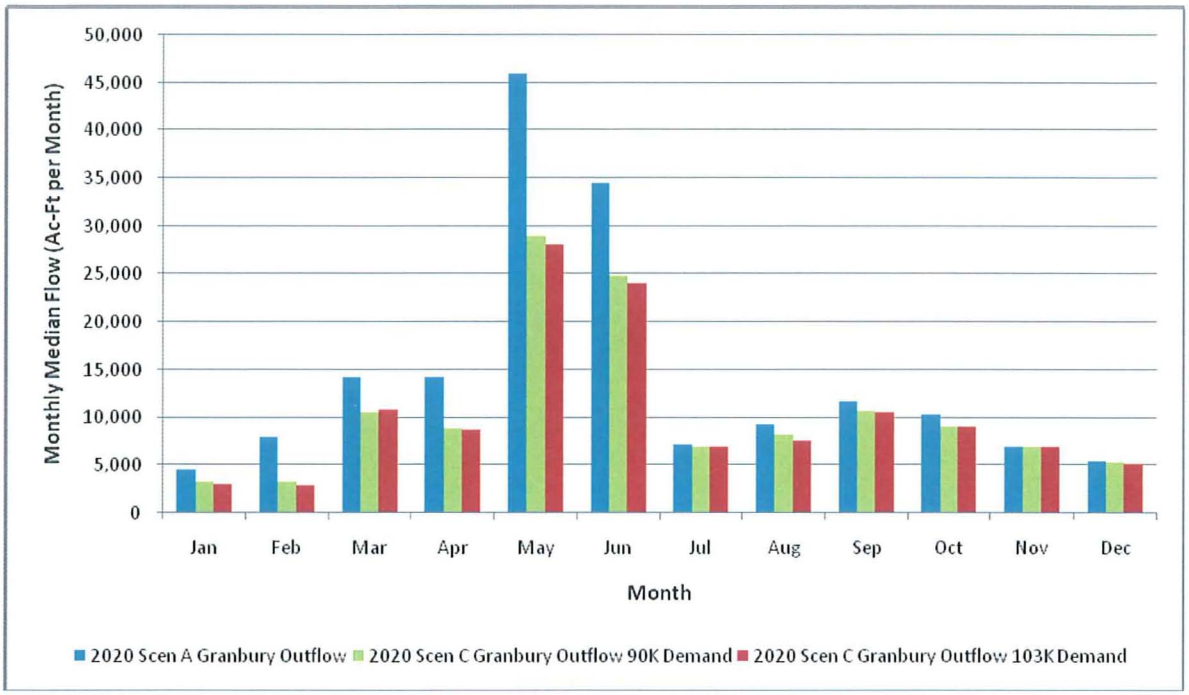


Figure 16
Simulated Annual Flow at Brazos River near Glen Rose Gage
Scenarios A and C – 2020 Conditions

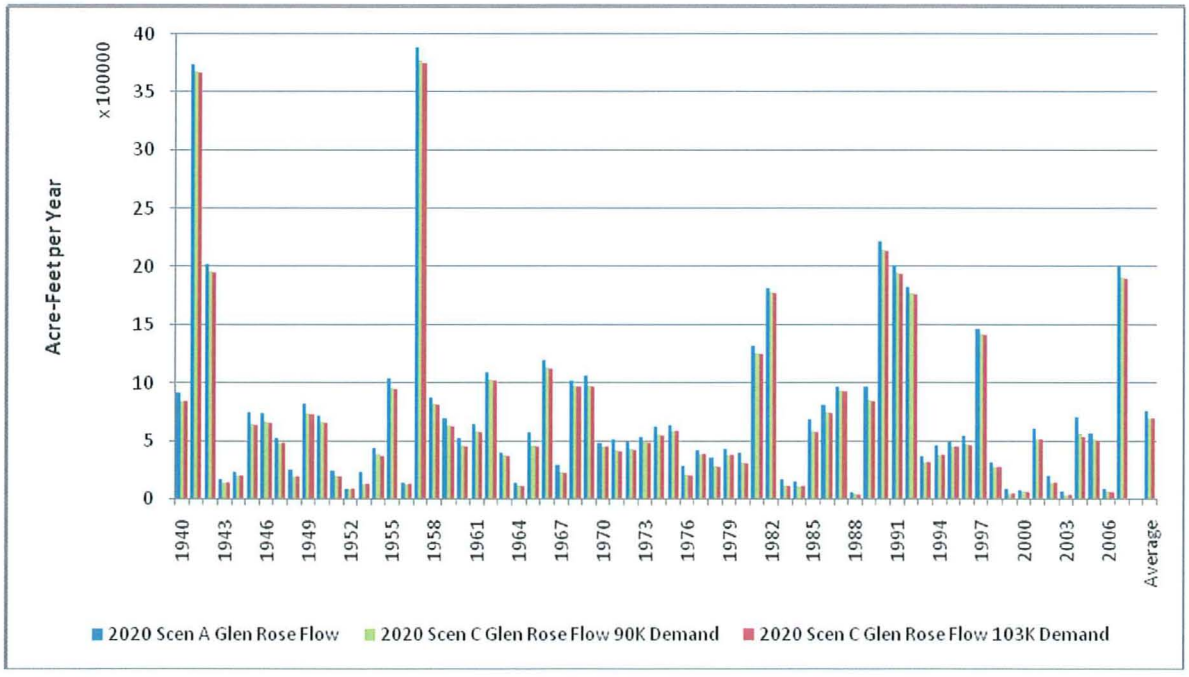


Figure 17
Exceedence Frequencies of Monthly Simulated Flow at Brazos River near Glen Rose Gage
Scenarios A and C – 2020 Conditions

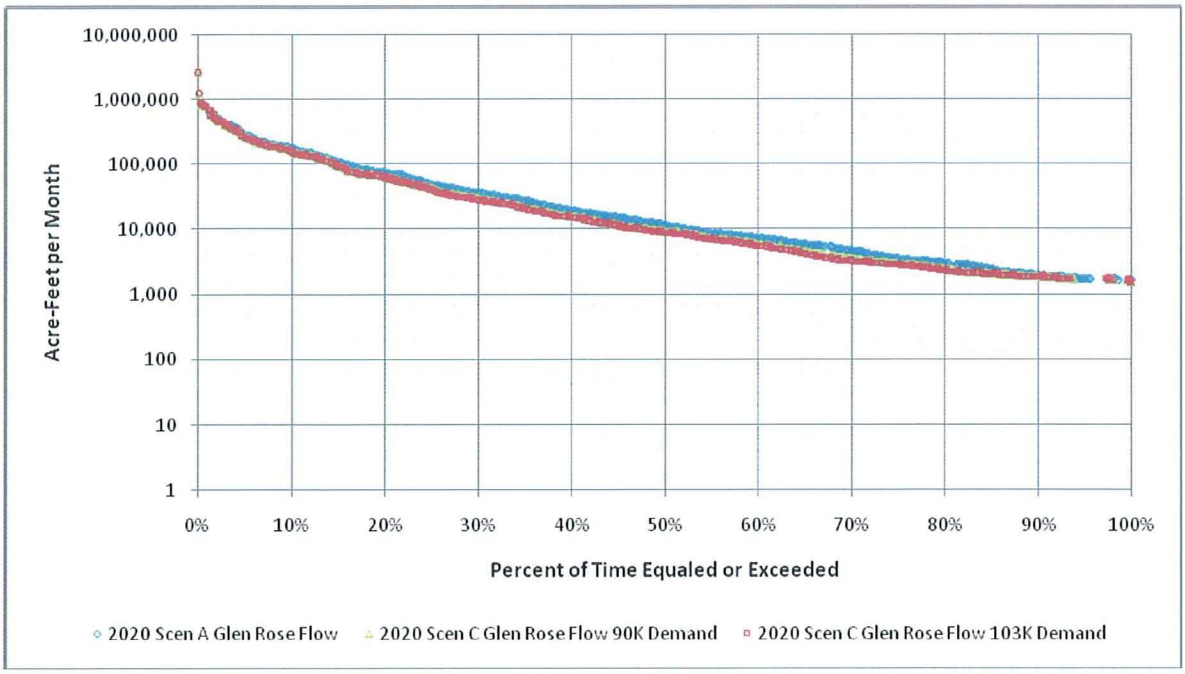
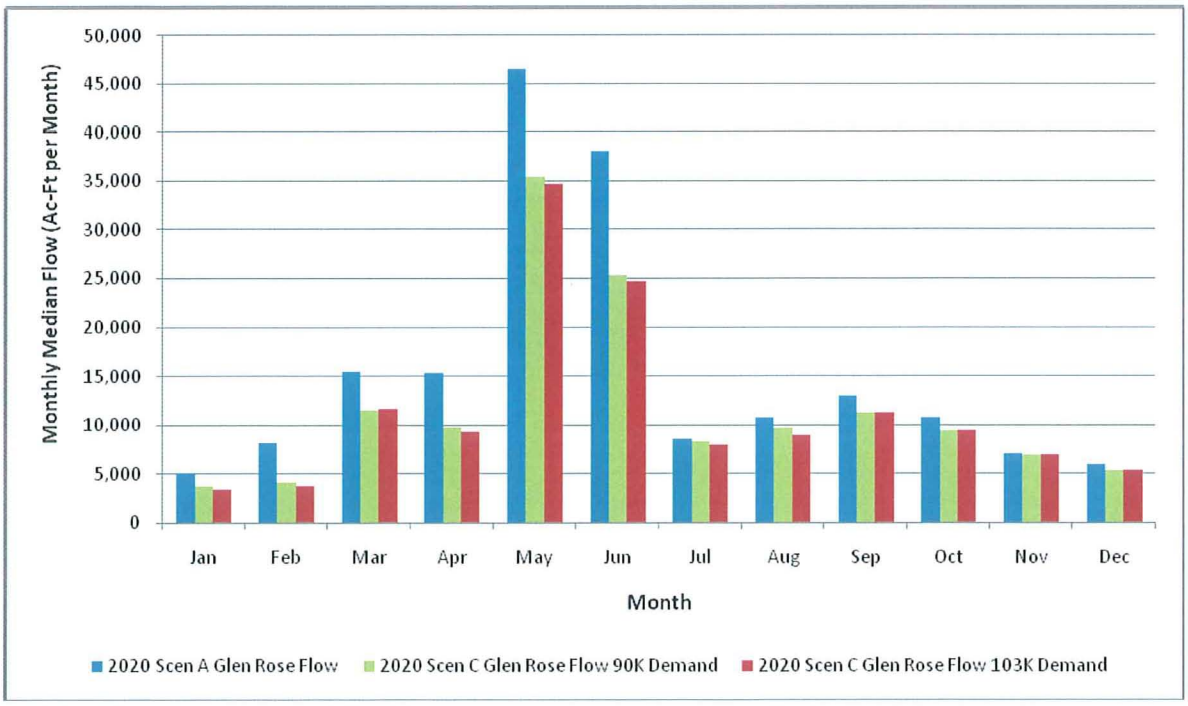


Figure 18
Monthly Median Simulated Flow at Brazos River near Glen Rose Gage
Scenarios A and C – 2020 Conditions



Comparison of WRAP and RiverWare Models

11. Attachment 2 is a CD-ROM containing executable files for the Water Rights Analysis Package, the model used for the Brazos Water Availability Model (WAM). The WAM was included in the original submission to the NRC because it is the basis for Dr. Ward's January 2008 report *Potential Impacts of Comanche Peak Cooling Tower Operation on Total Dissolved Solids in the Lower Reach of Lake Granbury*. The hydrology in the RiverWare model used for the Lake Granbury Dissolved Minerals Study is derived from the WAM as well. However, FNI does not recommend that the WAM be used for comparison of the impacts of Units 3 and 4. The WAM was initially used for water availability analysis to determine if there was sufficient water for the Units 3 and 4. This model looked at 2060 conditions, a period when existing water supplies in the Brazos River Basin are expected to be fully utilized. The scenarios developed using the WAM compared use of the water at Comanche Peak to use of water downstream, not conditions with and without Units 3 and 4. The WAM also has limited capabilities for modeling reservoir systems so it does not include realistic operating policies. The WAM also does not include hydropower operations. FNI chose RiverWare for its modeling of Lakes Possum Kingdom and Granbury because of its flexibility and water quality modeling capabilities. FNI recommends that the RiverWare models be used for comparison of the impacts of Units 3 and 4.

12. Attachment 2 also contains Excel spreadsheets with tabulated results of the RiverWare modeling of Scenarios A and C. These spreadsheets also contain the data used to make Figures 3 through 18.

Attachment 1 – Supplemental Description of Modeling Data

1. The hydrology from 1940 to 1998 used in the Riverware model is derived from the Texas Commission on Environmental Quality's Brazos River Basin Water Availability Model (TCEQ WAM). The TCEQ WAM uses monthly naturalized hydrologic data derived from historical USGS gage records. The TCEQ WAM includes maximum use authorized in every permanent water right in the Brazos River Basin. The WAM is designed to evaluate water availability based on a prior rights system where each water right is assigned a priority date based on the time period when the water supply was first developed. The model allocates water to rights with more senior priorities before water rights with more junior priorities, regardless of the geographic location of the water right in the basin.

2. The Brazos G Regional Water Planning Group modified the TCEQ WAM for use in developing the state-sponsored 2006 Brazos G Regional Water Plan. Brazos G made two significant changes to the TCEQ WAM. First, reservoir storage was adjusted to account for sediment accumulated by the year 2060, the last year of the planning cycle. The TCEQ WAM assumes the full storage authorized in each water right. Second, the Brazos G WAM has explicit modeling of Brazos River Authority contracts at the geographic location of the diversion. The TCEQ WAM aggregates Brazos River Authority water rights at one diversion location rather than at the actual diversion locations of Authority contracts. The Brazos G WAM gives a more realistic assessment of water availability for each Brazos River Authority contract.

3. FNI adopted the 2006 Brazos G WAM for use in our initial assessment of water availability for Units 3 and 4, with a few modifications. The most significant change was the modeling of Units 3 and 4, which was not included in the 2006 Brazos G Water Plan. (A subsequent amendment to the 2006 Plan added the demands for Units 3 and 4.) Other modifications are described in detail in the July 17, 2009 Memorandum to Bruce Turner *Modifications to the Brazos G WAM*.

4. The output of the FNI-modified Brazos G WAM was used for the Riverware hydrology, including inflows into Lake Possum Kingdom, intervening flows between Possum Kingdom and Lake Granbury, the intervening flows between Lake Granbury and the Glen Rose gage, and net evaporation-precipitation rates. Water passed to downstream senior water rights (excluding Brazos River Authority rights) was extracted from the FNI-modified Brazos G WAM as well. These releases assume that all downstream senior water rights are being operated at their maximum authorized diversion, a conservative assumption. These demands were used in the Riverware model when calculating releases from the Lake Granbury/Possum Kingdom system.

5. Riverware hydrology from 1999 to 2007 is based on the historical operation of the reservoirs and historical USGS stream gage records. Releases for downstream water rights were assumed to be the average release for each month for the 1940 to 1998 period simulated in the FNI-modified Brazos G WAM.

6. Both the Riverware model and the WAM model use a monthly time step. FNI believes that a monthly timestep is adequate to assess the impacts of Units 3 and 4. Neither Lake Granbury nor Lake Possum Kingdom fluctuates significantly on a day-to-day basis due to normal reservoir operations. (An influx of flood water can cause a significant daily change in reservoir elevation. However, the presence of additional demands for Units 3 and 4 are unlikely to impact flood operations of the reservoirs.) Daily fluctuations due to hydropower are attenuated in the 145 river miles between Lakes Possum Kingdom and Granbury. Daily diversions from the reservoirs are relatively small compared to the storage in the reservoir and do not cause significant daily fluctuations in reservoir storage.

7. Under Texas law, a "priority call" occurs when a senior water right holder notifies owners of upstream junior water rights to cease diversion and impoundment of inflow that would impact the reliability of the senior water right holder's diversions. Although the WAM models assume constant priority calls by senior water rights, at this time priority calls are very rare in Texas. It is possible that the Brazos River Authority could make a priority call on upstream junior water rights any time it feels that their supplies in Possum Kingdom or Lake Granbury would be compromised. It is also possible that the increased demands for the Units 3 and 4 could increase the possibility that the Authority may elect to exercise its right to make a priority call. However, there are three reasons why the demand for Units 3 and 4 are not a significant impact on upstream water rights. First, if water for Units 3 and 4 is not sold to Luminant for use at Comanche Peak, the Brazos River Authority will eventually sell this water at other locations in the Brazos Basin. Although these demands may not materialize in the 2020 time frame considered in these analyses, regional water plans show that the additional demands will materialize over the next 50 years. Therefore the possibility of a priority call on upstream water rights would be the same in 2060 regardless of the presence of Units 3 and 4. Second, stream losses in the reaches above Possum Kingdom and much of the water passed by upstream water right holders would be lost by the time it reaches Possum Kingdom. Therefore calls on smaller flows could be considered "futile calls", or calls on water that would not reach the downstream user. Finally, the Brazos River Authority already has agreements in place with many of the major

water rights holders above Possum Kingdom to not make a priority call on those rights. Most of the other water rights do not represent a significant impact on the Authority system.

8. The FNI-modified Brazos G WAM assumes that there are no priority calls on water rights above Possum Kingdom. This assumption gives a conservative assessment of available water for Possum Kingdom.