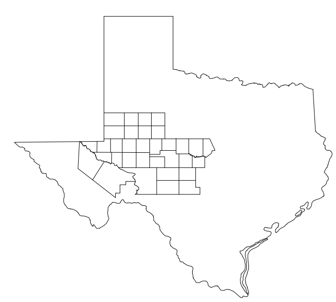
FINAL

EVALUATION OF SUPPLIES IN THE PECAN BAYOU WATERSHED

April 2009

Prepared for

The Region F Water Planning Group



CMD07215

Freese and Nichols, Inc.

FINAL

Region F
Water Planning Group

Freese and Nichols, Inc.
LBG-Guyton Associates, Inc.

Evaluation of Supplies in the Pecan Bayou Watershed

April 2009

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1 EXECUTIVE SUMMARY

This study presents the results the analyses of potential operating scenarios for four reservoirs in the Pecan Bayou watershed: Lake Brownwood, Lake Coleman, Hords Creek Reservoir and Lake Clyde. The *2006 Region F Water Plan* assumed that Lake Brownwood, which is the senior water rights holder in the watershed, would not make priority calls on Lake Coleman, Hords Creek Reservoir and Lake Clyde. This assumption is consistent with the operations of other major reservoirs in the region, but may not be appropriate for the Pecan Bayou watershed during times of drought. If Lake Brownwood fully exercises its senior priority right, the three upstream reservoirs have no reliable supply. However, under drought conditions it is possible that Lake Brownwood would call on inflows from the three upstream junior reservoirs. This study examines several different operational scenarios for regional water planning purposes.

Lake Brownwood, Lake Coleman and Hords Creek Reservoir are located in Region F. Lake Brownwood is the source of water for the Brown County Water Improvement District #1, which supplies water to the Cities of Brownwood, Early, Bangs and others in Brown and Coleman Counties. Lake Coleman and Hords Creek Reservoir supply water to the City of Coleman and its customers. Lake Clyde is in the Brazos G water planning region and supplies water to the City of Clyde and its customers. The City of Clyde also purchases water from the Cities of Abilene and Baird. Seven scenarios were developed that examined various conditions where a priority call is made by Lake Brownwood:

- *Base Scenario*: *Strict priority.* In this scenario Lake Clyde, Lake Coleman, and Hords Creek Reservoir continuously pass inflows to Lake Brownwood and other senior water rights as needed to fully satisfy diversion and storage rights. This scenario is identical to the assumptions used in the original TCEQ Colorado WAM.

- *Scenario 1: Holding All Inflow.* This scenario assumes that **all** water rights divert in upstream to downstream order and do not pass water to downstream senior water rights. No priority calls are made by any water right.

- *Scenario 2: No priority call by Lake Brownwood.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed

only to Lake Brownwood under strict priority. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 3: Priority call when Lake Brownwood storage is below 50%.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 50% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)
- *Scenario 4: Priority call when Lake Brownwood storage is below 70%.* This scenario assumes that Lakes Clyde, Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 70% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)
- *Scenario 5: Lake Coleman passes high flows.* This scenario assumes that Lake Coleman would pass only high flows to Lake Brownwood. A high flow is defined as a volume above the average monthly flow of 2,300 acre-feet. Lake Coleman retains all flows that are less than the average monthly flow. Lake Clyde and Hords Creek Reservoir operate as in Scenario 2.
- *Scenario 6: Lake Coleman passes high flows when Lake Brownwood is below 50%.* This scenario is identical to Scenario 3 except that Lake Coleman passes only high flows to Lake Brownwood when Lake Brownwood is less than 50% of the conservation capacity instead of all flows.

Table 1 compares the safe yield for the four reservoirs for each scenario. (Safe yield is the criteria used for water supply by the Region F Water Planning Group. Safe yield represents the amount of water that could have been supplied from a reservoir during the worst historical drought leaving a reserve supply equal to one year's supply at the end of the critical period.) Every scenario except Scenario 4 results in sufficient supply to meet projected demands from the three upstream reservoirs. Lake Brownwood has sufficient supplies to meet its projected demands in all scenarios.

Table 1
Safe Yield for Different Scenarios
(Values are Acre-Feet per Year)

Reservoir	Authorized Diversion	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
		Strict Priority	Holding all inflow	No priority call by Lake Brownwood	Priority call when Lake Brownwood storage is below 50%	Priority call when Lake Brownwood storage is below 70%	Lake Coleman passes high flows	Lake Coleman passes high flows when Lake Brownwood is below 50%
Lake Brownwood*	29,712	29,712	29,712	29,712	29,712	29,712	29,712	29,712
Hords Creek Reservoir	2,240	0	700	640	380	80	650	650
Lake Coleman	9,000	0	6,300	5,600	3,580	1,100	2,700	4,640
Lake Clyde	1,200	0	400	370	200	20	350	350
Total Supply	*42,152*	*29,712*	*37,112*	*36,322*	*33,872*	*30,912*	*33,412*	*35,352*

* Lake Brownwood yield is limited to its permitted diversion of 29,712 acre-feet per year.

2 INTRODUCTION

One of the major recommended strategies in the *2006 Region F Water Plan* is the Subordination of Downstream Senior Water Rights in the Lower Colorado River Basin. This strategy was a joint modeling effort between Regions F and K using the Texas Commission on Environmental Quality's Colorado River Water Availability Model (Colorado WAM). This modeling effort was conducted for planning purposes only. The two most significant assumptions of this strategy are: 1) water rights in Region K do not make priority calls on major upper basin rights located in Region F and Brazos G, and 2) these Region F rights do not make priority calls on each other. These assumptions resulted in more realistic estimates of water availabilities for most of the major water rights in Region F. However, the adoption of this strategy by the Region F planning group does not imply that any of the water rights holders have relinquished the right to make priority calls on junior water rights.

In some cases the full subordination assumption may not be appropriate. In the Pecan Bayou watershed the subordination strategy in the *2006 Region F Water Plan* assumed Lake Brownwood, which is the senior water rights holder in the watershed, would not make priority calls on Lake Coleman, Hords Creek Reservoir and Lake Clyde. Figure 1 is a map showing the location of these reservoirs. While this assumption may be representative of basin operations much of the time, under drought conditions it is possible that Lake Brownwood would call on inflows from the three upstream junior reservoirs. As such, the 2006 plan may have overestimated water supplies from the upstream reservoirs and underestimated supplies from Lake Brownwood. Also, a comparison of historical inflows into Lake Coleman and Hords Creek Reservoir developed in previous studies[1] to the inflows in the Colorado WAM indicates that the WAM flows may be overestimated. This study addresses these issues and evaluates several potential operating scenarios balancing water availability and use among users in the Pecan Bayou watershed.

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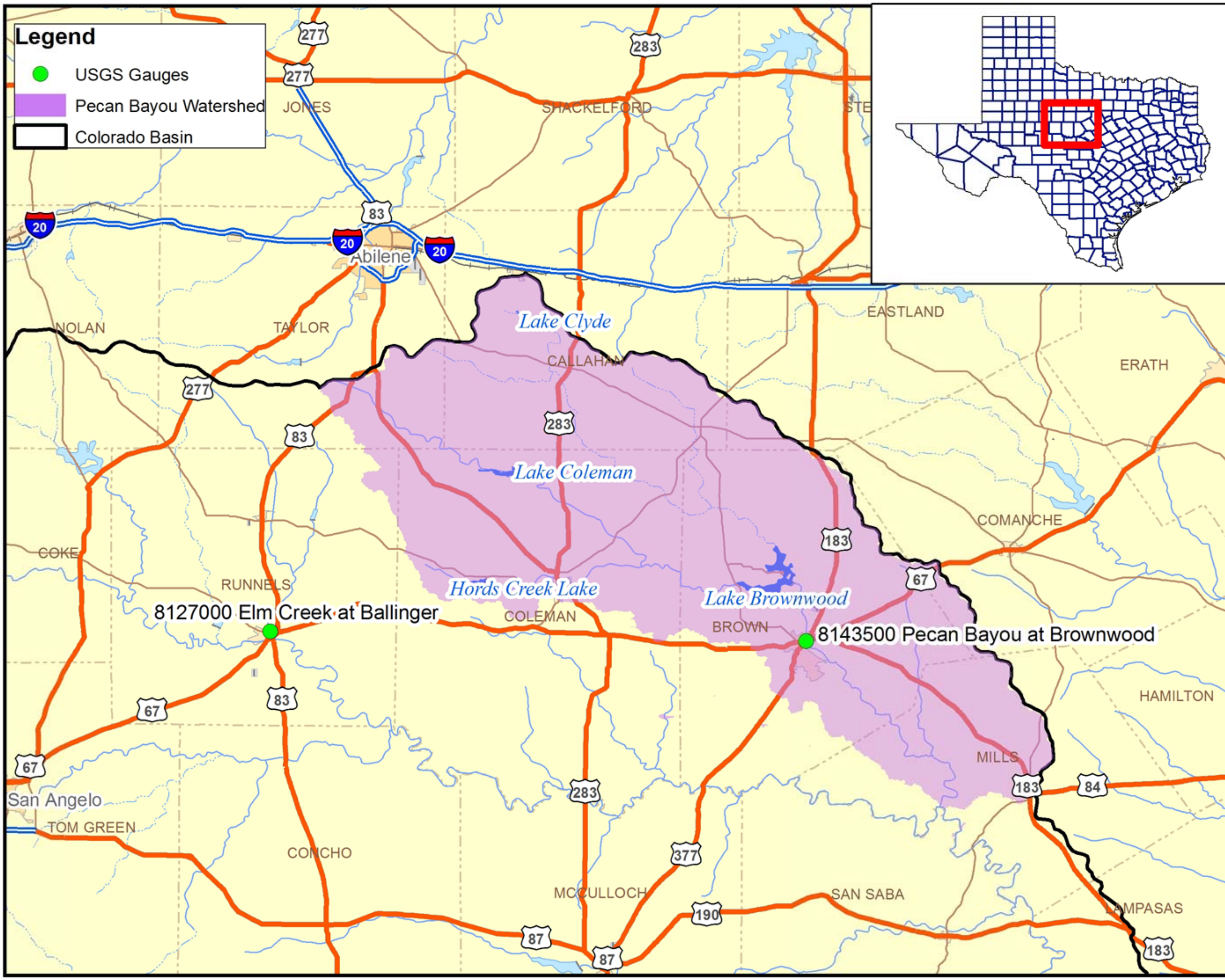
Region F Pecan Bayou Study

Location Map

FN JOB NO	CMD07215
FILE	Pecan Bayou
DATE	September 30, 2008
SCALE	1:3,000
DESIGNED	JJR
DRAFTED	JJR

FIGURE 1



2.1 Authorization and Objectives

This study was authorized by the Region F Regional Water Planning Group and is funded through a Research and Planning Grant sponsored by the Texas Water Development Board.

The Pecan Bayou Study addresses several concerns raised during the development of the 2006 Region F Water Plan. These concerns include the assumptions of basin operation during drought, potential inaccuracies of inflows to Lake Coleman and Hords Creek Reservoir that were used in the Colorado WAM modeling, and the resulting available supply to surface water users in the Pecan Bayou watershed. The objectives of this study are to correct potential technical inaccuracies of the data and develop a more realistic evaluation of potential supplies from the reservoirs in the Pecan Bayou watershed for regional water planning purposes.

2.2 Background

2.2.1 The Pecan Bayou Watershed

The study area is the Pecan Bayou watershed above the Pecan Bayou at Brownwood stream gage (USGS 08143500). Figure 1 is a location map of the watershed. This portion of the watershed has 1,660 sq. miles of drainage area and has four major reservoirs: Lake Brownwood, Lake Coleman, Hords Creek Reservoir, and Lake Clyde. Table 2 shows specific information about these reservoirs and their water rights. The watershed also has 64 other water rights with a total diversion of 6,013 acre-feet per year. All of these water rights are included in the Colorado WAM. Appendix A is a list of water rights in the Pecan Bayou Watershed above Lake Brownwood

2.2.2 Projected Water Needs in the Study Area

Table 3 shows projected water supply needs for the study area used in Regional Water Planning[2]. The Brown County Water Improvement District #1 (BCWID) obtains water from Lake Brownwood. BCWID provides both raw and treated water to the Cities of Brownwood,

Table 2
Reservoirs in the Pecan Bayou Watershed

Reservoir	Water Right Number	Owner	Water Right Holder	Drainage Area (Acres)	Priority Date	Authorized Conservation Storage (Acre-Feet)	Conservation Pool Elevation (Feet)	Authorized Diversion (Acre-Feet/Yr)
Lake Brownwood	CA 06-2464	Brown County WID#1	Brown County WID#1	1,565	9/29/1925	135,963	1,425	29,712
Lake Coleman	CA 06-1702	City of Coleman	City of Coleman	292	8/25/1958	40,000	1,717.5	9,000
Hords Creek Reservoir	CA 06-1705	U.S. Army Corps of Engineers	City of Coleman	48	3/23/1946	7,959	1,900	2,240
Lake Clyde	CA 06-1660	City of Clyde	City of Clyde	38	2/2/1965	5,748	1,872	1,200

CA – Certificate of Adjudication

Table 3
Projected Water Needs
(Values in Acre-Feet per Year)

Brown County Water Improvement District #1						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Member cities	4,271	4,303	4,261	4,182	4,156	4,156
Other contracts	4,402	4,461	4,505	4,544	4,582	4,644
Irrigation	6,970	6,970	6,970	6,970	6,970	6,970
BCWID Total	*15,643*	*15,734*	*15,736*	*15,696*	*15,708*	*15,770*
City of Coleman						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Coleman	1,285	1,269	1,252	1,235	1,223	1,223
Outside sales	257	259	256	250	249	251
Irrigation	1,348	1,348	1,348	1,348	1,348	1,348
Mining	17	18	18	18	18	18
Coleman Total	*2,907*	*2,894*	*2,874*	*2,851*	*2,838*	*2,840*
City of Clyde						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Clyde	271	264	247	230	217	211
Outside Sales	221	221	221	221	221	221
Clyde Total	*492*	*485*	*468*	*451*	*438*	*432*
Study Area Total	**19,042**	**19,113**	**19,078**	**18,998**	**18,984**	**19,042**

Projections are from the Texas Water Development Board and were used in Regional Water Planning

Early and Santa Anna, and a variety of other customers in Brown and Coleman Counties. The City of Coleman obtains water from Lake Coleman and Hords Creek Reservoir. The City of Clyde obtains some of its supply from Lake Clyde. The remainder of Clyde's supply comes from the Cities of Abilene and Baird.[3]

2.3 Inter-regional and Water Provider Coordination

The Pecan Bayou watershed is located mostly in Region F and discharges to the Colorado River above Lake Buchanan, which is located in Region K. A small portion of the upper Pecan Bayou watershed lies in the Brazos G Region and includes Lake Clyde. Due to the potential for impacts to water supplies outside of Region F, this study included inter-regional coordination with Regions G and K. Memoranda outlining the assumptions used for the study, findings of the study and potential impacts to water supplies in the adjoining region were provided to the chairman of each region (Region K and Brazos G). Copies of these memoranda are included in Appendix D.

As the primary water rights holders of the water supply sources, coordination meetings were held with representatives of Brown County WID #1 and the City of Coleman. Coordination with the City of Clyde was through the Brazos G consultants. A copy of the draft study report was provided to the Region F stakeholders.

3 METHODOLOGY

3.1 Priority Issues in the Pecan Bayou Watershed

In Texas, water is allocated using the prior appropriation doctrine, or "first in time, first in right". Every water right in Texas has a priority date which is based on the time of first beneficial use for older water rights or the water right application date for newer water rights. Under prior appropriation, a water right with a senior priority date can divert and store water before a junior water right holder. During times of low flow, a senior water right holder can make a 'priority call' on junior water rights, requesting that junior water right holders cease diverting and storing streamflow. This keeps diversions by the junior rights from impairing the senior water right holder's access to water. Priority calls are relatively rare in Texas. In the absence of a Watermaster, priority is generally not a factor in the day-to-day operation of most water rights. In watersheds that are overseen by a Watermaster, junior water rights holders may be cut off from diverting during times of low flow. Currently in Texas, there are two Watermaster programs: the South Texas Watermaster and the Rio Grande Watermaster[4].

The WAM models, including the Colorado WAM, are based on a strict interpretation of the prior appropriation doctrine. This strict approach assumes that a water right continuously makes a priority call both to meet its water supply needs and fill storage in reservoirs for future use, even during times when flow is relatively plentiful. (It should be noted that once water is legally stored in a reservoir it is not subject to a priority call.) The WAMs assume that a perpetual priority call is being made by senior water rights on junior water rights. The water right for Lake Brownwood is senior to the three upstream reservoirs. Therefore, using the strict approach to priority causes the Colorado WAM to assume that Lake Clyde, Lake Coleman and Hords Creek Reservoir pass all inflow any time that Lake Brownwood is not full and spilling. As a result, the Colorado WAM shows that Lake Clyde, Lake Coleman and Hords Creek Reservoir do not have a reliable yield.

3.2 Water Availability in the 2006 Region F Water Plan

One of the major recommended strategies in the *2006 Region F Water Plan* is the Subordination of Downstream Senior Water Rights in the Lower Colorado River Basin. This strategy was a joint modeling effort between Regions F and K using the Texas Commission on Environmental Quality's Colorado River Water Availability Model (Colorado WAM). This modeling effort was conducted for planning purposes only. The two most significant assumptions of this strategy are: 1) water rights in Region K do not make priority calls on major upper basin rights located in Region F and Brazos G, and 2) these Region F rights do not make priority calls on each other. These assumptions resulted in more realistic estimates of water availabilities for most of the major water rights in Region F. However, the adoption of this strategy by the Region F Planning Group does not imply that any of the water rights holders have relinquished the right to make priority calls on junior water rights.

The subordination modeling used in the 2006 Region F Plan assumed that Lake Clyde, Lake Coleman and Hords Creek Reservoir never pass water to Lake Brownwood. Although this allows these reservoirs to develop a reliable supply, it may not be a realistic assumption for how the watershed would operate under drought conditions. It is possible that Lake Brownwood would make a priority call on the upstream reservoirs. This study was initiated to investigate operation of the watershed using different assumptions about priority calls in the watershed.

3.3 Refinement of Naturalized Flows

Another aspect of this study is an examination of the flows used in the Colorado WAM. FNI has conducted several previous studies of the Pecan Bayou watershed using historical data[5,6,1] . The historical inflows into Lake Coleman, Hords Creek Reservoir and Lake Clyde from these studies have a relatively poor correlation to the naturalized flows used in the Colorado WAM. The current study uses refined naturalized flows that have a better correlation with the historical data. Appendix B contains more information on the development of the refined naturalized flows.

4 RESULTS

4.1 Operational Scenarios

In order to examine how priority might be exercised in the Pecan Bayou watershed, seven scenarios were developed that examined various conditions where a priority call is made by Lake Brownwood:

- *Base Scenario*: *Strict priority.* In this scenario Lake Clyde, Lake Coleman, and Hords Creek Reservoir continuously pass inflows to Lake Brownwood and other senior water rights as needed to fully satisfy diversion and storage rights. This scenario is identical to the assumptions used in the original TCEQ Colorado WAM.

- *Scenario 1: Holding All Inflow.* This scenario assumes that **all** water rights divert in upstream to downstream order and do not pass water to downstream senior water rights. No priority calls are made by any water right.

- *Scenario 2: No priority call by Lake Brownwood.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 3: Priority call when Lake Brownwood storage is below 50%.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 50% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 4: Priority call when Lake Brownwood storage is below 70%.* This scenario assumes that Lakes Clyde, Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 70% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 5: Lake Coleman passes high flows.* This scenario assumes that Lake Coleman would pass only high flows to Lake Brownwood. A high flow is defined as a volume above the average monthly flow of 2,300 acre-feet. Lake Coleman retains all flows that are less than the average monthly flow. Lake Clyde and Hords Creek Reservoir operate as in Scenario 2.
- *Scenario 6: Lake Coleman passes high flows when Lake Brownwood is below 50%.* This scenario is identical to Scenario 3 except that Lake Coleman passes only high flows to Lake Brownwood when Lake Brownwood is less than 50% of the conservation capacity instead of all flows.

Table 4 shows the safe yields of the four reservoirs for each scenario. The safe yield is defined as the annual volume of water available from a reservoir that leaves a year's supply of water in the reservoir at the end of a simulation including the drought-of-record. Safe yield is used as the definition of available water by the Region F Water Planning Group and other water providers in the area. These scenarios were evaluated under current reservoir sediment conditions. Table 5 shows the percentage of the months in the 59-year simulation period (1940 to 1998) that each reservoir is full. Table 6 shows the minimum storage encountered in the simulation. Additional results from the modeling scenarios may be found in Appendix C.

Table 4
Safe Yield for Different Scenarios
(Values are Acre-Feet per Year)

	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Reservoir	**Strict Priority**	**Holding all inflow**	**No priority call by Lake Brownwood**	**Priority call when Lake Brownwood storage is below 50%**	**Priority call when Lake Brownwood storage is below 70%**	**Lake Coleman passes high flows**	**Lake Coleman passes high flows when Lake Brownwood is below 50%**
Lake Brownwood*	29,712	29,712	29,712	29,712	29,712	29,712	29,712
Hords Creek Reservoir	0	700	640	380	80	650	650
Lake Coleman	0	6,300	5,600	3,580	1,100	2,700	4,640
Lake Clyde	0	400	370	200	20	350	350
Total Supply	*29,712*	*37,112*	*36,322*	*33,872*	*30,912*	*33,412*	*35,352*

* Lake Brownwood yield is limited to its permitted diversion of 29,712 acre-feet per year.

Table 5
Percentages of Time Reservoirs are Full in Each Scenario

	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Lake Brownwood	22.7%	20.8%	6.7%	6.7%	7.5%	6.6%	6.7%
Hords Creek Reservoir	4.4%	6.1%	5.8%	6.3%	6.3%	5.8%	5.8%
Lake Coleman	4.3%	15.0%	13.5%	15.0%	15.2%	9.8%	13.8%
Lake Clyde	4.2%	8.5%	6.7%	6.4%	6.1%	6.7%	6.7%

Table 6
Minimum Storage in Each Simulation

	Base Scenario		Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6	
	Storage (Ac-Ft)	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**
Lake Brownwood	43,390	33%	33,412	25%	32,727	25%	32,750	25%	41,024	31%	34,747	26%	32,727	25%
Hords Creek Reservoir	0	0%	750	10%	668	9%	448	6%	99	1%	620	8%	620	8%
Lake Coleman	0	0%	6,297	17%	5,700	15%	3,640	10%	1,117	3%	2,862	8%	4,743	13%
Lake Clyde	47	1%	399	7%	384	7%	245	4%	49	1%	427	8%	427	8%

Scenario 1 allows each reservoir to divert and impound all of the inflows into the reservoir, limited only by the reservoir's ability to store water. Water is never passed to downstream water rights based on priority. Although this type of operation is typical of the day-to-day operation of the Pecan Bayou and other watersheds in Texas, it does not take into account the possibility that a downstream senior water right could exercise its right by making a priority call. Scenario 2 assumes that Lake Brownwood does not make priority calls. Scenarios 3 through 6 assume that Lake Brownwood makes priority calls only under certain conditions, such as when its storage is relatively low or during periods of high flows into Lake Coleman.

Scenario 1 assumes that no water right makes a priority call at any time on the four reservoirs or on anyone else. Scenarios 2 through 6 assume that other senior water rights, excluding the rights associated with the four reservoirs, continuously make priority calls. Senior water rights between the upstream reservoirs (Lake Coleman, Hords Creek Reservoir and Lake Clyde) and Lake Brownwood can make priority calls on the upstream reservoirs. Senior water rights downstream of Lake Brownwood can make calls on that reservoir. There are a few water rights above Lake Coleman, and Lake Coleman can make priority calls on these water rights as well if they have priority dates that are junior to Lake Coleman. However, unlike the original Colorado WAM, these scenarios do not assume that senior water rights below Lake Brownwood can make priority calls on water rights above Lake Brownwood. It is unlikely that such a priority call would be successful in practice.

Scenarios 5 and 6 assume that Lake Coleman only passes higher flows to Lake Brownwood. The model uses a monthly time step. High flow events typically last only a few days in this watershed, so this type of operation cannot be directly modeled. For these scenarios, we assumed that flows could only be passed during months with higher-than-average flows, and that only the portion of the flow above the average was subject to priority call. The average monthly inflow into Lake Coleman is 2,300 acre-feet per month. Say that during a given month Lake Coleman received 5,000 acre-feet of inflow. The model assumes that 2,700 acre-feet of that inflow was subject to priority call. Lake Coleman has the ability to divert or impound flows below 2,300 acre-feet per month. In Scenario 5, the flow was passed downstream unless Lake Brownwood was full and spilling. In Scenario 6, flows were only passed downstream when

Lake Brownwood was less than 50 percent full. At other times Lake Coleman can retain all inflow.

4.2 Modeling Results

Tables 4 through 6 and Appendix C show the following results:

- Overall, there appears to be sufficient supplies in the Pecan Bayou watershed to meet future demands.
- Relaxing the strict priority assumption of the Base Scenario results in a reliable supply being available from the three upstream reservoirs (Lake Coleman, Hords Creek Reservoir and Lake Clyde). Comparing these results to Table 3, only Scenario 4 does not result in sufficient water to meet projected upstream demands from these reservoirs.
- Looking at the total supply in the watershed, the strict priority interpretation of the Base Scenario results in the least overall supply. Scenario 1, where no water right makes a priority call, results in the most supply. Scenarios 2 and 6 have the most supplies of the scenarios with priority calls by water rights.
- Comparing Scenario 1 to the other Scenarios in Table 5 shows that the passage of water to senior water rights has a significant impact on the frequency that Lake Brownwood is full. (The Base Scenario and Scenarios 2 through 6 assume that water rights other than the four reservoirs make continuous priority calls.) Table 6 shows that this assumption has less impact on the minimum storage in the reservoir.
- Minimum storage is an indication of the reliability of the supply. A smaller minimum storage indicates that the occurrence of a drought that is more severe than the historical record used in the modeling could reduce the supply from the reservoir. Comparing the Lake Brownwood minimum storages in Table 6, note that the assumption that there is about 10,000 acre-feet more water in storage in the Base Scenario than in Scenarios 1, 2, 3, 5 or 6. Scenario 4, which does not generate enough supply from upstream reservoirs to meet demands, has less impact on Lake Brownwood minimum storage. Allowing the three upstream reservoirs to retain sufficient water to develop a reliable supply could

impact future supplies from Lake Brownwood if a drought occurs that is more severe than the historical drought of record.

4.3 Evaluation of Scenarios

At this time, the Region F Water Planning Group has not selected a scenario to use for regional water planning. Scenarios 2, 3, 5 or 6 would meet regional water planning requirements and supply sufficient water to meet projected needs. Adoption of any of these scenarios by the Region F Water Planning Group would be for planning purposes only. Implementation of any of these scenarios would be at the discretion of the water rights holders.

Based on the current operation and the proposed scenarios outlined in this study, it is likely that there will be little to no impacts to natural resources for any of the scenarios that supply sufficient water for projected needs. If the Region F Planning Group selects a preferred scenario for the 2011 Regional Water Plan, a more detailed analysis of the potential impacts to natural resources will be conducted at that time.

5 CONCLUSIONS AND RECOMMENDATIONS

The Colorado WAM assumes that water is passed through upstream reservoirs in the Pecan Bayou watershed any time the storage in Lake Brownwood falls below its full conservation level. This is not how the basin has operated historically and likely will not operate in this manner in the near future. The seven scenarios developed for this study present varied operational assumptions for the four reservoirs, ranging from strict priority operation to no priority assumptions. Based on the results of this study, we found:

- All scenarios, with the exception of Scenario 4, will provide sufficient supplies to water users in the Pecan Bayou watershed to meet the projected needs through 2060. Scenario 4 results in supply shortages for the cities of Clyde and Coleman.
- Of the scenarios with priority calls by water rights, Scenarios 2 and 6 result in the highest total supply in the watershed. Scenario 1, which is strict interpretation of priority, results in the lowest total supply.
- The primary differences observed among the priority analyses are the storage levels in the reservoirs during drought. Under strict priority, the storage levels in the upper reservoirs are empty or near empty. For Scenarios 2, 3, 5 and 6, the upper reservoirs do not go dry and the minimum storage level in Lake Brownwood is at about 25% of its capacity.

As part of this study, we have been coordinating with the owners of the reservoirs in the Pecan Bayou watershed. We recommend that the Region F Water Planning Group continue to coordinate with the stakeholders to select the appropriate assumptions for evaluation of supplies from the reservoirs in the Pecan Bayou watershed for regional water planning purposes for the 2011 Region F Water Plan.

6 LIST OF REFERENCES

[1] Freese and Nichols et al.: Region F Regional Water Plan, prepared for the Region F Water Planning Group, January 2001.

[2] Texas Water Development Board: Regional Water Planning Data Web Interface (DB07), available on-line at http://www.twdb.state.tx.us/data/db07/DefaultSelect.asp

[3] HDR, Inc. et al: 2006 Brazos G Regional Water Plan, prepared for the Brazos G Water Planning Group, January 2006.

[4] Texas Commission on Environmental Quality: Watermaster Programs, available on-line at http://www.tceq.state.tx.us/nav/util_water/watermaster.html

[5] Freese and Nichols, Inc. Hydrologic Study of Lake Brownwood and the Pecan Bayou Watershed, prepared for the Brown County Water Improvement District #1, March 1965.

[6] Freese and Nichols, Inc.: Memorandum Report Lake Brownwood Operation Study, prepared for the Brown County Water Improvement District #1, May 1999.

Appendix A
List of Pecan Bayou Water Rights

Table A-1: Study Area Water Rights
River Order

WR Number	Type	Permit #	Owner Name	Amount in Ac-Ft/Yr	Use	Priority Date	Acreage	Res Name	Reservoir Capacity (Ac-Ft)	Stream Name	Other Stream	County	Remarks
1660	**CA**		**CITY OF CLYDE**	**1000**	**Mun**	**2/2/1965**		**LAKE CLYDE**	**5748**	**N PRONG PECAN**		**Callahan**	**& 7, 2/6/86,8/16/88-200 AF 12**
1661	CA		L G CHRANE	26	Irr	5/15/1967	39		29	DUDLEY FRK		Taylor	RES EXEMPT, 160 ACRE TRACT
1662	CA		L G CHRANE	35	Irr	5/15/1967	36		35	GOATHEAD CRK		Taylor	RES EXEMPT, 320 ACRE TRACT
1663	CA		LINDA JO PARKER	36	Irr	5/15/1967	38		36	STRUGGLE CRK		Taylor	RES EXEMPT, 160 ACRE TRACT
1664	CA		ROSALEA C BONNER ET AL	164	Irr	10/13/1969	82		200	W PRONG BURNT BR		Callahan	RES EXEMPT, 426.67 ACRE TRACT
1665	CA		DENNIS JOE HOLBERT ET UX	30	Irr	8/7/1951	20		18	PECAN BAYOU		Coleman	206.20 ACRE TRACT
1667	CA		JOHN D MONTGOMERY	120	Irr	7/29/1974	76		124	LTL PECAN		Callahan	RES EXEMPT
1666	CA		J H SMART	65	Irr	2/24/1969	65	LITTLE PECAN	76	LTL PECAN		Callahan	RES EXEMPT, 85 AC TR
1669	CA		THE BAKER FAMILY TRUST	156	Irr	9/5/1972	151		287	LTL PECAN		Coleman	479.62 ACRE TRACT - SAME RES AS 14-1670
1670	CA		KENNETH H WALKER	46	Irr	4/22/1975	46		287	LTL PECAN		Coleman	SAME RES AS 14-1669.5/06 MAIL RETD:RTS
1671	CA		BURKETT WATER SUPPLY CORP		D&L	10/28/1964			90	PECAN BAYOU		Coleman	DOMESTIC & LIVESTOCK ONLY
1672	CA		EDWIN M EDWARDS ET UX		D&L	1/26/1970			93	TURKEY CRK		Callahan	DOM & LIVESTOCK, RES EXEMPT
1673	CA		ESTATE OF CLAUD JOY	22	Irr	1/1/1966	33			TURKEY CRK		Callahan	170 ACRE TRACT
1674	CA		PAULINE COATS LAWSON	88	Irr	9/9/1968	44		88	TURKEY CRK		Callahan	RES EXEMPT, 165.1 ACRE TRACT
1675	CA		YVONNE PEEVEY & E GALLIVAN	2	Irr	1/1/1963	2			TURKEY CRK		Callahan	107 ACRE TRACT
1676	CA		ESTATE OF DAN L CHILDRESS ET AL	45	Irr	3/16/1964	23		45	BOOGER HOLLOW		Callahan	RES EXEMPT, 145.2 ACRE TRACT
1677	CA		CHAD CUNNINGHAM ET UX	90	Irr	5/13/1963	90		111	TURKEY CRK		Callahan	RES EXEMPT
1678	CA		WELDON J LAMB ET AL	134	Irr	12/9/1963	134		183	COTTONWOOD CRK		Callahan	RESERVOIR EXEMPT
1679	CA		DOROTHY W WHITTINGTON	40	Irr	3/24/1969	40		132	GARDNER CRK		Callahan	RES EXEMPT SAME AS 14-1680 & 1681, 91.52
1680	CA		COLLIS EAGER	40	Irr	3/24/1969	40		132	GARDNER CRK		Callahan	RES EXEMPT SAME AS 14-1679 & 1681, 178
1681	CA		MATACORP LTD A TEXAS LP	40	Irr	3/24/1969	40		132	GARDNER CRK		Callahan	RES EXEMPT SAME AS 14-1679 & 1680, 79.66
1682	CA		G V CUNNINGHAM	30	Irr	2/10/1971	30		185	BEE CRK		Callahan	RES EXEMPT SAME AS 14-1683 E RATE, 123.6
1683	CA		OLIVER D WORTHY	65	Irr	2/10/1971	65		185	BEE CRK		Callahan	RESERVOIR EXEMPT.5/06 MAIL RETD:RTS/NDAA
1684	CA		RAYMOND A DEBUSK	7	Irr	1/1/1966	14			TURKEY CRK		Callahan	102 ACRE TRACT
1685	CA		KENT J DAVIS DVM	51.08	Irr	10/6/1969	25.54		197	TURKEY CRK		Brown	RES EXEMPT
1685	CA		JOHN R AUGHINBAUGH	48.92	Irr	10/6/1969	24.46			TURKEY CRK		Brown	
1687	CA		HARVEL R STAMBAUGH	50	Irr	4/23/1969	35		50	W HOLLOWAY		Brown	407.9 AC TR, RES EXEMPT
1686	CA		LAWRENCE BYRD	101	Irr	4/6/1970	60		101	E HOLLOWAY		Brown	RES EXEMPT.5/06 MAIL RETD:RTS/NDAA/UTF
1688	CA		EFFIE LUCILE ASHWORTH ENGLE	52	Irr	1/1/1965	55			PECAN BAYOU		Brown	5/06 MAIL RETD:RTS/NDAA/UTF
1689	CA		LAKEWOOD RECREATIONAL CENTER	22	Irr	8/9/1965	32		150	BRAWSHAW CRK		Eastland	RESERVOIR EXEMPT - 69.32 ACRE TRACT
1690	CA		CLAYTON MAXWELL CHANDLER TR	452	Irr	5/30/1964	226			PECAN BAYOU		Brown	440 ACRE TRACT
1691	CA		G A DAY	15	Irr	1/1/1964	10	LAKE BROWNWOOD		PECAN BAYOU		Brown	2 TRACTS
1695	CA		R & N CATTLE CO	34.235	Irr	2/2/1970	38.04			JIM NED CRK		Taylor	
1695	CA		BELIA I LOYOLA	145.765	Irr	2/2/1970	161.96		180	JIM NED CRK		Taylor	5/06 MAIL RETD:NOT DELIVERABLE/UTF
1694	CA		J W VINSON		D&L	2/21/1966			12	E JIM NED CRK		Taylor	2 EXEMPT RES. IRR EXP 12/1/90. D&L ONLY
1696	CA		GERALD N REID	49	Irr	3/1/1947	49			JIM NED CRK		Taylor	128 ACRE TRACT
1697	CA		TOMMY JOE & HELEN R ABBOTT	5	Irr	11/22/1918	12		450	RED BANK CRK		Taylor	POFD ALSO 1763 & 1764.6/06 MAIL RETD
1697	CA		TOMMY JOE & HELEN R ABBOTT	7	Irr	6/20/1961				RED BANK CRK		Taylor	6/06 MAIL RETD MARKED "DECEASED"
1697	CA		TOMMY JOE & HELEN R ABBOTT	48	Ind	6/20/1961				RED BANK CRK		Taylor	FISH FARMING.6/06 MAIL RETD "DECEASED"
1763	CA		ERWIN T BAUCUM TRUSTEE	2.7	Irr	11/22/1918	6.2			RED BANK CRK		Taylor	SEE 14-1697 FOR RES & RATE, 2.7 A/F
1763	CA		ERWIN T BAUCUM TRUSTEE	3.5	Irr	6/20/1961				RED BANK CRK		Taylor	3.5 A/F, 6.2 ACRES OUT OF 6.2 AC TR
1764	CA		I H STEED TRUSTEE	26.9	Irr	11/22/1918	61.4			RED BANK CRK		Taylor	SEE 14-1697 FOR RES & RATE, 26.9 A/F
1764	CA		I H STEED TRUSTEE	34.5	Irr	6/20/1961				RED BANK CRK		Taylor	34.5 A/F, 61.4 ACRES OUT OF 69.36 AC TR
1698	CA		DANIE MAY ALDRIDGE ET AL		Rec	10/20/1969			324	BUCK CRK		Coleman	MAY REDUCE USE AFTER 1/1/85
1699	CA		CENTRAL COLORADO RIVER AUTH	51	Mun	3/14/1947			150	S FRK JIM NED CRK		Coleman	51 AF FOR MUNICIPAL & INDUSTRIAL USE
1699	CA		CENTRAL COLORADO RIVER AUTH		Ind	3/14/1947				S FRK JIM NED CRK		Coleman	51 AF FOR MUNICIPAL & INDUSTRIAL USE
3297	P	3010	JOHN W. CASEY	15	Irr	11/11/1974	20		30	JIM NED CRK		Coleman	6/07 MAIL RETD: RTS/ANK/UTF
1701	CA		BRAND JONES ET UX	90	Irr	1/1/1963	100			JIM NED CRK		Coleman	1200.95 ACRE TRACT
1702	**CA**		**CITY OF COLEMAN**	**4500**	**Mun**	**8/25/1958**		**LAKE COLEMAN**	**40000**	**JIM NED CRK**		**Coleman**	
1702	**CA**		**CITY OF COLEMAN**	**4500**	**Ind**	**8/25/1958**		**LAKE COLEMAN**		**JIM NED CRK**		**Coleman**	
3323	P	3158	R O MCCARTY ET UX	90	Irr	12/9/1974	98		90	INDIAN CRK		Coleman	SCS SITE 25A, JIM NED CR WS PROJ
1704	CA		CITY OF COLEMAN	769	Mun	8/29/1922		LAKE SCARBOROUGH		INDIAN CRK		Coleman	
1704	CA		CITY OF COLEMAN		Rec	8/29/1922		LAKE SCARBOROUGH	1360	INDIAN CRK		Coleman	
1705	**CA**		**CITY OF COLEMAN**	**2220**	**Mun**	**3/23/1946**		**HORDS CREEK RES**	**7959**	**HORDS CRK**		**Coleman**	**MUNI TO DOM,AMEND 1/86**
1705	**CA**		**CITY OF COLEMAN**	**20**	**D&L**	**3/23/1946**				**HORDS CRK**		**Coleman**	**AMEND 1/24/86 MUN TO DOMESTIC**
1706	CA		JOHN D & JOYCE W RHONE	74	Irr	1/1/1962	74			HORDS CRK		Coleman	297.06 ACRE TRACT
1707	CA		E & N HODGES FAMILY PARTNERSHIP	124	Irr	1/1/1914	62			HORDS CRK		Coleman	

Table A-1: Study Area Water Rights
River Order

WR Number	Type	Permit #	Owner Name	Amount in Ac-Ft/Yr	Use	Priority Date	Acreage	Res Name	Reservoir Capacity (Ac-Ft)	Stream Name	Other Stream	County	Remarks
1708	CA		ELITHE KIRKLAND ET AL	86	Irr	1/20/1965	43		86	BACHELOR PRONG		Coleman	RESERVOIR EXEMPT, 519.6 AC TR
1709	CA		WAYNE F CREEK	20	Irr	1/1/1930	20			HORDS CRK		Coleman	
5772	P	5772	COLEMAN ISD	12	Irr	4/18/2002	2	MEMORY LAKE		LTL CONCHO CRK		Coleman	SC
3424	P	3202	CITY OF COLEMAN		Rec	4/8/1975			184	LTL CONCHO CRK		Coleman	SCS SITE NO 38A
1703	CA		CITY OF COLEMAN	500	Irr	4/15/1974	57			JIM NED CRK		Coleman	104.27 AC TR, REUSE WASTEWATER 1702-4&5
1710	CA		WARREN FAMILY RANCH PARTNERSHP	26	Irr	1/1/1948	26			JIM NED CRK		Coleman	326.5 ACRE TRACT
3232	P	3030	WARREN FAMILY RANCH PARTNERSHP	175	Irr	6/24/1974	175			JIM NED CRK		Coleman	
1711	CA		S E WEAVER	28	Irr	1/1/1907	20			JIM NED CRK		Coleman	220 ACRE TRACT, ALSO CO 25
1712	CA		CENTRAL COLORADO RIVER AUTH	200	Mun	3/28/1939			400	MUD CRK		Coleman	
3342	P	3061	CITY OF SANTA ANNA	75	Mun	1/13/1975		LAKE SAN TANA	703	MUD CRK		Coleman	
1713	CA		HAROLD W & JOANN CAGLE	33.9	Irr	6/1/1966	27.25			JIM NED CRK		Brown	40.302 AC TRACT; NEW OWNER RFI
1713	CA		JOHN JACOB HEGI ET UX	139.1	Irr	6/1/1966	165.281			JIM NED CRK		Brown	165.281 AC TRACT
1714	CA		JEFF FITZGERALD	28	Irr	7/5/1964	23			JIM NED CRK		Brown	108 ACRE TRACT
1716	CA		JOSEPH CYRIL PRINCE JR	19	Irr	1/1/1927	15			JIM NED CRK		Brown	65 AC TR, SEE 14-1715 FOR RATE
1717	CA		DONALD E MARSH	24	Irr	1/1/1927	19			JIM NED CRK		Brown	125.84 AC TR, SEE 14-1715 FOR RATE
1715	CA		ROBERT W PRINCE ET UX	63	Irr	1/1/1927	34			JIM NED CRK		Brown	56.78 AC TRACT, RATE SAME AS 1716-1720
1715	CA		D JACK BREWER JR	234	Irr	1/1/1927	117			JIM NED CRK		Brown	340.72-ACRE TRACT, "
1718	CA		HERMAN LEWIS LEHMAN ET UX	104	Irr	1/1/1927	52			JIM NED CRK		Brown	60.11 AC TR, SEE 14-1715 FOR RATE
1719	CA		NADA A AUSTIN	120	Irr	1/1/1927	60			JIM NED CRK		Brown	60.11 AC TR, SEE 14-1715 FOR RATE
1720	CA		A J NEWTON	29	Irr	1/1/1927	23			JIM NED CRK		Brown	RATE:SEE 1715.5/06 MAIL RETD:RTS/NDAA/UF
1721	CA		J A CATE JR ESTATE	427	Irr	1/1/1927	195			JIM NED CRK		Brown	200 ACRE TRACT
1722	CA		JOE DAN WEEDON	27	Irr	1/1/1962	20	LAKE BROWNWOOD		JIM NED CRK		Brown	201.33 ACRE TRACT
2454	**CA**		**BROWN COUNTY WID 1**	**29712**	**Mun**	**9/29/1925**		**LAKE BROWNWOOD**	**114000**	**PECAN BAYOU**	**JIM NED CRK**	**Brown**	**AMEND 2/15/2006:CHG TO MULTIUSE**
2454	**CA**		**BROWN COUNTY WID 1**		**Ind**	**9/29/1925**		**LAKE BROWNWOOD**		**PECAN BAYOU**	**JIM NED CRK**	**Brown**	**AMEND 2/15/2006:CHG TO MULTIUSE**
2454	**CA**		**BROWN COUNTY WID 1**		**Irr**	**9/29/1925**	**7891**	**LAKE BROWNWOOD**		**PECAN BAYOU**	**JIM NED CRK**	**Brown**	**AMEND 2/15/2006:CHG TO MULTIUSE**
			Total	***47,965***					***174,642***				

CA Certificate of Adjudication
P Permit

Mun Municipal
Ind Industrial
Irr Irrigation
Rec Recreation
D&L Domestic and livestock

Table A-2
Summary of Water Right Diversions in the Pecan Bayou Watershed
Study Area by Location and Priority Date
(Values in Acre-Feet per Year)

Location	Priority Date Senior to Brownwood (9/29/1925)	Between Brownwood and Hords (9/30/1925-3/23/1946)	Between Hords and Coleman (3/24/1946-8/25/1958)	Between Coleman and Clyde (8/26/1958-2/2/1965)	Junior to Clyde (2/3/1965)
Above Clyde	0	0	0	0	0
Above Coleman	35	0	100	183	195
Above Hords Creek	0	0	0	0	0
Above Brownwood and Below Coleman, Clyde & Hords	921	1,240	56	1,005	2,278

Appendix B
Hydrology

Appendix B: Hydrology

Refinement of Naturalized Flows

The Colorado WAM uses naturalized flows at the Pecan Bayou at Brownwood gage to estimate the inflows for Lake Coleman, Hords Creek Reservoir, Lake Clyde and Lake Brownwood, as well as other water rights in the watershed. Naturalized flows are historical flows that have been adjusted to remove the effects of upstream diversions, reservoirs and return flows. The WAM uses the drainage area ratio method to distribute the naturalized flows among the water rights. A drainage area ratio is the ratio of the drainage area of a watershed with known flows to a watershed with unknown flows. The known flows are multiplied by the ratio to estimate flows at the unknown location. The drainage area method is widely used in hydrologic studies and typically produces good results as long as the two watersheds have similar land use, soil type and topography, and are adjacent to each other geographically. However, the method may not provide a reasonable estimate of flows if the two watersheds have different hydrologic characteristics, watersheds that are separated geographically, or for small ratios (watersheds that are small relative to the known watershed).

FNI has conducted several previous studies of the Pecan Bayou watershed using historical data[1,2,3] . Using techniques similar to those used in previous studies, historical flows were calculated for the four reservoirs. Table B.1 is a summary of the methods used in this study. Figures B-1 to B-4 are double mass curves comparing these historical flows to the flow data from the Colorado WAM. These comparisons show that:

1. The inflow into Lake Brownwood using the methods of Table 1 are similar to the Colorado WAM naturalized flow. No adjustments or changes were made to the naturalized flows of the Colorado WAM.

[1] Freese and Nichols, Inc. Hydrologic Study of Lake Brownwood and the Pecan Bayou Watershed, prepared for the Brown County Water Improvement District #1, March 1965.
[2] Freese and Nichols, Inc.: Memorandum Report Lake Brownwood Operation Study, prepared for the Brown County Water Improvement District #1, May 1999.
[3] Freese and Nichols et al.: Region F Regional Water Plan, prepared for the Region F Water Planning Group, January 2001.

Table B.1
Methods Used to Calculate Inflows in Lake Brownwood and Reservoirs Upstream

Reservoir	Period	Method
Lake Clyde	Jan 1940 - Jan 1970	Double mass curve with Elm Creek near Ballinger
	Feb 1971 – Sep 1985	Mass balance
	Oct 1985 – Dec 1998	Double mass curve with Elm Creek near Ballinger
Lake Coleman	Jan 1940 – Apr 1975	Double mass curve with Elm Creek near Ballinger
	May 1975 – Dec 1996	Mass balance
	Jan 1997 – Dec 1988	Double mass curve with Elm Creek near Ballinger
Hords Creek	Jan 1940 – May 1948	Double mass curve with Elm Creek near Ballinger
	June 1948 – Dec 1998	Mass balance
Lake Brownwood	Jan 1959 – Sep 1983	Naturalize incremental flows at Pecan Bayou at Brownwood and apply drainage area ratio.
	Oct 1983 – Dec 1996	Mass balance to calculate incremental flow below Clyde, Coleman, and Hords Creek. Add inflow into these reservoirs to calculate total naturalized flows.

2. The cumulative inflows into Hords Creek Reservoir using the methods of Table 1 are 30% lower than the flows of the Colorado WAM . The main reason of this difference is that the WAM calculates inflows using the drainage area ratio method with flows into Lake Brownwood, which may be not representative of the actual inflows into Hords Creek. Therefore, firm yield for Hords Creek Reservoir is going to be lower using the recalculated flows than the yield using the Colorado WAM.

3. The cumulative inflows into Lake Coleman recalculated in this study are 5% higher than the flows of the Colorado WAM. The differences can be explained within the uncertainty of the hydrologic series. This Pecan Bayou Study used the recalculated flows, but this change should not produce significant increases in the firm yield of Lake Coleman.

4. The cumulative inflows into Lake Clyde recalculated flows in this study are 28% lower than the flows of the Colorado WAM. The main reason of this difference is that the WAM calculates inflows using the drainage area ratio method with flows

Figure B-1

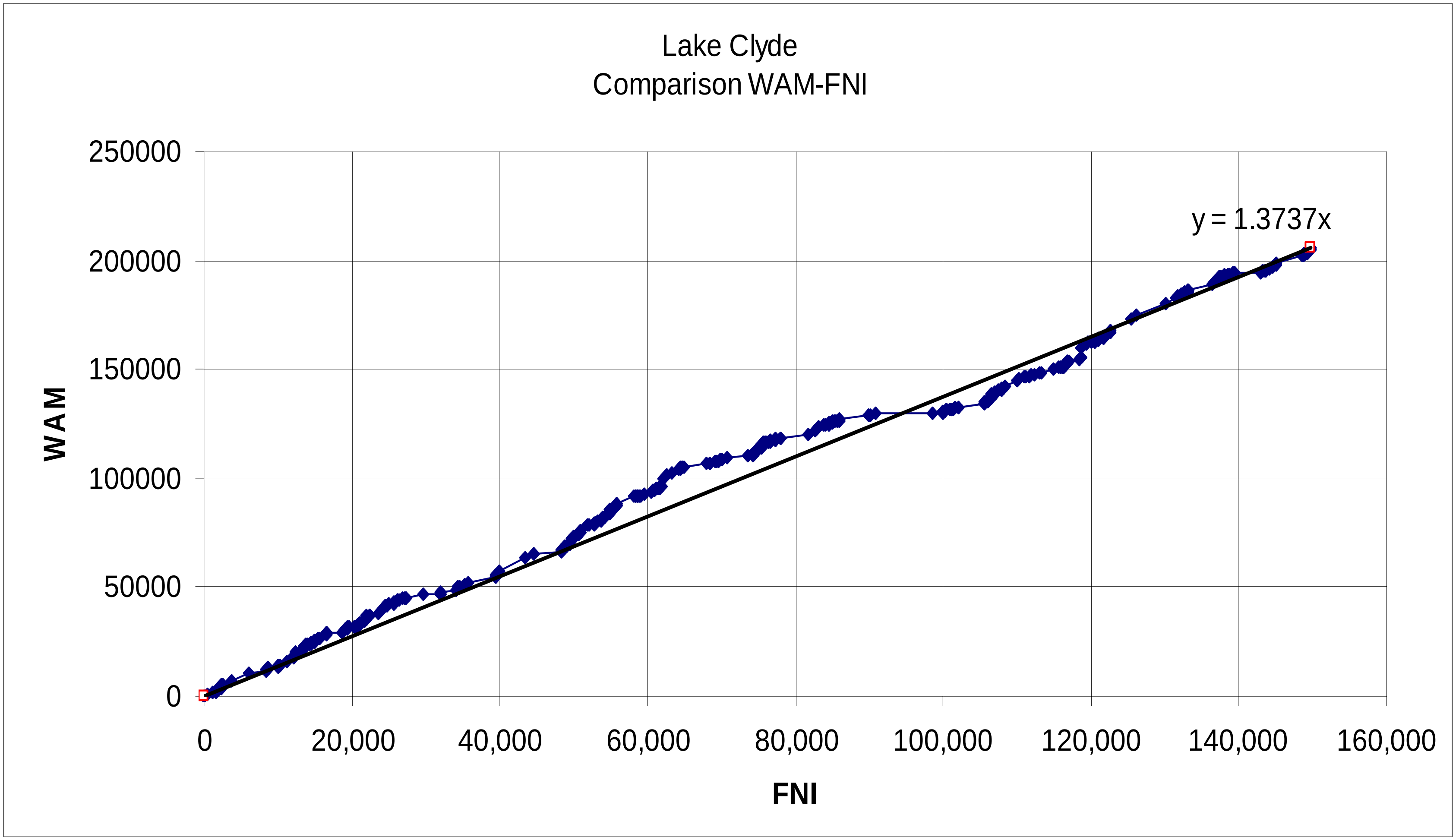
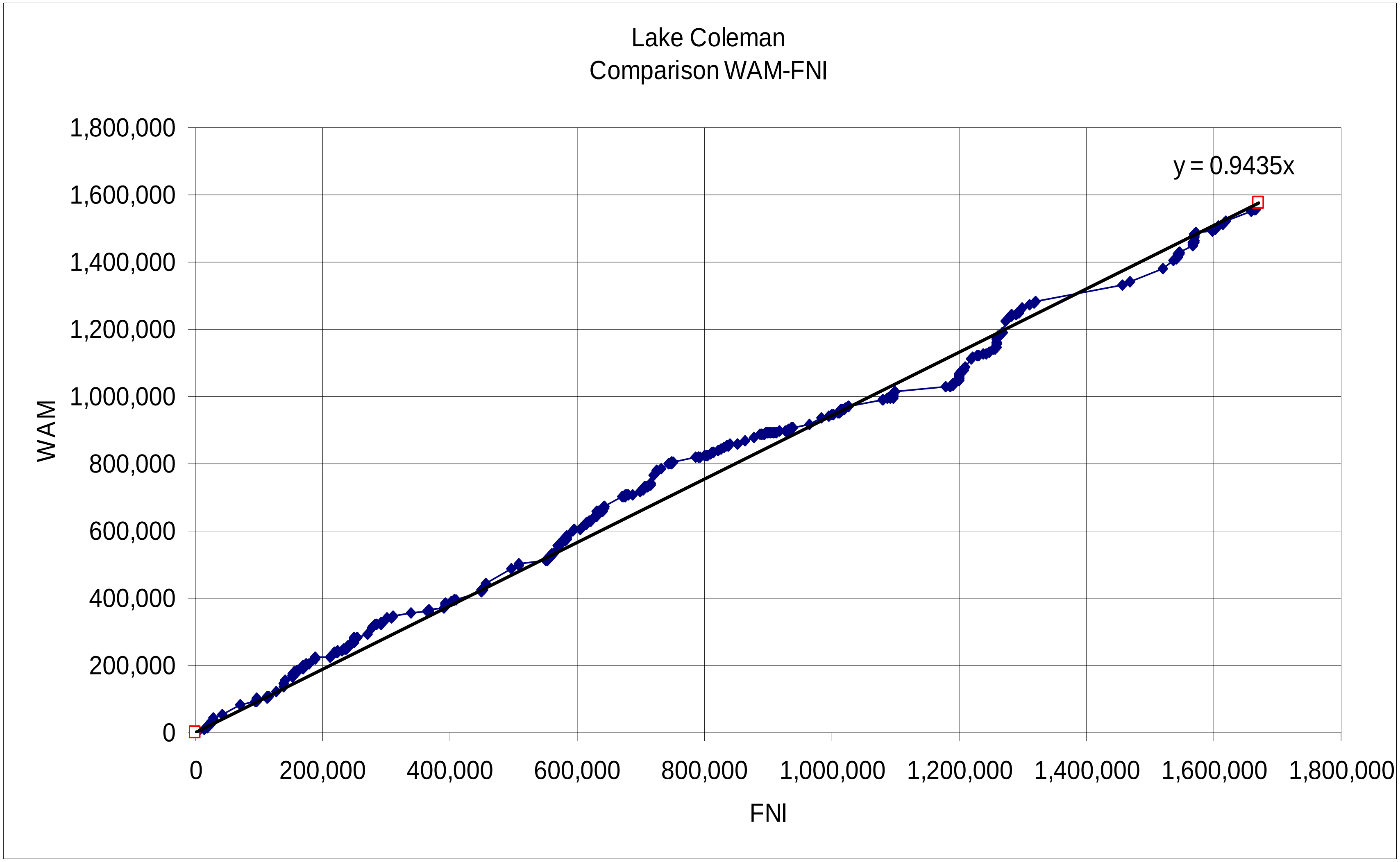
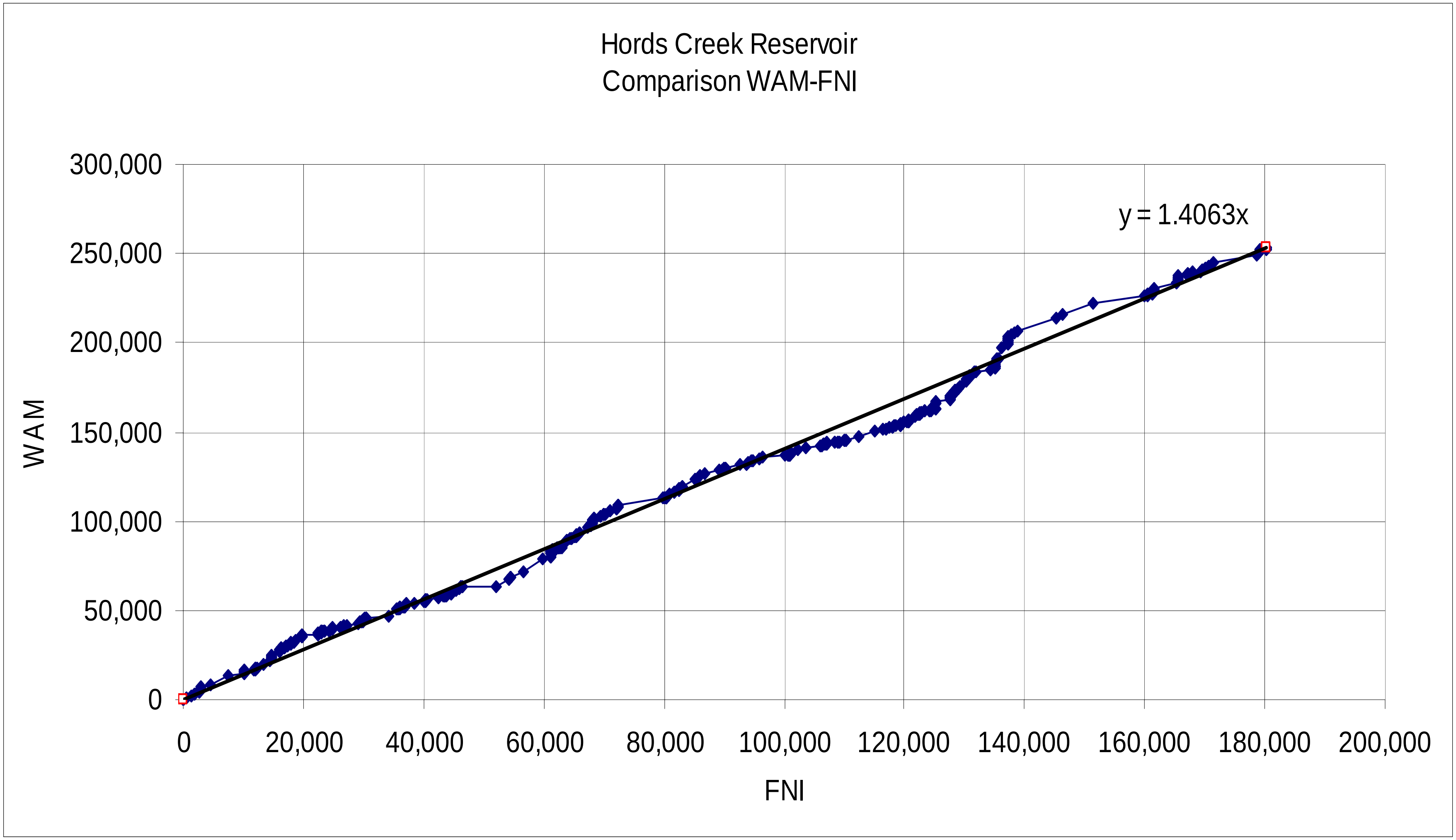

Lake Clyde
Comparison WAM-FNI
250000
200000
150000
100000
50000
0
WAM
y = 1.3737x
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
FNI

Figure B-2



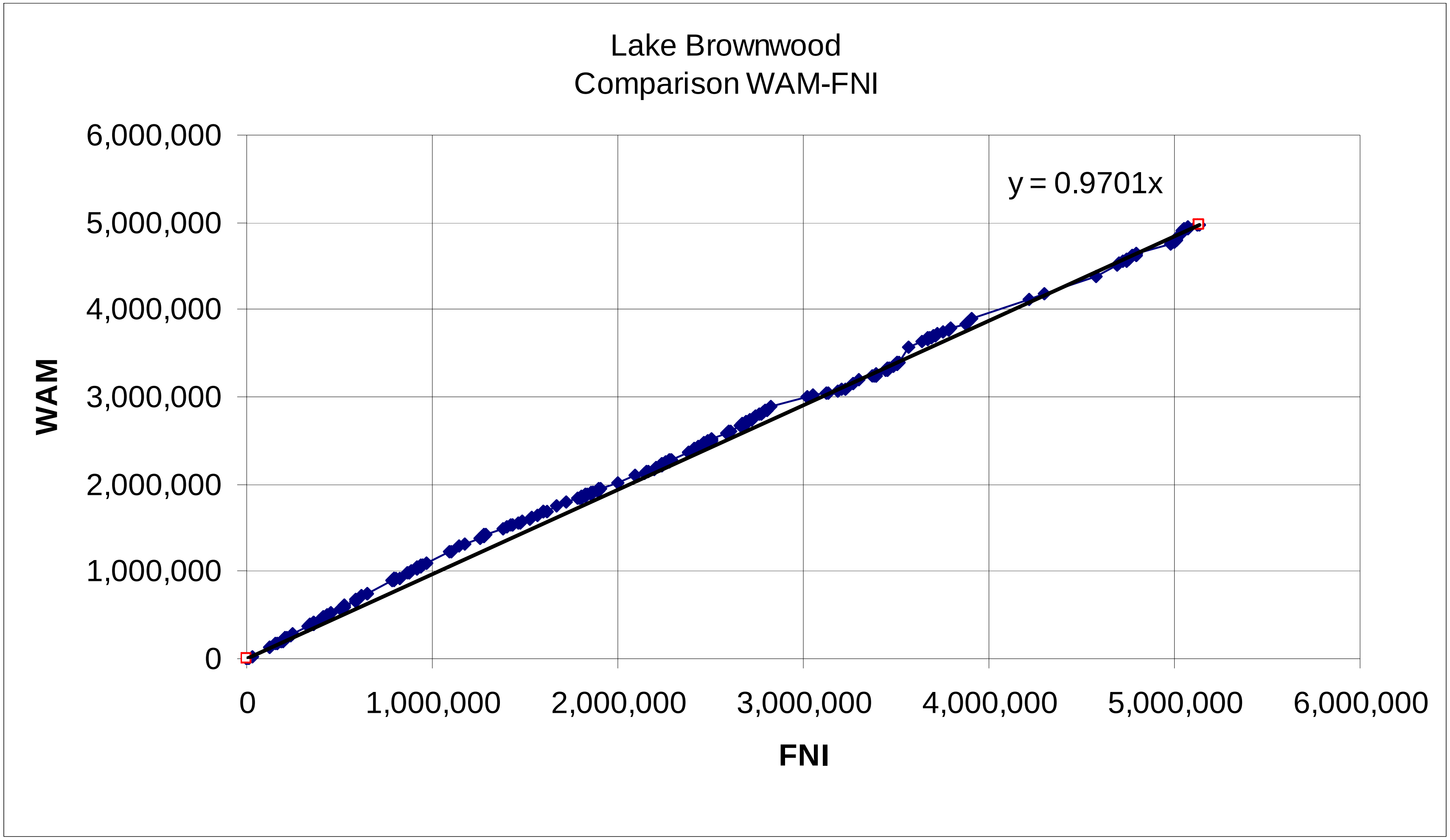
Lake Coleman
Comparison WAM-FNI
y = 0.9435x
WAM
FNI
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
1,400,000
1,600,000
1,800,000

Figure B-3



Hords Creek Reservoir
Comparison WAM-FNI
y = 1.4063x
300,000
250,000
200,000
150,000
100,000
50,000
0
WAM
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
FNI

Figure B-4


Lake Brownwood
Comparison WAM-FNI
y = 0.9701x
WAM
FNI
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000

into Lake Brownwood, which may be not representative of the actual inflows into Lake Clyde. The recalculated flows use a correlation with the gage in the Elm Creek near Ballinger. The long term correlation between the flow calculated with mass balance and the gaged flows in the Elm Creek is acceptable. Therefore, the recalculated flows to Lake Clyde were used in this study.

There are several potential explanations for this better correlation with Elm Creek flows. The Pecan Bayou at Brownwood gage is located relatively far downstream of Lake Coleman, Hords Creek Reservoir and Lake Clyde, while the Elm Creek watershed is located adjacent to the watersheds of Hords Creek and Lake Coleman. It is also closer to the Lake Clyde watershed, which is relatively small. It is likely that rainfall patterns for the Elm Creek watershed more closely match these upper reservoirs than does the Brownwood gage watershed. The Elm Creek watershed has a drainage area of 471 square miles, which is closer to the drainage areas of the reservoirs, while the Brownwood gage has a drainage area of over 1,600 square miles. The Brownwood gage ceased operation in 1983. In the WAM, the naturalized flows after 1983 were estimated using the Pecan Bayou near Mullin gage (USGS 04143600), which is located even farther away from the three reservoirs and has a drainage area of over 2,000 square miles. Finally, there may be topographic or other characteristics of the upper portion of Pecan Bayou that are more similar to the Elm Creek watershed than the lower portion of the Pecan Bayou watershed.

The inflows into Lake Brownwood correlate fairly well with the historical flows from previous studies. Lake Brownwood is geographically very close to the Pecan Bayou at Brownwood gage. Therefore, the Lake Brownwood flows from the Colorado WAM were retained. The historical flows at the upstream reservoir were substituted for the flows in the Colorado WAM and used for the modeling in this study.

The final naturalized flows for each reservoir are show in Tables B.2 to B.5

Evaluation of Channel Losses

In the watershed between the upstream reservoirs and Lake Brownwood, there is one pair of stream gages in an upstream-to-downstream configuration, Hords Creek near

Valera (USGS 8141500) and Hords Creek near Coleman (USGS 8142000). These two gages have an overlapping period of record from May 1947 to September 1970. The Valera gage is located 1.6 miles downstream of Hords Creek Reservoir. The Coleman gage is located about 10 miles downstream of the Valera gage. (Although there are data from other gages in the watershed, these gages do not have another stream gage upstream or downstream so that flows at the two locations can be compared.) Historical flows at the Coleman gage were compared to estimated flows derived from historical inflows into Hords Creek Reservoir multiplied by the drainage area ratio plus measured flows at the Valera gage. The following compares the averages over the analysis period:

Average Inflow Hords Creek Lake = 277 ac-ft/month	(5.8 ac-ft/sq.mile)
Average Hords Creek near Valera (downstream of Hords Creek)	= 108 ac-ft/month
Expected gain with DAR method (Valera to Coleman) = 5.8 ac-ft/month/sq-mile x 53 sq.miles	= 306 ac-ft/month
Expected average flow near Coleman = 108+306	= 414 ac-ft/month
Gage flow near Coleman	= 463 ac-ft/month

On average, flow at the Coleman gage is greater than the estimated flow using upstream data. This implies that, over the long term, flow gains are greater than losses in the reach. Therefore long-term channel losses cannot be specifically identified. These results are assumed to be applicable to the remainder of the watershed.

Evaporation

The mass balance calculations used evaporation rates from the Colorado WAM. These rates are calculated on data of evaporation and precipitation published by the Texas Water Development Board.

Table B.2
Inflow to Lake Clyde
(Values are Acre-Feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1940	0	104	0	386	730	421	3	510	74	0	79	0	2307
1941	0	137	101	1296	2341	2230	33	116	30	1348	128	61	7821
1942	38	22	5	996	987	62	61	42	74	1002	27	36	3352
1943	10	3	52	5	57	0	46	0	0	0	0	0	173
1944	0	101	13	0	321	3	68	279	77	529	0	2	1393
1945	1	2	7	308	48	315	854	0	0	1	0	0	1536
1946	0	0	0	0	2147	106	5	4	343	0	78	4	2687
1947	1	0	1	0	216	191	0	0	0	691	7	267	1374
1948	32	1	0	73	27	74	98	17	0	84	0	0	406
1949	0	0	0	80	632	106	37	0	3	67	0	4	929
1950	0	0	0	0	25	0	1	2	377	0	0	0	405
1951	0	0	0	0	1319	682	0	173	1	0	0	0	2175
1952	0	0	0	84	162	140	0	0	683	0	2	0	1071
1953	0	0	4	0	583	0	142	614	14	249	3	0	1609
1954	0	0	0	2437	2328	68	0	0	0	0	0	0	4833
1955	0	0	0	0	2108	190	48	62	795	304	0	0	3507
1956	0	0	0	184	3652	0	0	0	0	40	34	0	3910
1957	0	0	0	439	3506	1112	7	0	41	3672	136	33	8946
1958	25	56	61	31	197	82	1	24	38	6	7	4	532
1959	8	16	1	3	13	506	312	13	0	245	46	44	1207
1960	229	45	55	266	96	3	18	41	0	9	5	11	778
1961	22	11	8	1	8	906	101	0	818	34	104	53	2066
1962	33	14	11	34	5	103	394	15	49	381	19	31	1089
1963	14	9	6	6	510	127	0	0	0	0	8	1	681
1964	2	34	4	98	4	3	0	640	169	4	8	5	971
1965	4	4	2	2	2350	359	9	0	100	30	75	28	2963
1966	131	78	58	483	1079	189	1	183	200	36	84	89	2611
1967	93	56	29	3	81	116	78	0	29	3	5	10	503
1968	368	103	331	639	860	17	370	32	6	3	31	59	2819

Table B.2 (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	35	24	47	150	2955	533	3	50	732	184	164	389	5266
1970	244	0	541	2878	622	0	0	33	2	7	0	12	4339
1971	6	0	26	45	160	98	0	198	583	163	4	142	1425
1972	65	15	27	0	0	4	0	16	0	77	71	6	281
1973	190	164	116	69	0	0	0	0	736	0	9	0	1284
1974	42	25	28	604	0	0	0	104	3781	879	239	44	5746
1975	45	799	53	165	447	0	0	72	0	0	66	0	1647
1976	37	11	22	0	0	0	0	0	0	148	28	0	246
1977	0	55	56	295	184	349	0	0	0	0	0	0	939
1978	0	16	2	0	10	0	0	4130	0	0	0	0	4158
1979	73	0	783	7752	1477	5	0	0	0	22	0	0	10112
1980	39	0	0	0	338	34	0	350	108	187	12	44	1112
1981	0	86	345	0	0	510	0	0	0	3467	0	0	4408
1982	0	0	317	26	181	225	45	0	0	0	0	15	809
1983	0	0	61	0	0	0	12	0	0	0	0	0	73
1984	31	0	34	6	0	0	0	3	0	400	38	0	512
1985	250	62	143	0	0	24	409	0	0	213	15	6	1122
1986	4	22	10	10	148	1590	24	134	182	764	277	294	3459
1987	195	457	834	297	1620	687	130	78	118	25	37	103	4581
1988	74	60	49	34	73	119	33	13	39	6	1	21	522
1989	19	55	36	36	76	1461	10	20	151	16	6	9	1895
1990	18	27	40	84	490	88	36	132	661	293	107	72	2048
1991	150	91	52	22	141	597	57	58	273	480	156	2694	4771
1992	772	3985	1270	368	185	316	109	103	56	17	52	49	7282
1993	57	50	78	48	40	84	4	22	31	41	4	18	477
1994	23	24	9	15	3096	203	13	11	67	71	232	98	3862
1995	70	46	79	200	120	416	29	454	82	35	61	44	1636
1996	41	30	27	84	292	138	13	192	3449	156	239	219	4880
1997	149	464	484	323	198	3492	203	40	12	29	37	90	5521
1998	62	68	124	34	144	90	12	27	7	25	25	14	632

Table B.3
Inflow to Lake Coleman
(Values are Acre-Feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1940	0	1181	2	4375	8263	4767	35	5777	837	0	891	0	26128
1941	1	1558	1151	14676	26501	25249	380	1309	336	15256	1450	688	88555
1942	434	245	54	11270	11178	704	690	478	842	11341	304	412	37952
1943	116	31	584	52	646	0	522	0	0	0	0	0	1951
1944	0	1139	150	1	3630	29	772	3156	868	5983	2	20	15750
1945	11	19	78	3481	547	3570	9672	0	0	8	0	0	17386
1946	12	11	13	14	24323	1221	75	70	3897	14	897	61	30608
1947	22	11	22	15	2466	2183	24	23	17	7832	88	3042	15745
1948	382	32	22	854	328	870	1143	232	30	972	18	19	4902
1949	6	5	6	911	7161	1203	432	11	40	761	9	53	10598
1950	19	16	20	23	307	31	46	53	4295	22	18	19	4869
1951	23	21	23	26	14963	7753	43	2002	40	26	22	23	24965
1952	28	25	32	992	1879	1628	55	51	7766	31	51	28	12566
1953	32	28	78	37	6637	52	1667	7014	201	2850	64	32	18692
1954	33	29	35	27631	26396	821	61	59	43	36	30	33	55207
1955	41	36	49	53	23910	2205	613	778	9051	3478	33	35	40282
1956	27	31	41	2133	41396	86	104	97	85	495	416	28	44939
1957	34	28	34	5005	39719	12637	157	74	494	41594	1549	391	101716
1958	319	667	729	388	2265	979	92	352	469	90	89	61	6500
1959	150	212	54	66	195	5792	3579	223	76	2819	555	537	14258
1960	2620	531	658	3053	1137	103	265	536	61	149	99	161	9373
1961	282	149	122	56	139	10304	1192	76	9297	417	1212	638	23884
1962	402	192	163	421	116	1240	4513	208	597	4350	250	386	12838
1963	228	175	283	314	6009	1704	309	178	77	51	128	42	9498
1964	62	430	246	1349	278	308	319	7441	1986	113	140	92	12764
1965	96	107	236	284	26843	4343	430	215	1222	390	899	352	35417
1966	1536	935	879	5716	12469	2439	335	2270	2342	457	999	1041	31418
1967	1113	692	527	270	1116	1567	1157	193	433	102	106	156	7432
1968	4186	1183	3786	7289	9772	272	4283	421	117	58	372	681	32420
1969	422	292	591	1781	33505	6105	194	676	8331	2111	1900	4421	60329

Table B.3 (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1970	2777	1794	7802	4420	5393	3918	436	145	253	197	202	285	27622
1971	287	239	201	780	2442	11142	287	11220	14915	8545	2257	3018	55333
1972	1842	1422	828	462	2565	910	704	209	511	3058	1971	1136	15618
1973	1748	1633	1906	5290	683	8271	2006	608	1296	1656	710	650	26457
1974	610	481	715	246	437	126	97	3218	24392	18859	13041	3243	65465
1975	2770	7145	2260	1419	237	358	0	32	0	41	96	0	14358
1976	119	307	572	418	79	500	0	559	591	1073	0	0	4219
1977	276	0	1711	4891	304	227	0	0	88	0	0	0	7496
1978	0	0	0	0	0	0	0	54494	0	0	0	0	54494
1979	0	0	8063	4038	3846	792	0	0	0	0	0	0	16739
1980	0	0	66	101	89	0	0	0	0	0	0	0	256
1981	0	322	849	203	360	406	0	0	608	80248	5634	3032	91661
1982	0	213	691	293	0	8471	641	0	0	0	0	0	10308
1983	307	0	28	128	79	150	0	0	0	0	0	0	692
1984	0	0	19	77	0	124	0	33	0	475	0	0	728
1985	1400	86	1712	1915	0	0	1930	0	0	485	0	0	7529
1986	0	72	119	28	361	10628	160	202	2144	6008	3346	7656	30723
1987	2763	5942	7472	1187	1699	2205	0	0	0	0	0	0	21269
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	206	143	1901	4582	0	0	888	0	86	0	7806
1990	78	146	283	4190	7079	2302	0	0	7230	2418	154	0	23880
1991	1816	1040	592	35	428	3320	48	0	12200	5972	2420	137884	165753
1992	10310	52134	17748	2969	0	2750	60	137	740	0	0	0	86847
1993	0	58	409	35	255	61	0	0	0	0	11	0	828
1994	33	76	47	0	21228	396	0	33	97	255	1241	15	23421
1995	0	0	265	361	0	0	1014	0	0	0	0	0	1641
1996	0	0	68	353	1051	48	0	0	26021	592	1228	1577	30938
1997	1682	5256	5485	3653	2236	39545	2295	454	140	328	417	1015	62506
1998	697	767	1398	382	1626	1019	141	301	83	288	288	162	7152

Table B.4
Inflow to Hords Creek Reservoir
(Values are Acre-Feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1940	0	124	0	461	870	502	4	608	88	0	94	0	2751
1941	0	164	121	1545	2790	2658	40	138	35	1606	153	72	9322
1942	46	26	6	1186	1177	74	73	50	89	1194	32	43	3995
1943	12	3	61	5	68	0	55	0	0	0	0	0	205
1944	0	120	16	0	382	3	81	332	91	630	0	2	1658
1945	1	2	8	366	58	376	1018	0	0	1	0	0	1830
1946	1	1	1	1	2560	129	8	7	410	1	94	6	3222
1947	2	1	2	2	260	230	3	2	2	824	9	320	1657
1948	40	3	2	90	34	74	1368	4	13	157	3	15	1804
1949	39	39	98	740	1782	114	3	492	0	157	0	0	3464
1950	0	0	0	0	54	1	69	265	174	0	0	4	567
1951	1	2	0	0	3628	1294	0	104	12	177	0	6	5224
1952	18	0	0	229	87	0	0	32	621	14	26	0	1027
1953	15	0	234	0	22	1443	1495	259	53	110	10	0	3641
1954	34	39	29	1878	866	251	0	0	20	11	59	7	3194
1955	22	54	1	24	1046	680	478	16	393	0	0	0	2714
1956	27	37	6	5812	2122	0	14	10	0	156	40	4	8228
1957	0	0	22	2004	3183	1415	72	0	0	0	35	15	6746
1958	8	46	64	64	77	313	526	0	185	0	6	0	1289
1959	0	0	0	94	258	54	980	0	0	377	206	136	2105
1960	586	47	40	29	0	0	76	108	0	70	0	0	956
1961	237	75	61	0	0	1363	239	0	120	59	0	0	2154
1962	0	16	0	90	0	118	21	0	105	170	0	0	520
1963	0	4	25	0	1240	396	0	0	62	0	17	0	1744
1964	38	32	136	821	0	17	0	0	1067	0	106	2	2219
1965	12	66	42	0	7518	306	0	0	137	14	0	3	8098
1966	0	0	79	242	200	793	0	0	750	0	0	0	2064
1967	11	0	114	5	0	181	0	0	227	0	22	19	579
1968	2074	286	558	792	2586	519	0	0	0	0	4	24	6843

Table B.4 (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	0	0	115	204	2490	1088	0	0	216	146	2	361	4622
1970	265	201	1068	405	3623	712	0	0	127	0	0	2	6403
1971	12	0	18	24	412	0	0	893	1531	2399	234	178	5701
1972	10	101	20	40	150	121	0	0	0	60	0	0	502
1973	0	20	58	1204	110	397	18	0	235	1005	0	0	3047
1974	0	0	74	22	0	0	0	0	2193	2795	1257	486	6827
1975	441	656	227	354	656	0	0	0	0	0	0	0	2334
1976	0	6	0	0	0	0	463	0	0	0	0	0	469
1977	0	0	95	708	63	0	0	0	0	0	0	0	866
1978	0	10	0	0	0	0	0	1046	0	0	0	0	1056
1979	0	13	266	370	233	46	127	0	0	0	0	3	1058
1980	0	3	0	0	698	69	0	0	765	0	26	138	1699
1981	44	24	705	45	0	0	0	0	6	89	0	0	913
1982	0	9	9	0	0	2307	0	0	0	0	0	0	2325
1983	2	0	29	0	0	5	0	0	15	0	0	0	51
1984	7	0	0	0	0	22	0	53	81	0	17	316	496
1985	46	24	54	0	0	3	0	0	315	452	0	0	894
1986	0	1	10	0	162	1122	0	12	0	369	0	91	1767
1987	66	242	542	93	2421	789	0	36	0	0	0	0	4189
1988	0	0	0	0	0	66	0	0	0	0	0	0	66
1989	0	27	5	0	171	0	0	0	219	0	0	0	422
1990	0	26	92	422	1098	0	0	0	0	0	0	0	1638
1991	46	0	2	0	0	114	0	24	546	502	444	6333	8011
1992	1225	5132	8407	642	0	700	97	0	0	0	0	0	16203
1993	0	5	32	0	0	77	0	0	0	0	0	0	114
1994	0	26	10	0	3859	0	0	60	0	0	8	0	3963
1995	0	0	8	161	52	1453	0	0	0	0	0	0	1674
1996	0	0	0	0	959	0	0	0	1238	0	160	0	2357
1997	0	538	679	378	448	7038	282	0	0	0	0	0	9363
1998	15	18	259	0	1077	0	0	0	0	0	30	0	1399

Table B.5
Inflow to Lake Brownwood
(Values are Acre-Feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1959	0	0	195	1924	5834	19758	96526	0	2542	32498	2225	2207	163709
1960	22021	4281	2027	11019	1594	0	0	977	266	5818	0	0	48004
1961	20557	14628	1851	820	1927	80676	9259	0	8879	5916	2260	412	147184
1962	235	803	0	3906	717	22403	27946	0	23155	17276	0	436	96877
1963	24	335	346	722	51358	14025	0	0	0	517	2370	0	69697
1964	1744	2157	1388	53572	240	696	513	1139	32921	1553	24537	421	120880
1965	972	3347	407	1714	133048	2542	0	193	2476	1977	5733	0	152409
1966	208	0	1719	22974	41725	9999	360	6549	31174	209	1703	475	117095
1967	1603	1328	2954	4220	7527	6717	3555	784	19724	0	711	367	49489
1968	130770	9189	41413	30746	78017	14141	3972	0	0	0	1567	606	310422
1969	1107	874	5749	10139	87435	17567	0	2568	22292	7720	4614	23220	183284
1970	12191	8848	43564	13298	31977	24212	0	921	375	321	0	509	136215
1971	68	880	401	1712	2570	12641	0	61379	51206	61748	5413	7246	205265
1972	4062	3414	3277	3869	5127	860	1767	360	202	2101	886	1435	27359
1973	2788	2498	3384	16914	1476	9279	4064	0	1570	21711	1858	102	65644
1974	510	1052	896	923	2698	1828	0	6784	87669	97676	47906	9293	257235
1975	10415	35236	5615	8651	14218	2415	2042	111	201	0	835	0	79739
1976	741	1489	1084	2106	1956	0	2233	528	0	3920	415	14	14484
1977	484	212	12211	20016	3046	0	0	0	0	0	625	484	37078
1978	185	241	1368	460	493	329	1684	91091	2387	305	0	0	98542
1979	1626	1925	21538	5224	4907	16554	2459	5637	409	426	0	135	60840
1980	703	36	589	822	14546	4142	0	0	5395	789	477	2566	30064
1981	988	1539	12646	2511	3197	7681	1248	0	910	82583	2747	1346	117396
1982	770	1540	3886	1795	13485	51450	4338	0	0	438	352	1903	79958
1983	341	0	4367	1116	0	15871	611	0	0	1719	0	0	24026
1984	471	1462	4178	1446	445	13690	1035	1401	3292	14538	0	10788	52746
1985	19332	303	9784	3521	767	2908	4483	1709	1819	10213	0	0	54840
1986	2855	0	3221	1850	19506	195516	1365	0	31763	63589	14946	47553	382165
1987	19413	20491	41483	4015	36009	71183	6022	2149	5637	0	0	0	206402
1988	806	69	1079	1020	959	49122	3839	3888	0	0	7776	0	68559

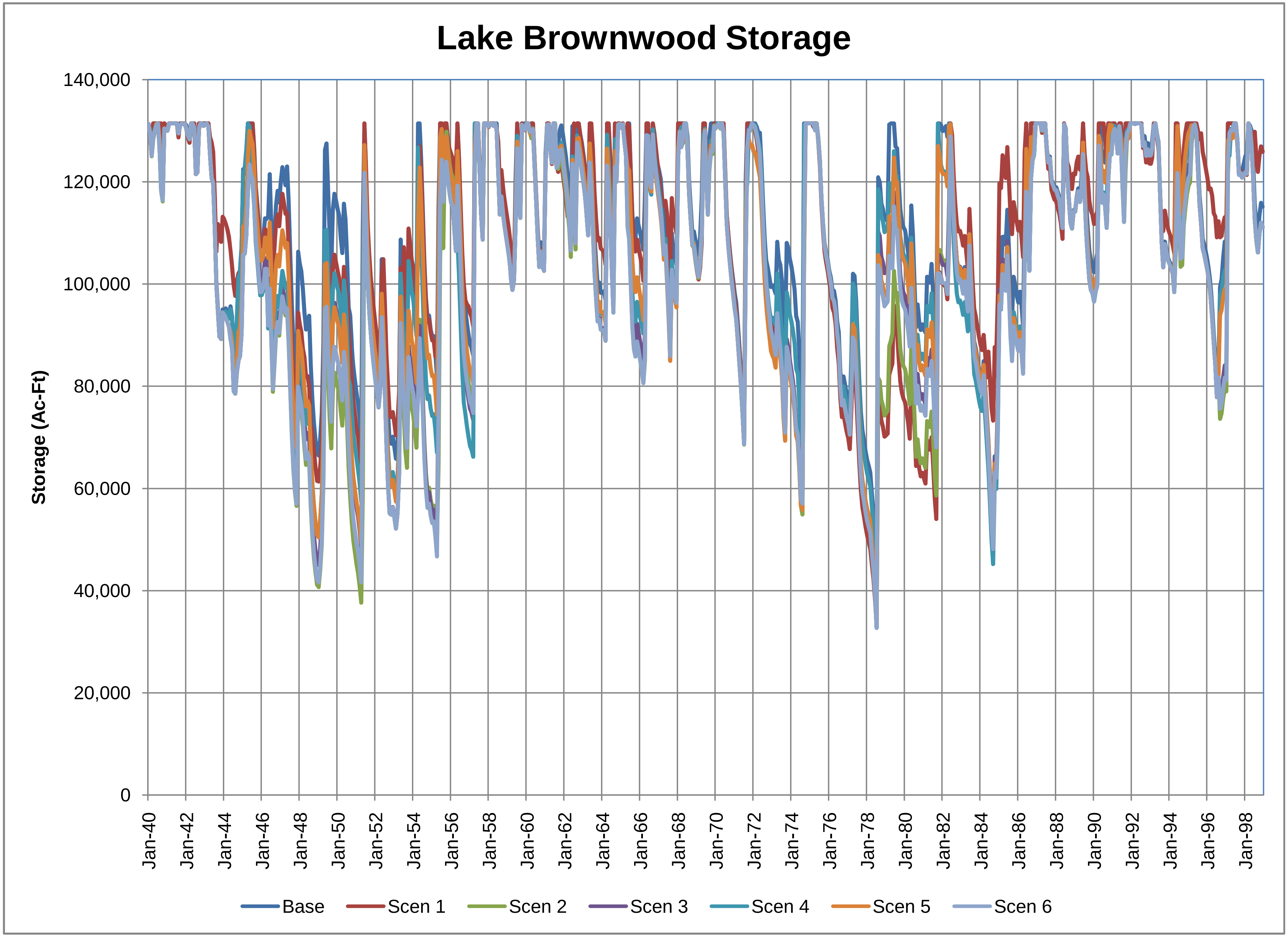
Table B.5 (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1989	0	6360	1320	1676	12524	27017	0	0	167	216	0	193	49473
1990	2159	3422	3079	48245	73131	37997	10	3839	16688	10398	2324	0	201293
1991	13282	66	2450	1544	26502	34450	1788	6570	83774	7308	20833	312339	510906
1992	80201	275764	115736	11478	0	21264	22366	0	354	7600	0	0	534763
1993	516	2239	7396	2939	1701	560	0	0	0	21033	0	589	36973
1994	7	630	1036	0	188563	10457	845	158	3156	3505	8841	2228	219425
1995	549	438	0	22674	4335	3160	193	2798	635	3493	0	0	38273
1996	0	0	0	2013	1955	15717	0	1837	54250	212	3610	4201	83794

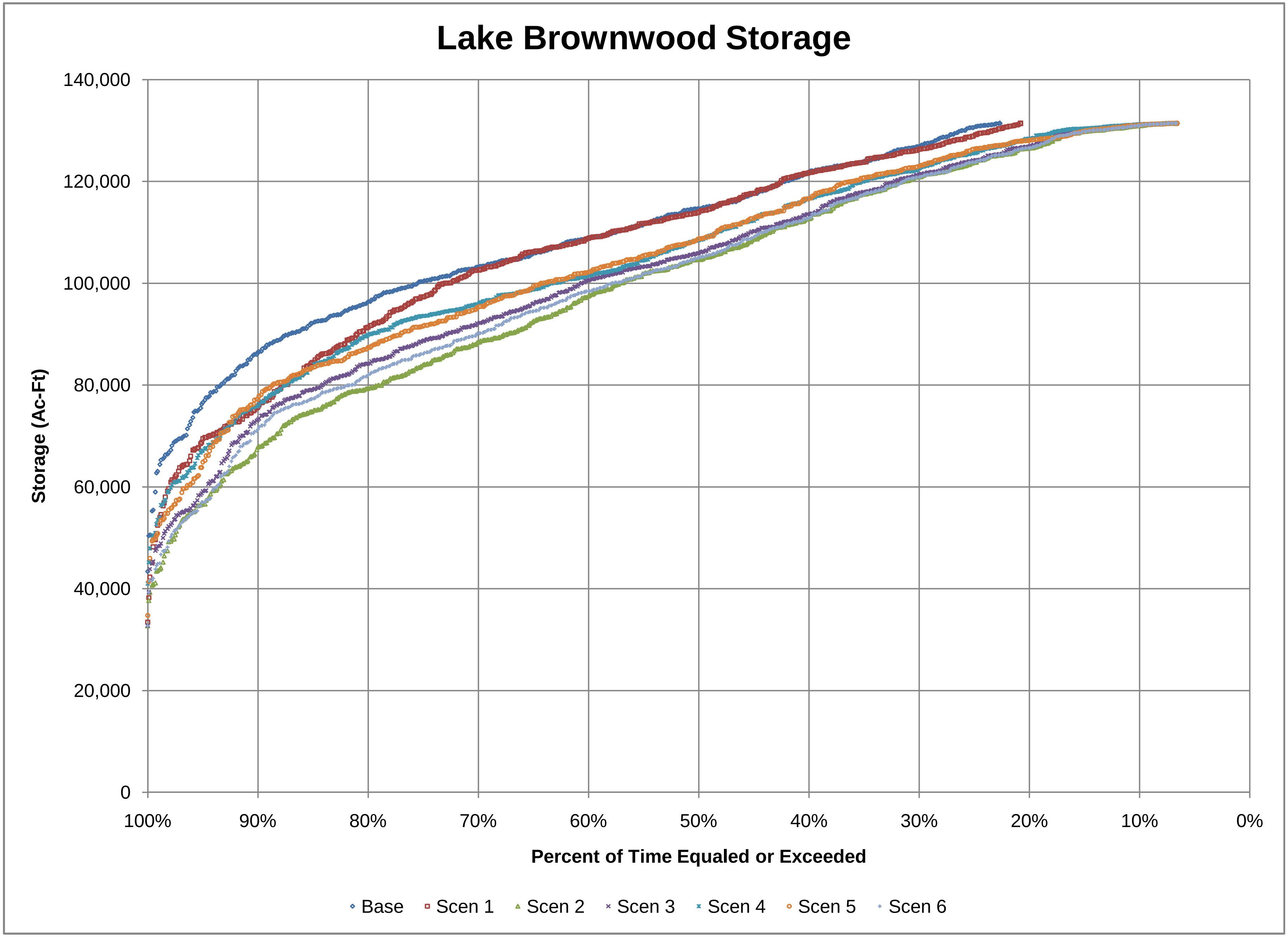
Appendix C
Modeling Results

Comparison of Reservoir Storage for the Base Scenario and Scenarios 1 through 6

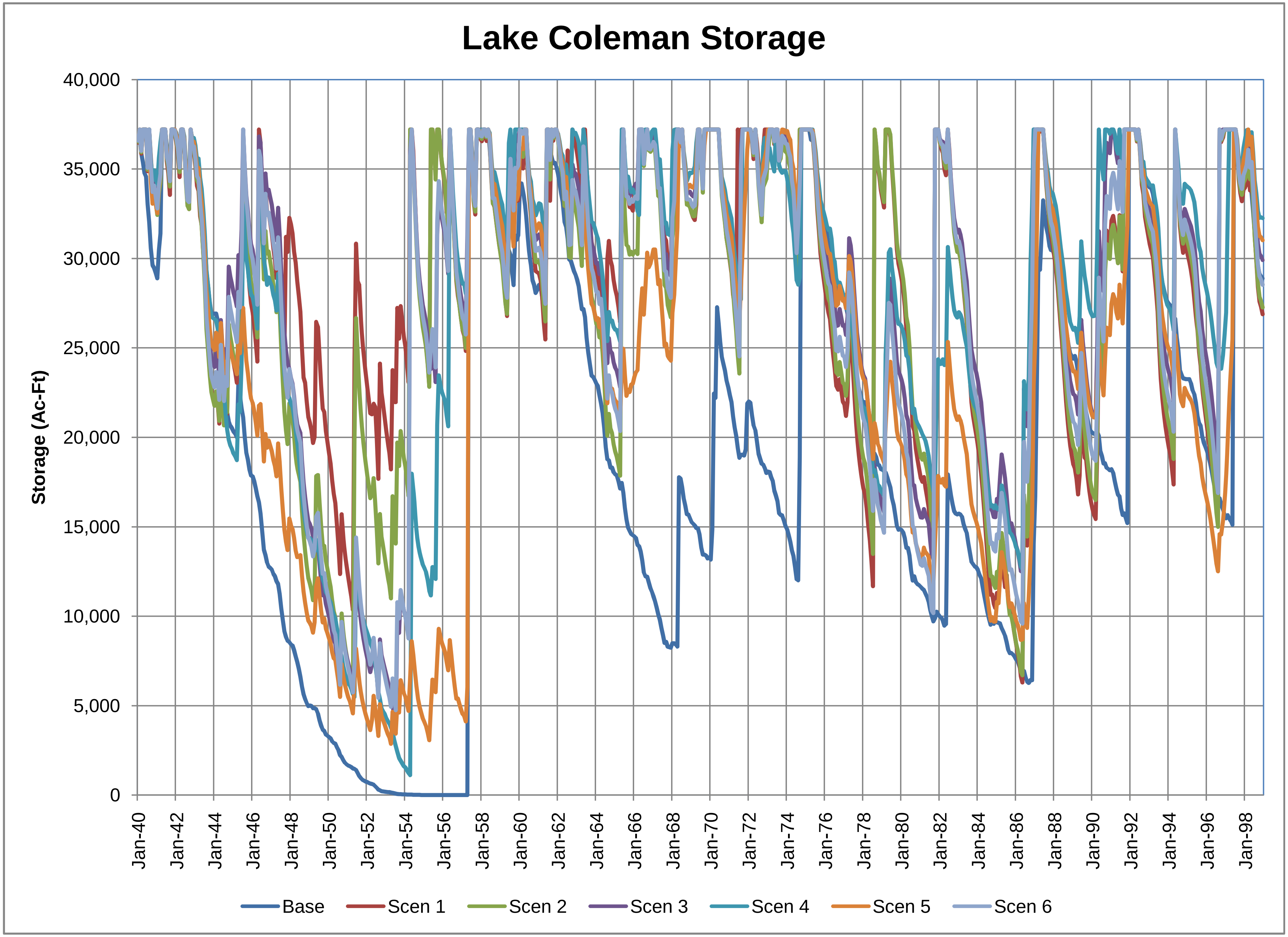
Simulated Reservoir Storage Traces
Range of Storage



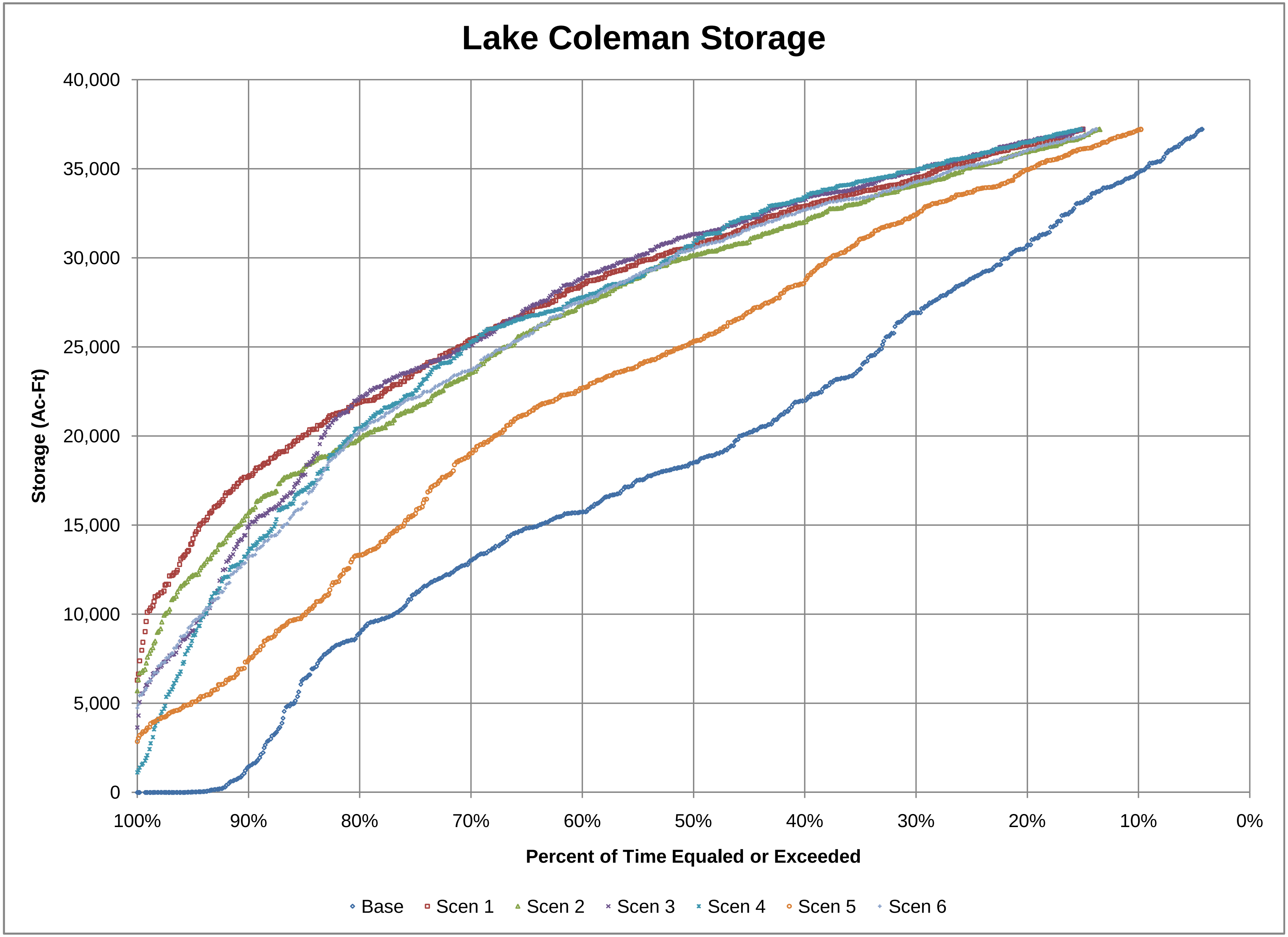
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6

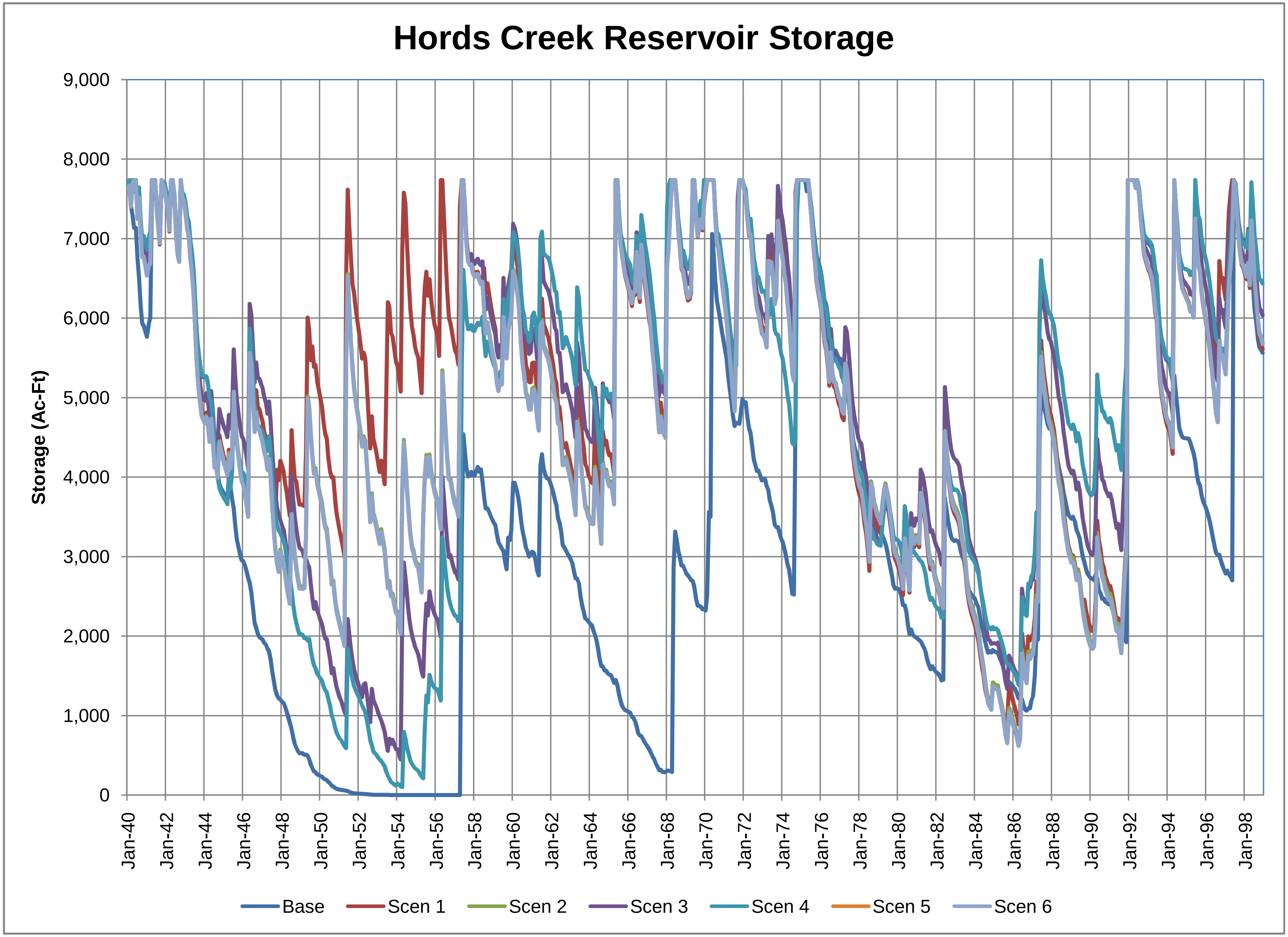


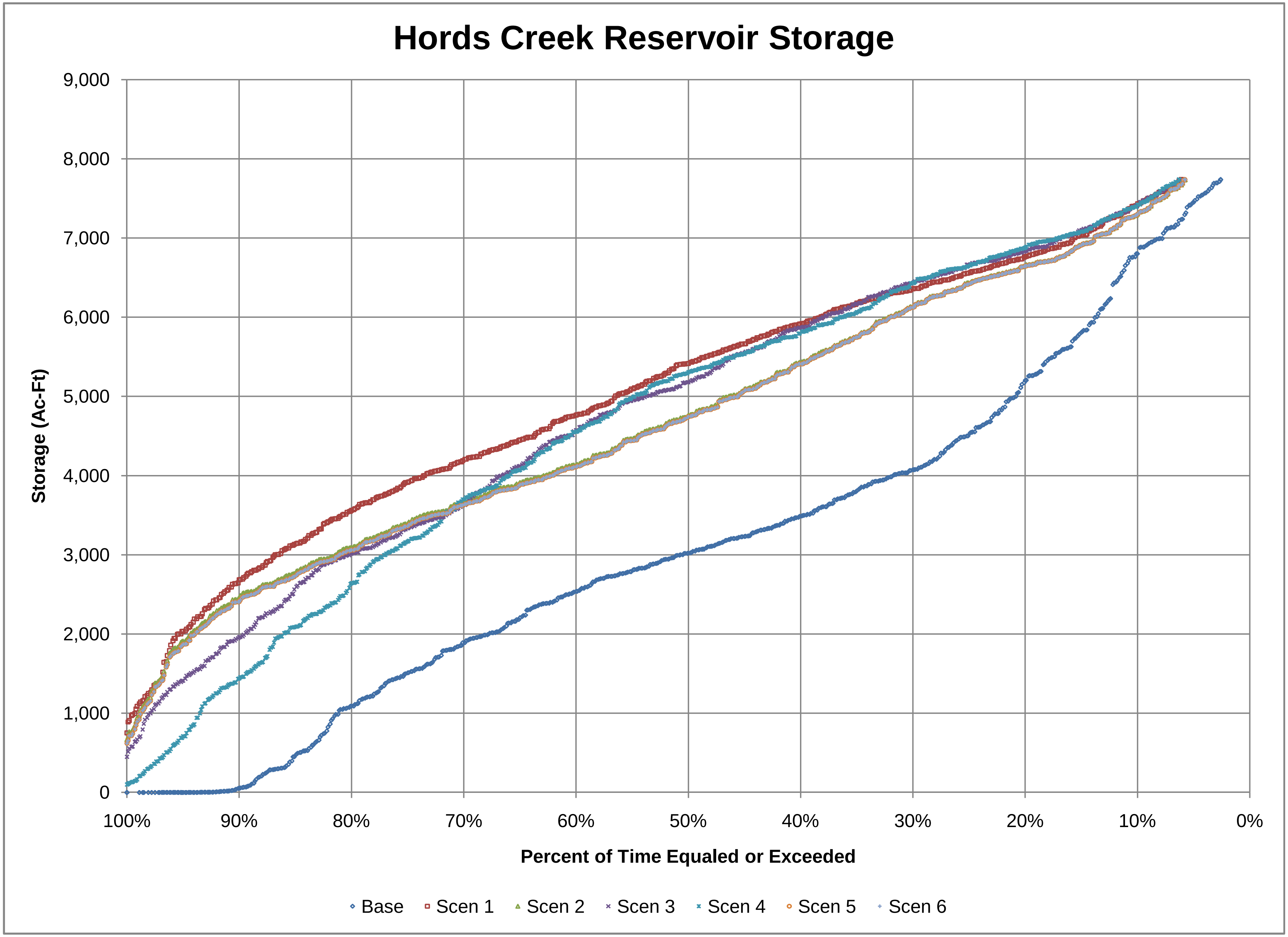
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6



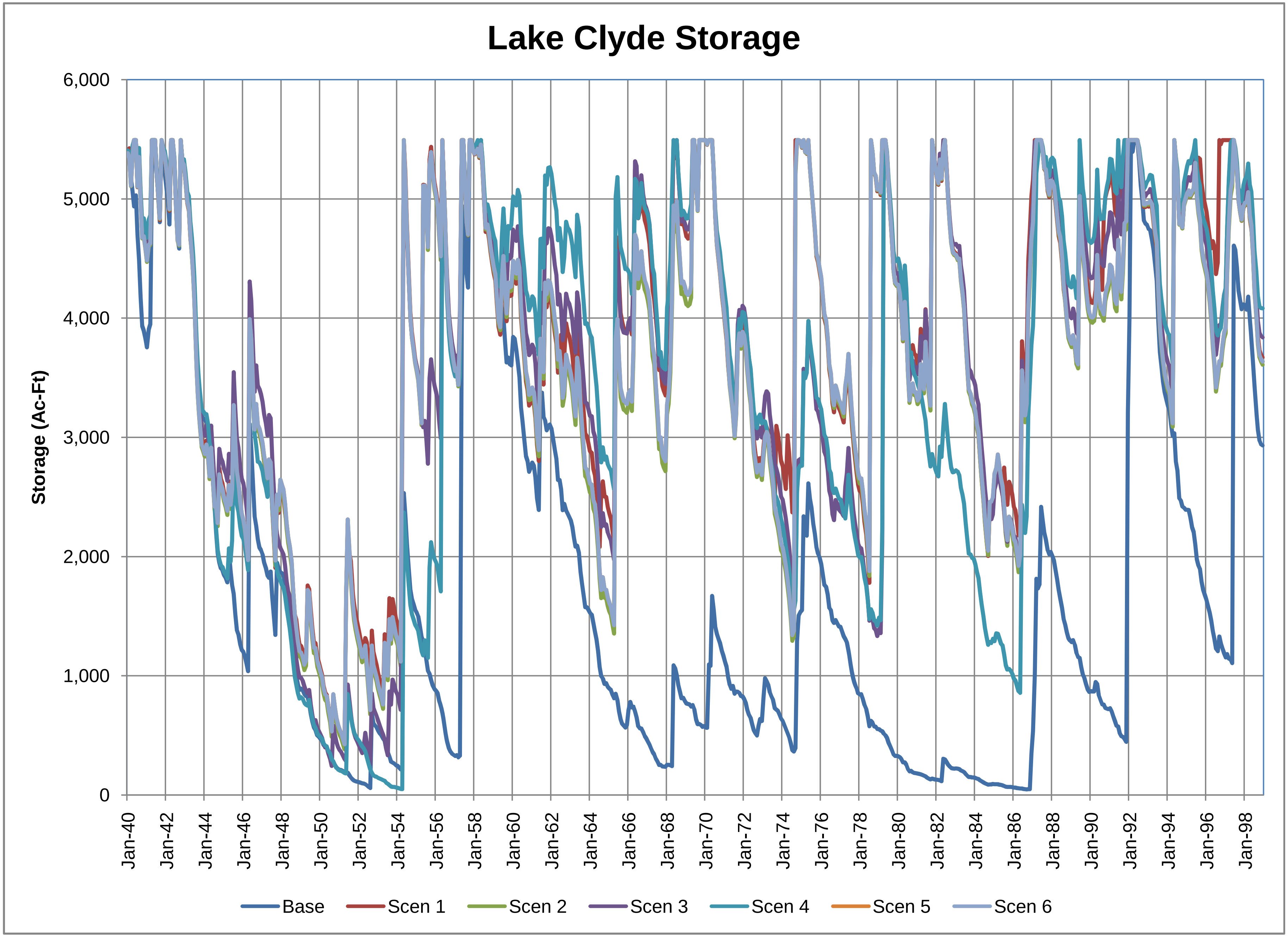
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6


Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6

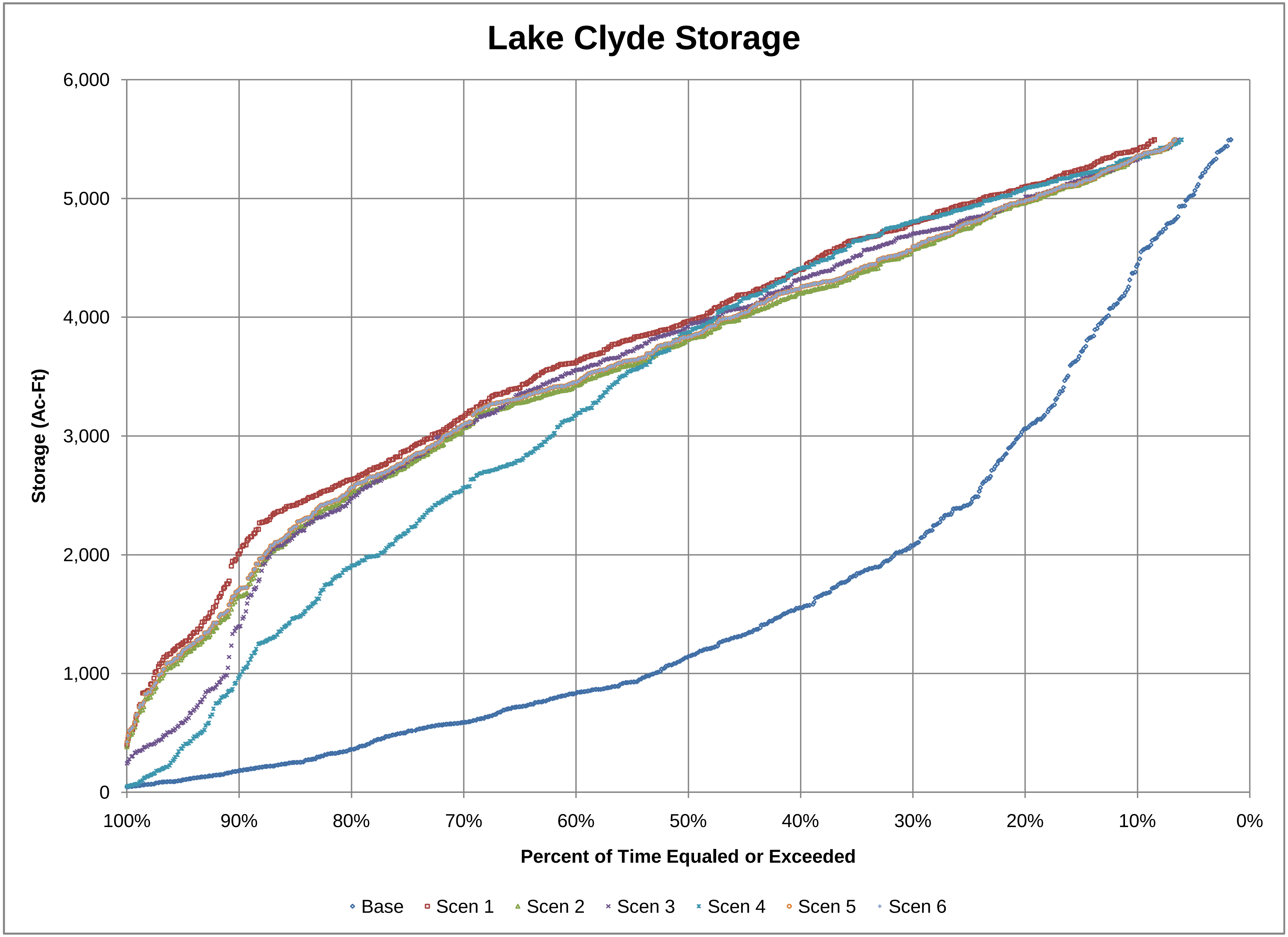

Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6



Hords Creek Reservoir Storage
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6



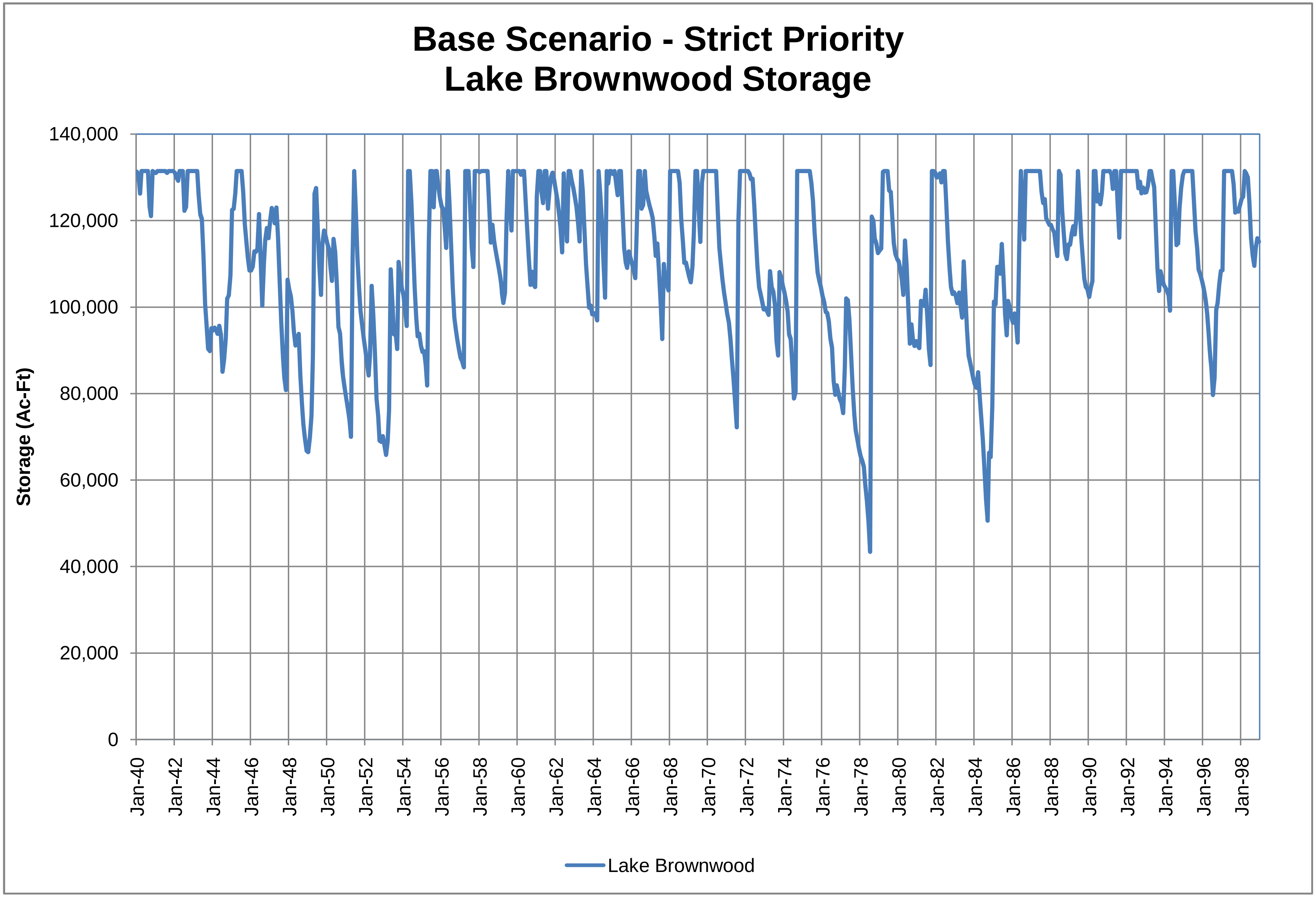
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6



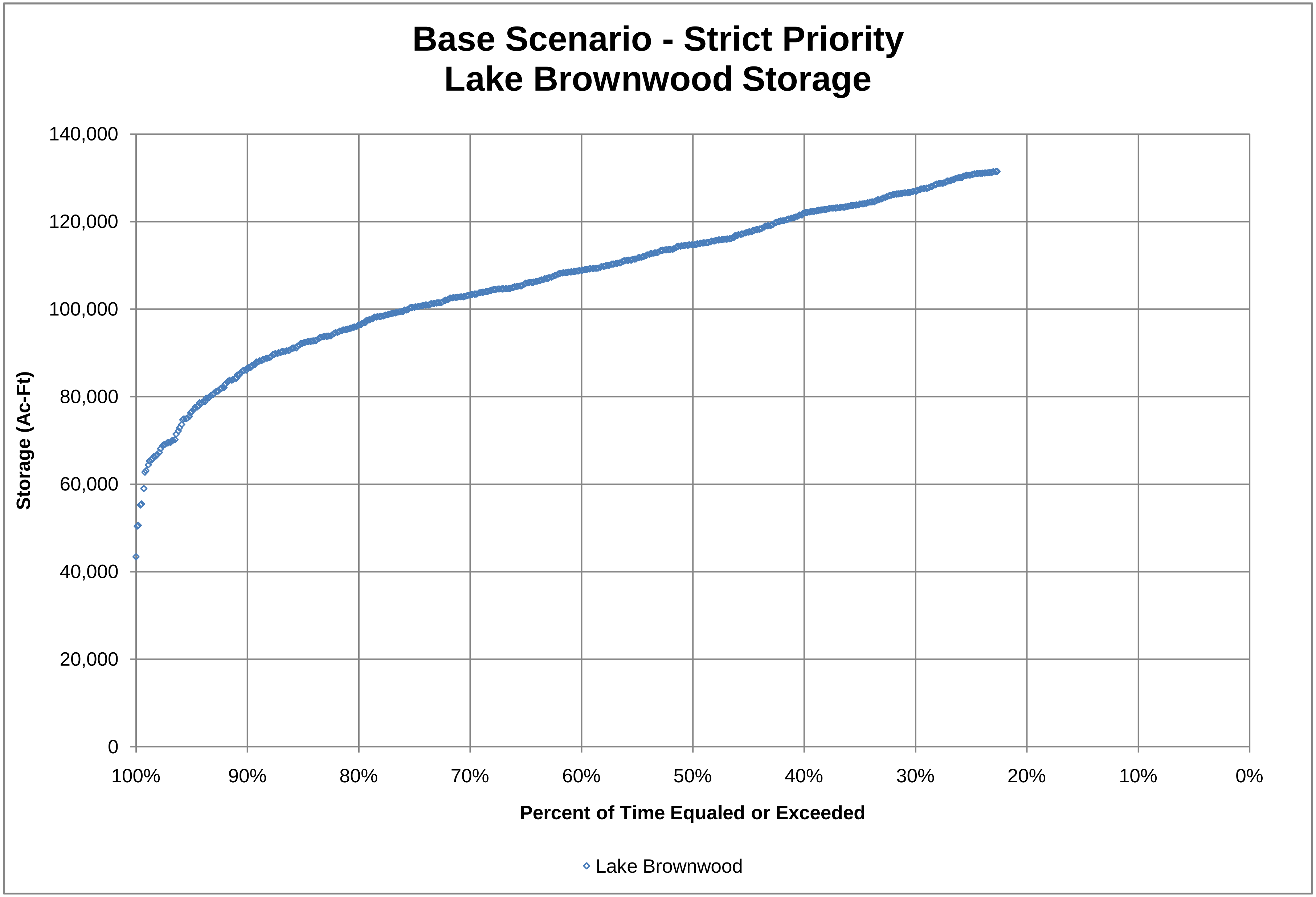
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Base
Scen 1
Scen 2
Scen 3
Scen 4
Scen 5
Scen 6

Base Scenario: Strict Priority

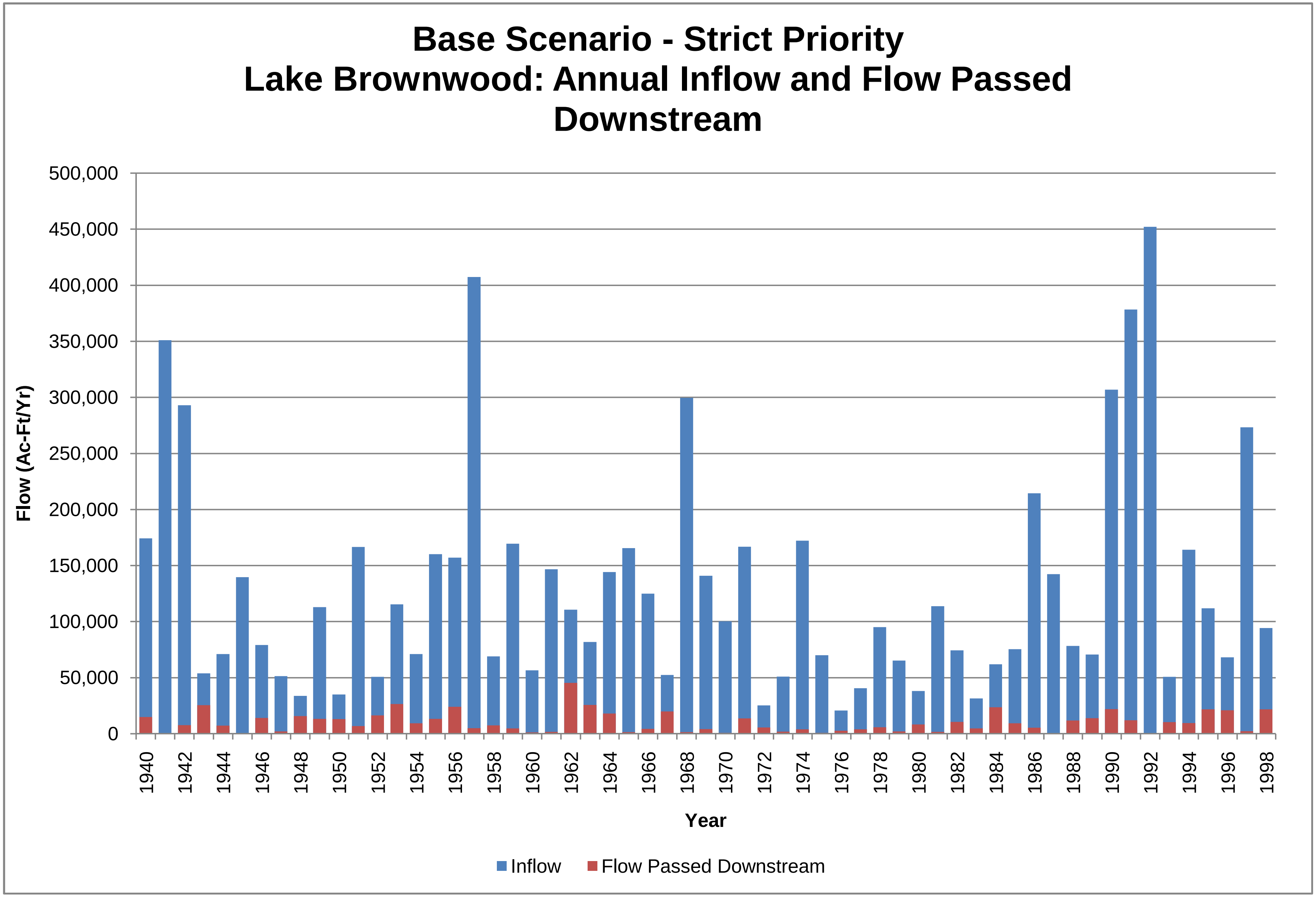
Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream

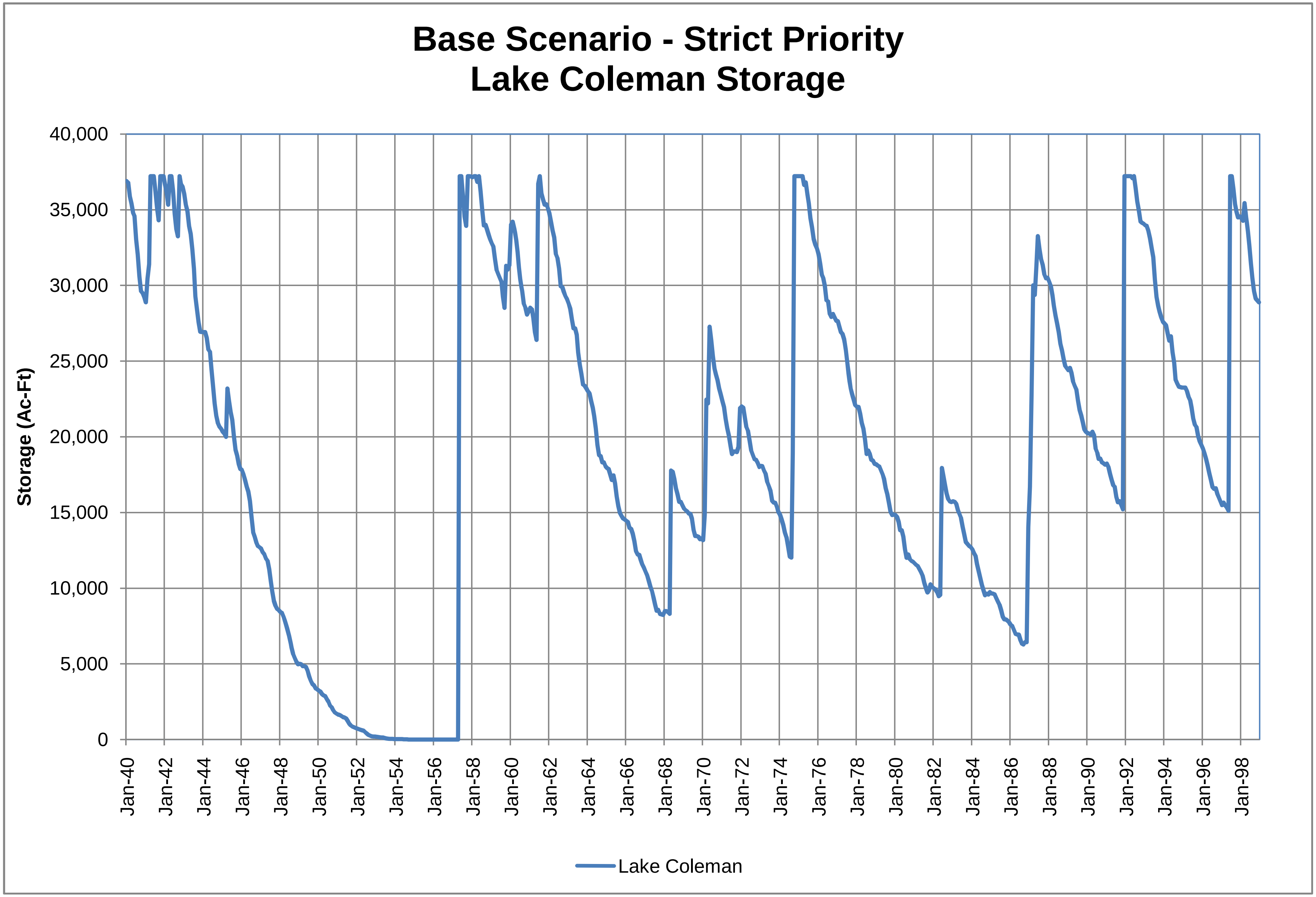


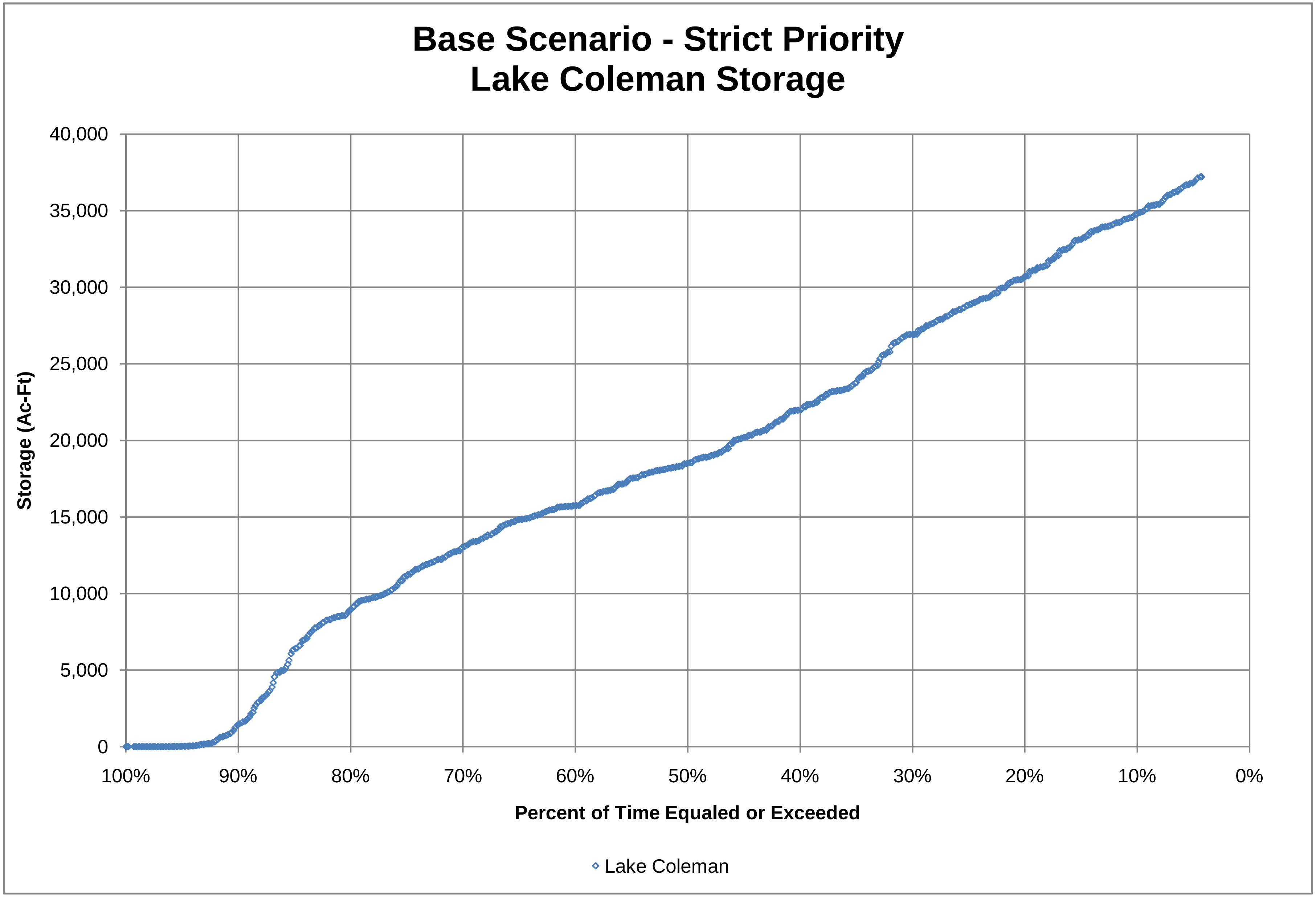
Base Scenario - Strict Priority
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Brownwood



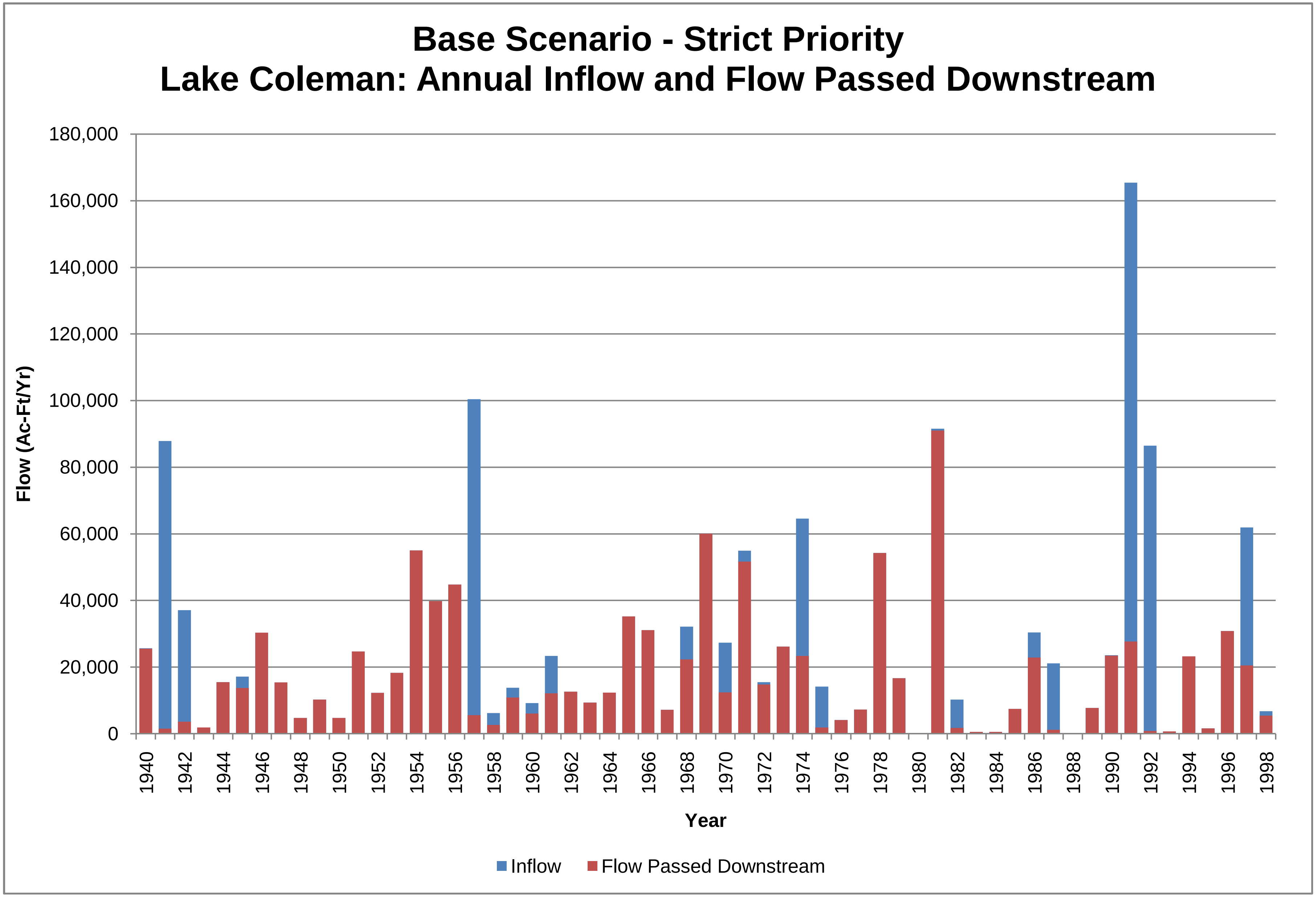
Base Scenario - Strict Priority
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood


Base Scenario - Strict Priority
Lake Brownwood: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

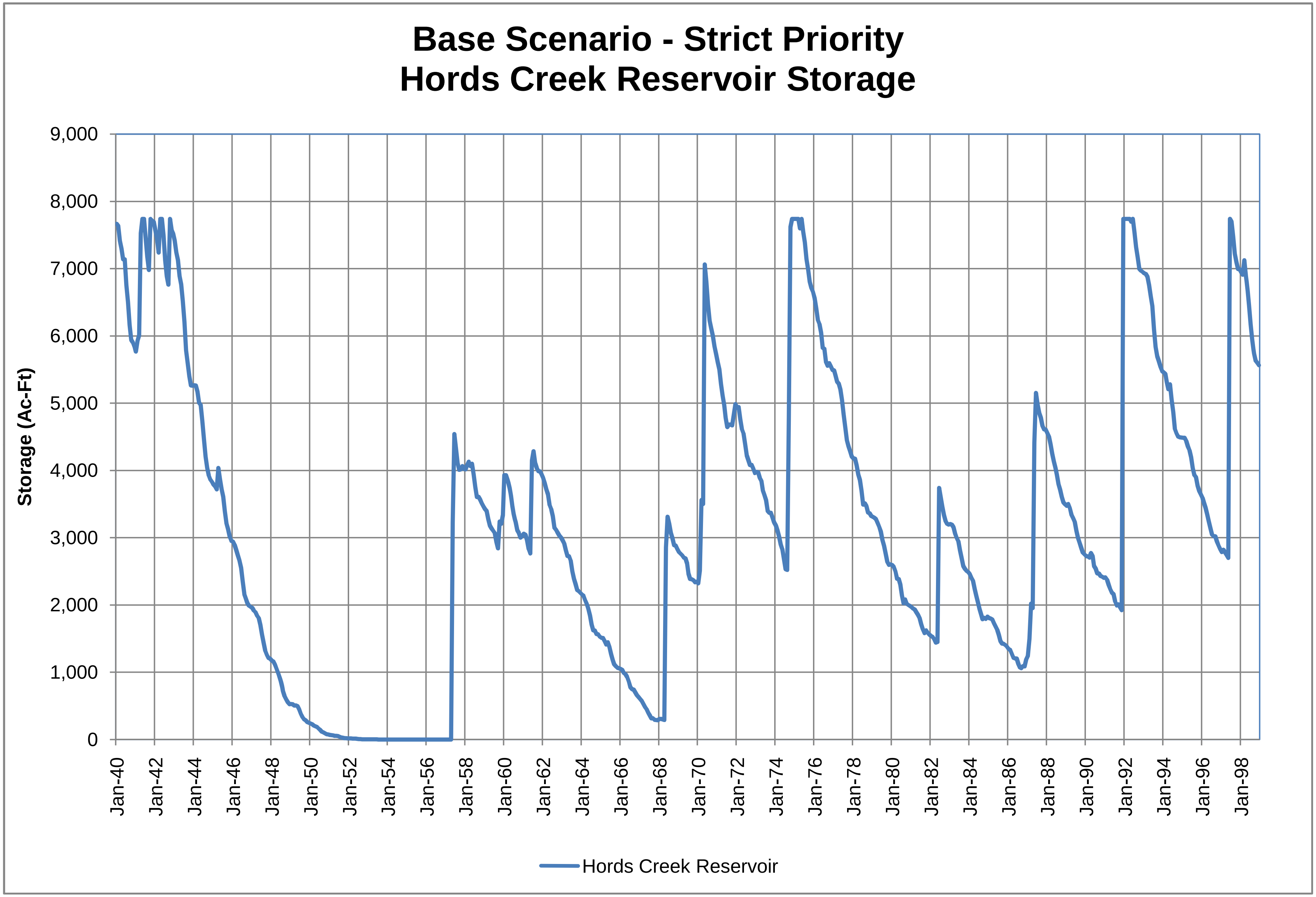

Base Scenario - Strict Priority
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman



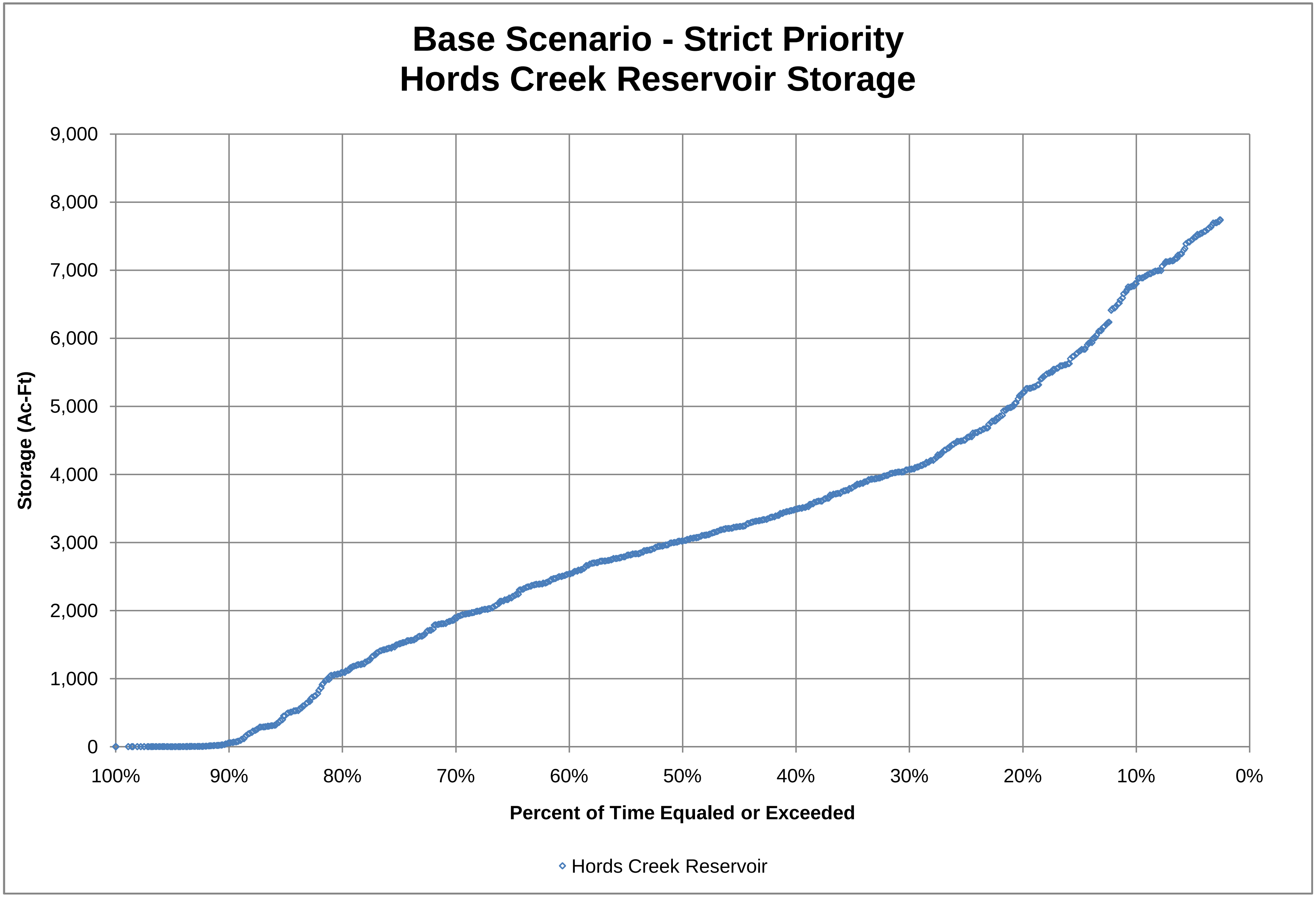
Base Scenario - Strict Priority
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman

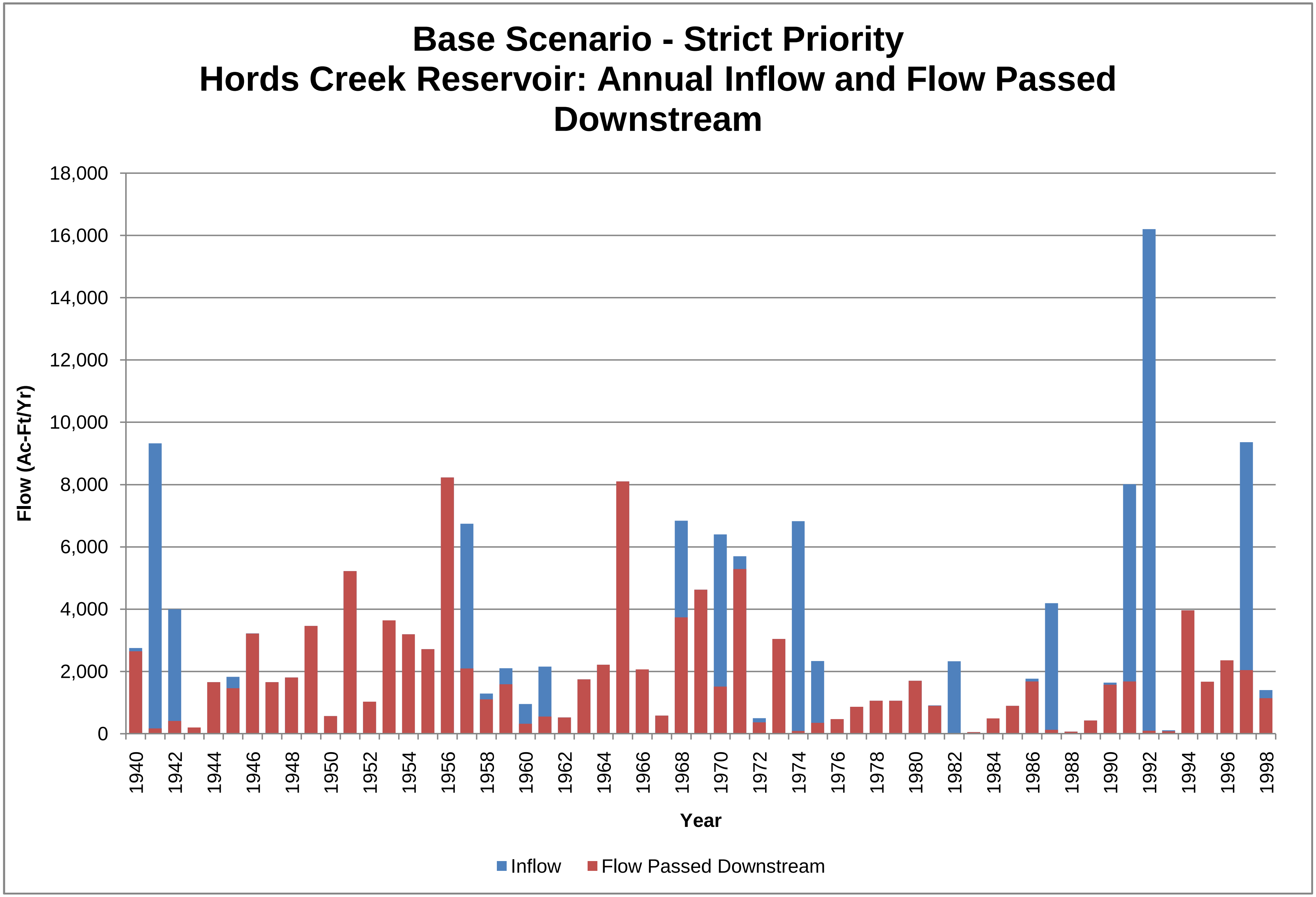


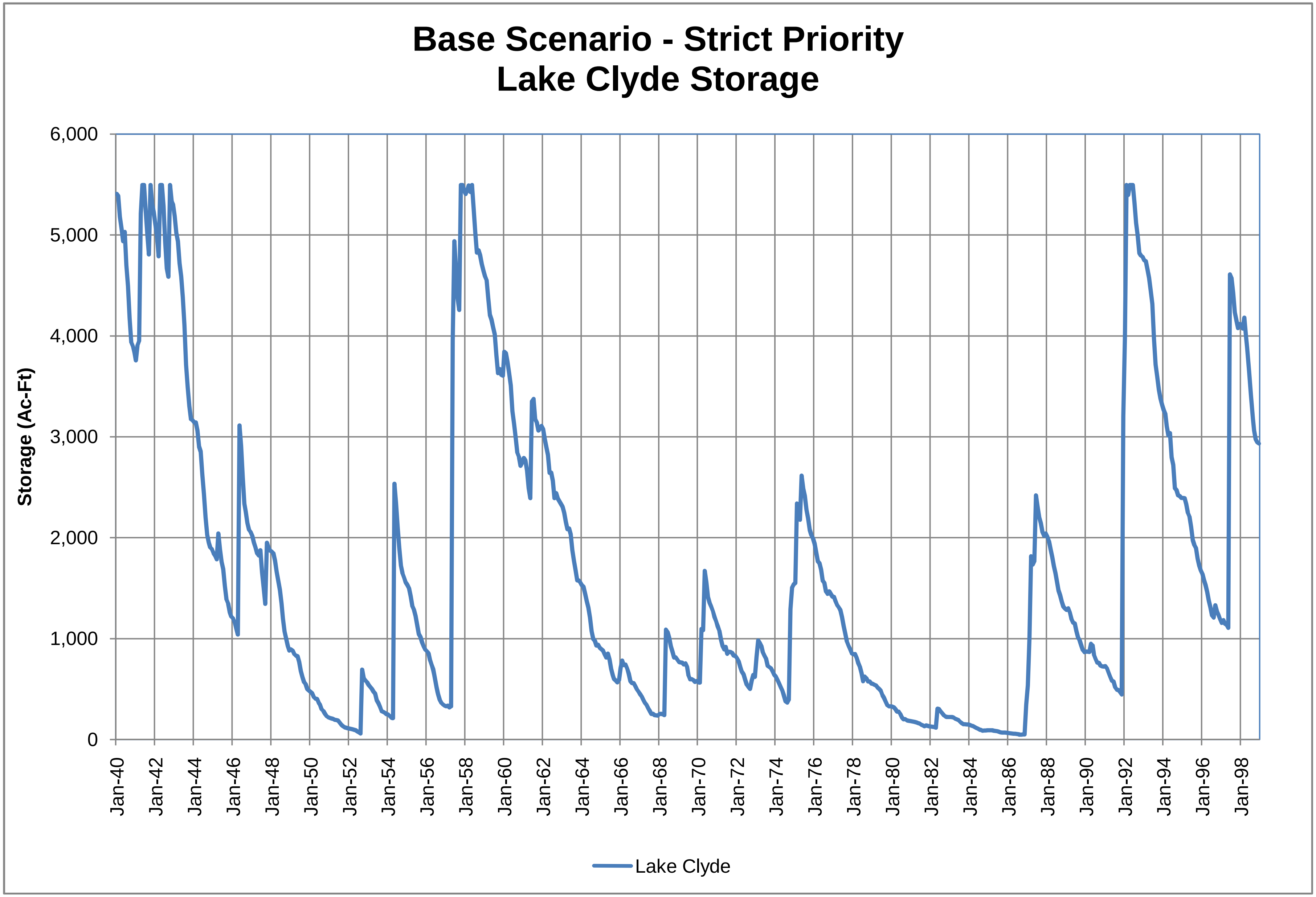
Base Scenario - Strict Priority
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

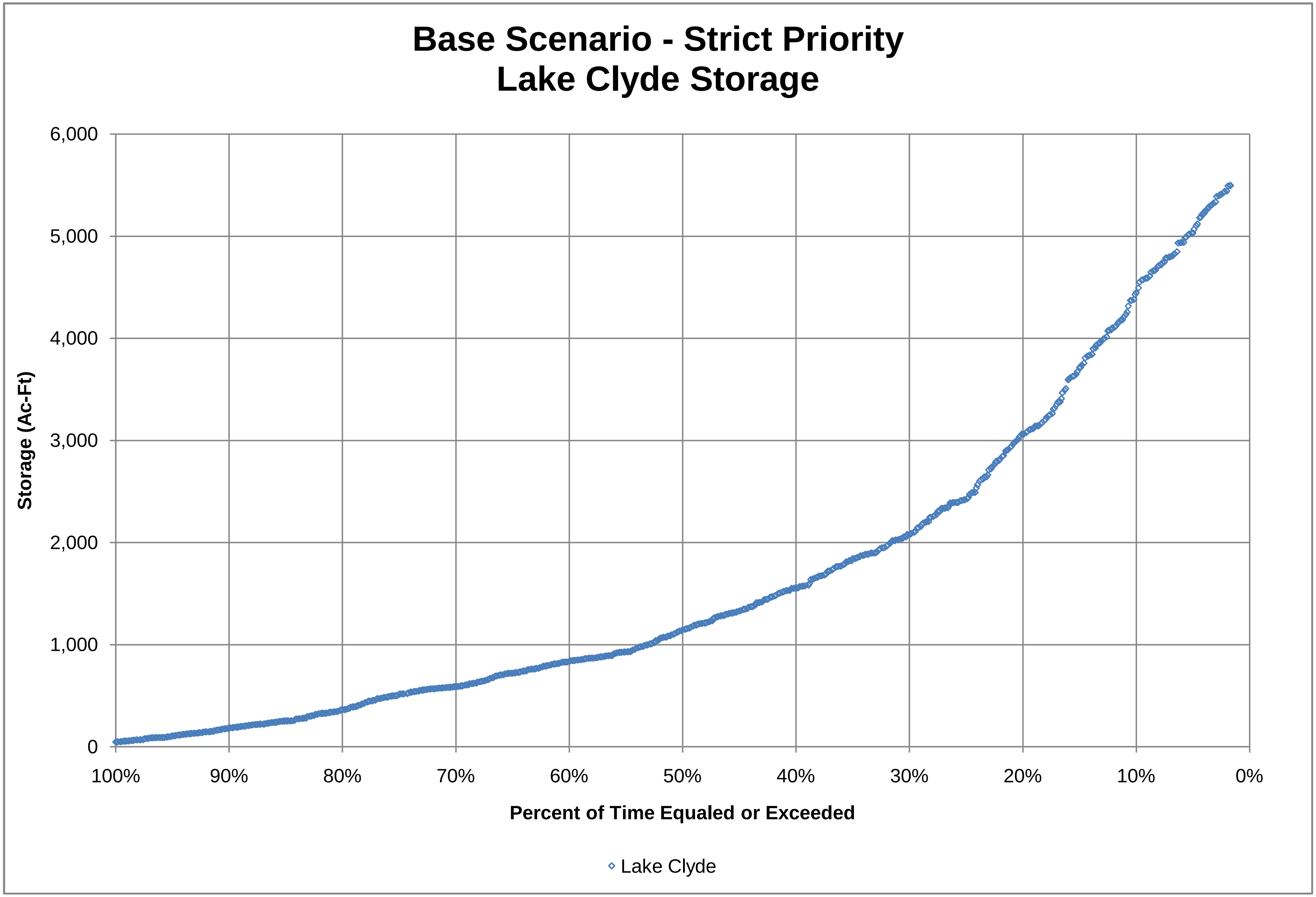


Base Scenario - Strict Priority
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Hords Creek Reservoir

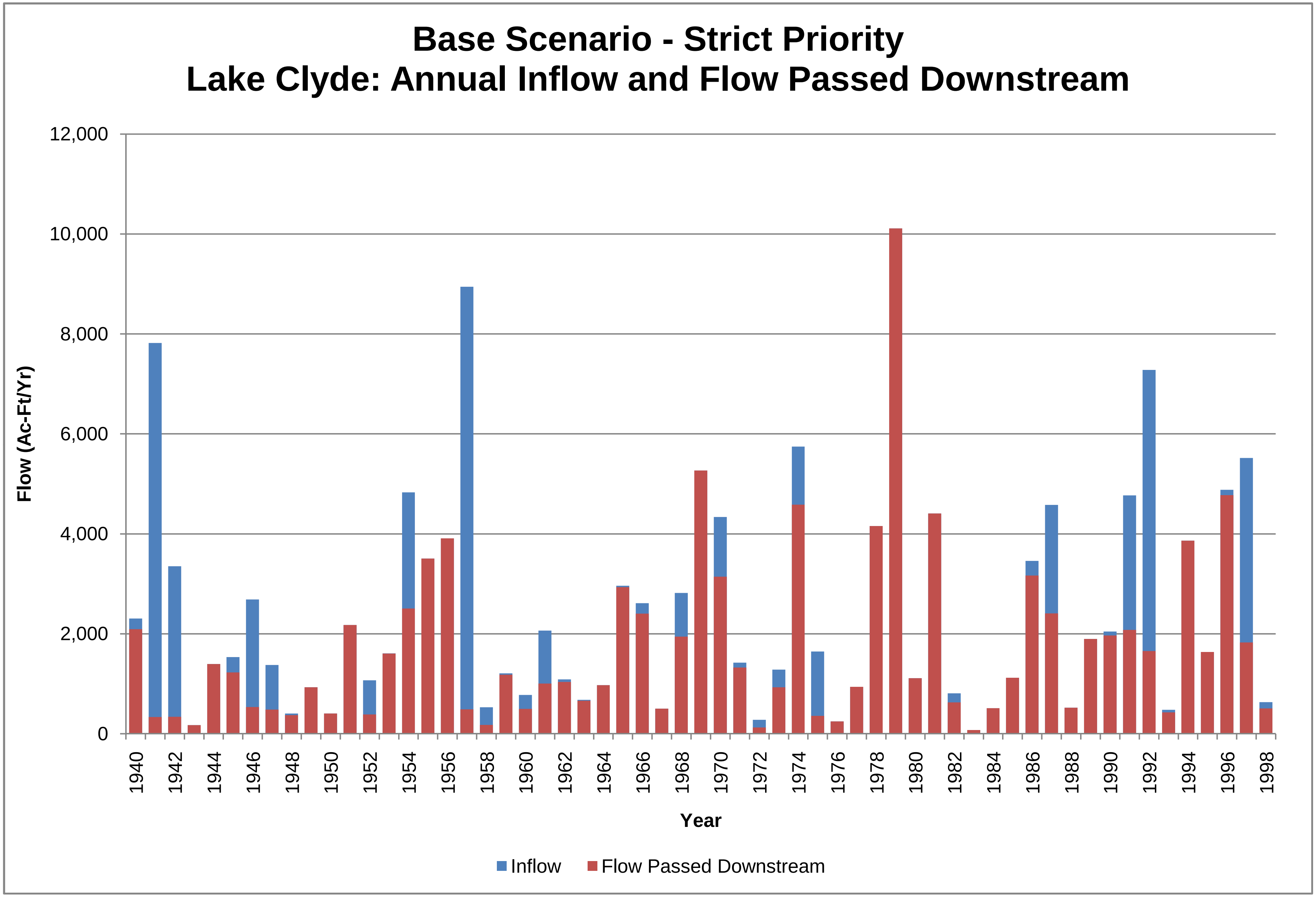

Base Scenario - Strict Priority
Hords Creek Reservoir Storage
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir


Base Scenario - Strict Priority
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream


Base Scenario - Strict Priority
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Clyde



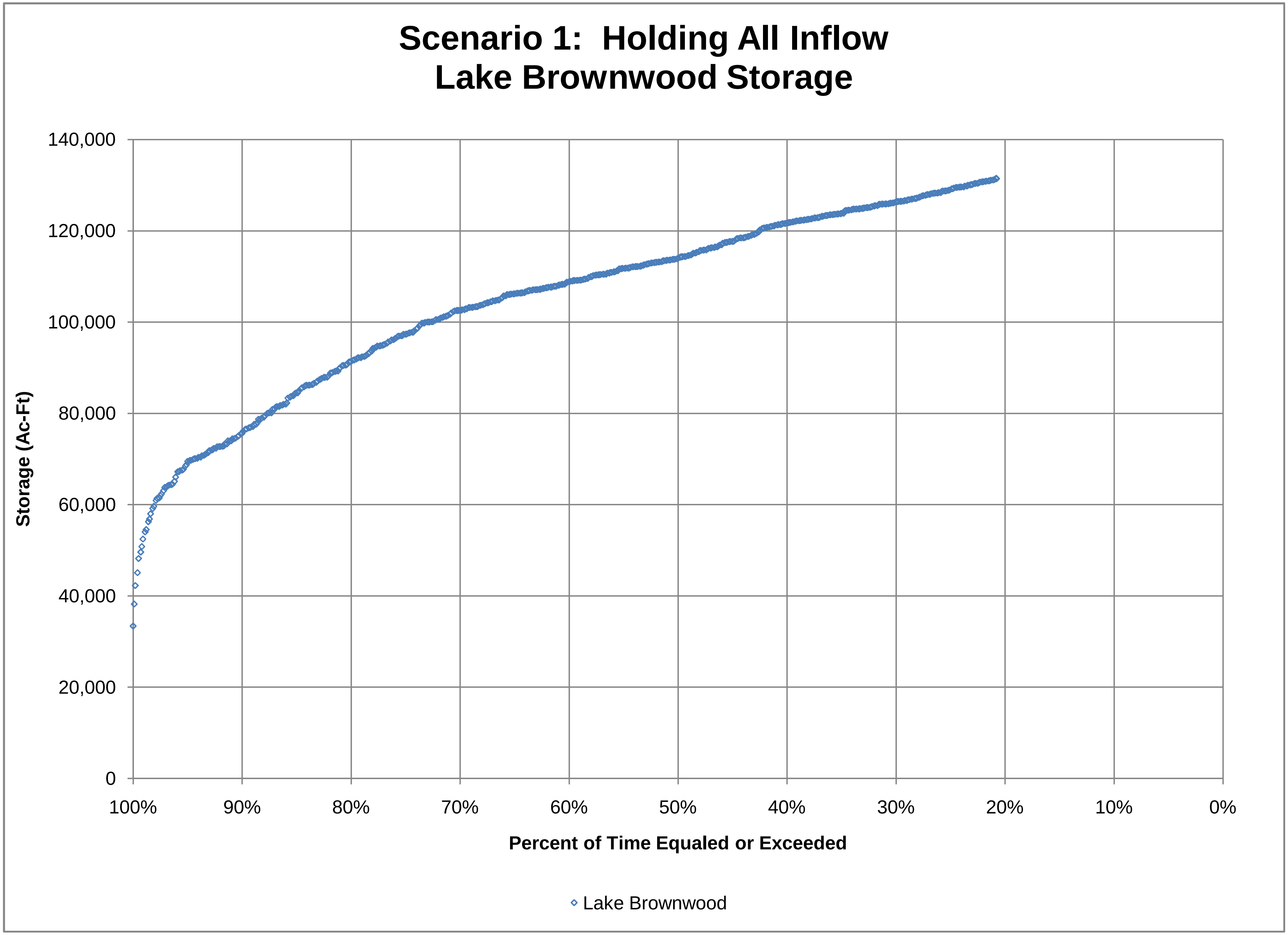
Base Scenario - Strict Priority
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde



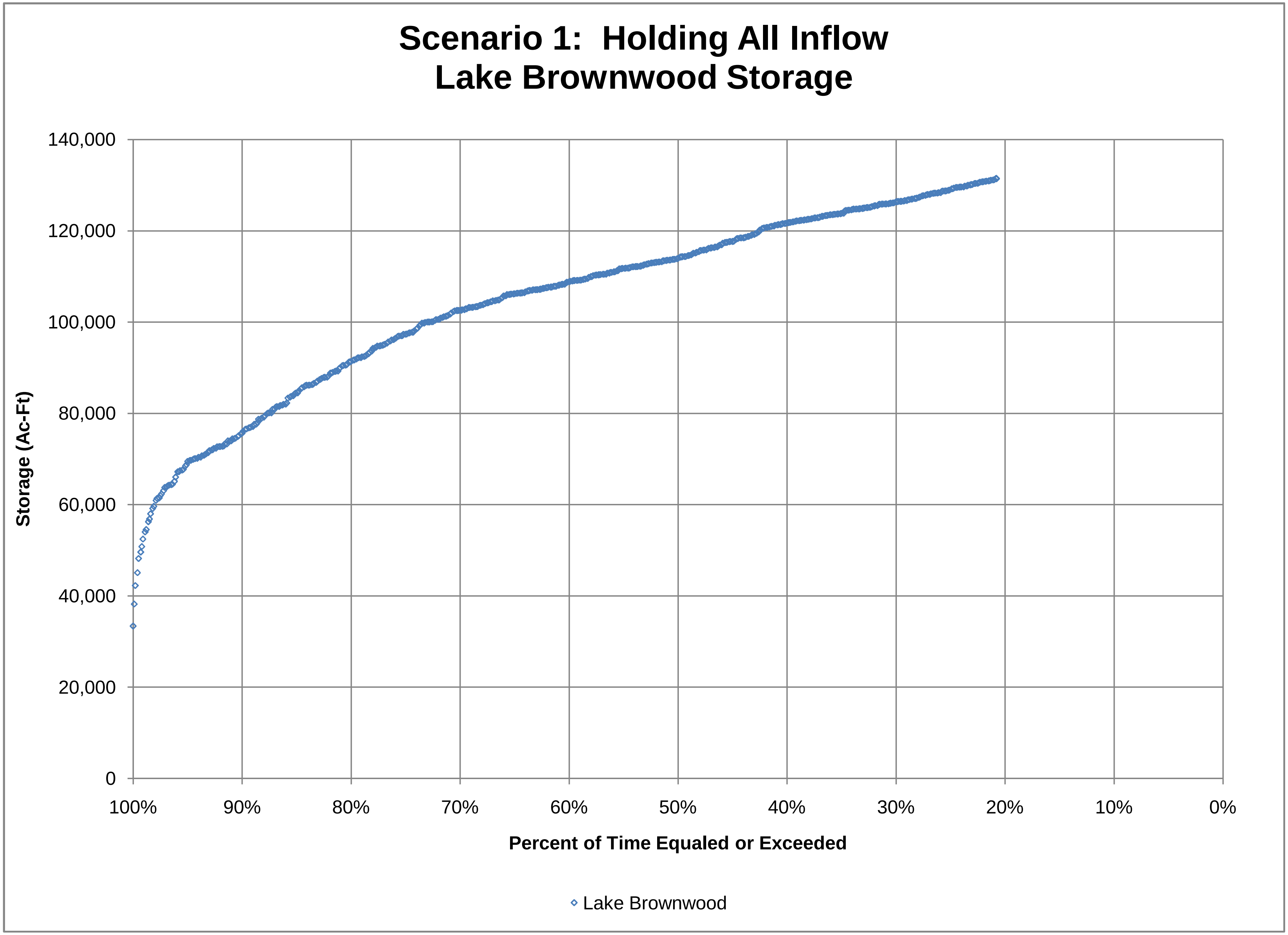
Base Scenario - Strict Priority
Lake Clyde: Annual Inflow and Flow Passed Downstream
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (Ac-Ft/Yr)
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

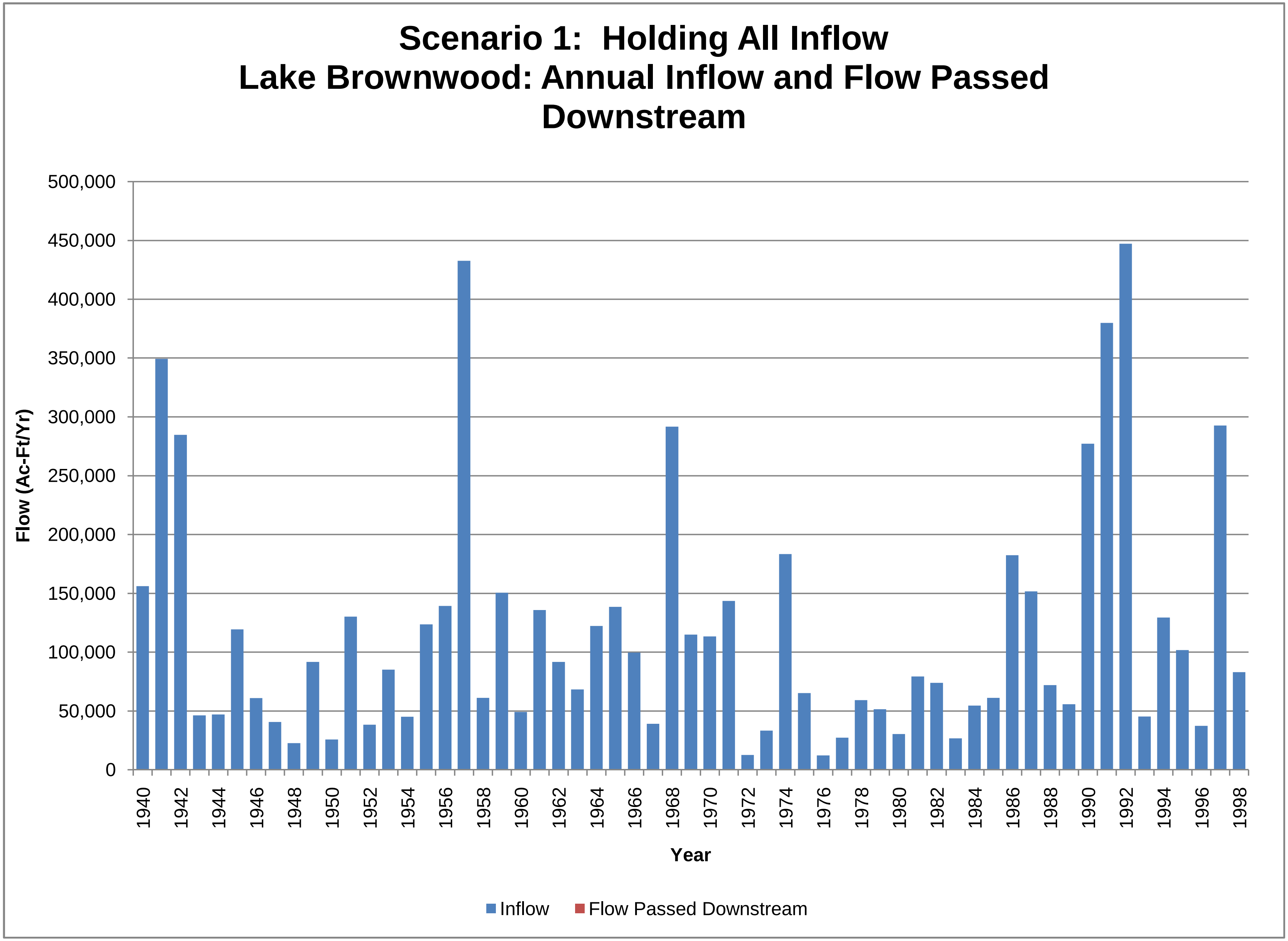
Scenario 1: Holding All Inflow

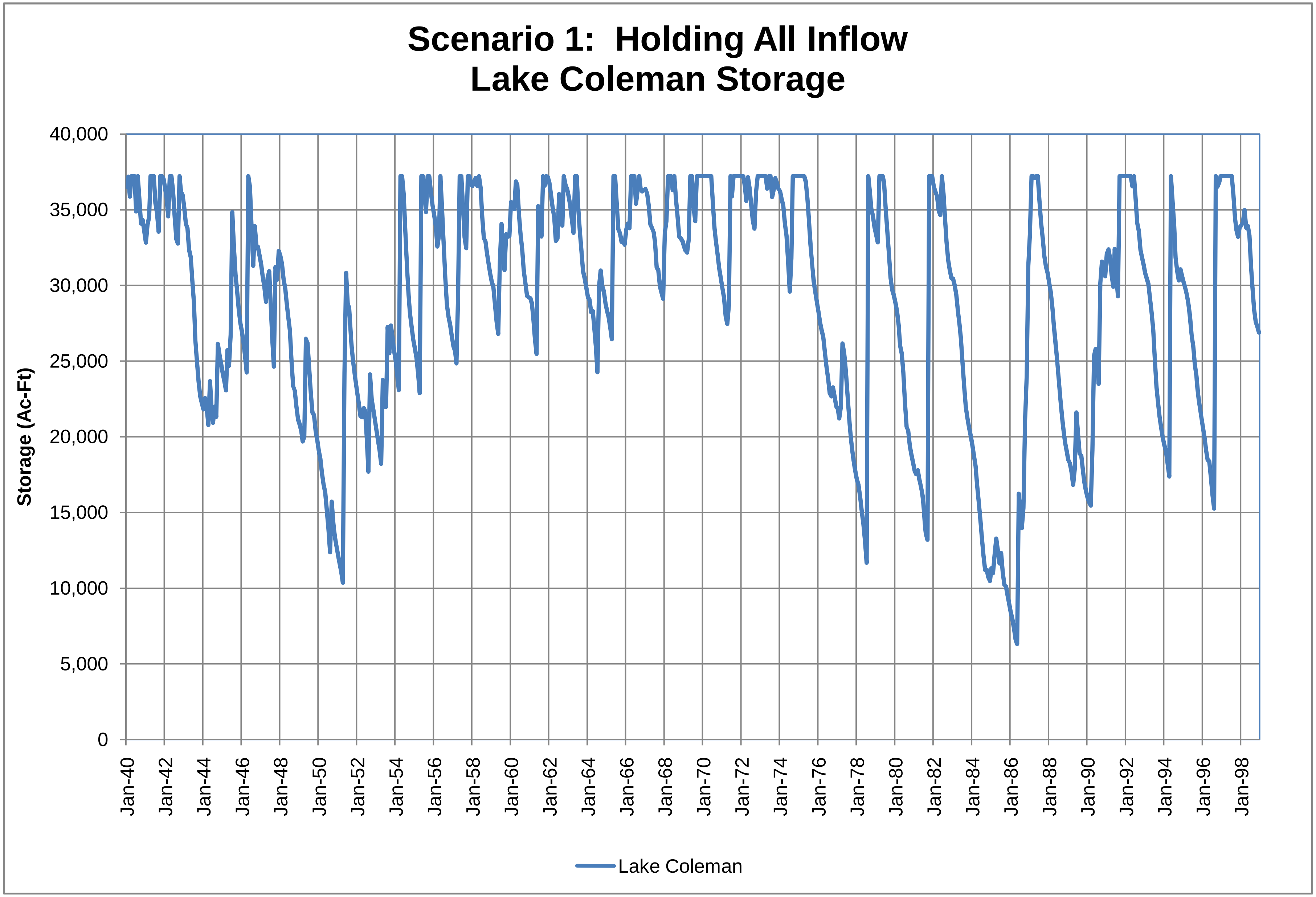
Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream



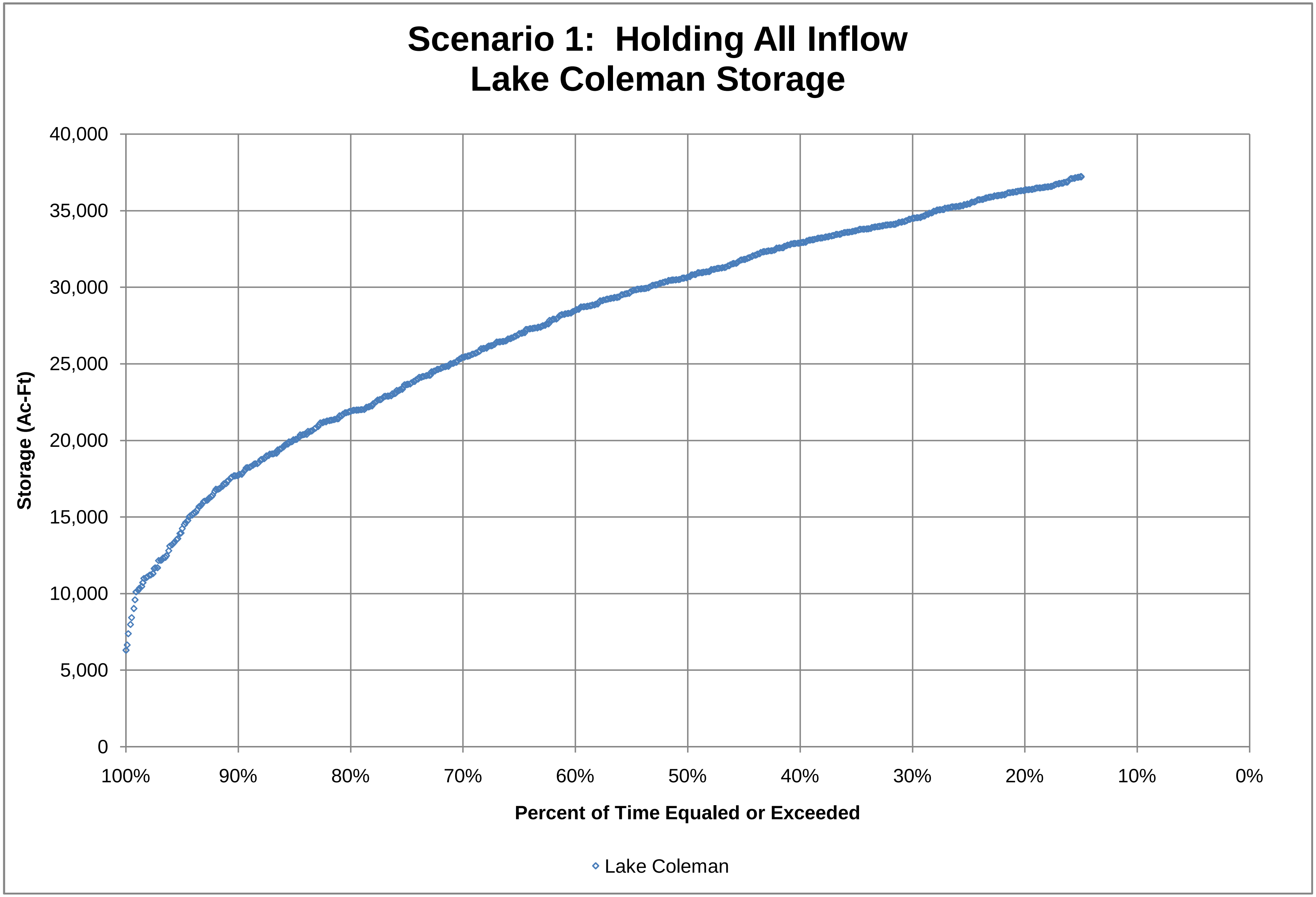
Scenario 1: Holding All Inflow
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood

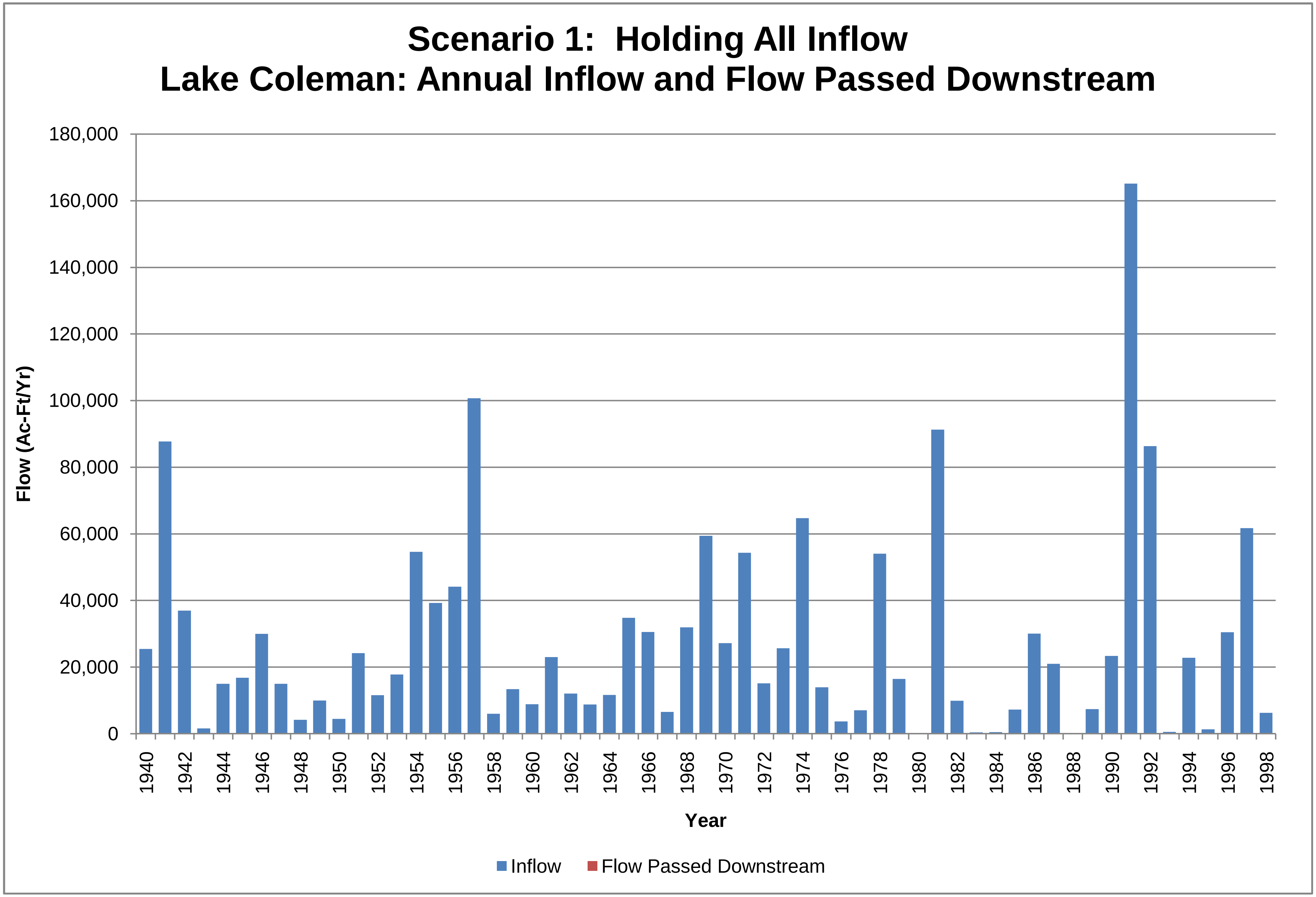

Scenario 1: Holding All Inflow
Lake Brownwood Storage
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood

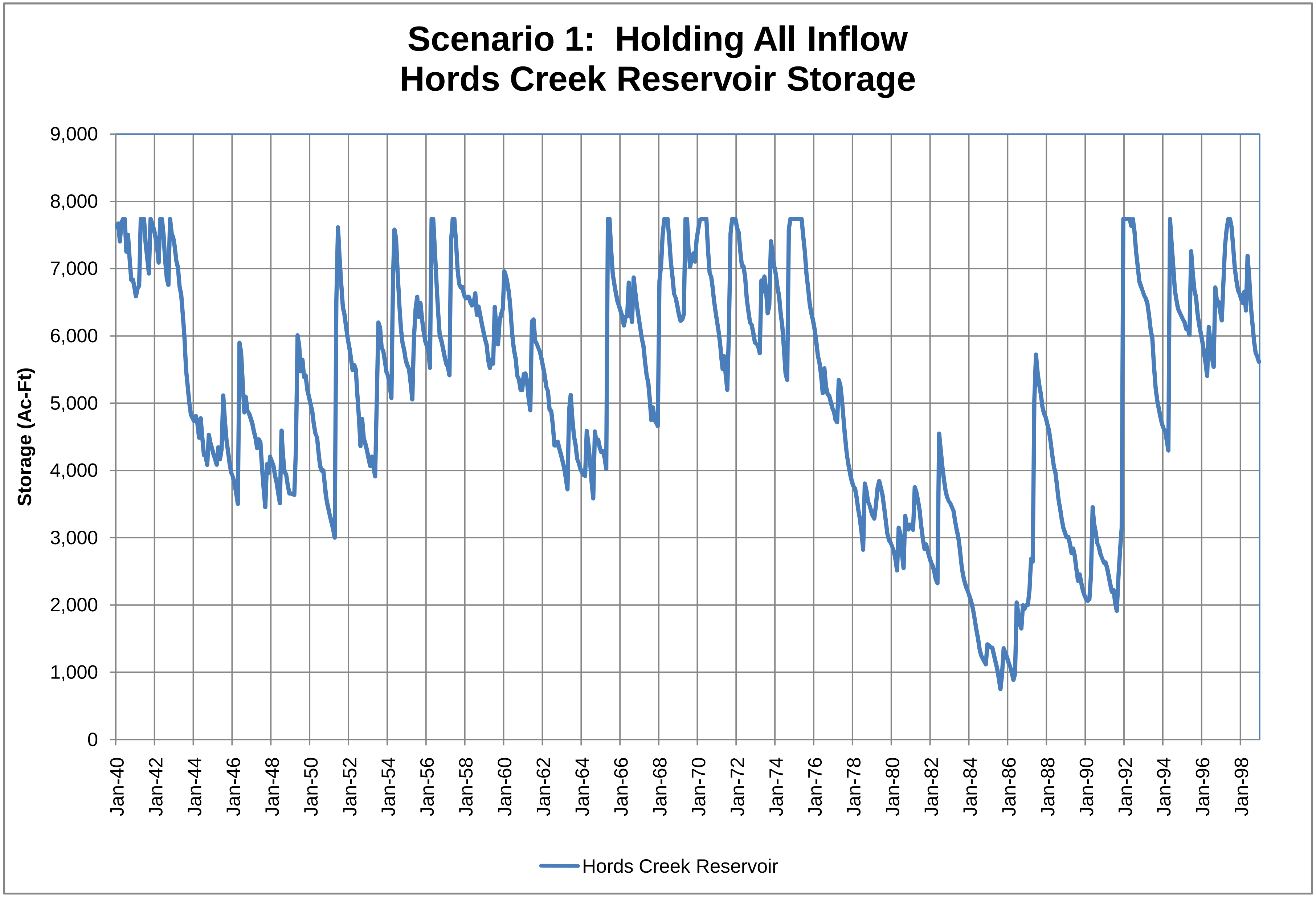

Scenario 1: Holding All Inflow
Lake Brownwood: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream



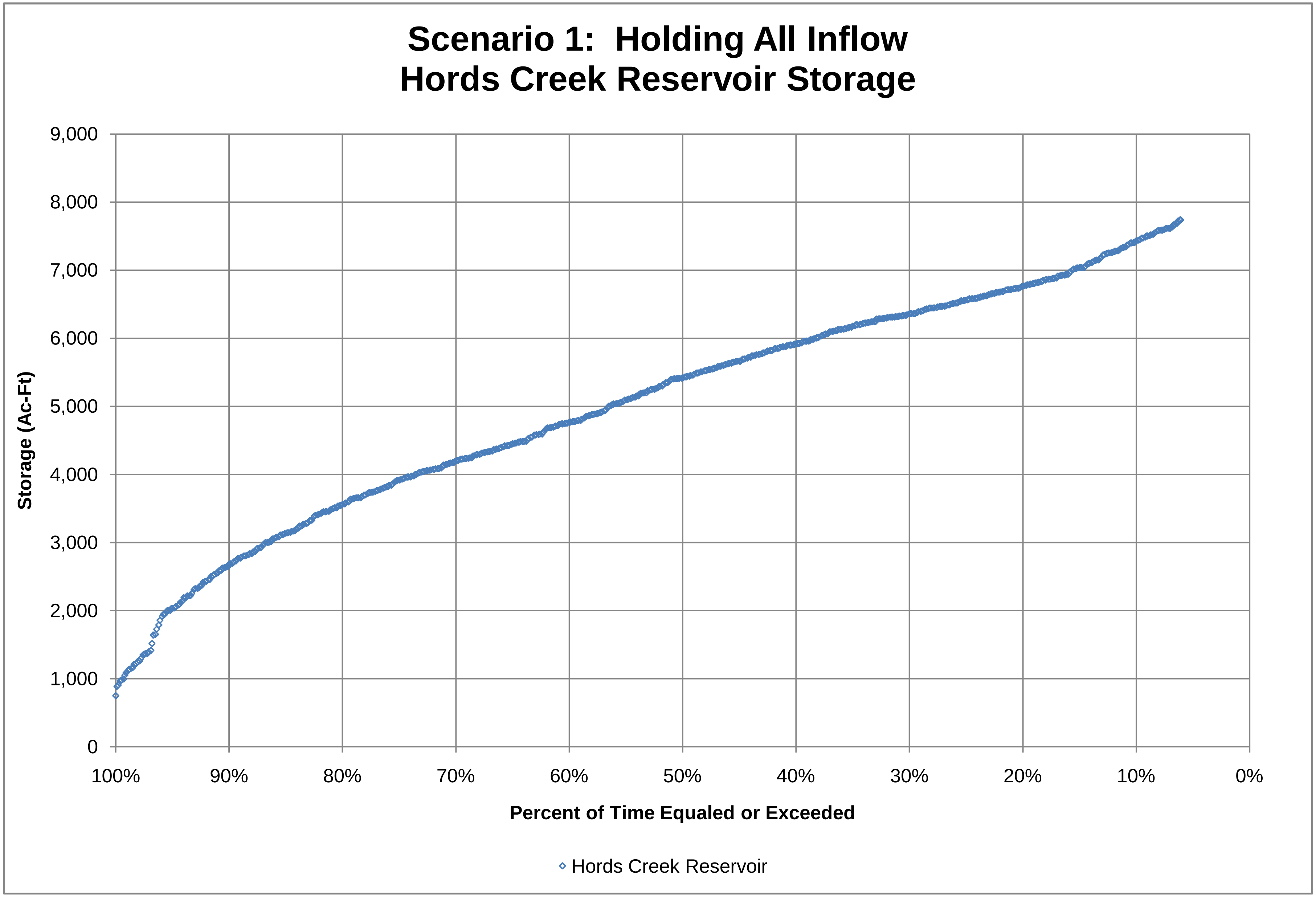
Scenario 1: Holding All Inflow
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman


Scenario 1: Holding All Inflow
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman

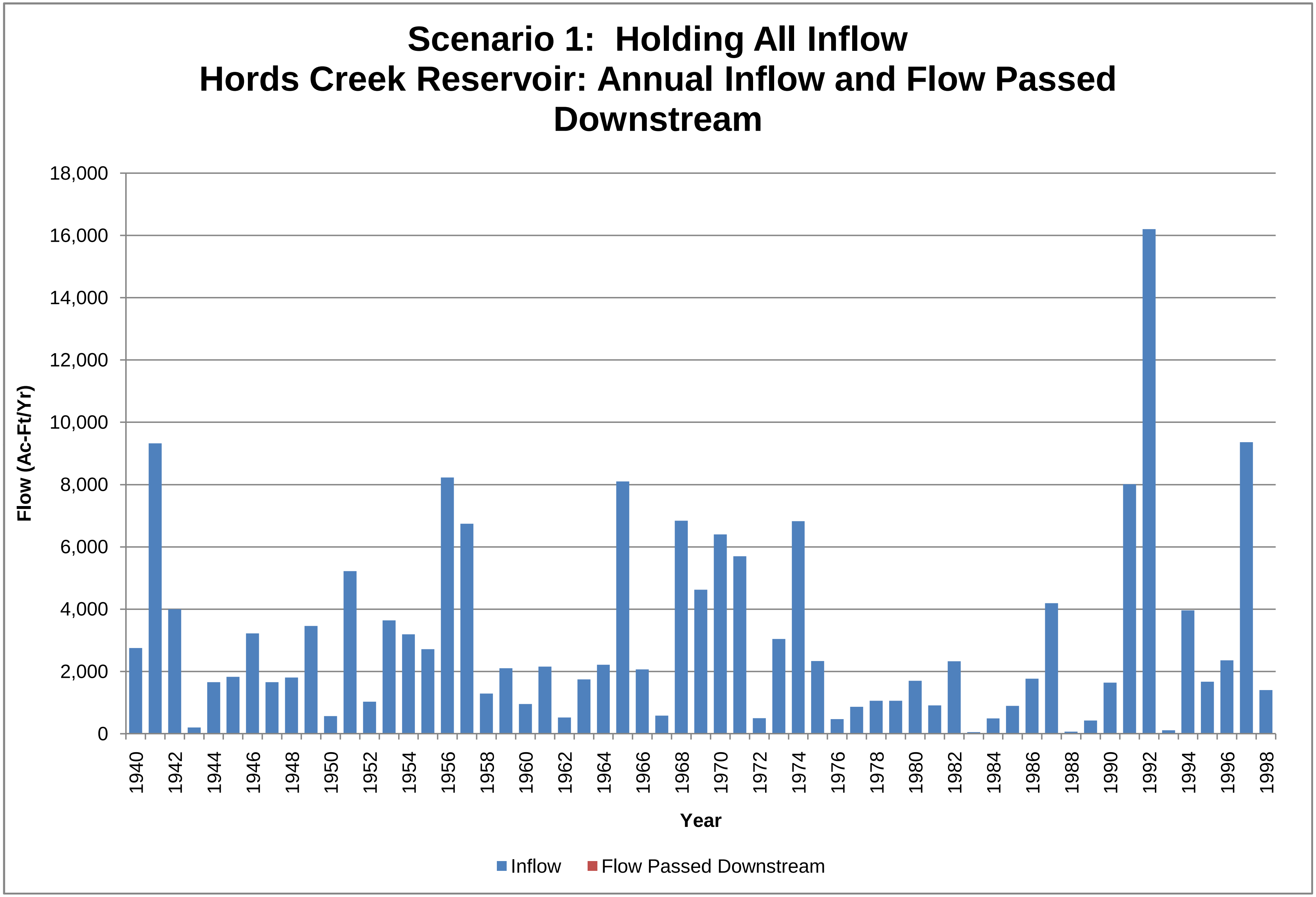

Scenario 1: Holding All Inflow
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream



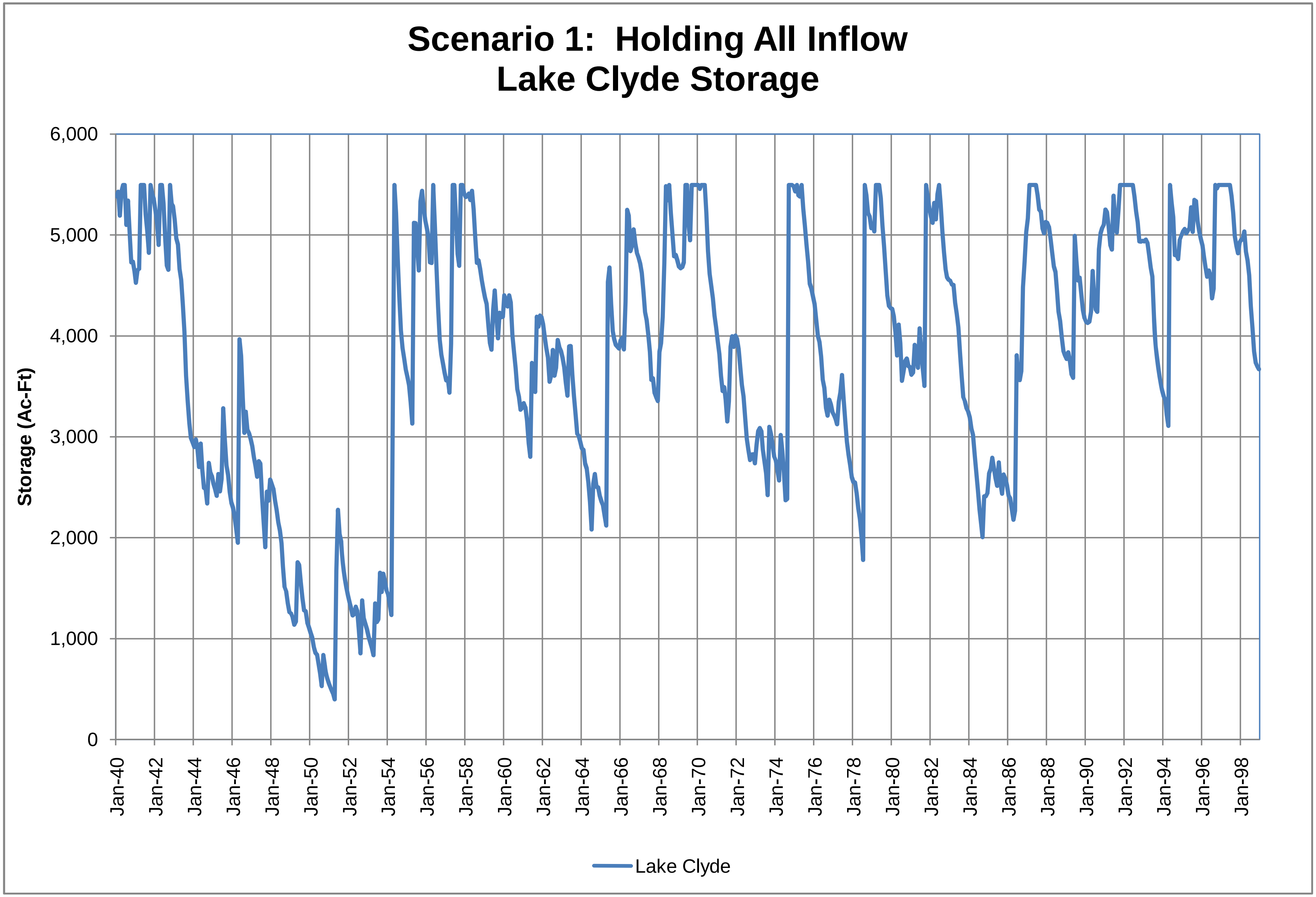
Scenario 1: Holding All Inflow
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Hords Creek Reservoir

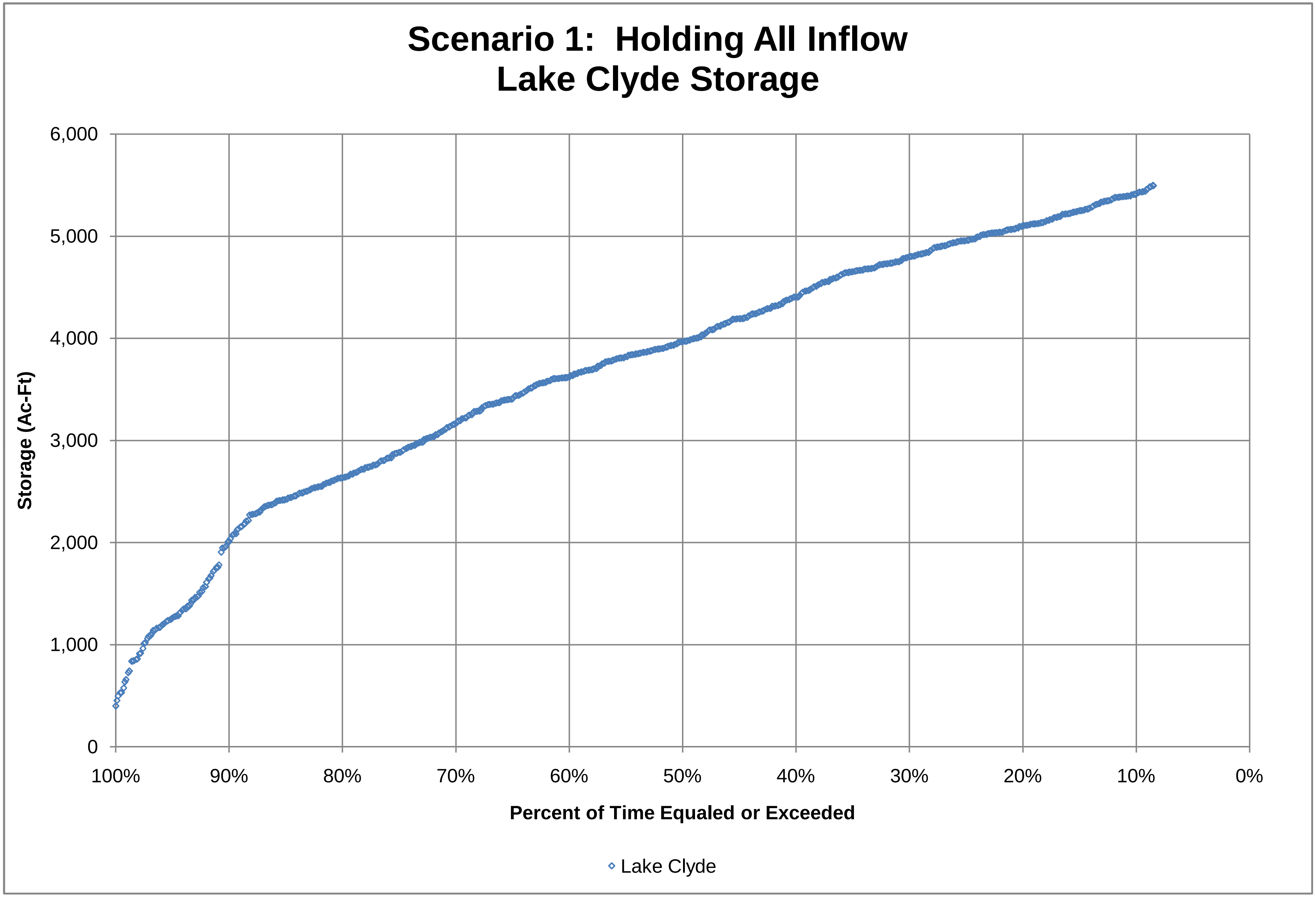


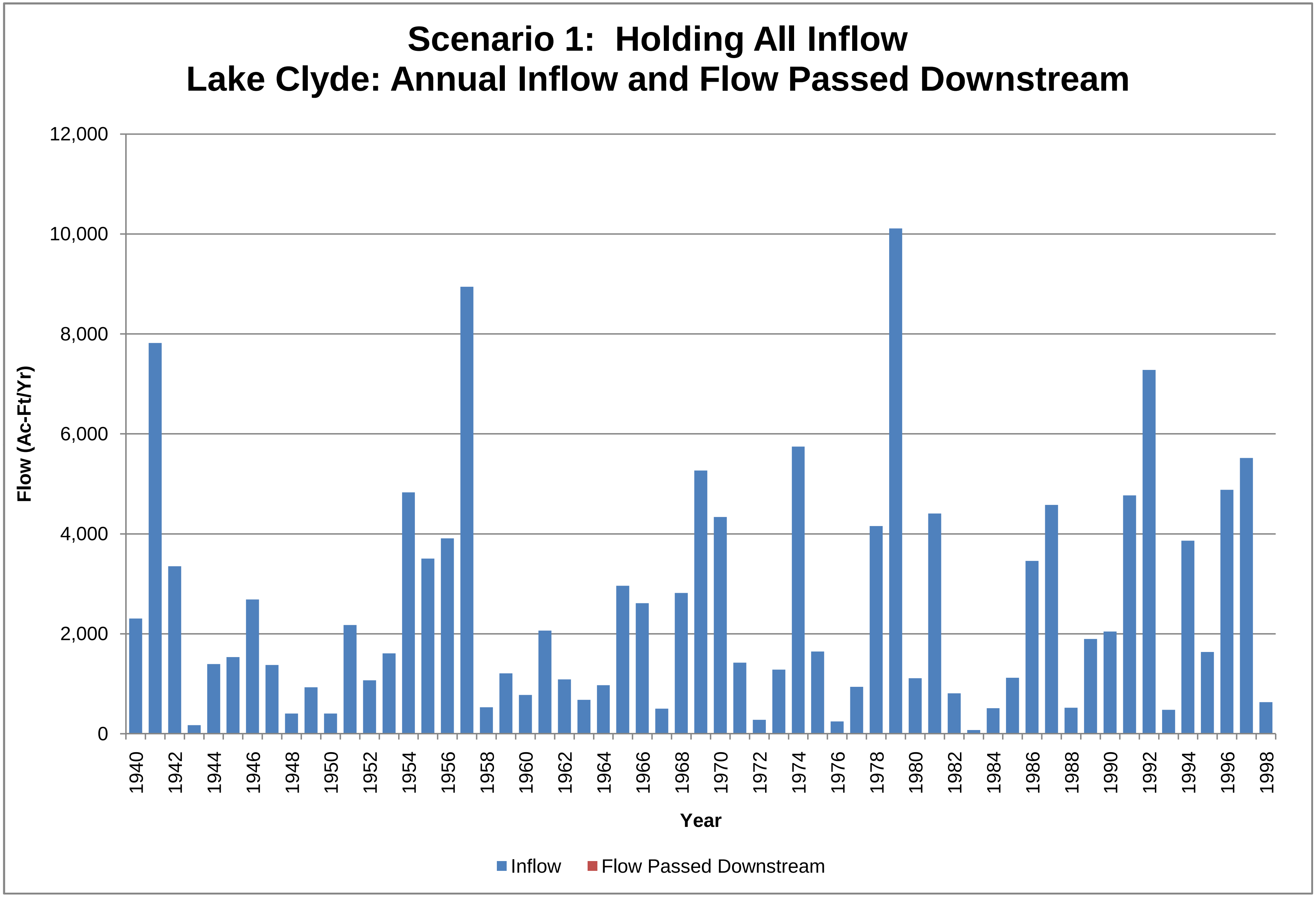
Scenario 1: Holding All Inflow
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir



Scenario 1: Holding All Inflow
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

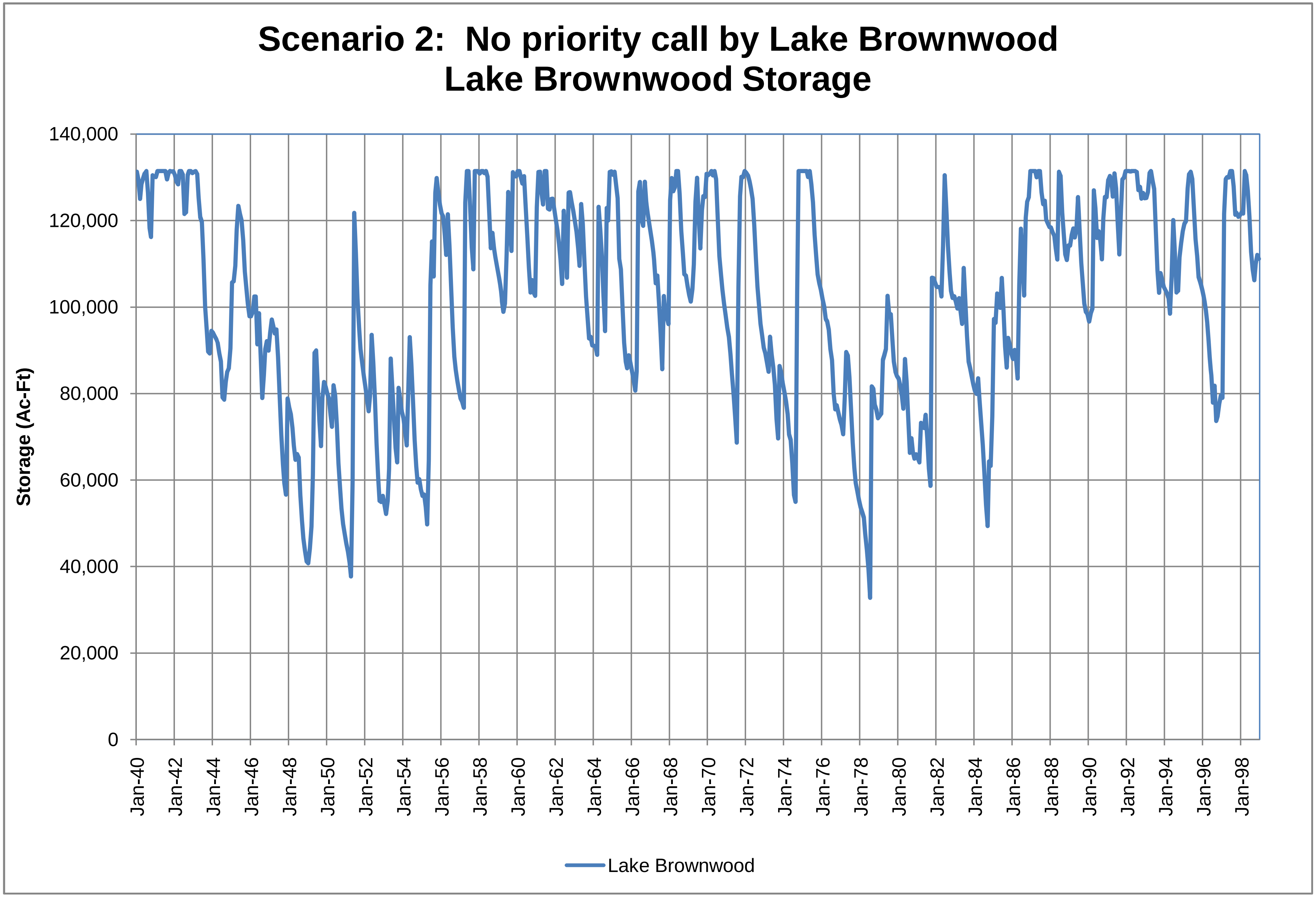

Scenario 1: Holding All Inflow
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Clyde

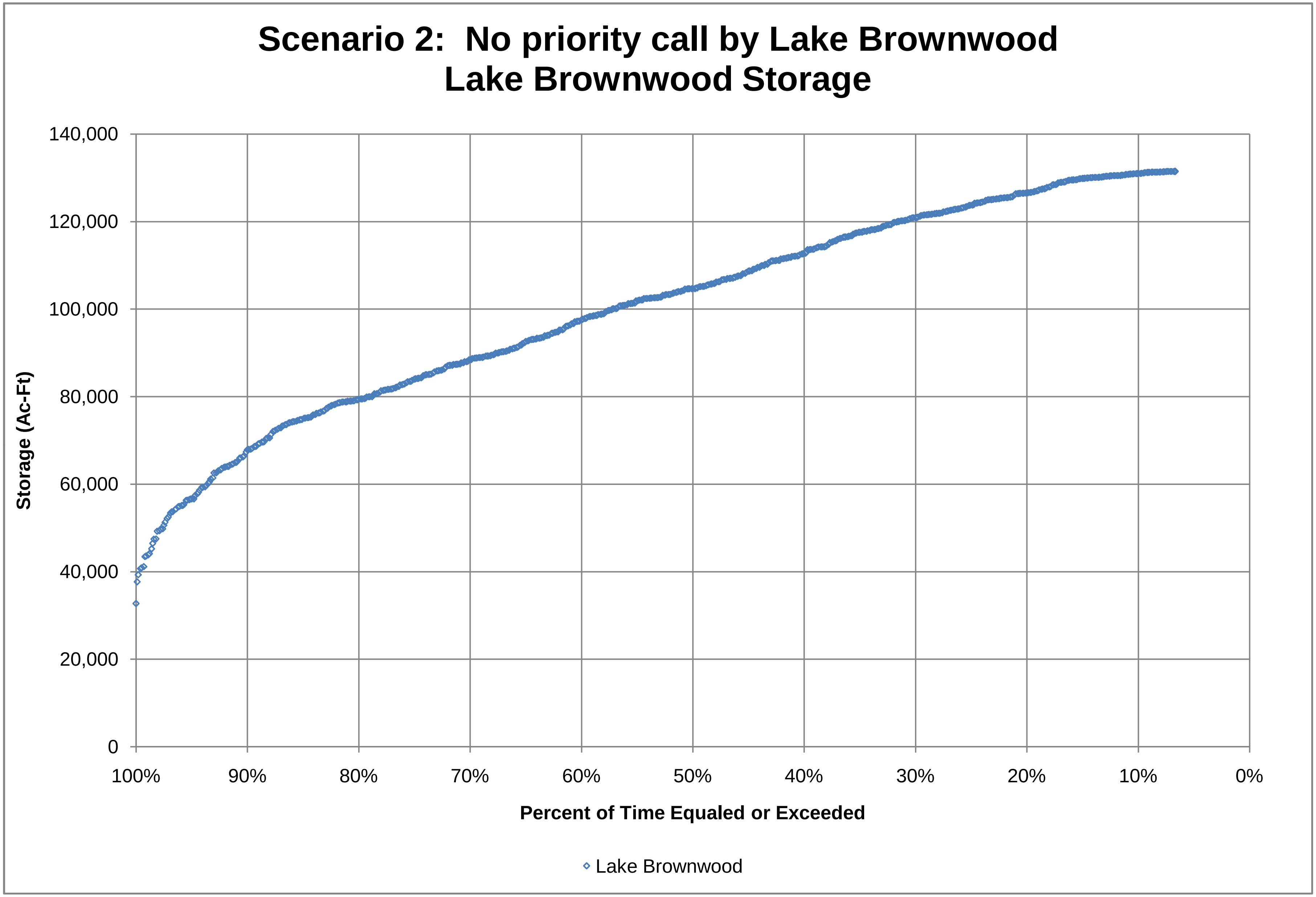

Scenario 1: Holding All Inflow
Lake Clyde Storage
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde

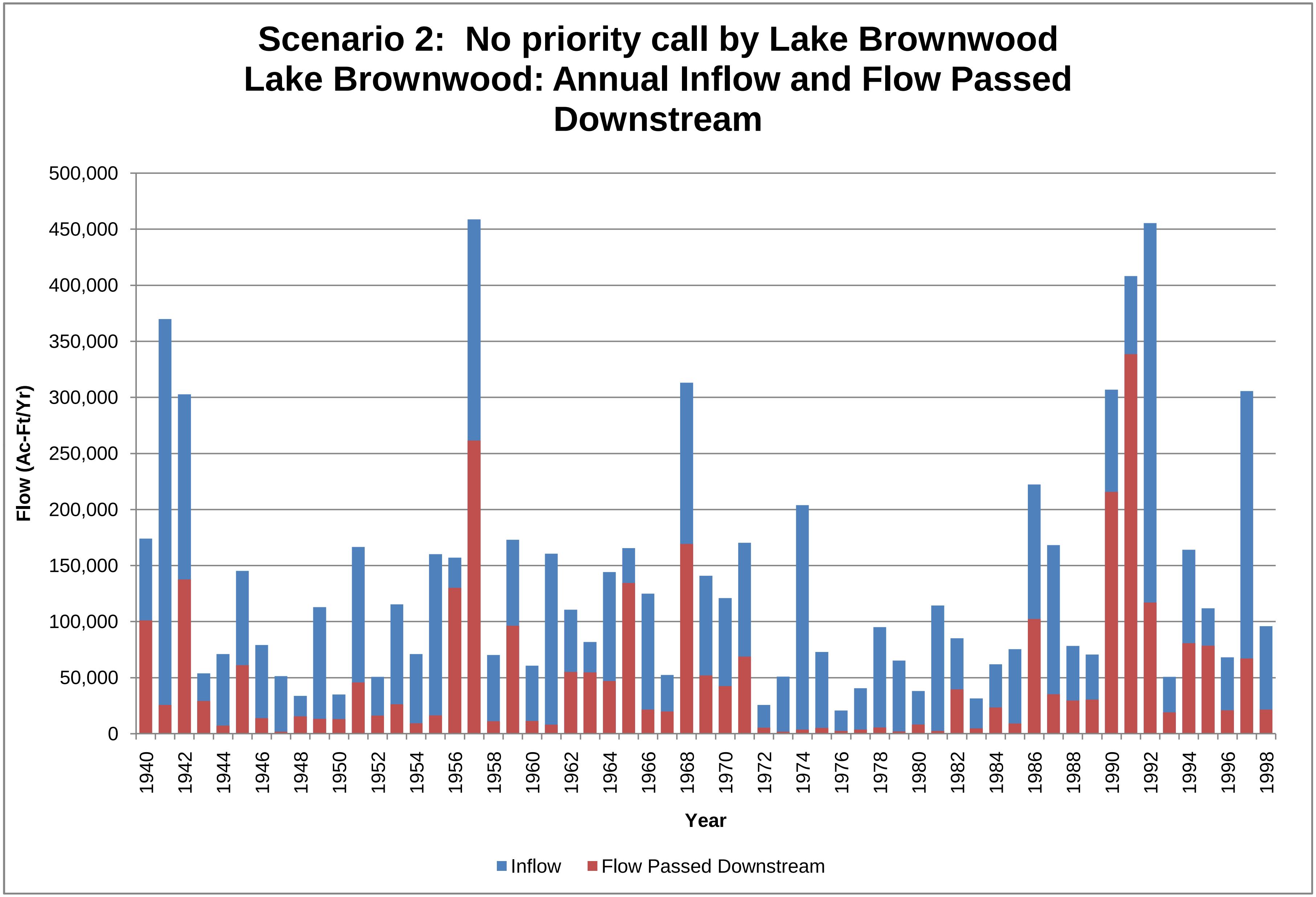

Scenario 1: Holding All Inflow
Lake Clyde: Annual Inflow and Flow Passed Downstream
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (Ac-Ft/Yr)
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

Scenario 2: No priority call by Lake Brownwood

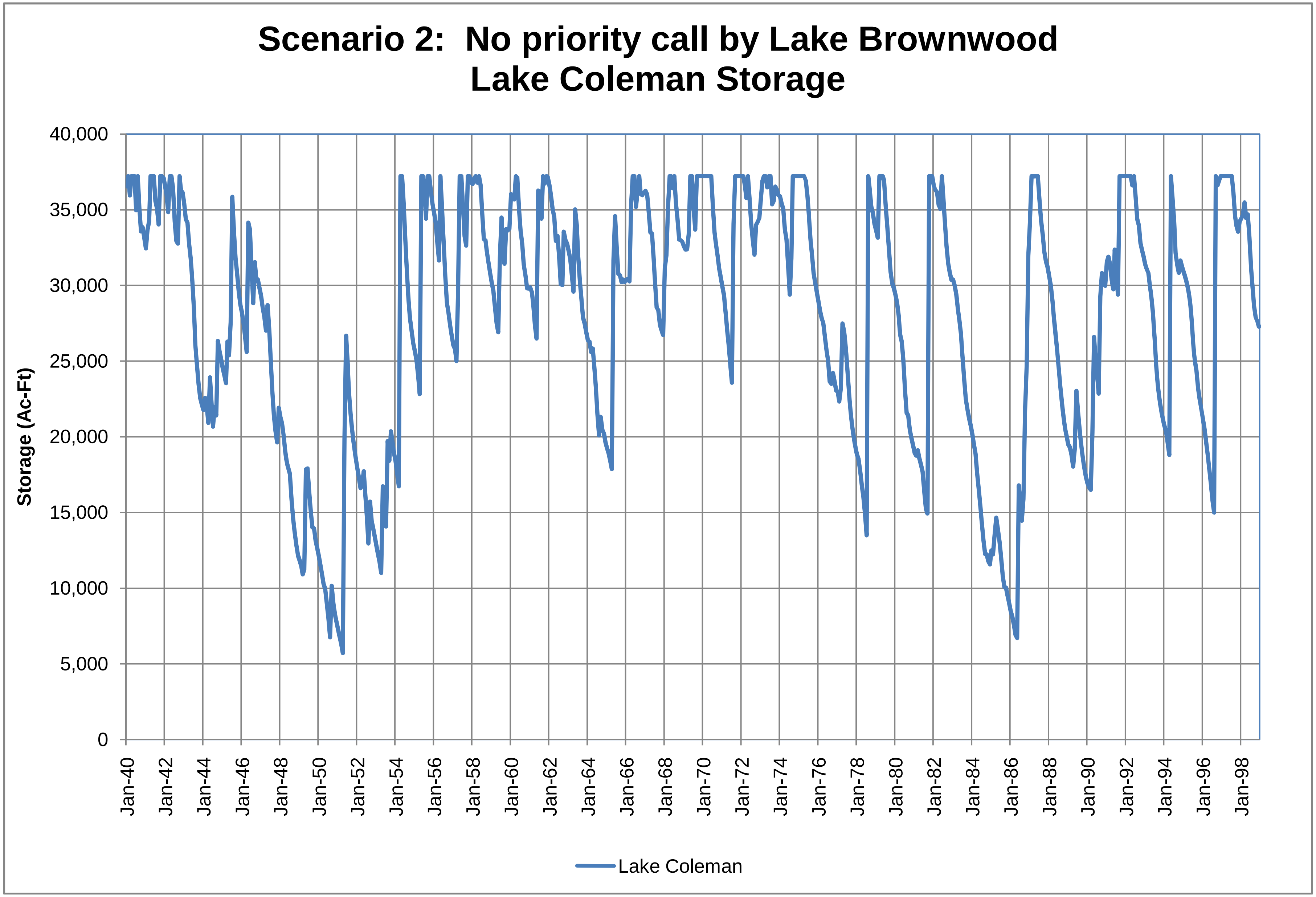
Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream


Scenario 2: No priority call by Lake Brownwood
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Brownwood

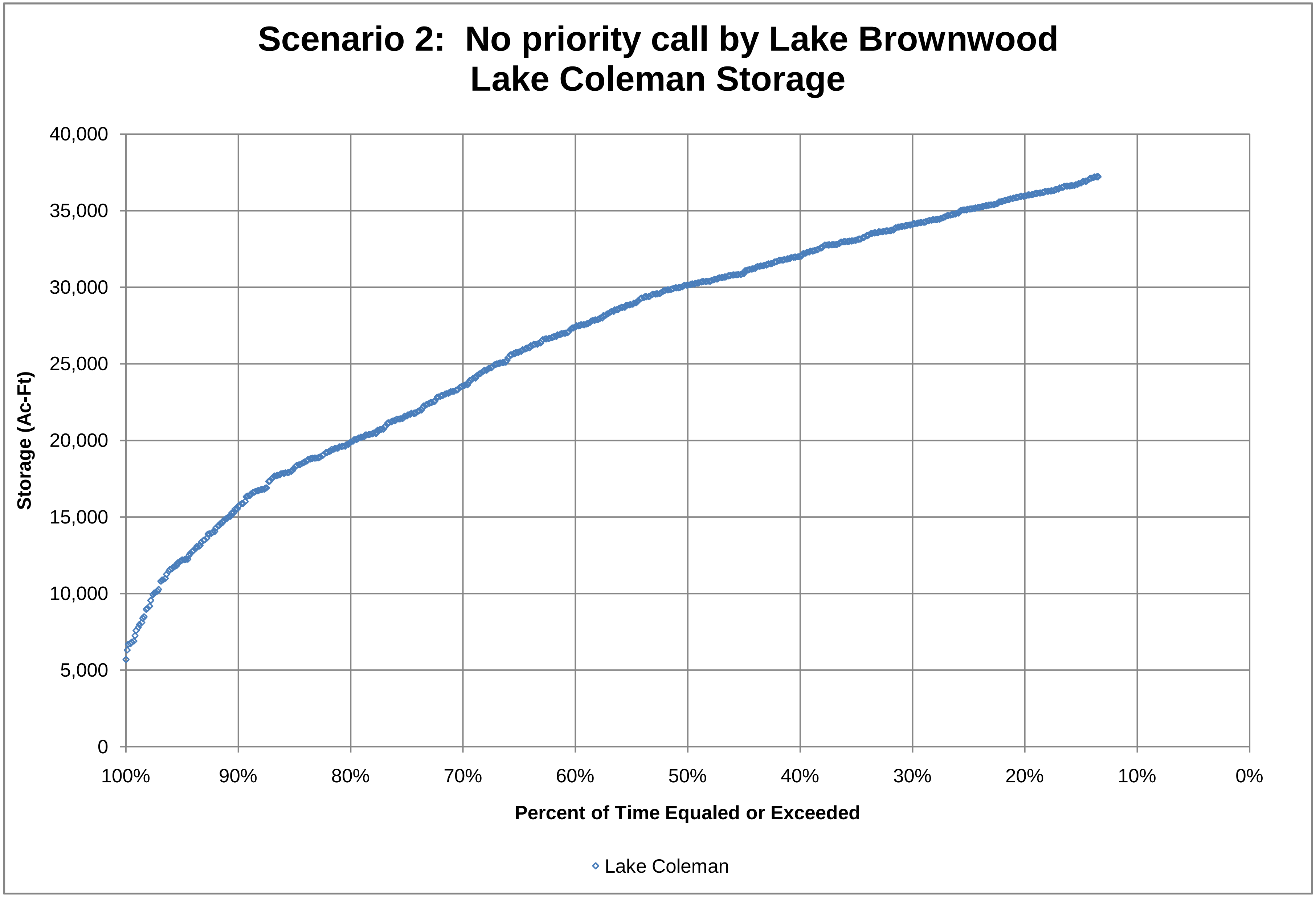

Scenario 2: No priority call by Lake Brownwood
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood

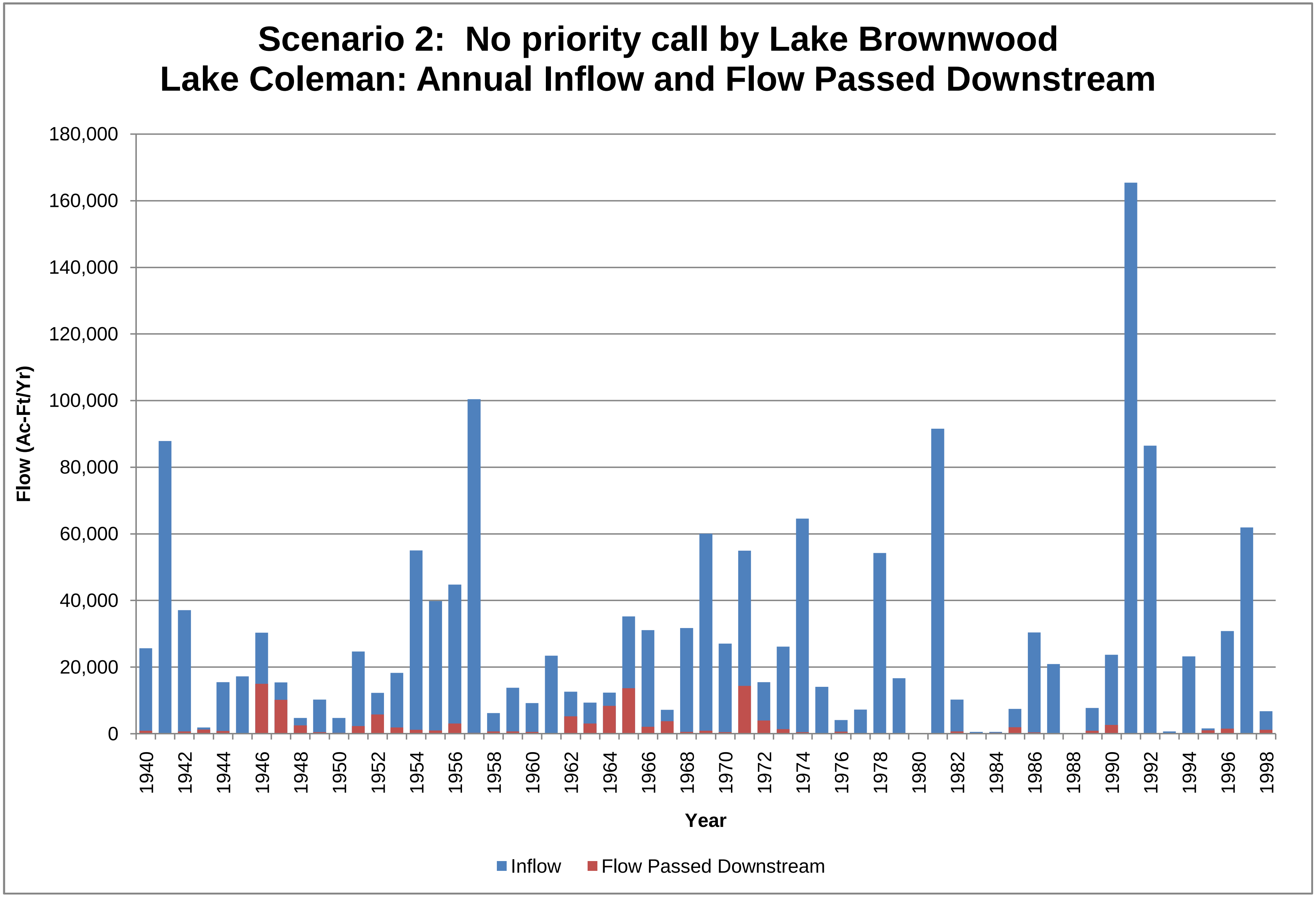


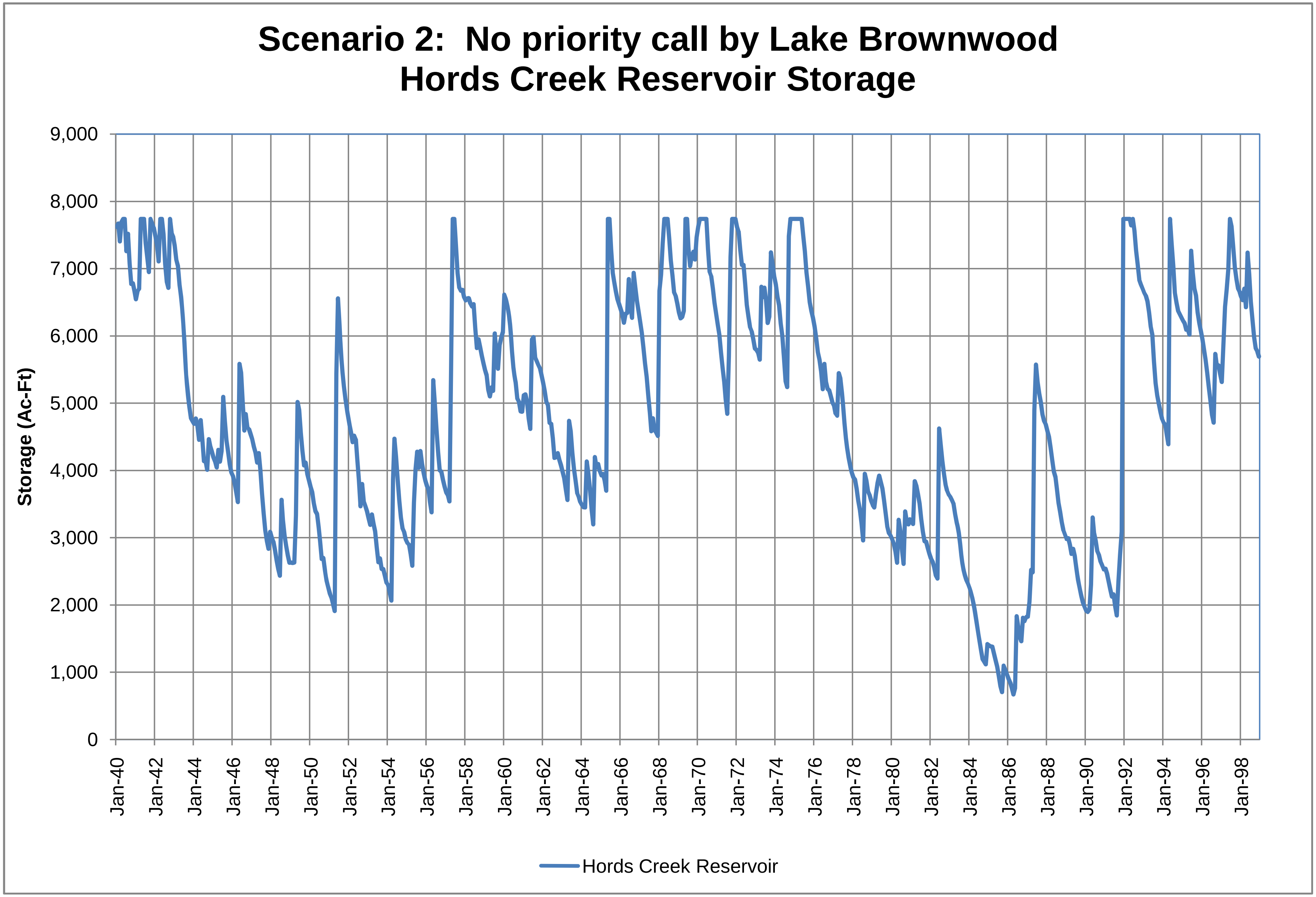
Scenario 2: No priority call by Lake Brownwood
Lake Brownwood: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

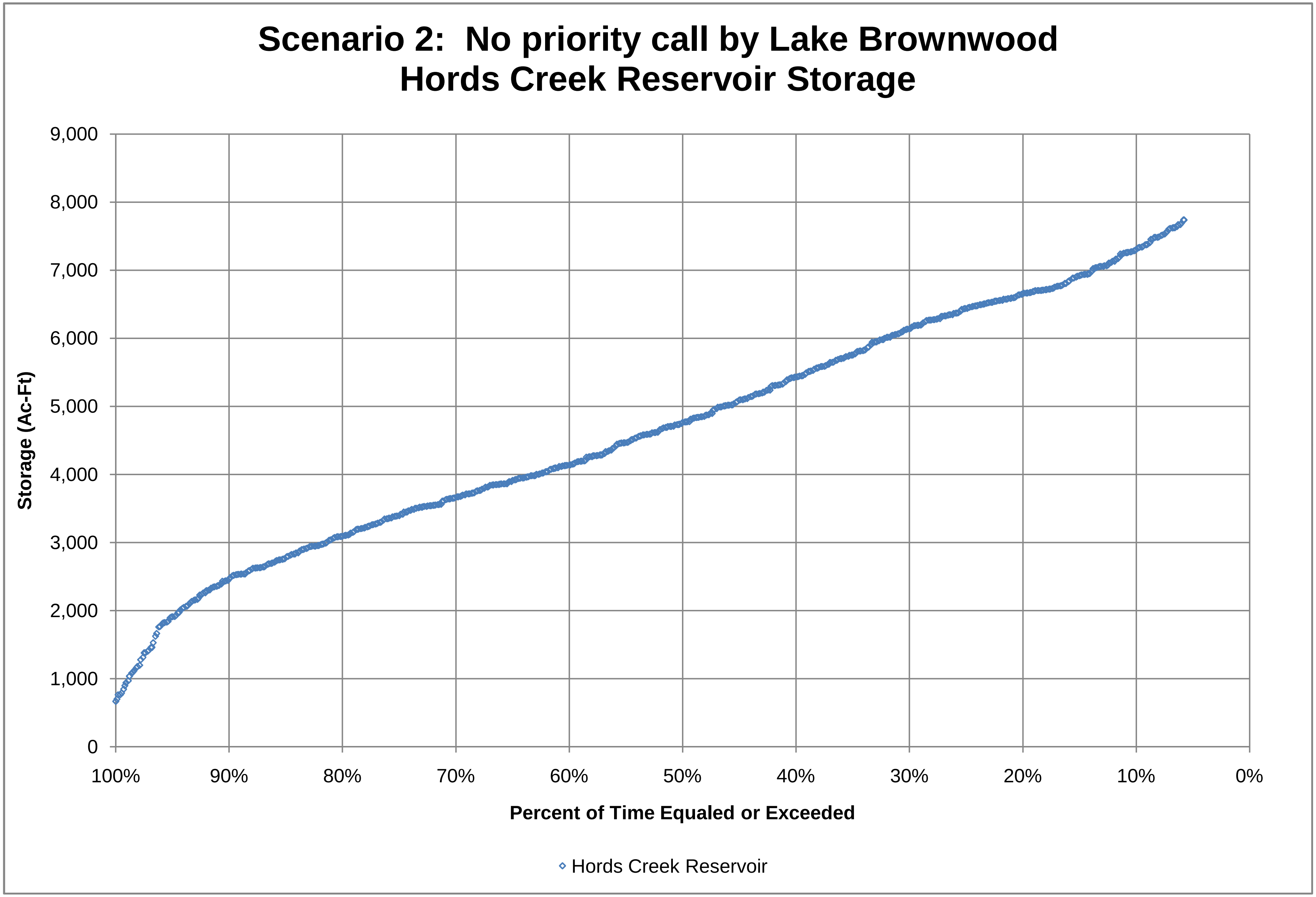


Scenario 2: No priority call by Lake Brownwood
Lake Coleman Storage
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Storage (Ac-Ft)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman

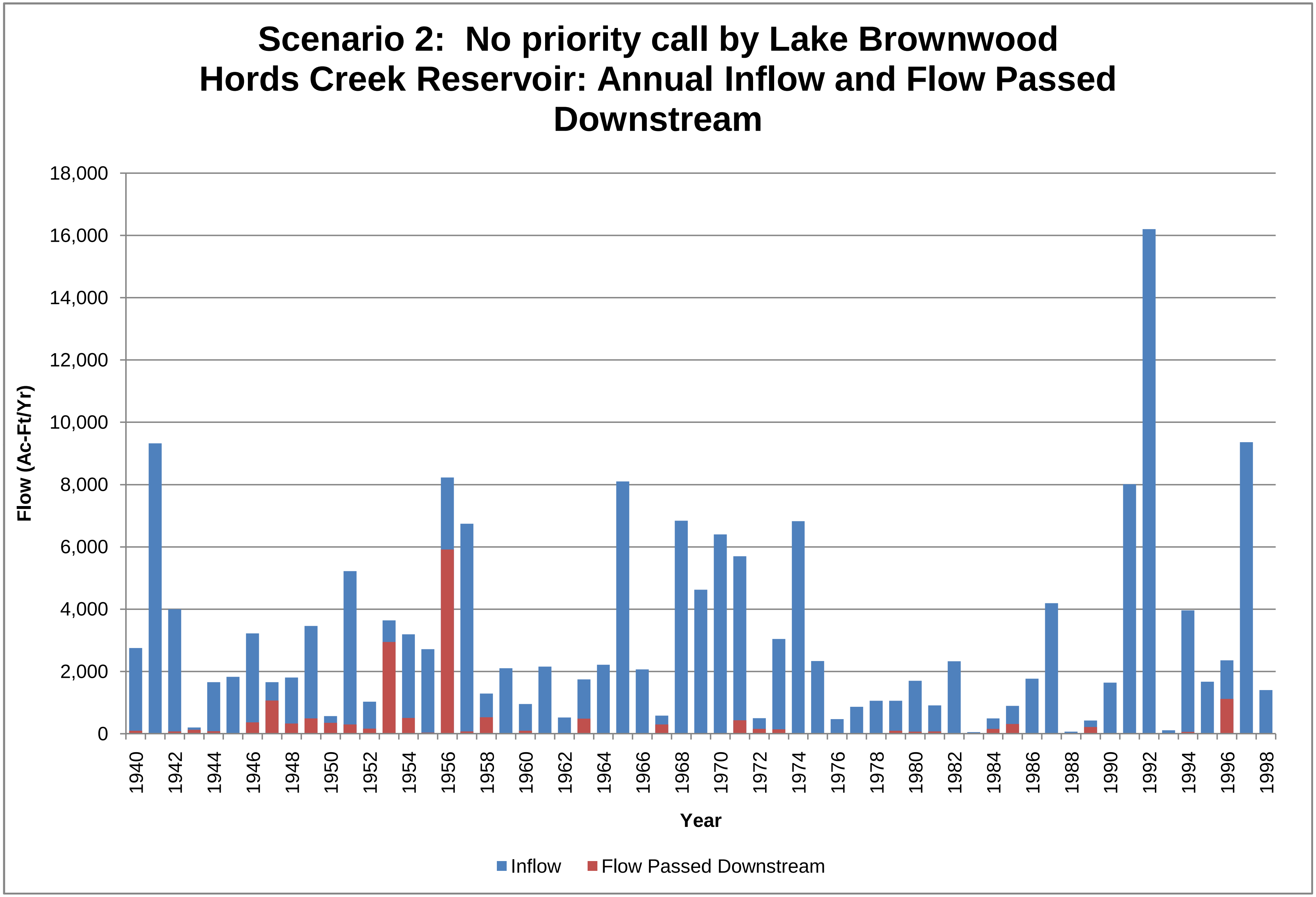

Scenario 2: No priority call by Lake Brownwood
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman

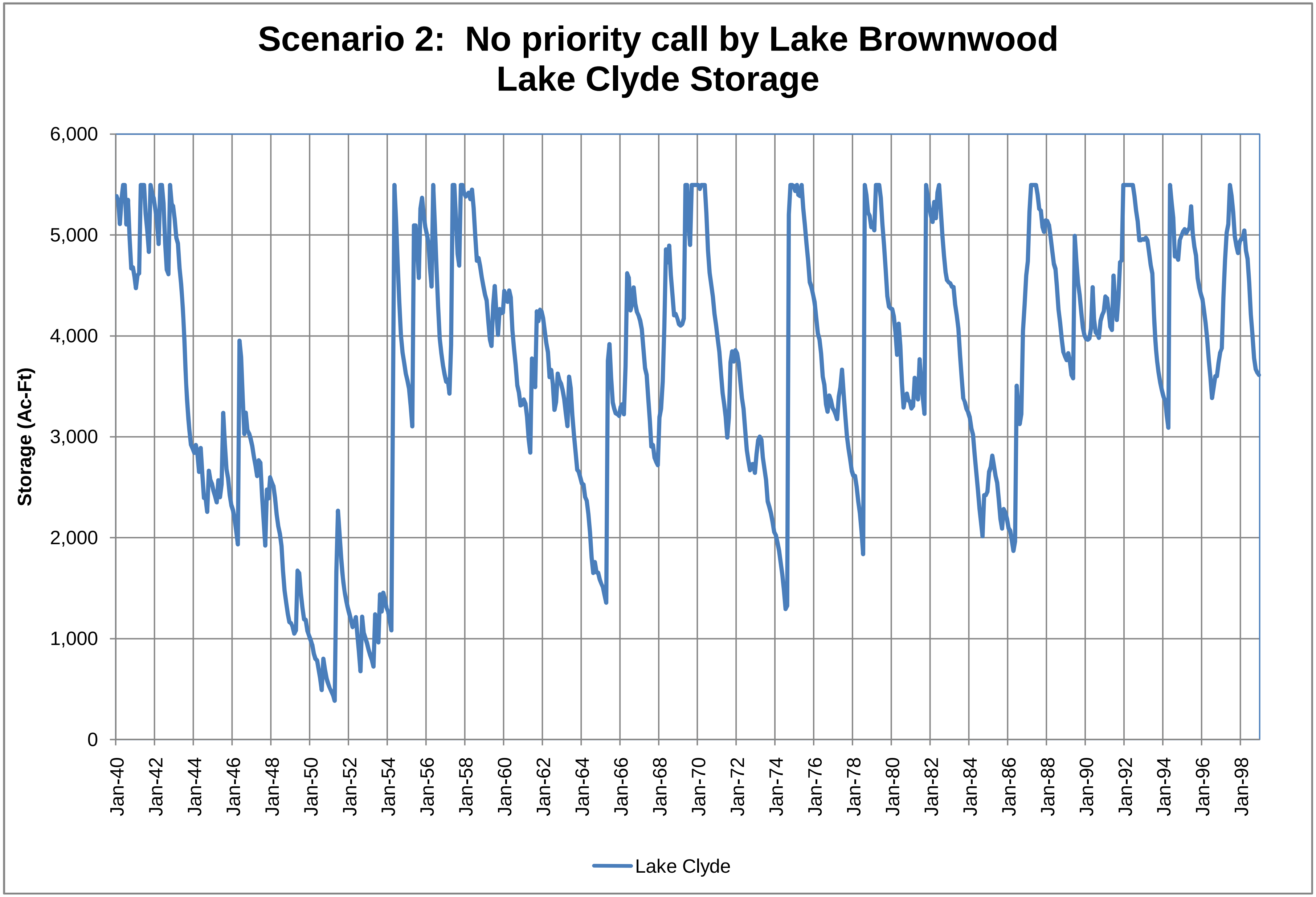

Scenario 2: No priority call by Lake Brownwood
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

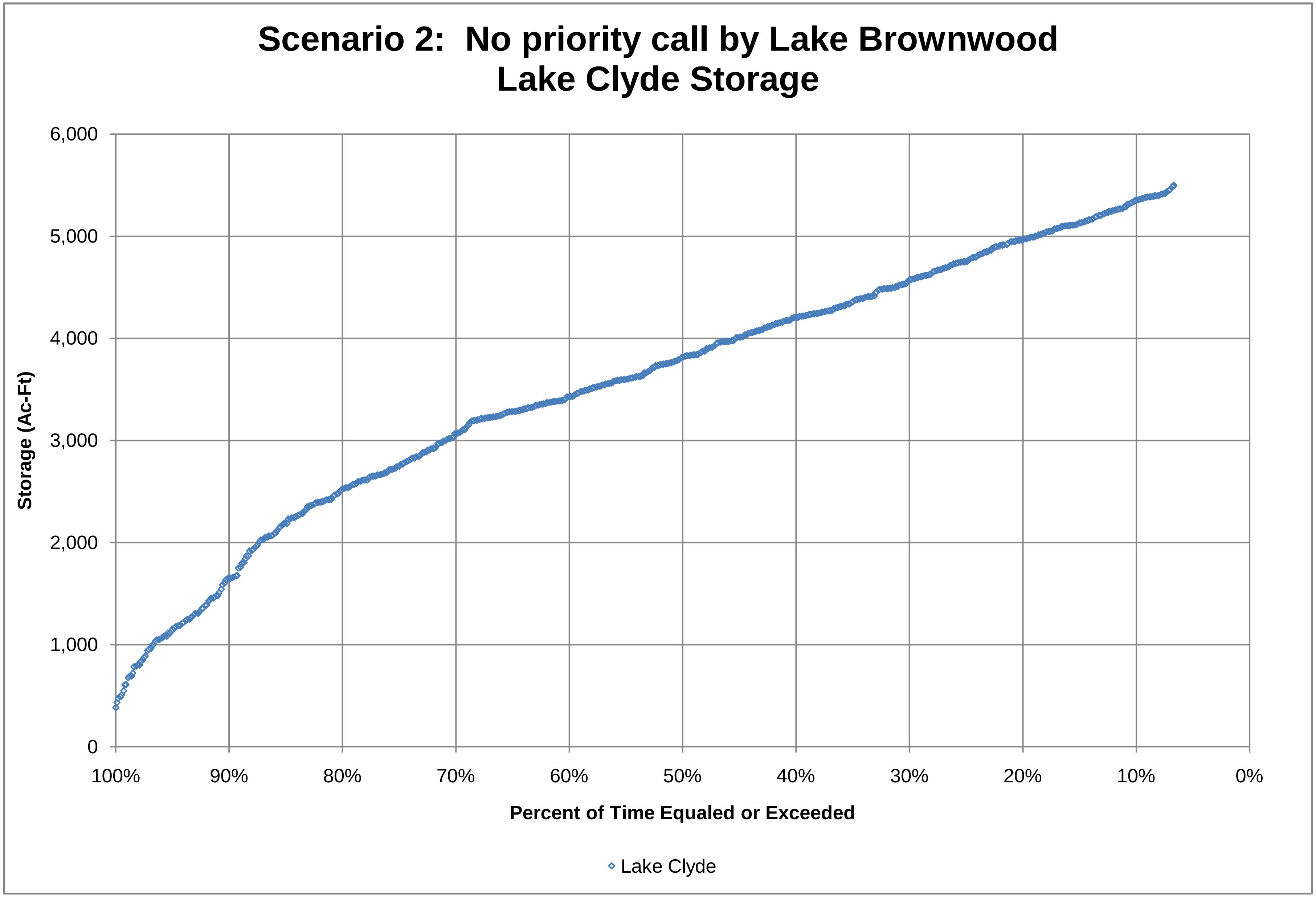

Scenario 2: No priority call by Lake Brownwood
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Hords Creek Reservoir

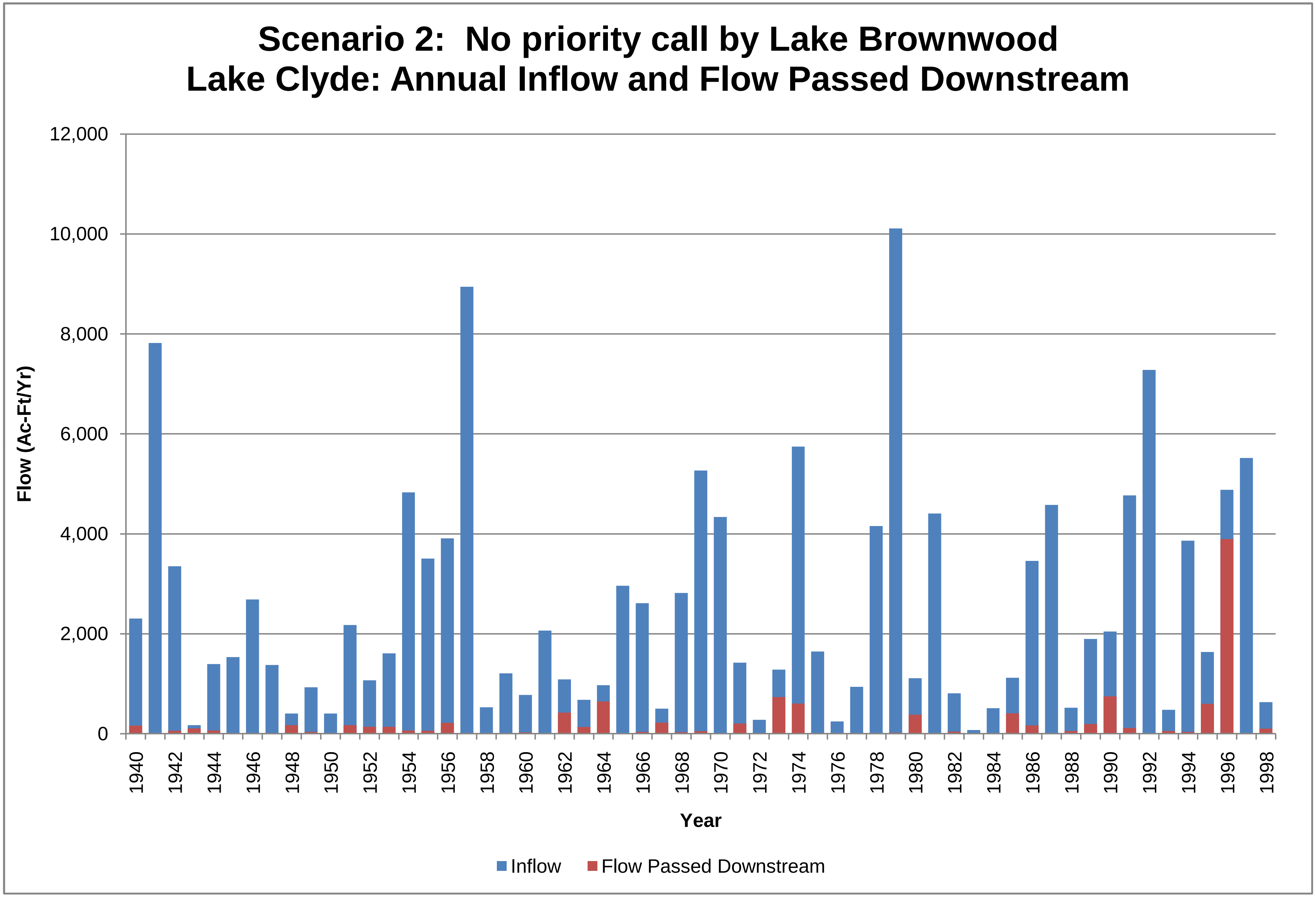


Scenario 2: No priority call by Lake Brownwood
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir


Scenario 2: No priority call by Lake Brownwood
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream


Scenario 2: No priority call by Lake Brownwood
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Clyde

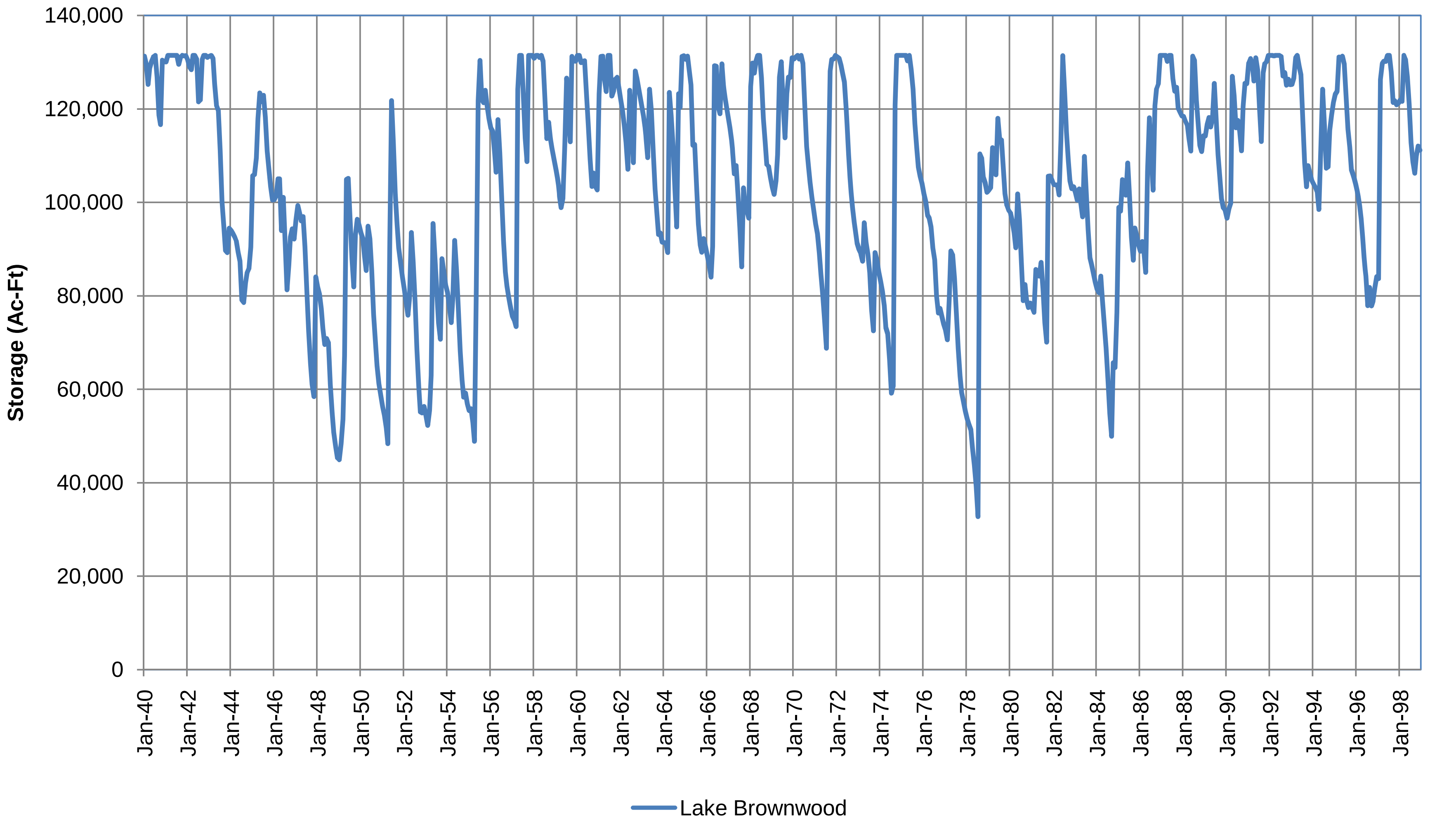

Scenario 2: No priority call by Lake Brownwood
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde

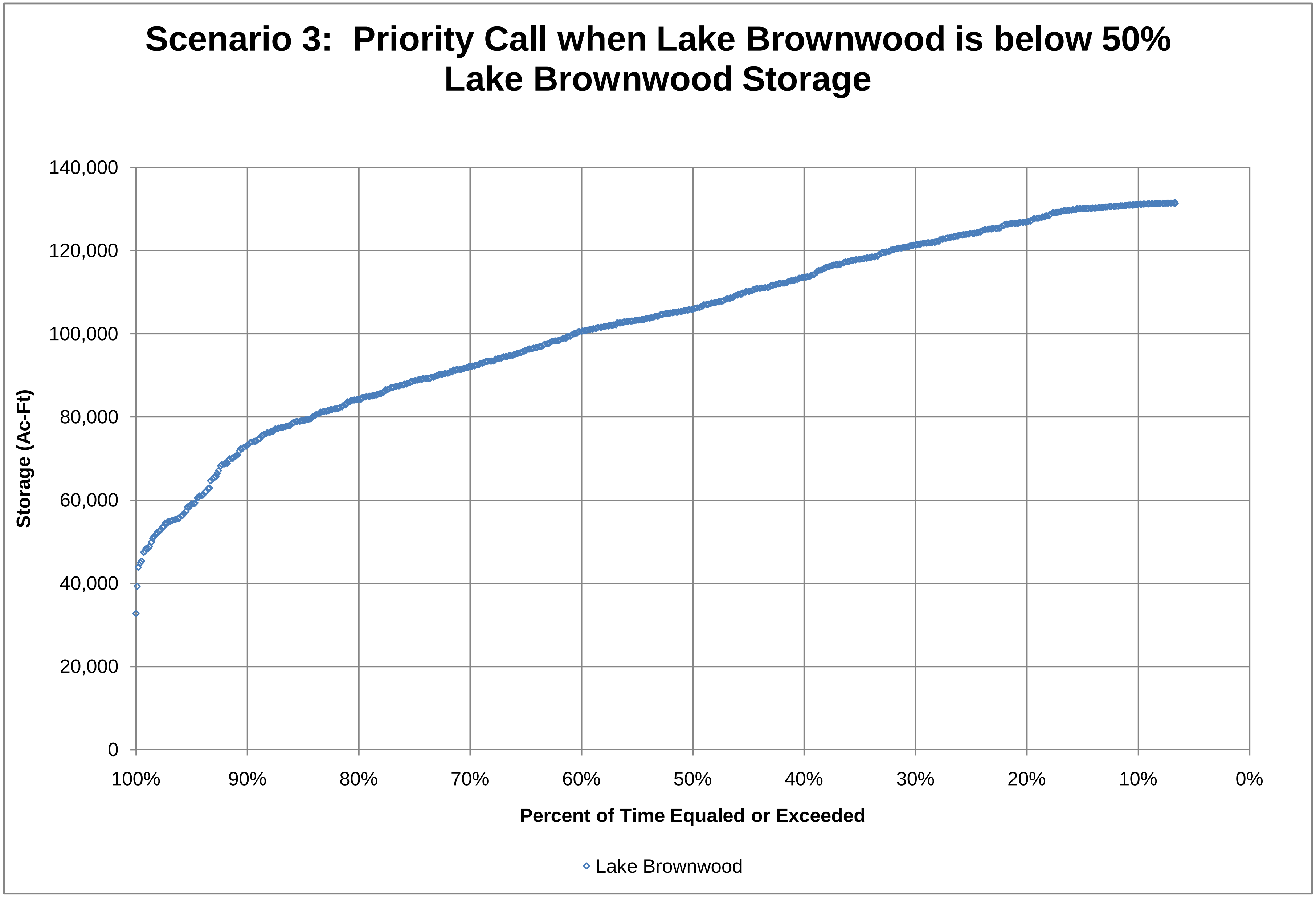

Scenario 2: No priority call by Lake Brownwood
Lake Clyde: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

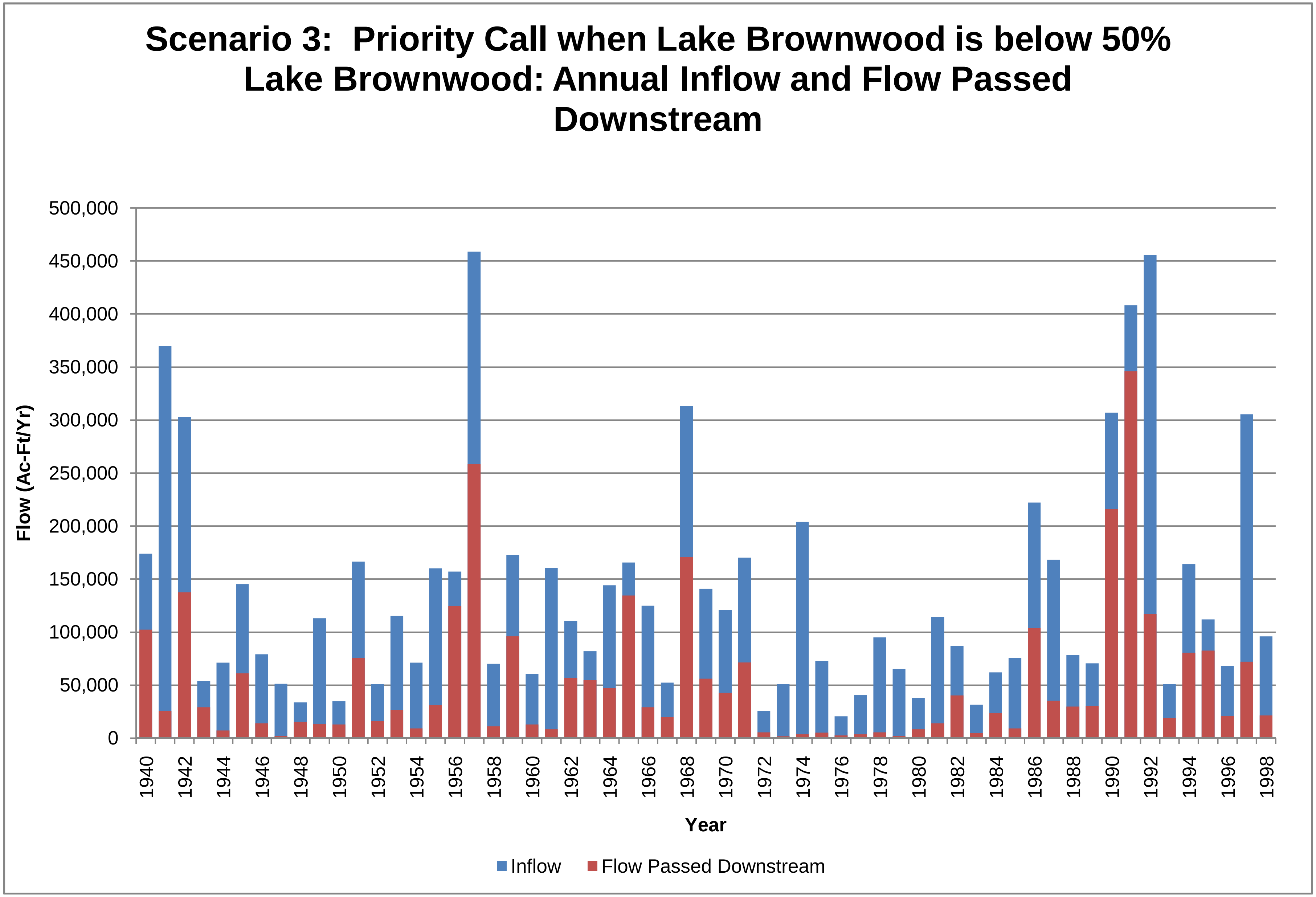
Scenario 3: Priority call when Lake Brownwood storage is below 50%

Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream

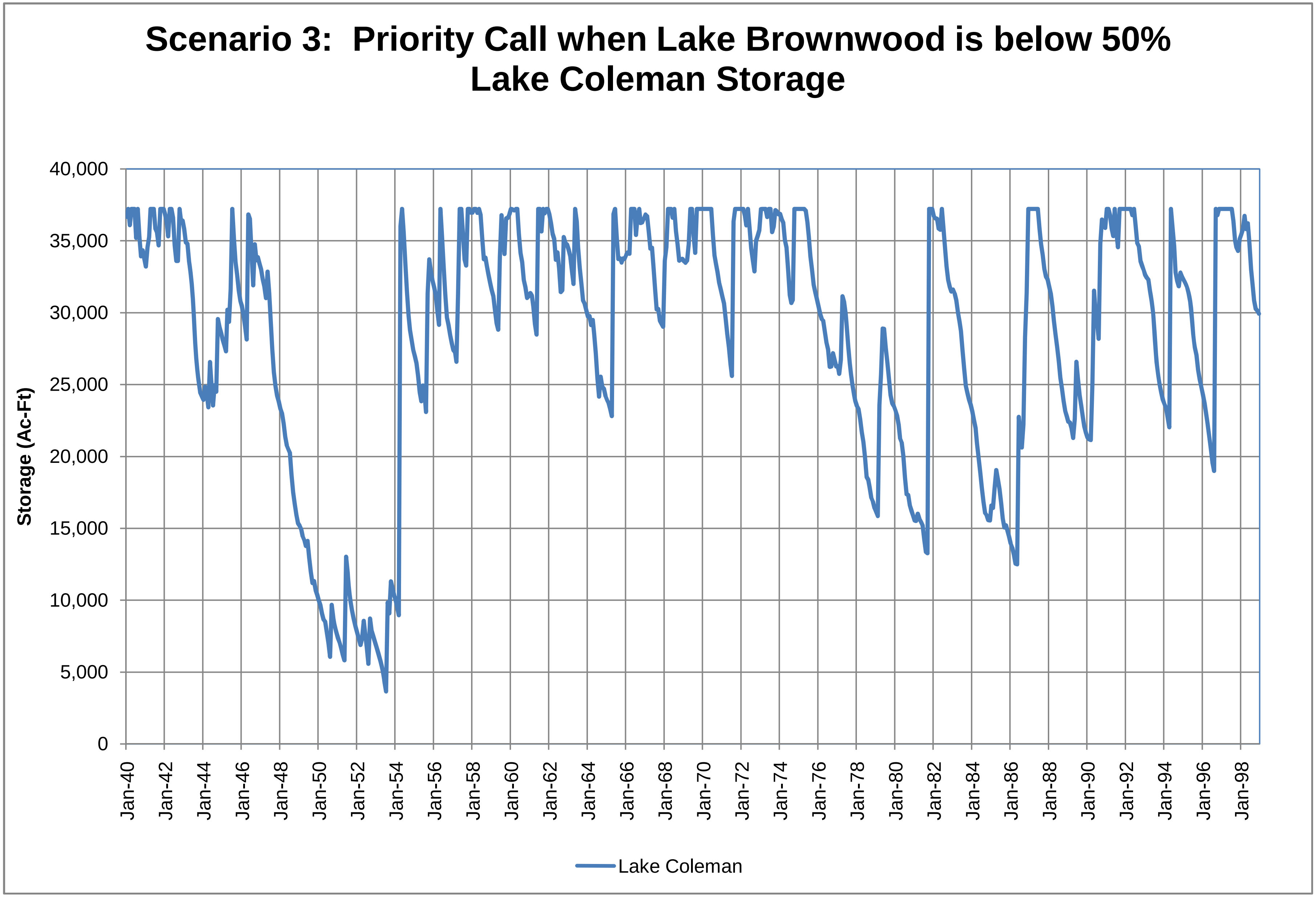
Scenario 3: Priority Call when Lake Brownwood is below 50% Lake Brownwood Storage



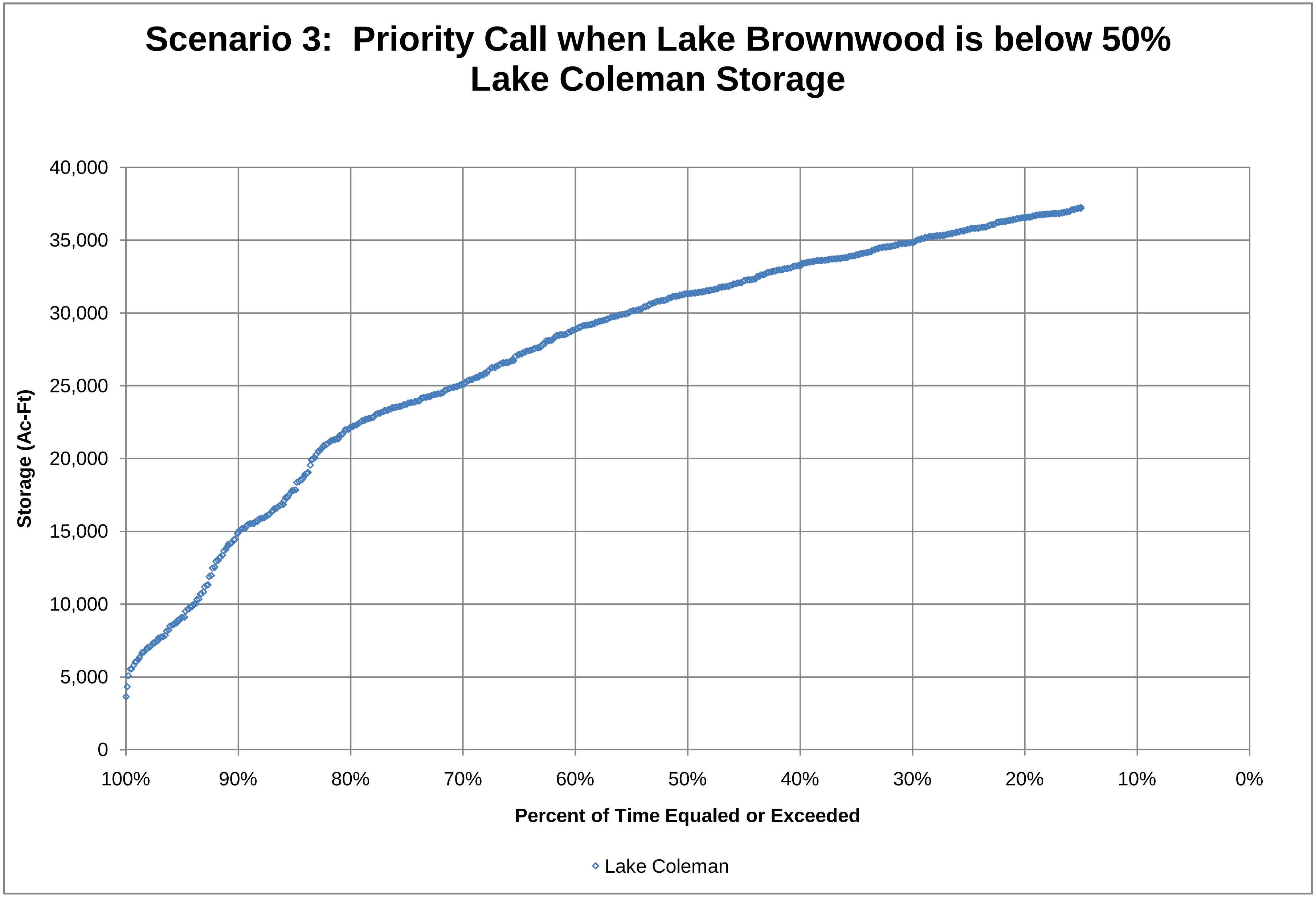

Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Brownwood Storage
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood



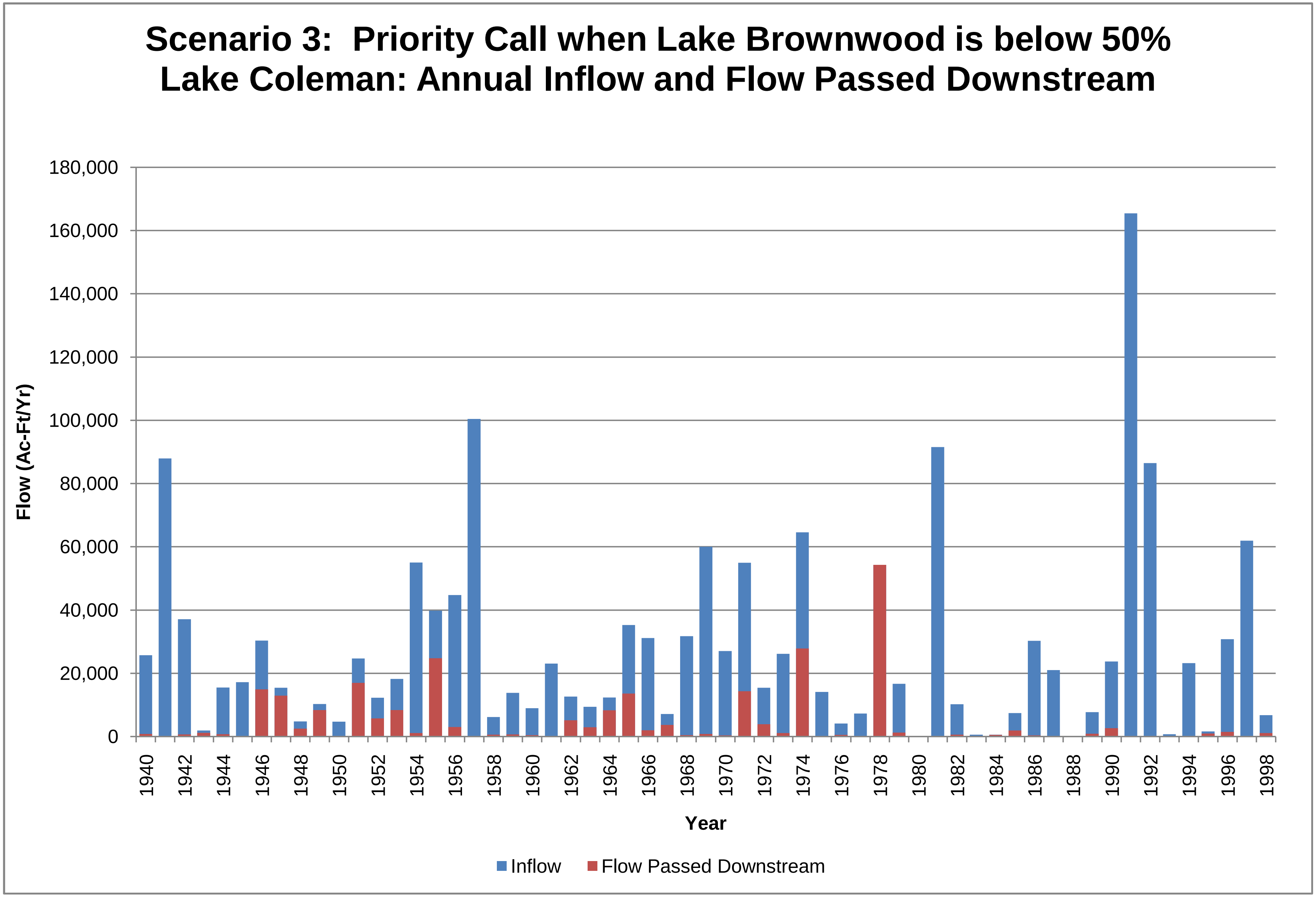
Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Brownwood: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream



Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman

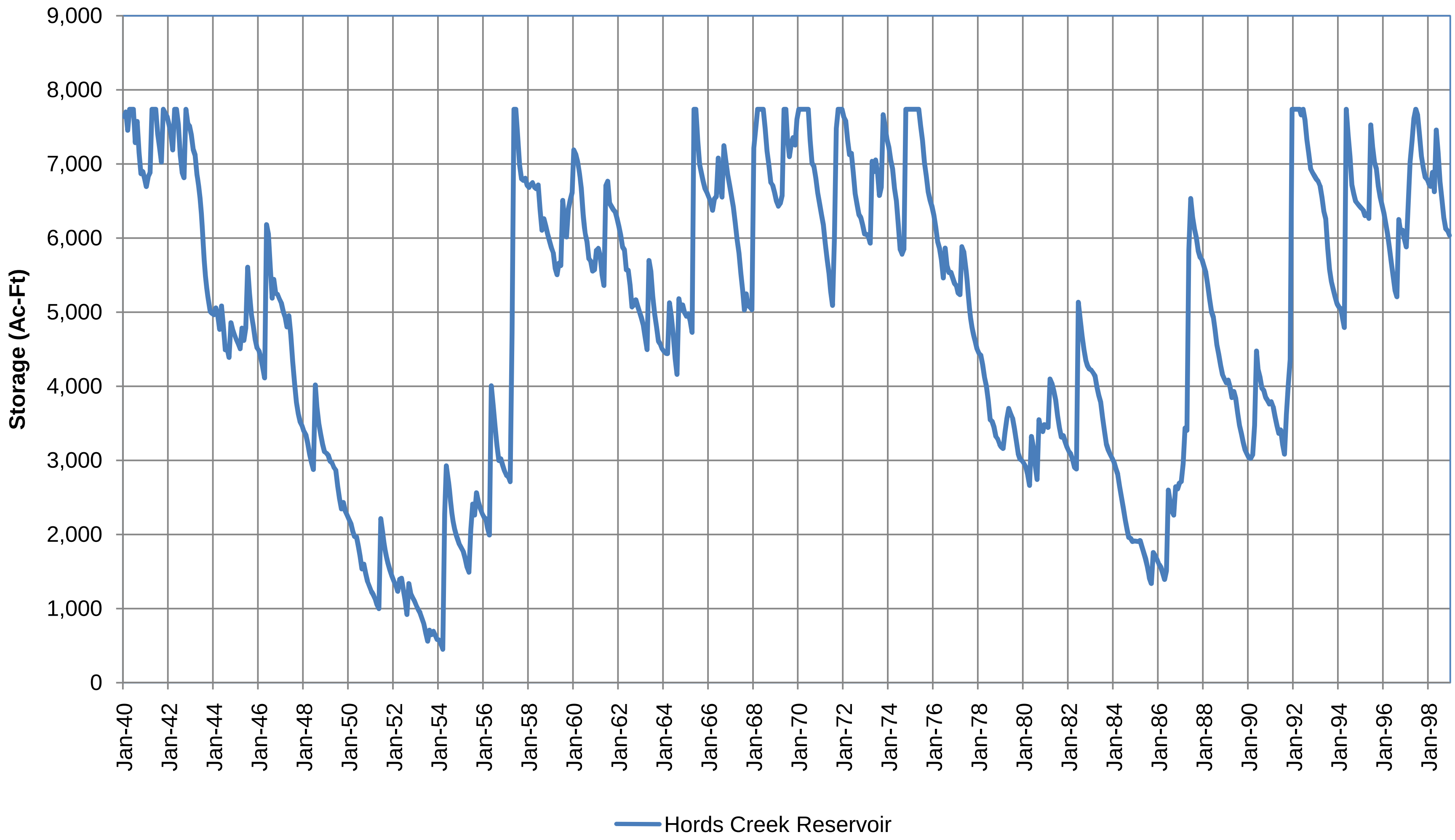


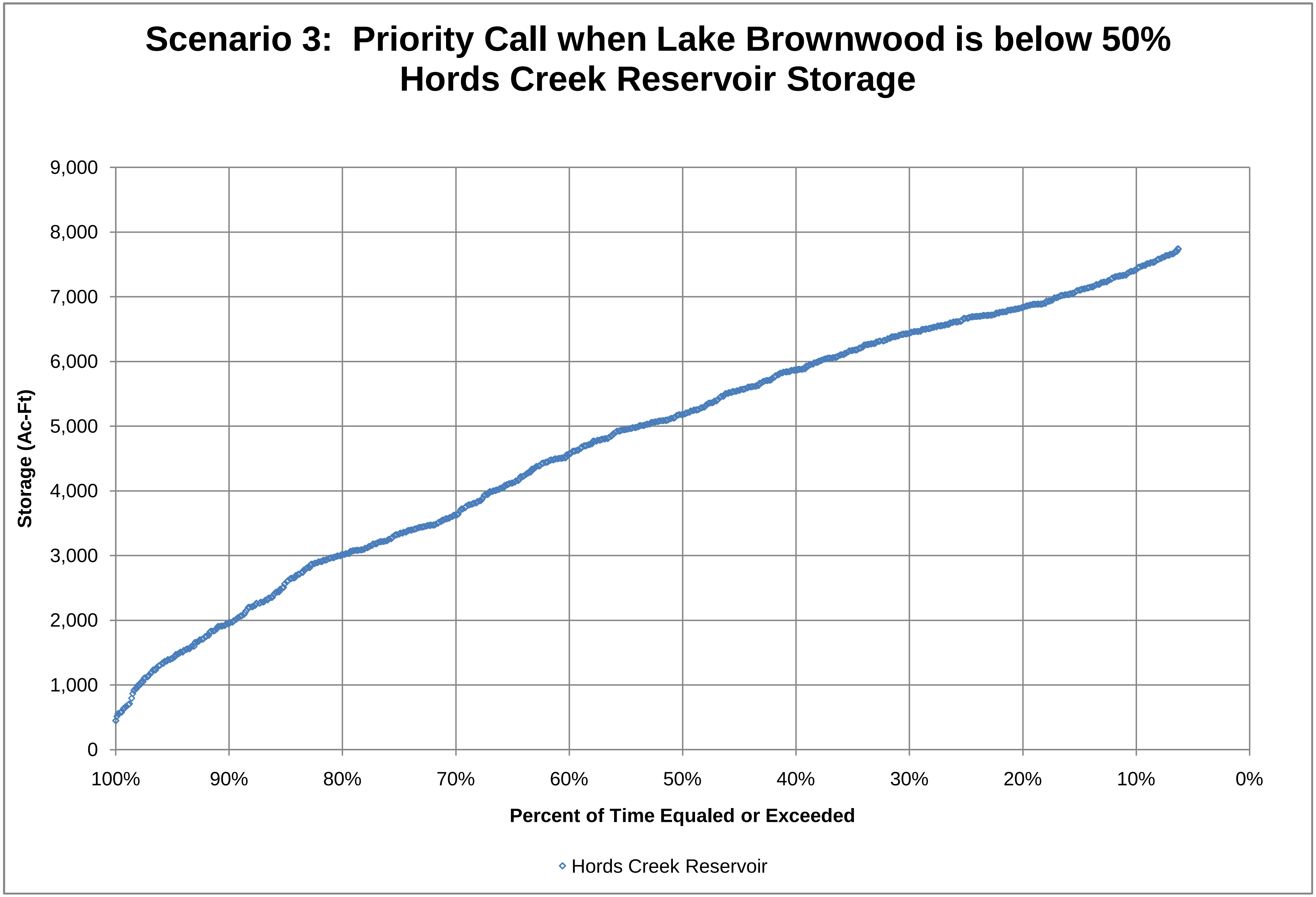
Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman

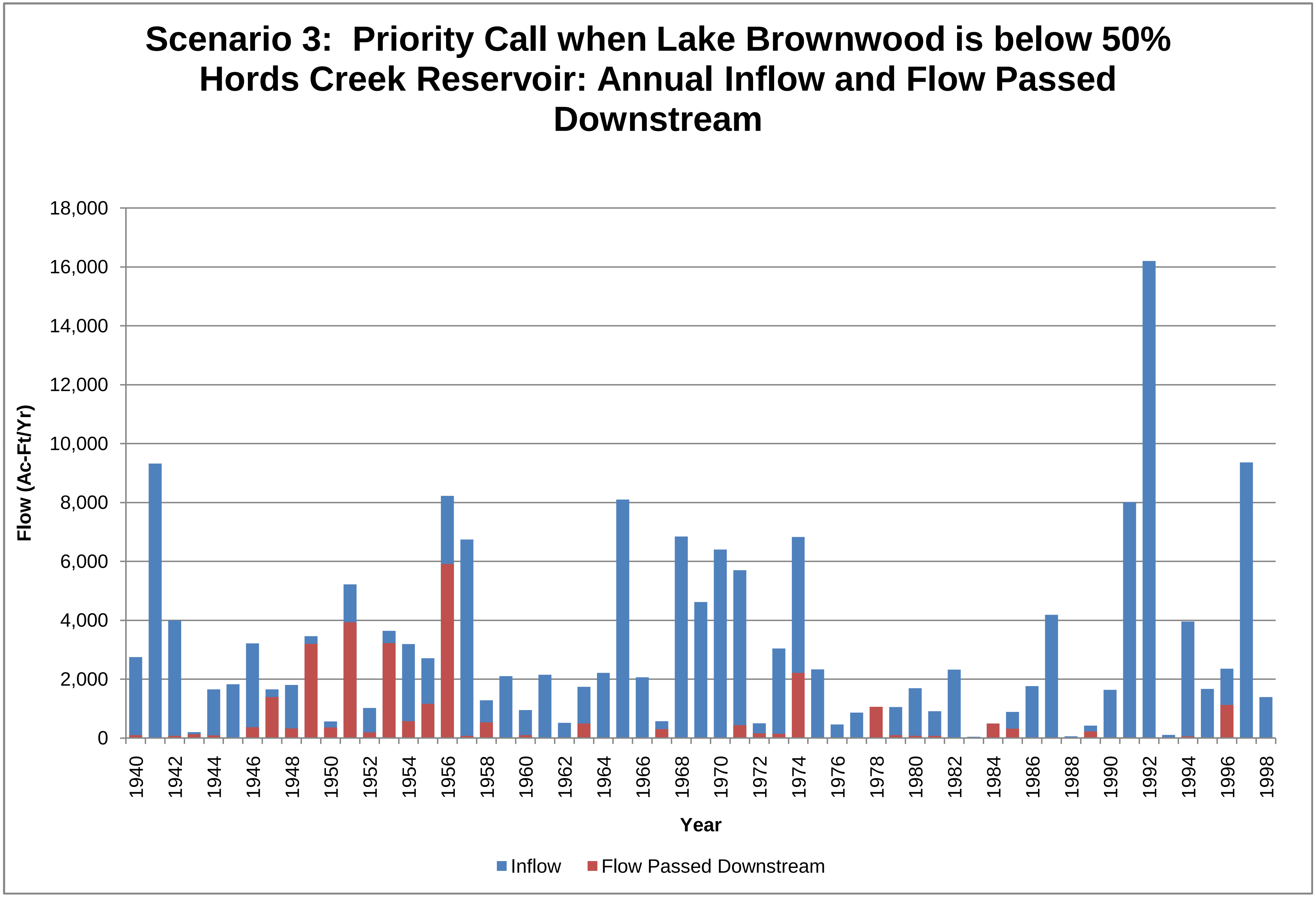


Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

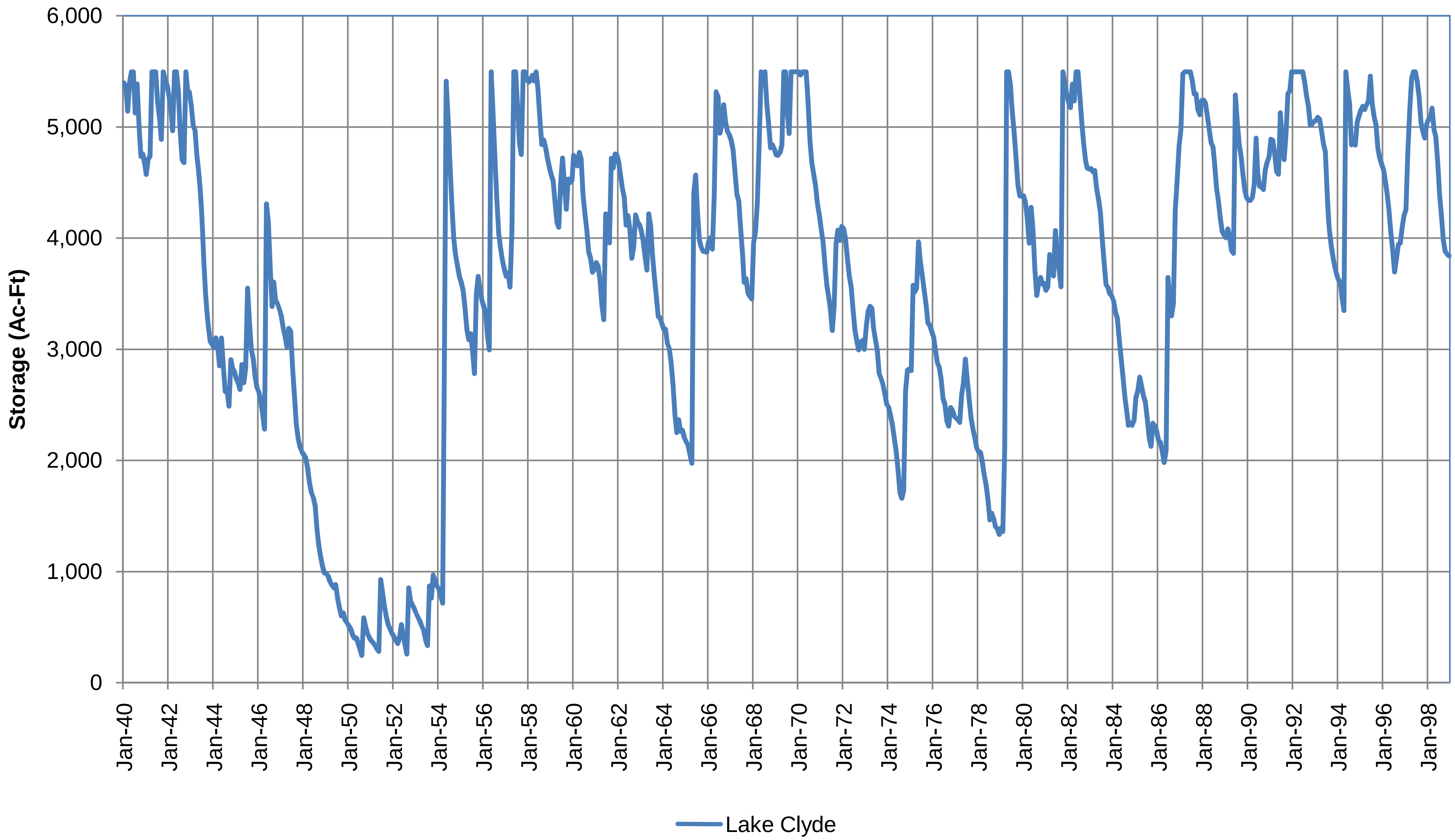
Scenario 3: Priority Call when Lake Brownwood is below 50%
Hords Creek Reservoir Storage

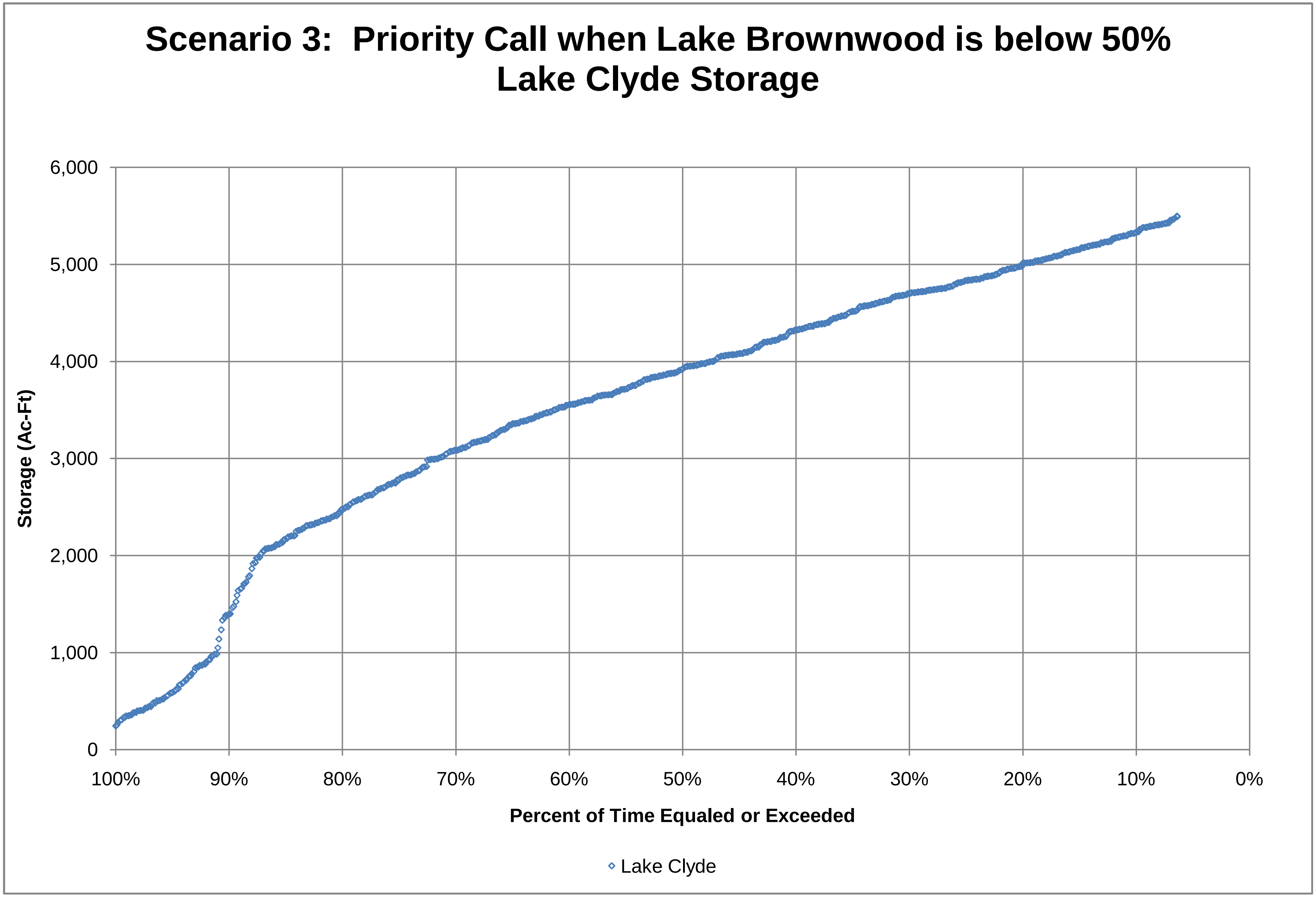


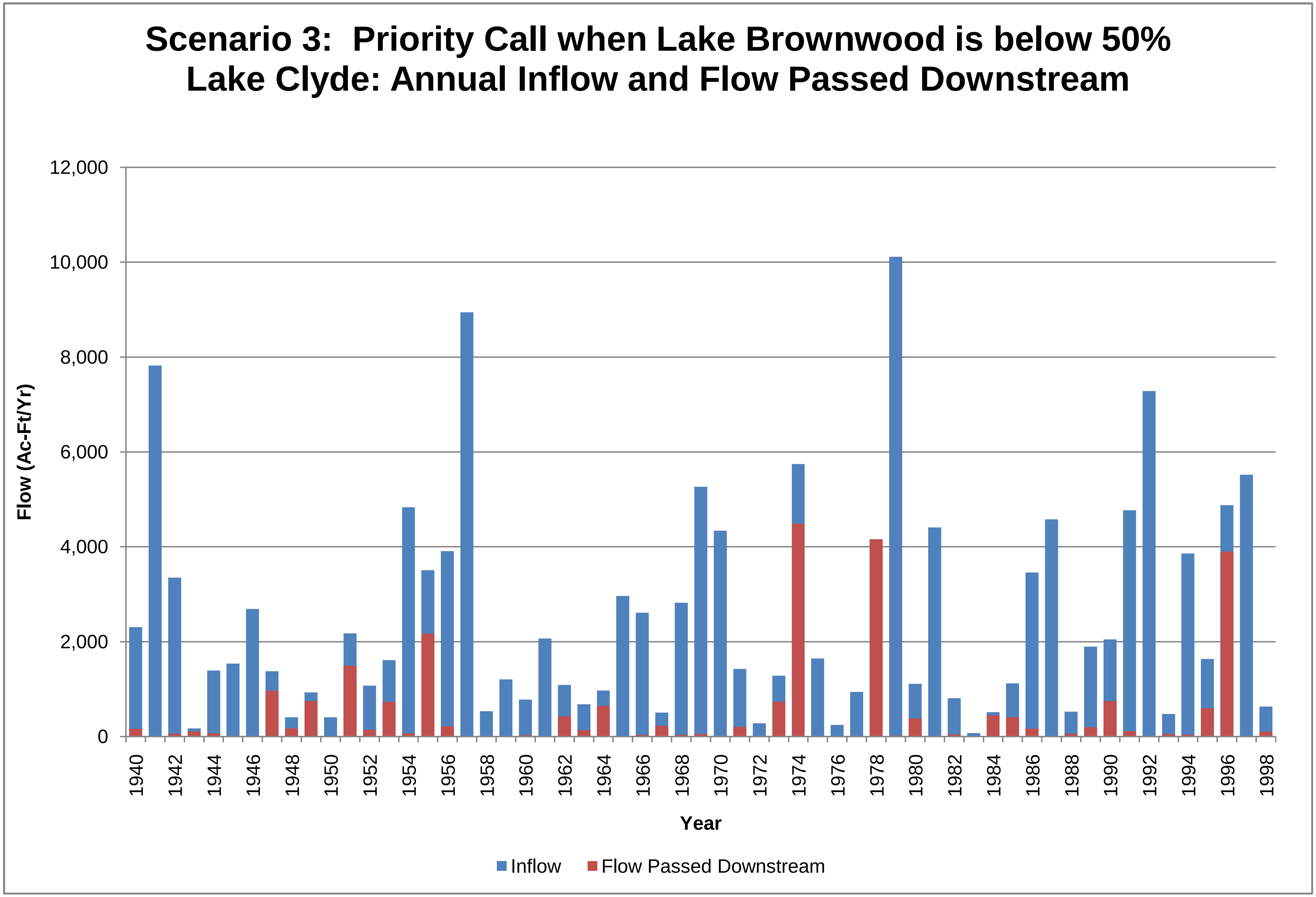

Scenario 3: Priority Call when Lake Brownwood is below 50%
Hords Creek Reservoir Storage
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir


Scenario 3: Priority Call when Lake Brownwood is below 50%
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Clyde Storage



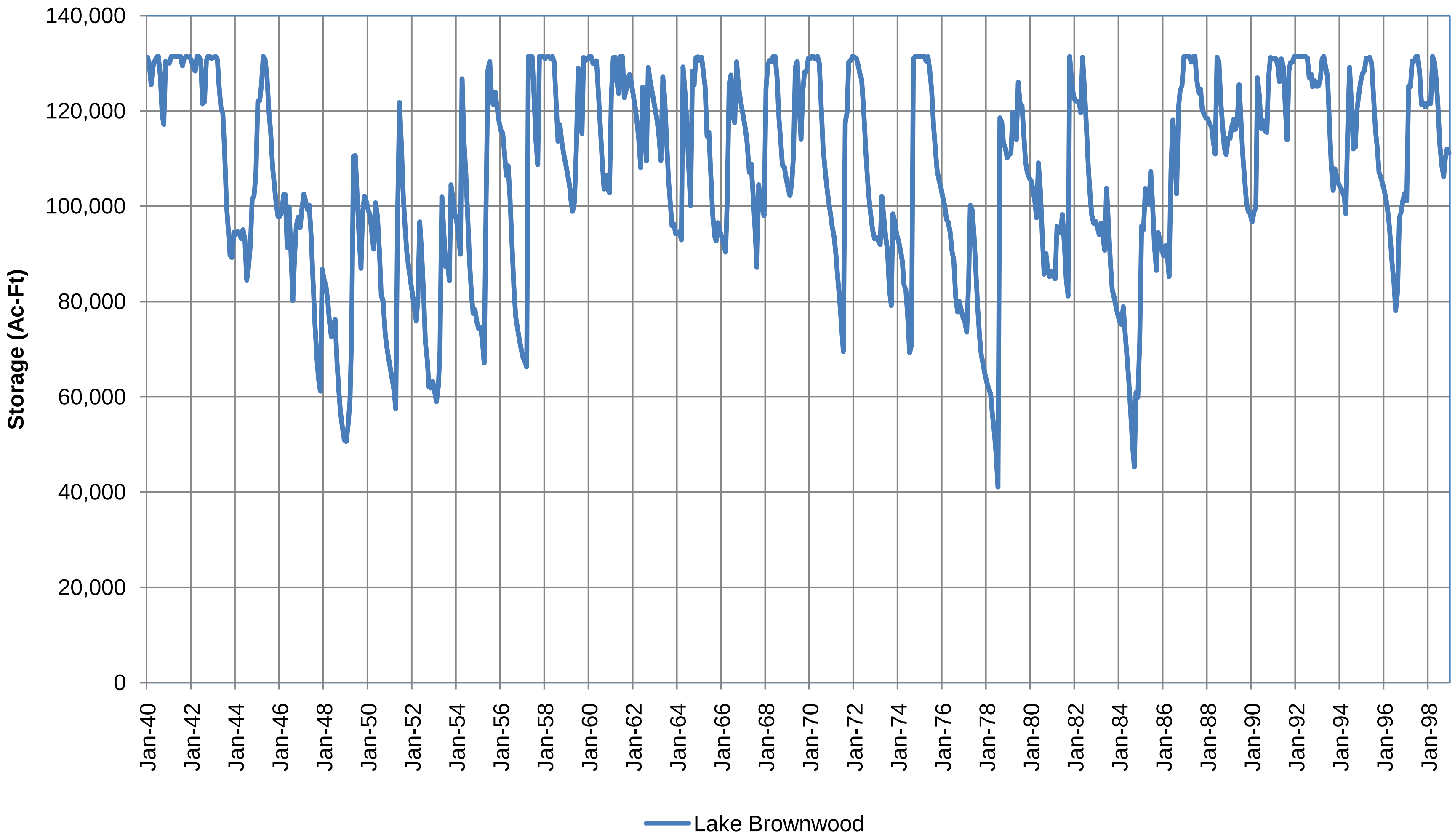

Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde

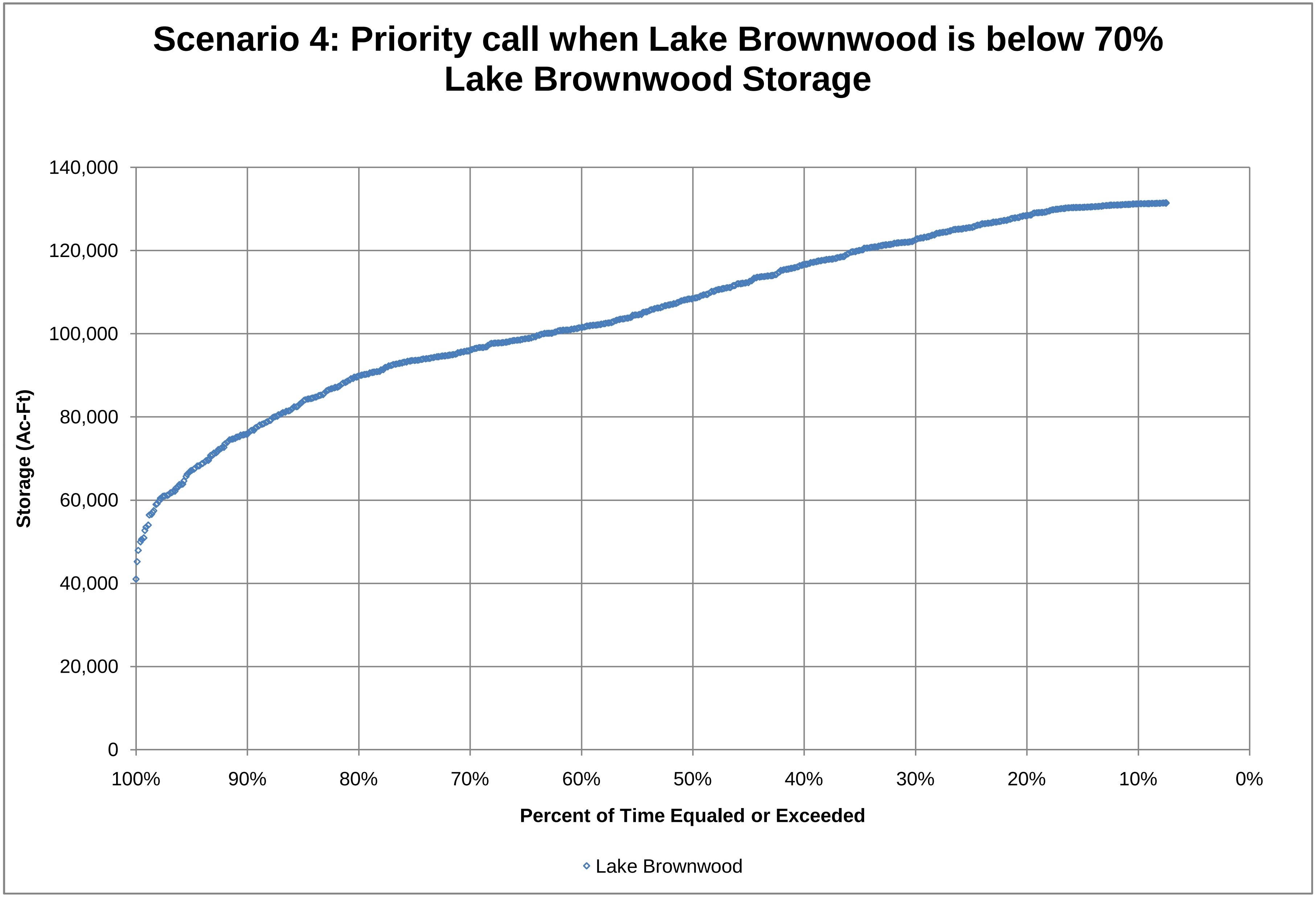

Scenario 3: Priority Call when Lake Brownwood is below 50%
Lake Clyde: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

Scenario 4: Priority call when Lake Brownwood storage is below 70%

Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream

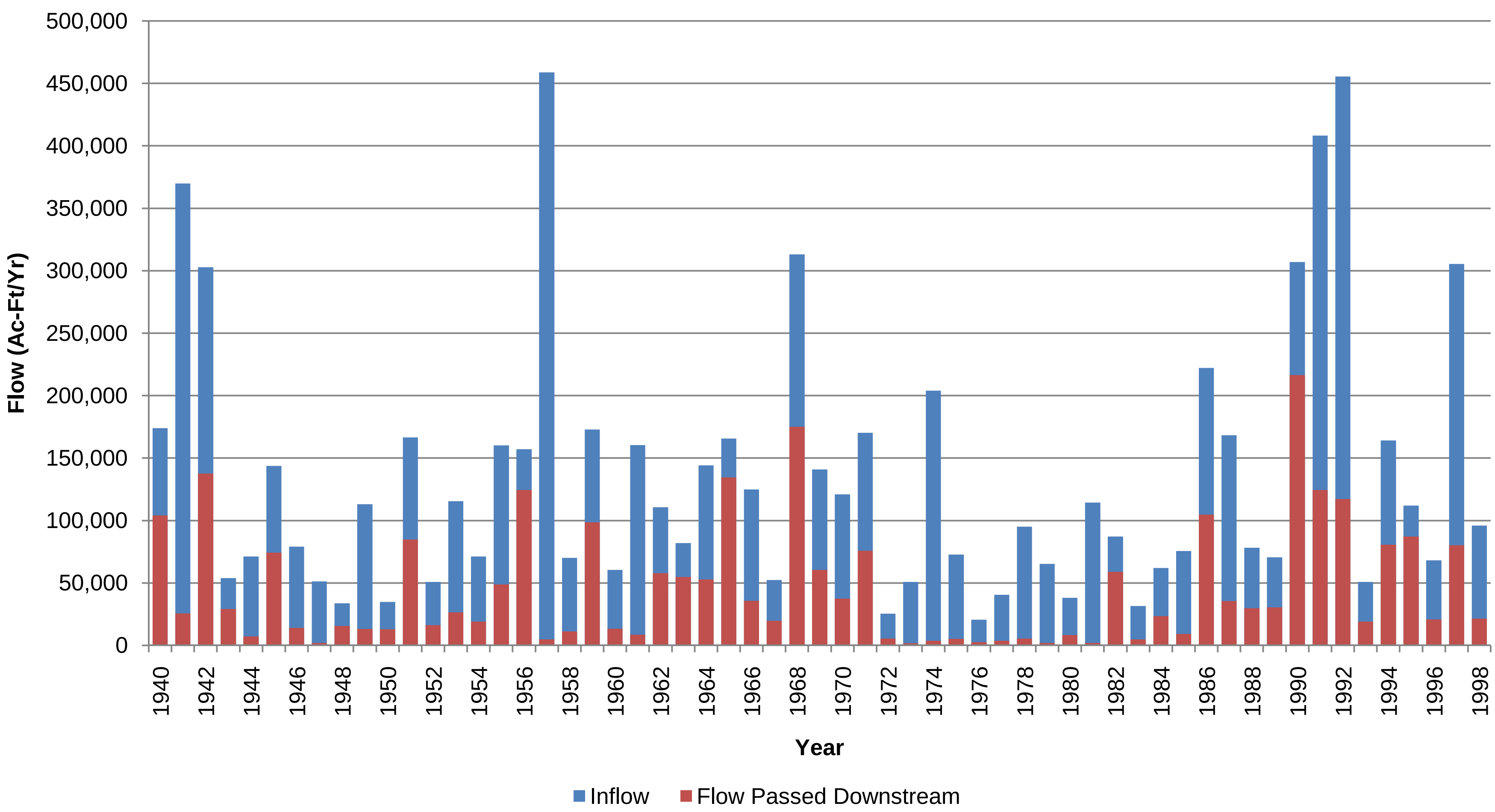
Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Brownwood Storage

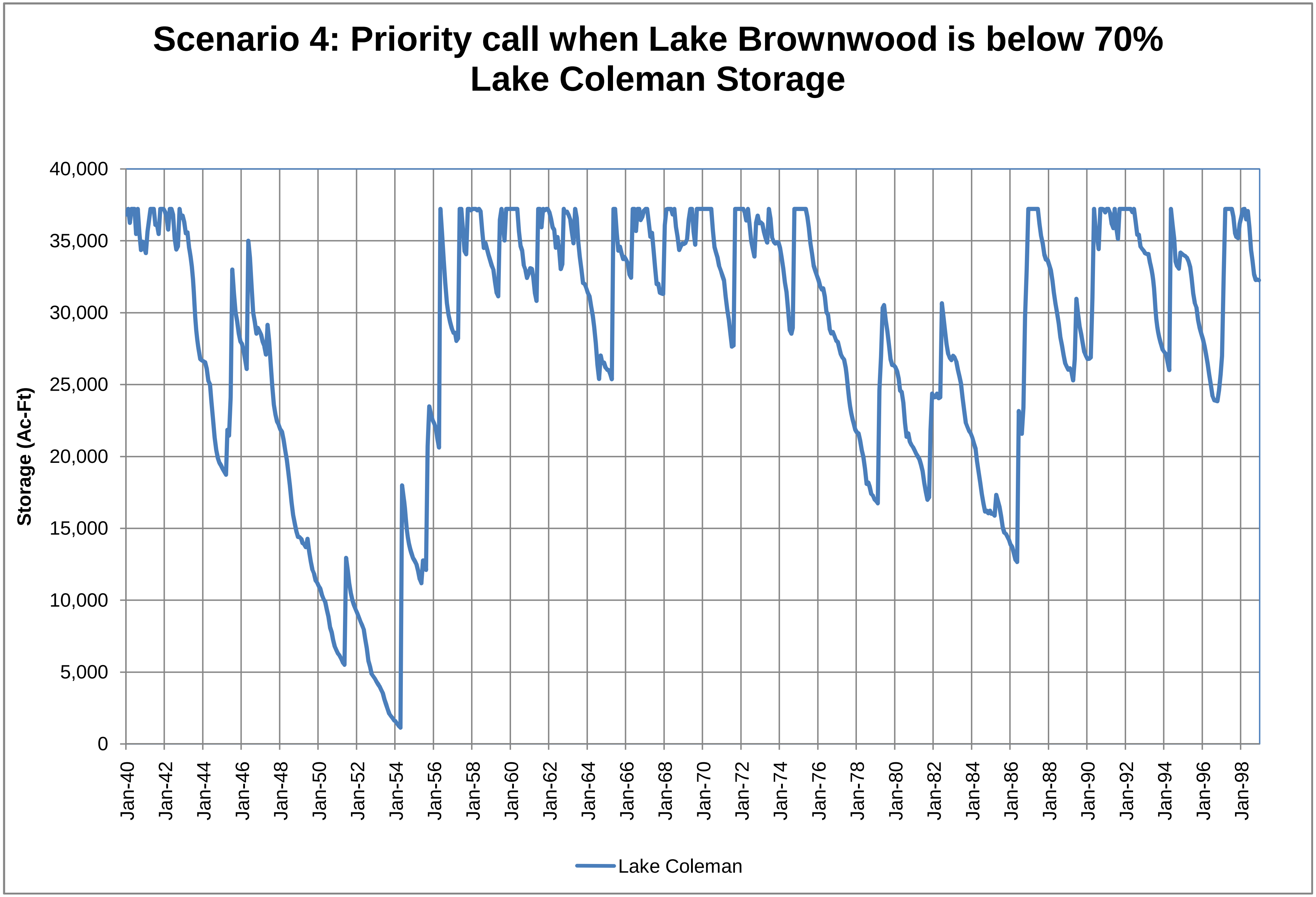




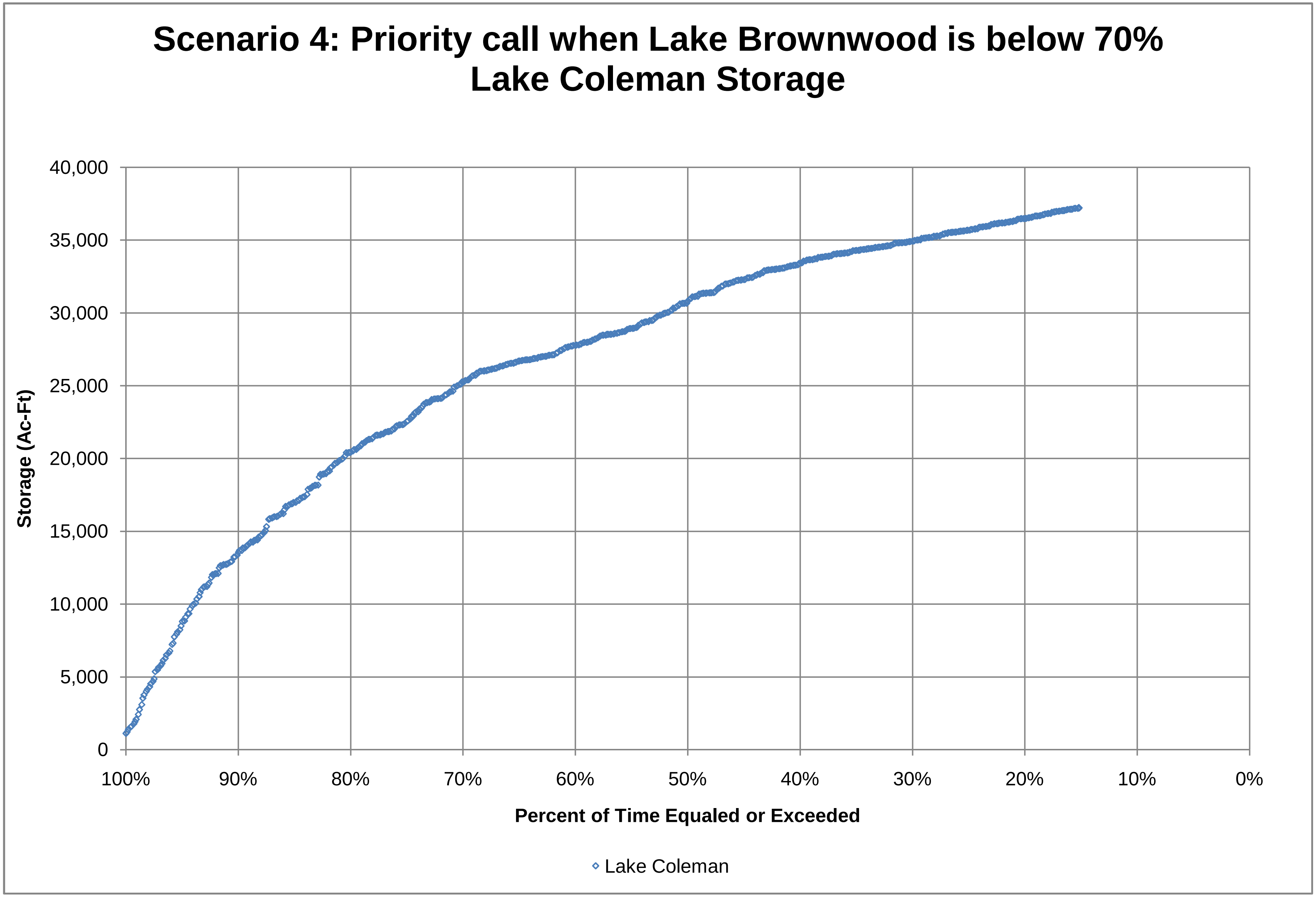
Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood

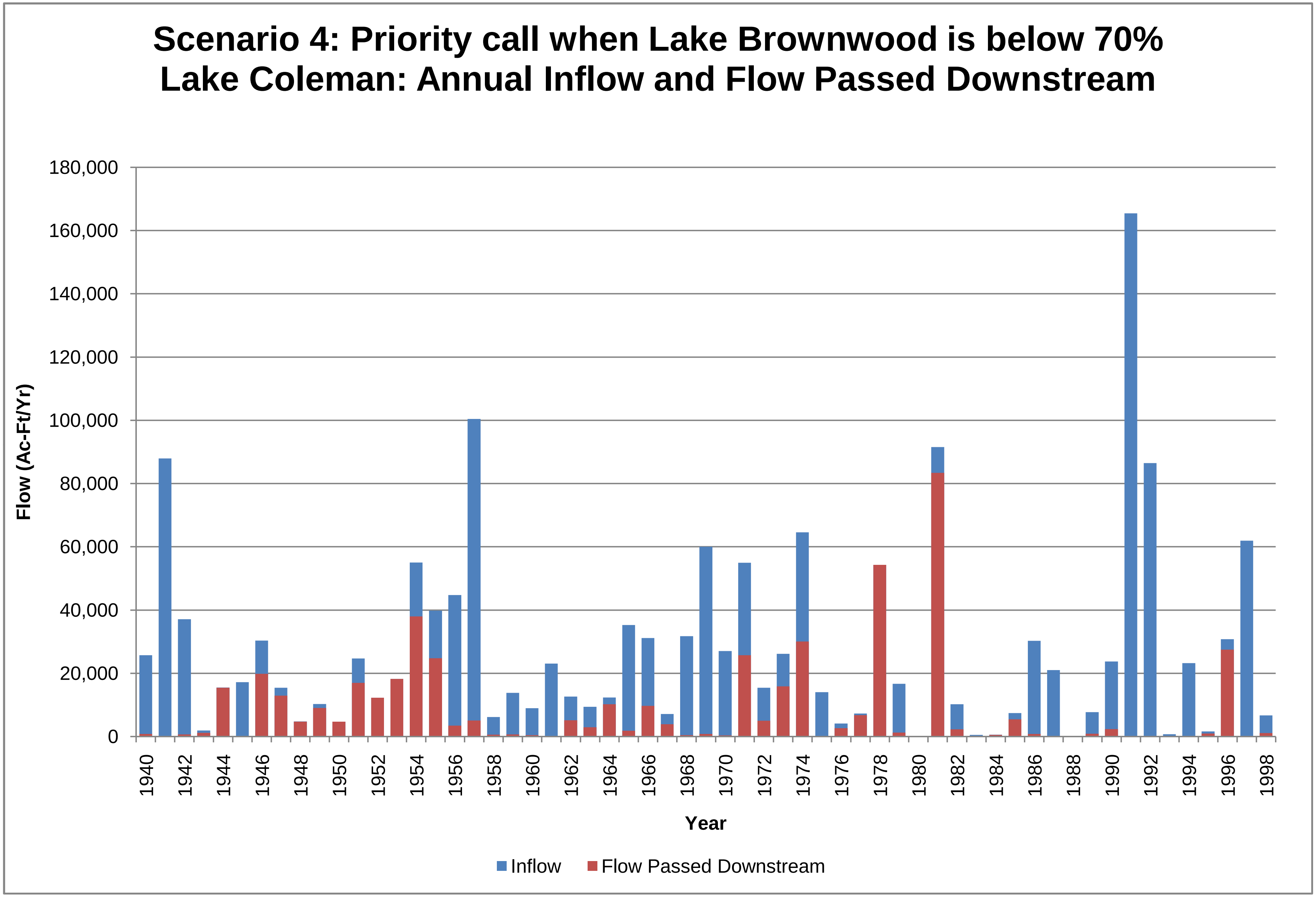
Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Brownwood: Annual Inflow and Flow Passed Downstream

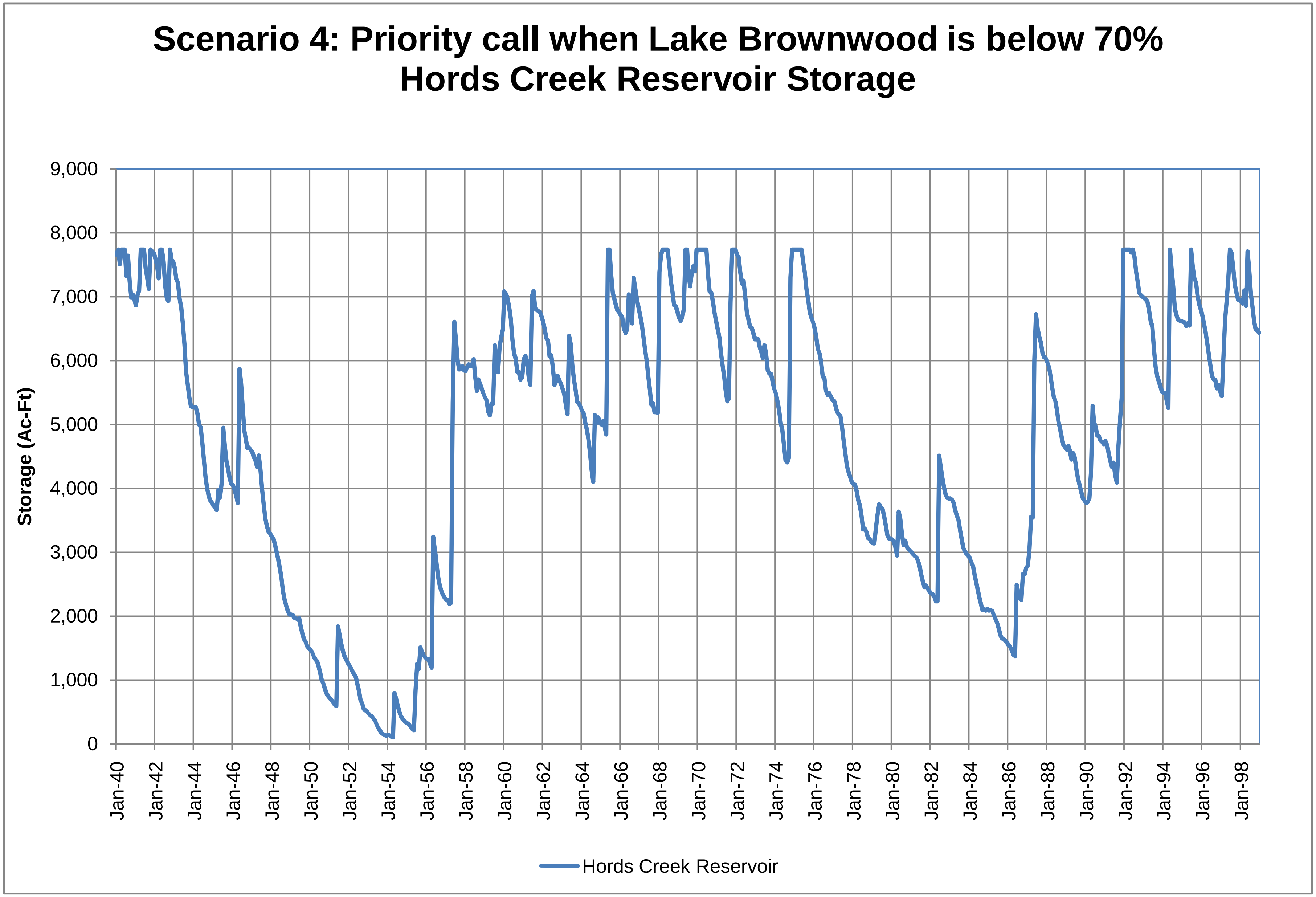




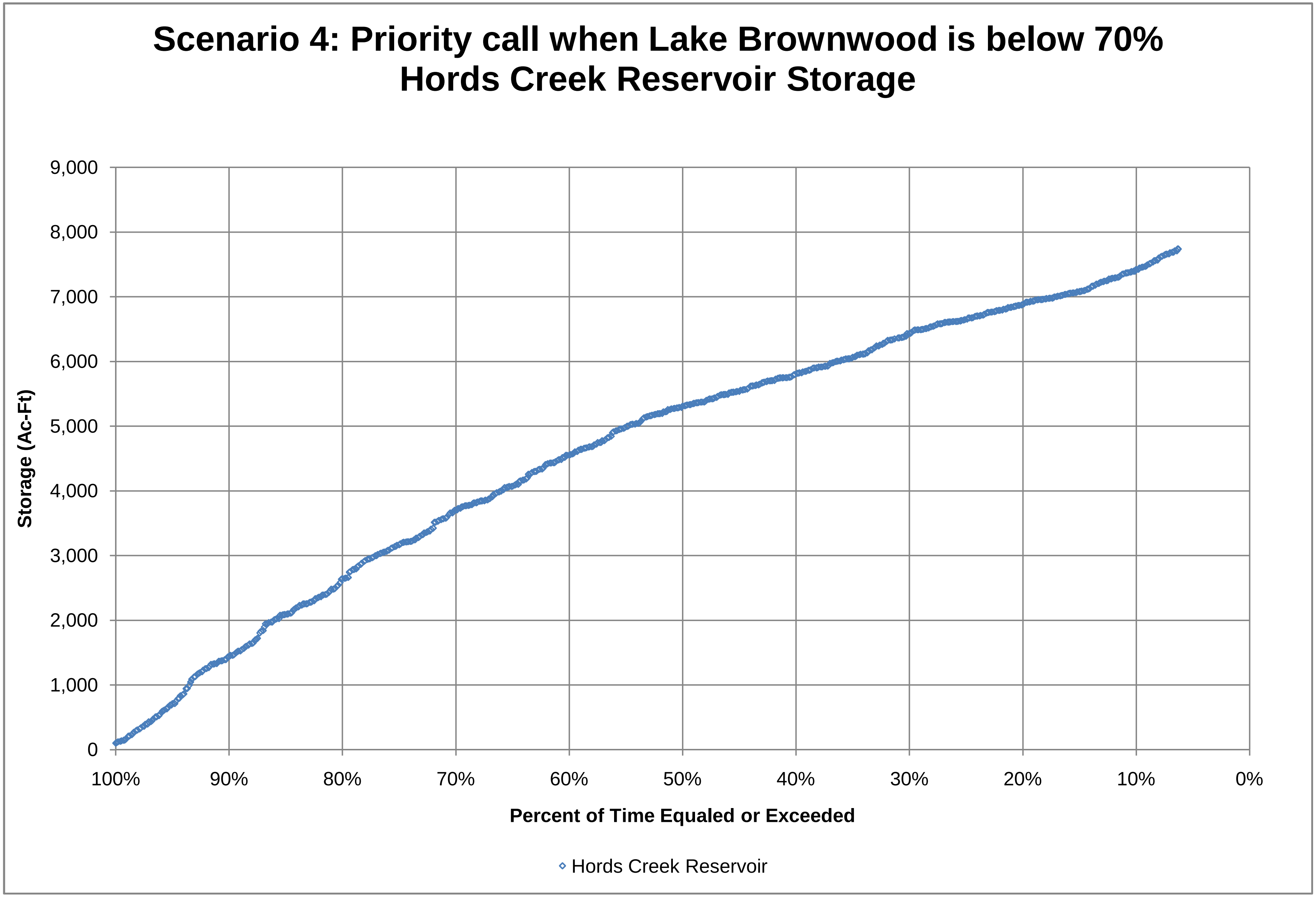
Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman

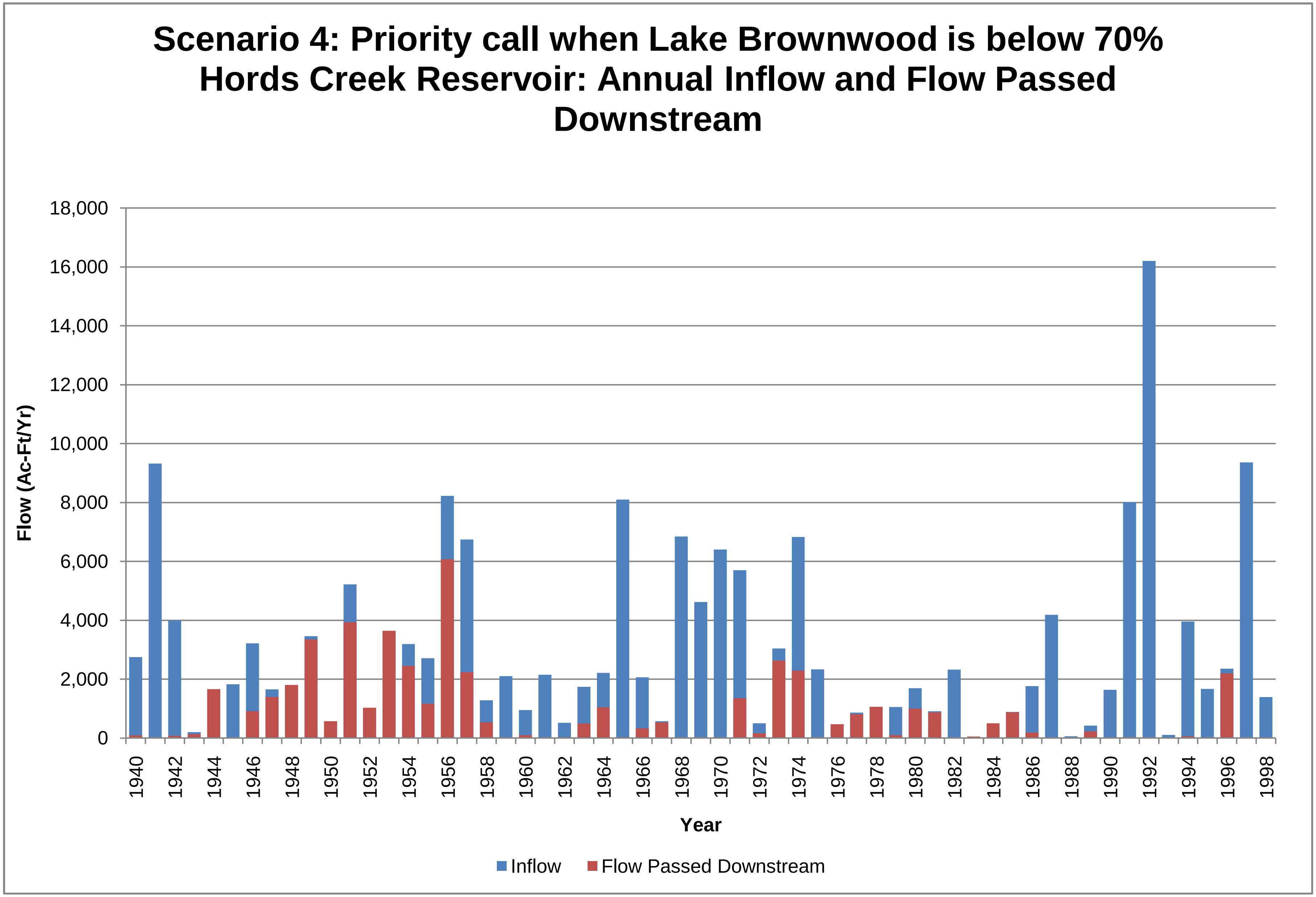

Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman

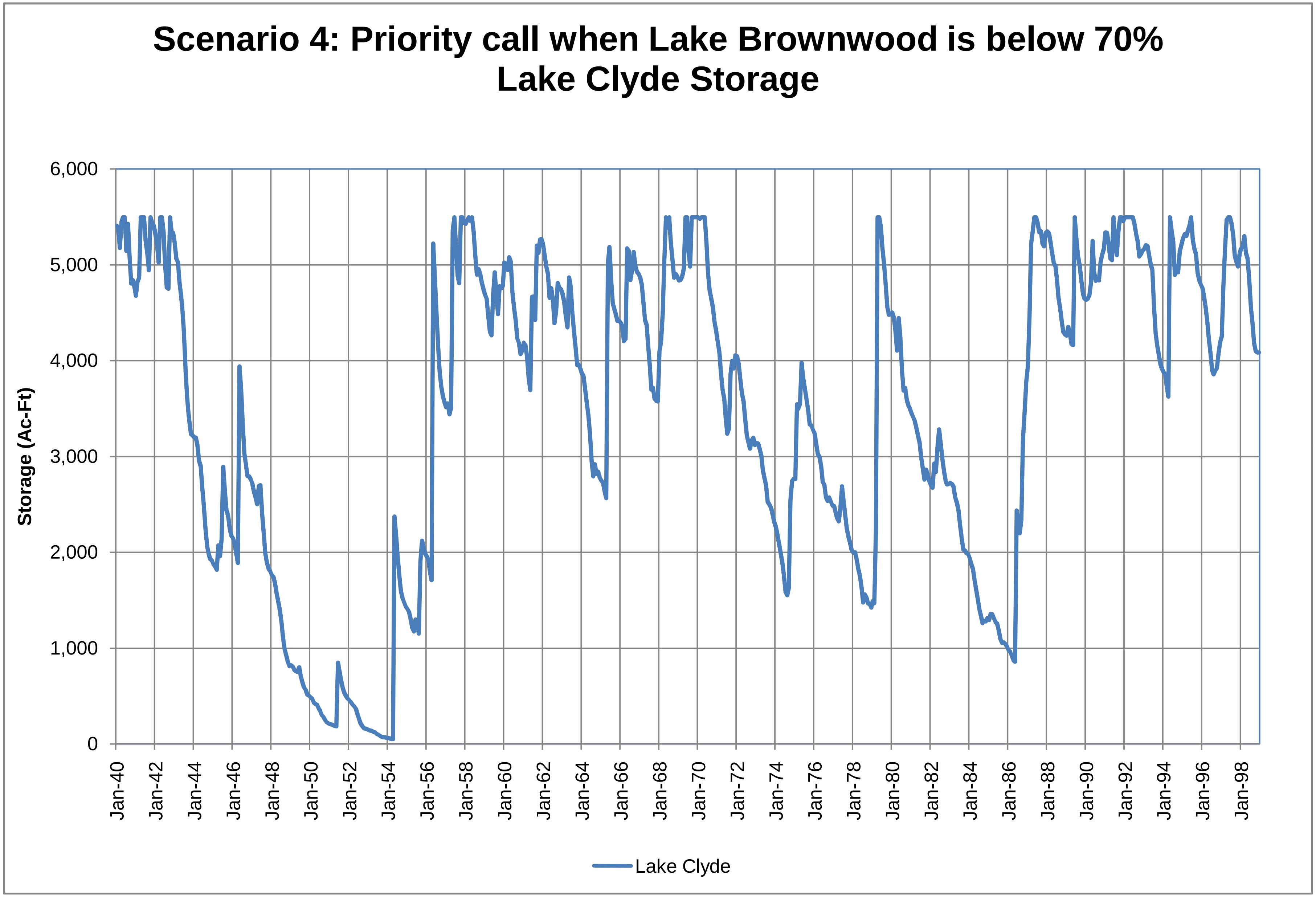

Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

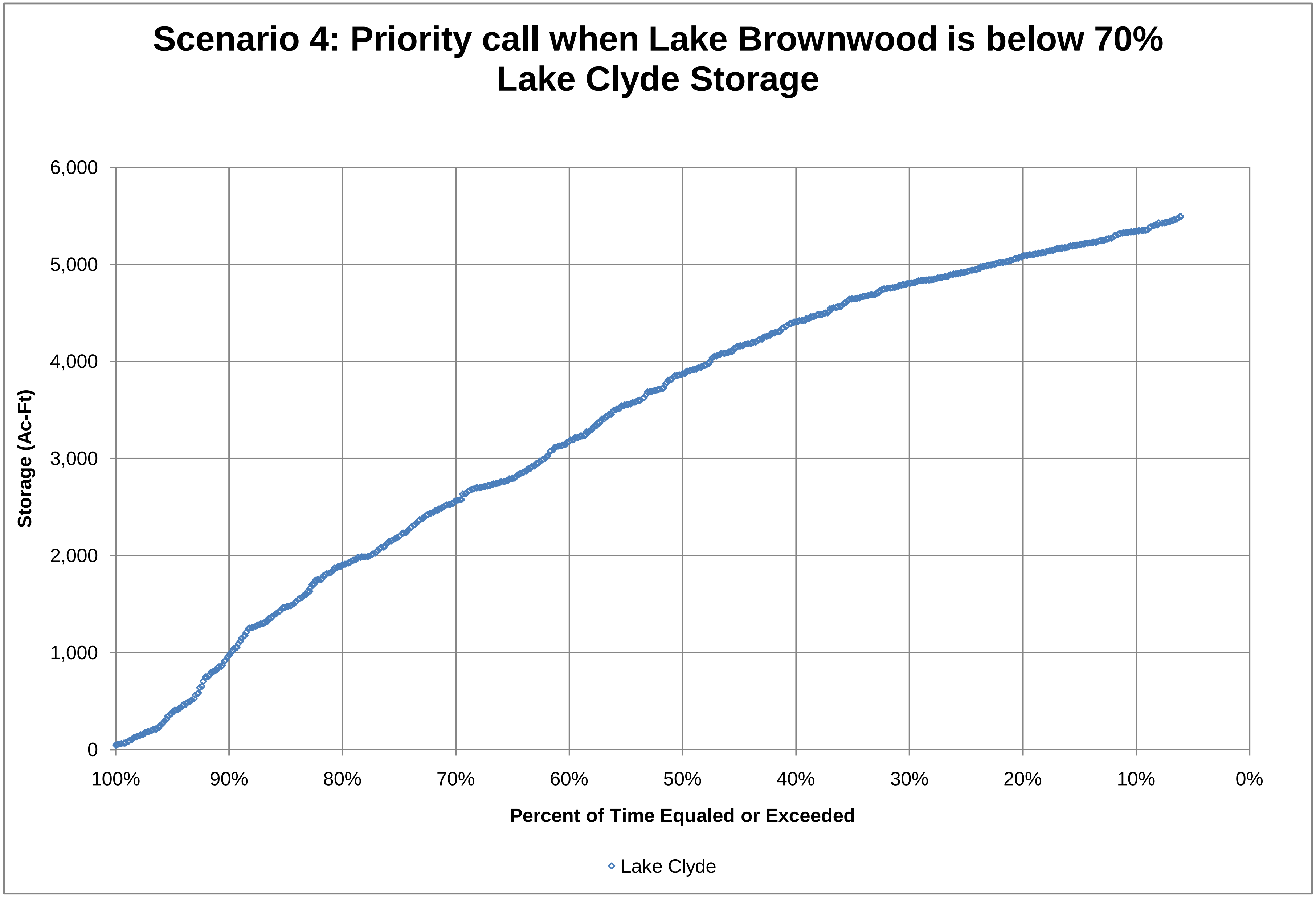


Scenario 4: Priority call when Lake Brownwood is below 70%
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Hords Creek Reservoir

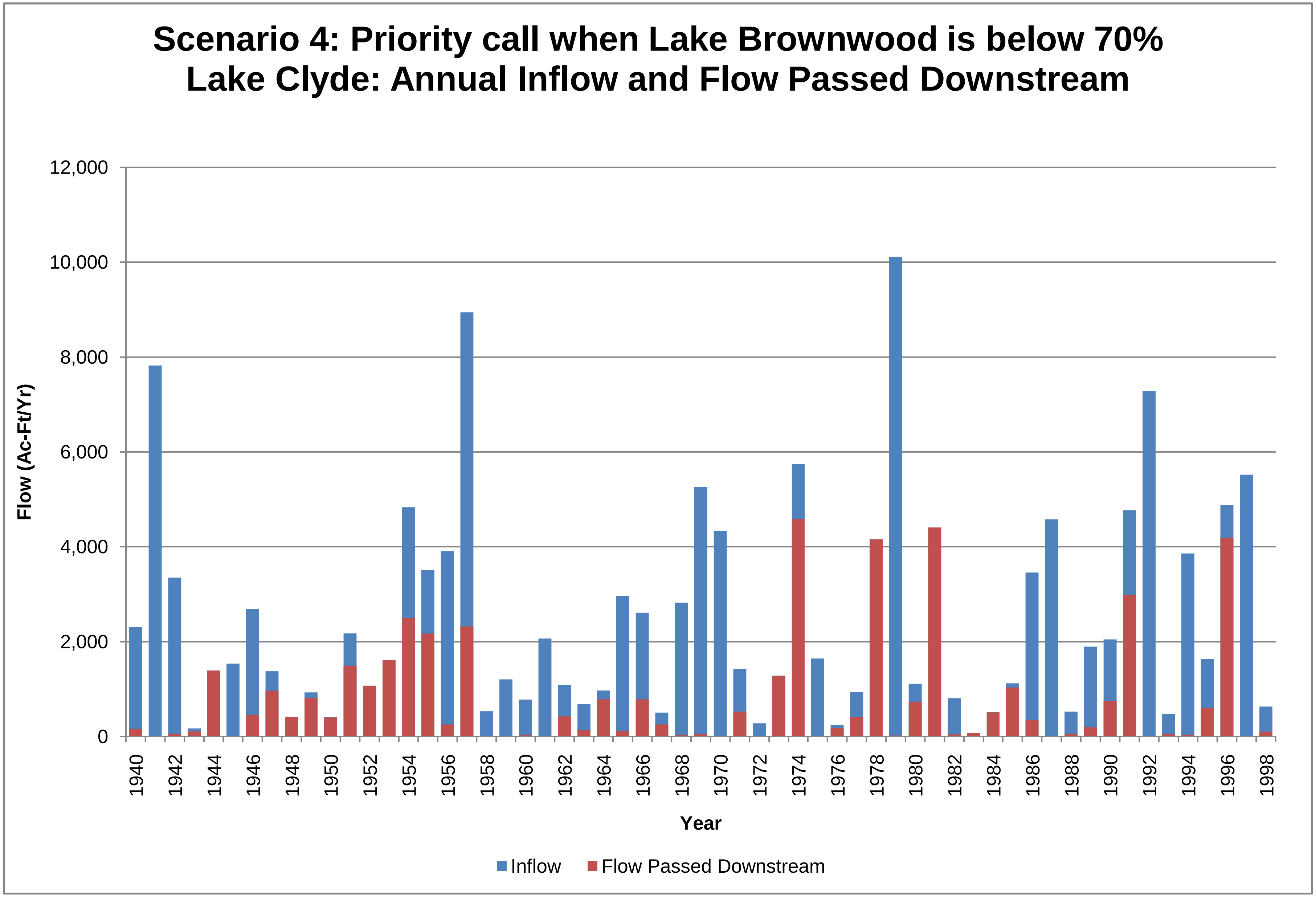

Scenario 4: Priority call when Lake Brownwood is below 70%
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir


Scenario 4: Priority call when Lake Brownwood is below 70%
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream


Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Clyde

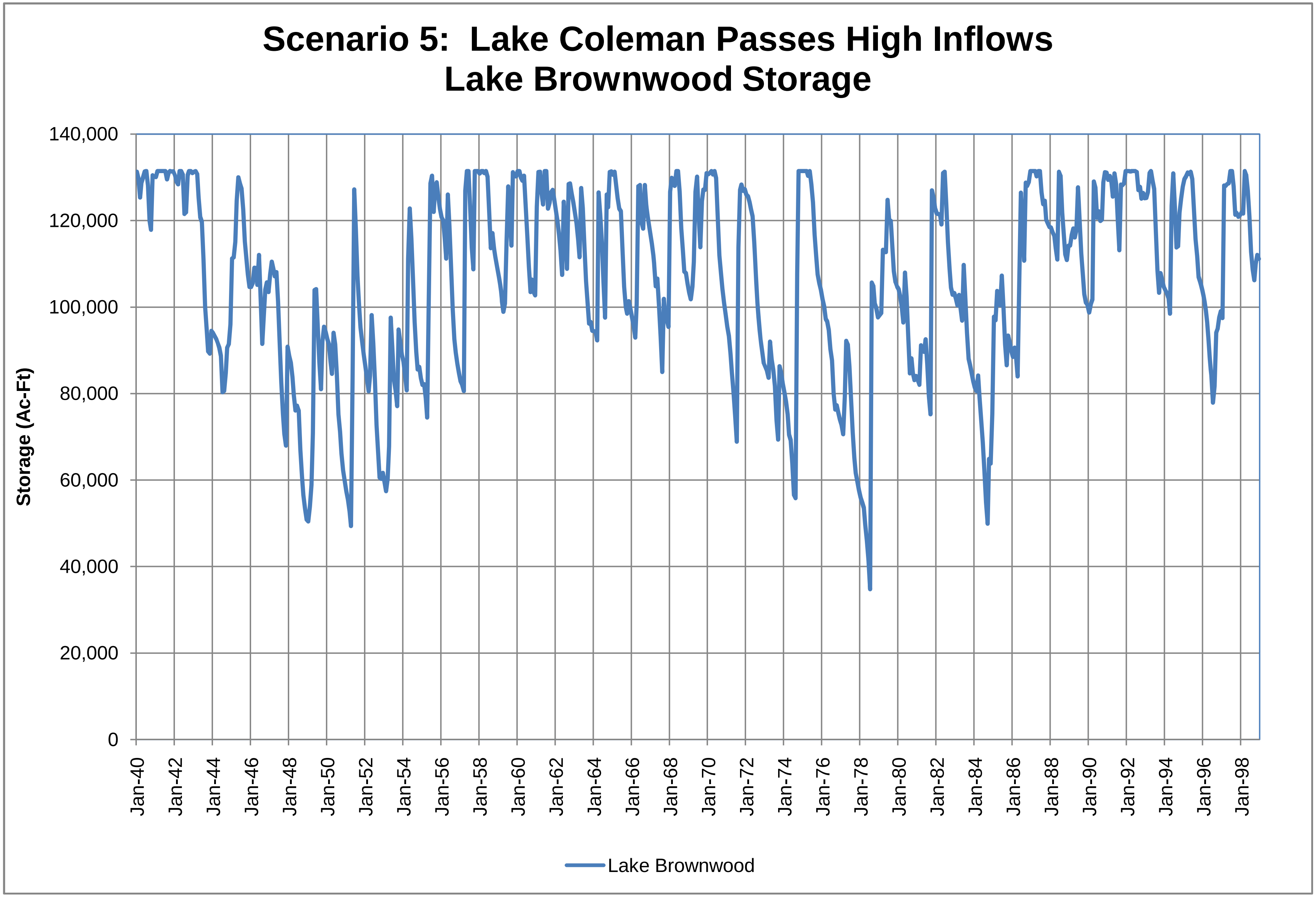


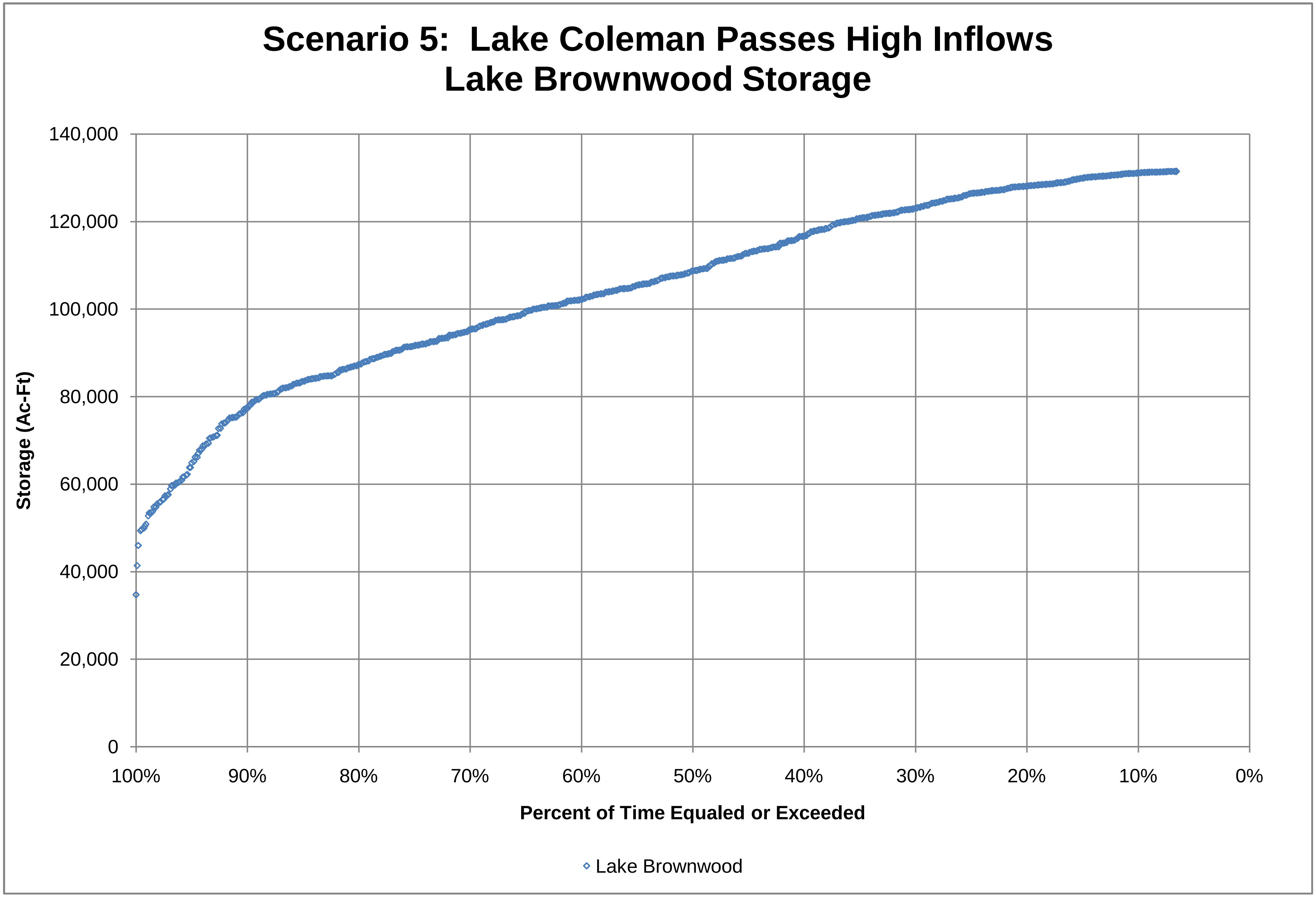
Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Clyde Storage
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde


Scenario 4: Priority call when Lake Brownwood is below 70%
Lake Clyde: Annual Inflow and Flow Passed Downstream
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (Ac-Ft/Yr)
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

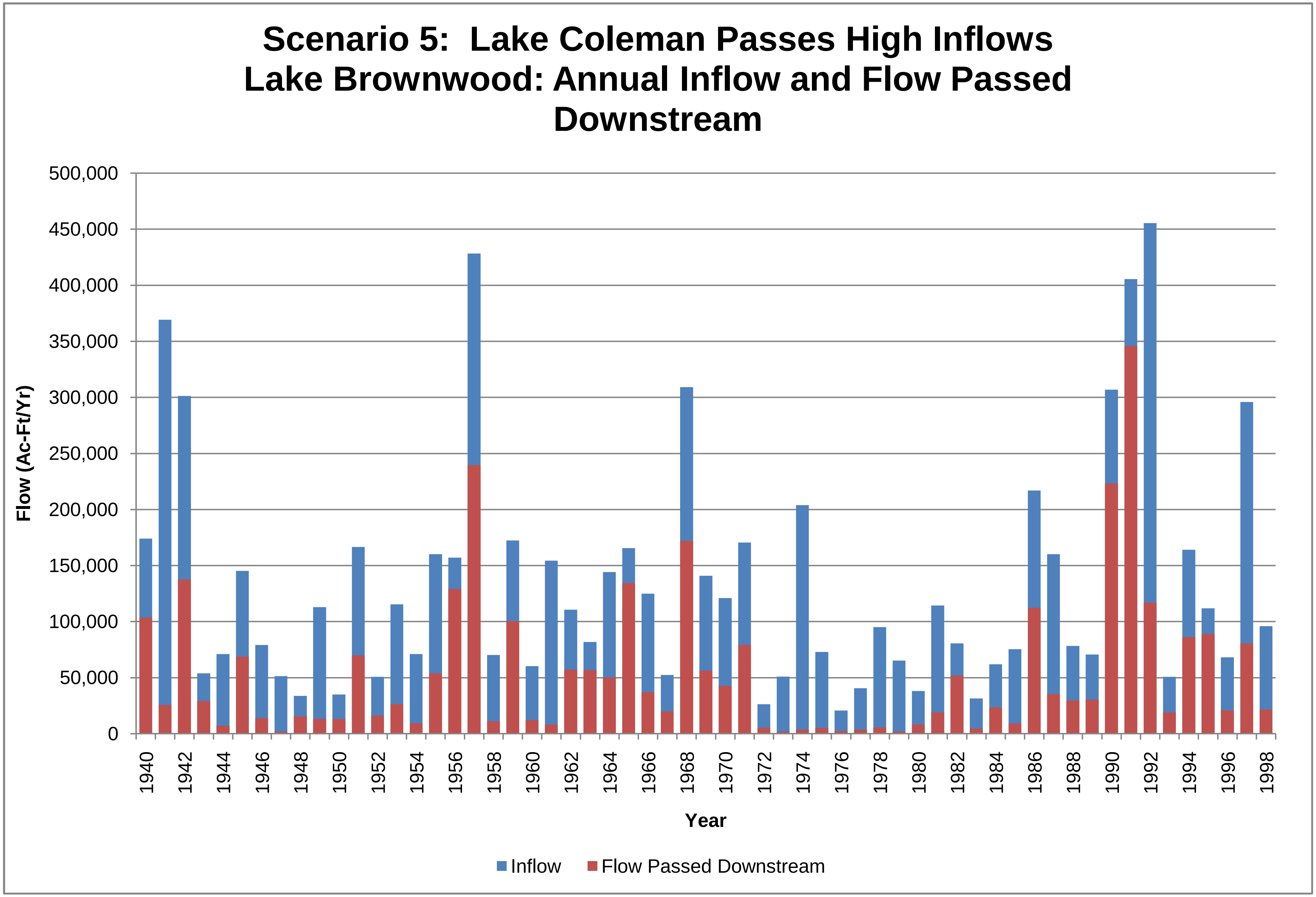
Scenario 5: Lake Coleman passes high flows

Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream

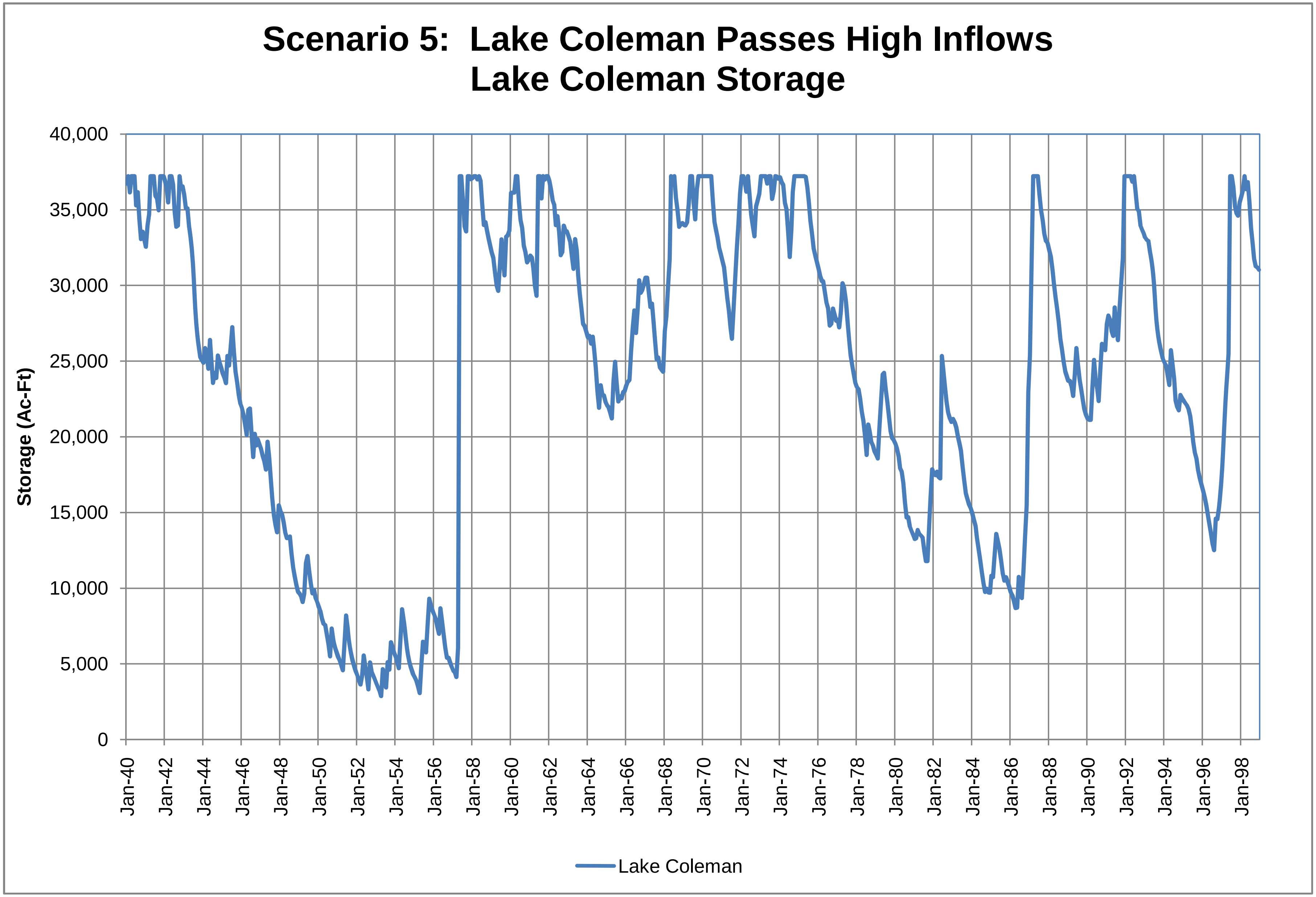

Scenario 5: Lake Coleman Passes High Inflows
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Brownwood

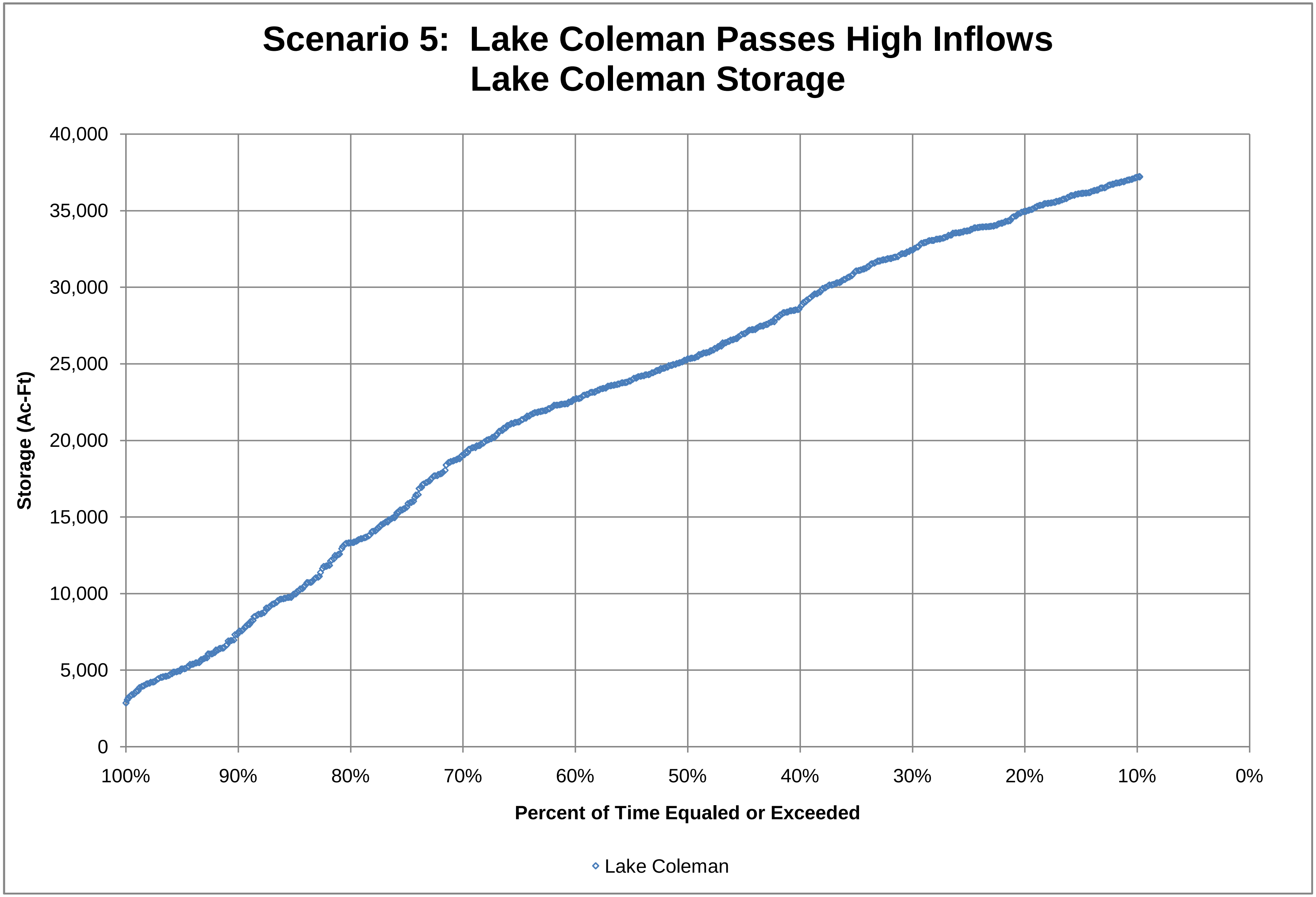


Scenario 5: Lake Coleman Passes High Inflows
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood

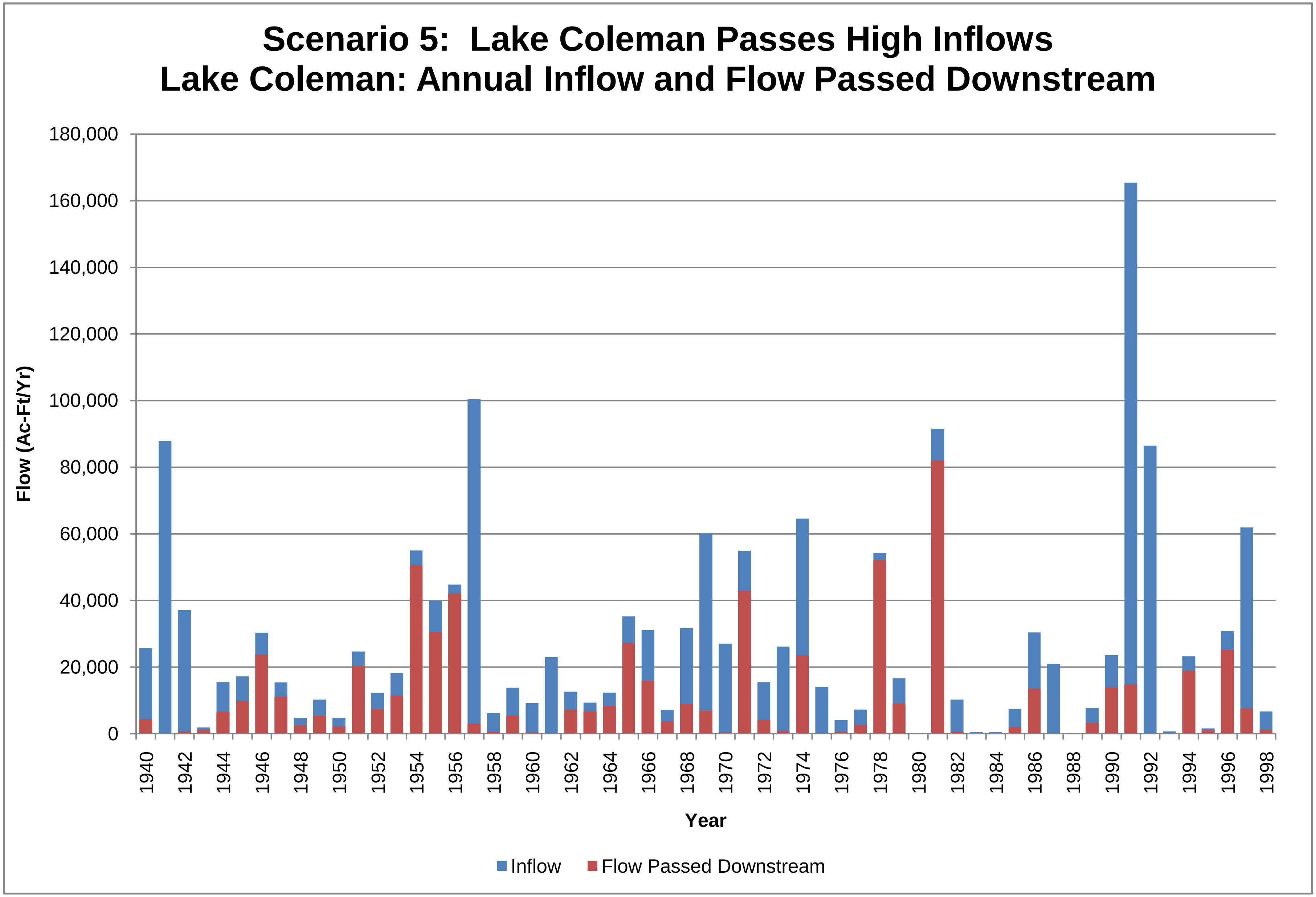


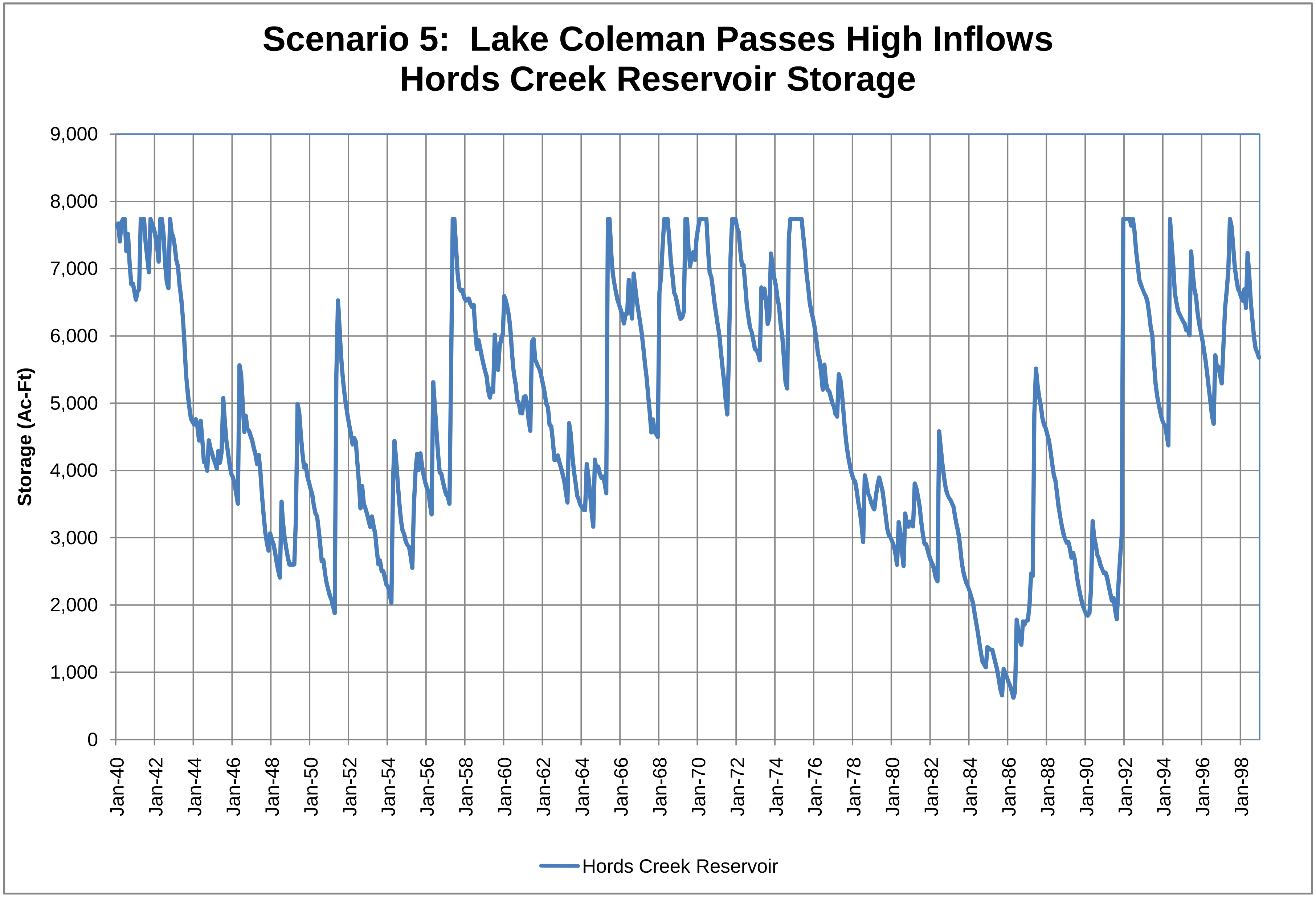
Scenario 5: Lake Coleman Passes High Inflows
Lake Brownwood: Annual Inflow and Flow Passed Downstream
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Flow (Ac-Ft/Yr)
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream


Scenario 5: Lake Coleman Passes High Inflows
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman

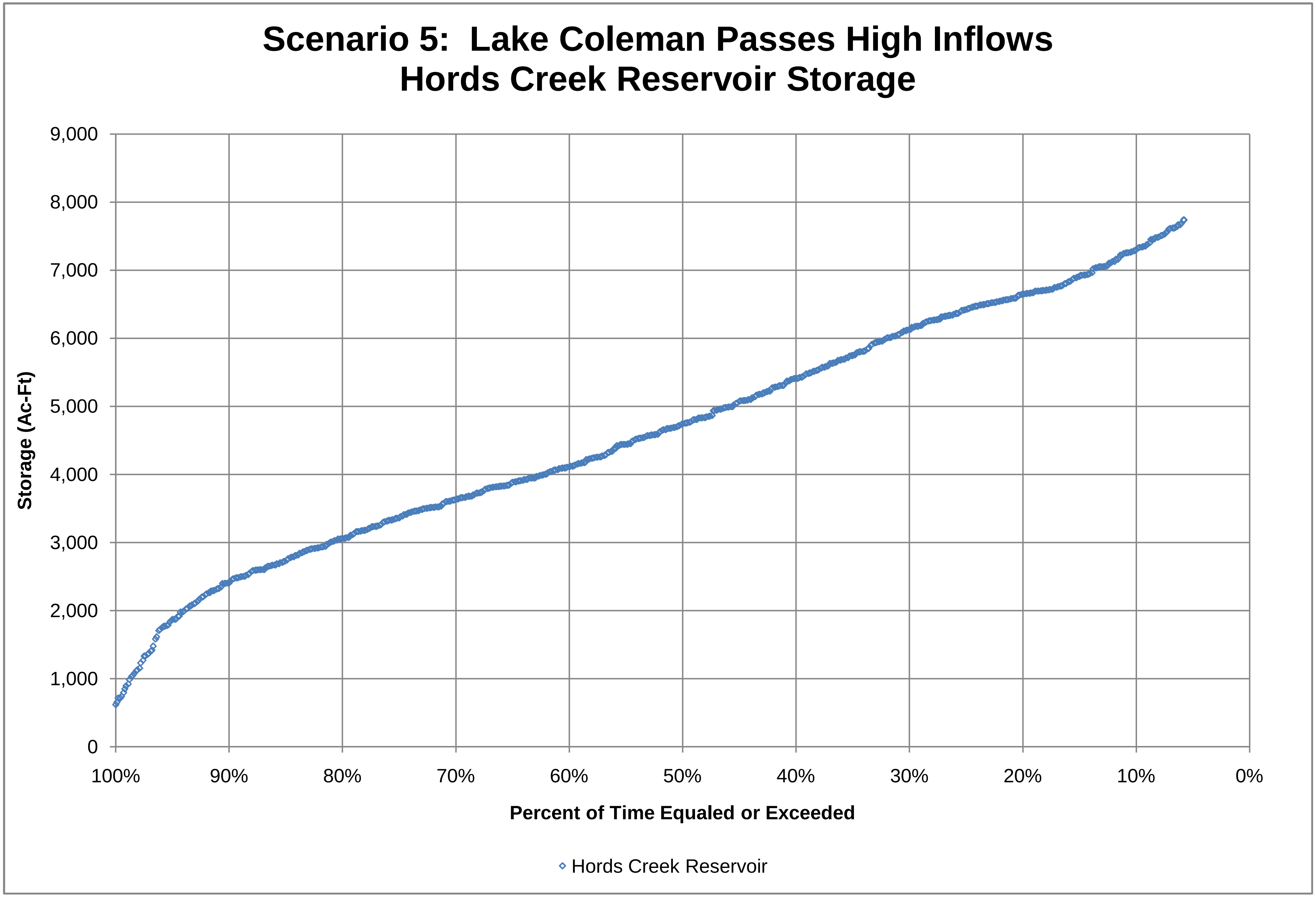


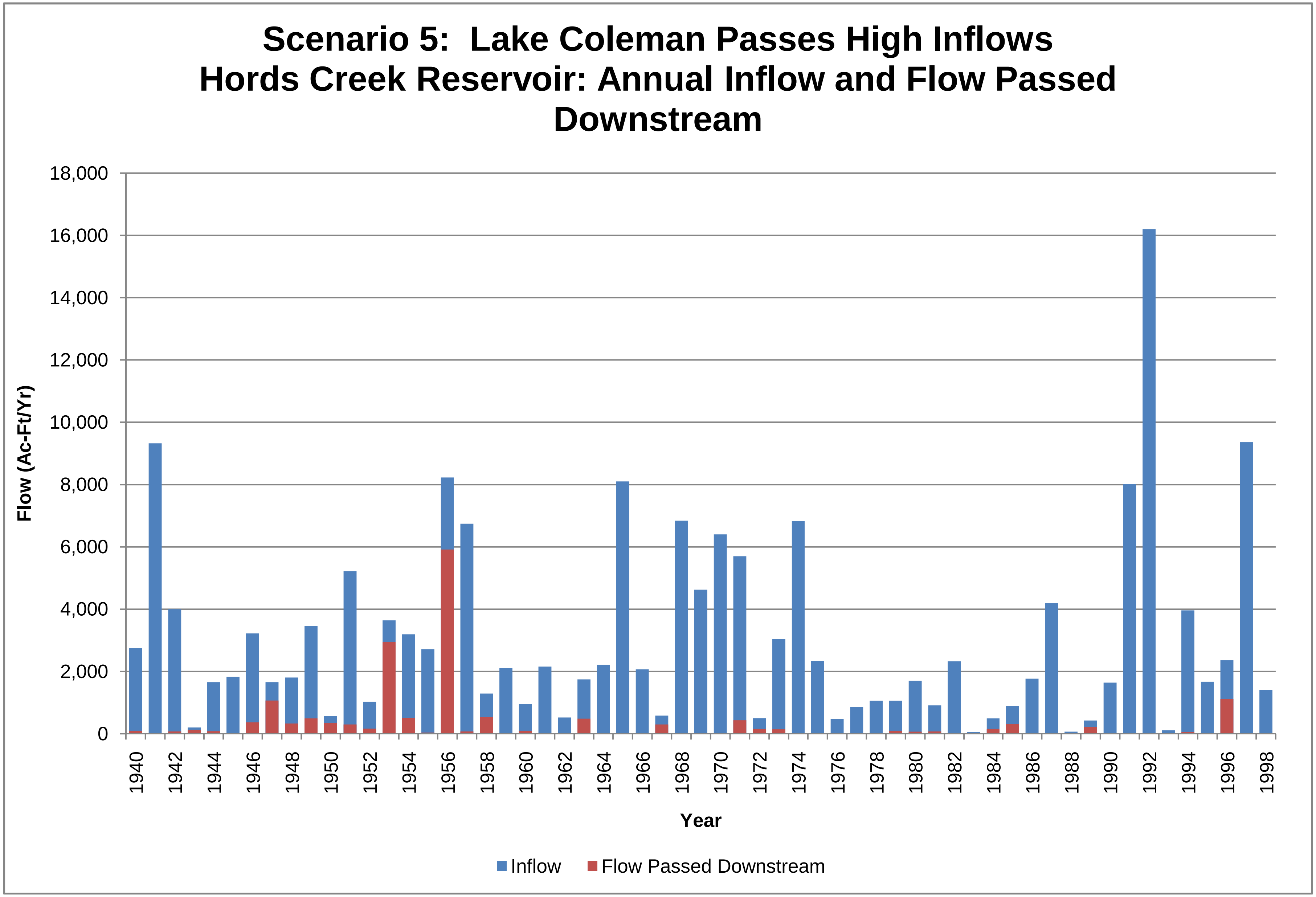
Scenario 5: Lake Coleman Passes High Inflows
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman


Scenario 5: Lake Coleman Passes High Inflows
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

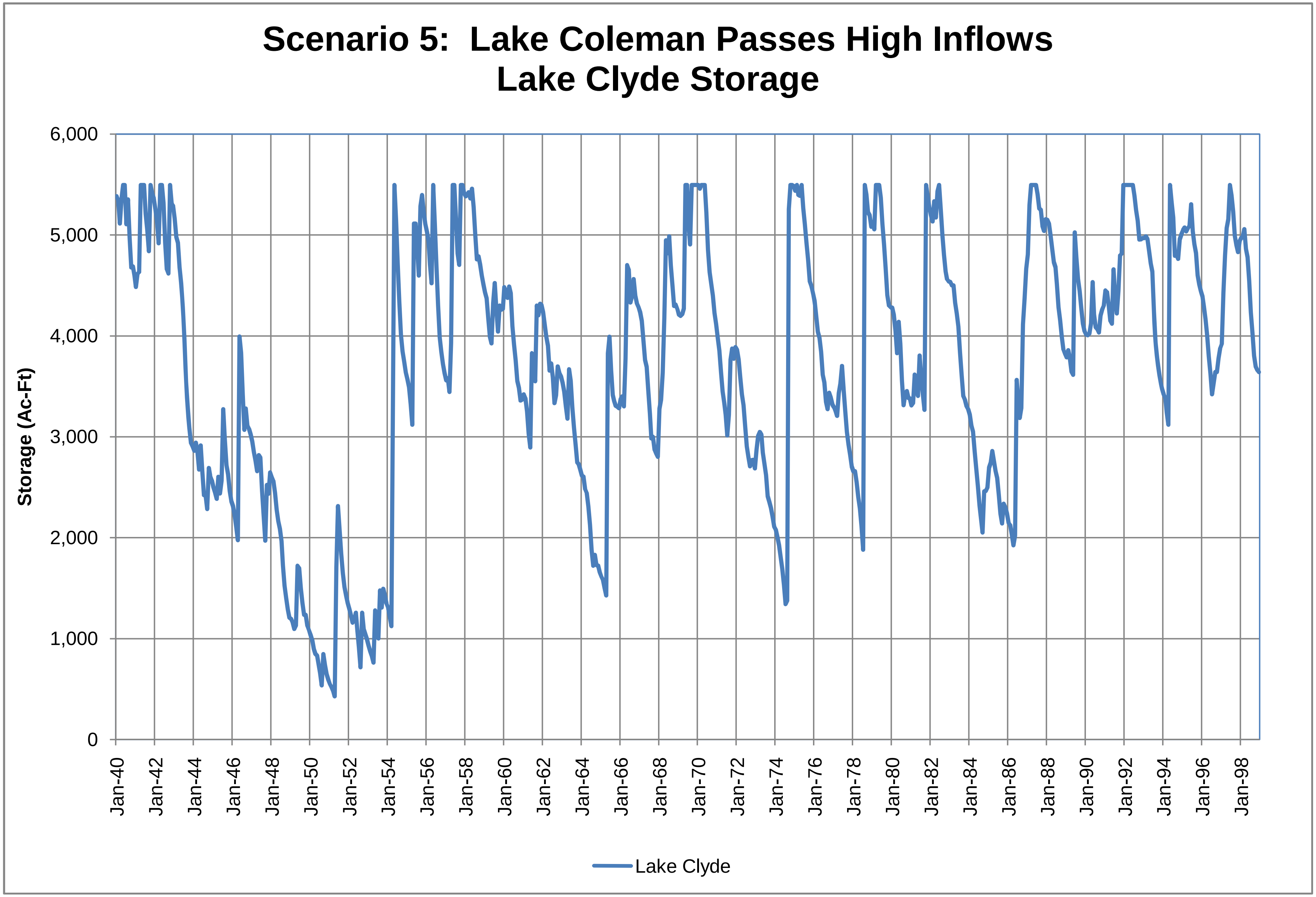


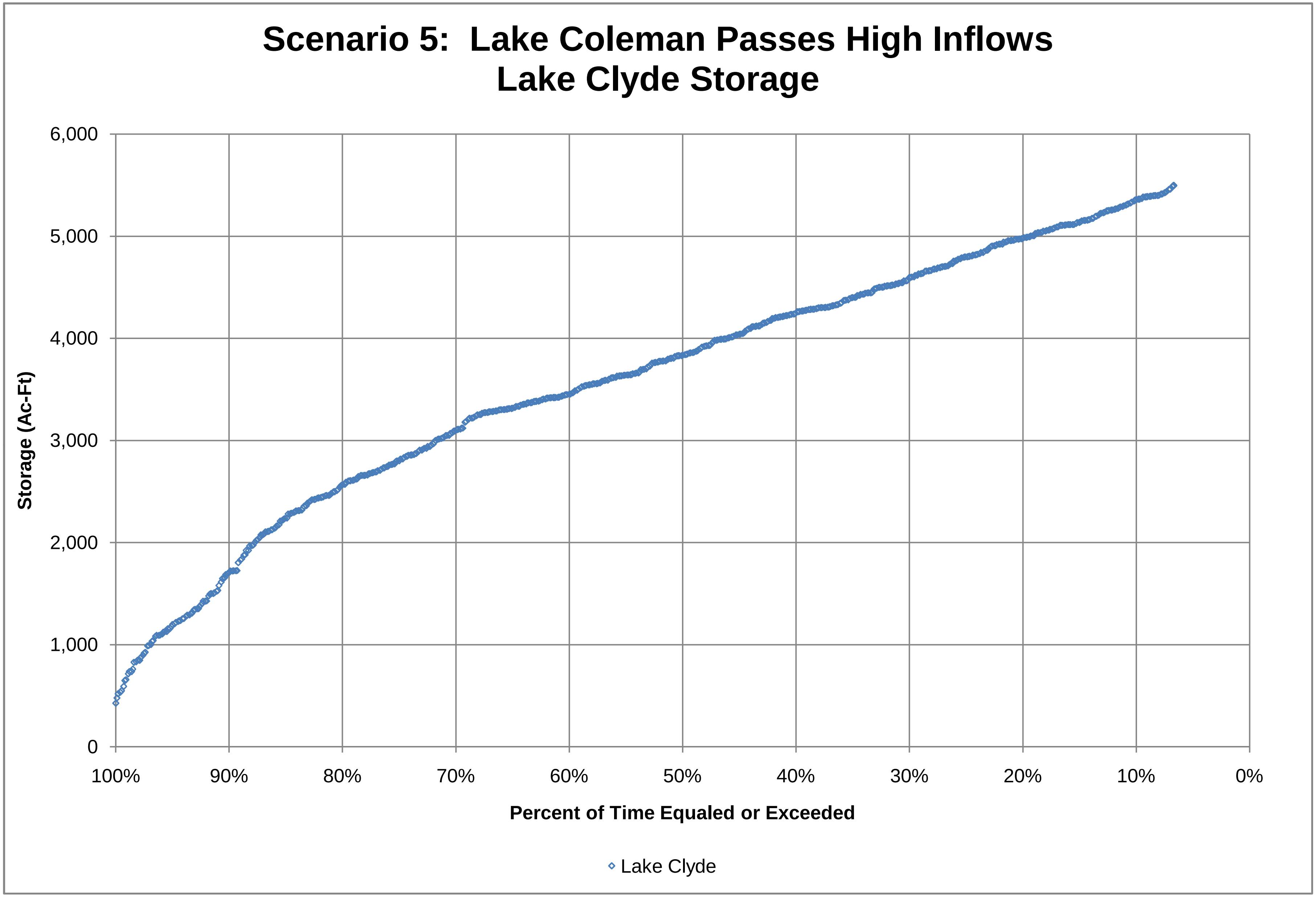
Scenario 5: Lake Coleman Passes High Inflows
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Hords Creek Reservoir

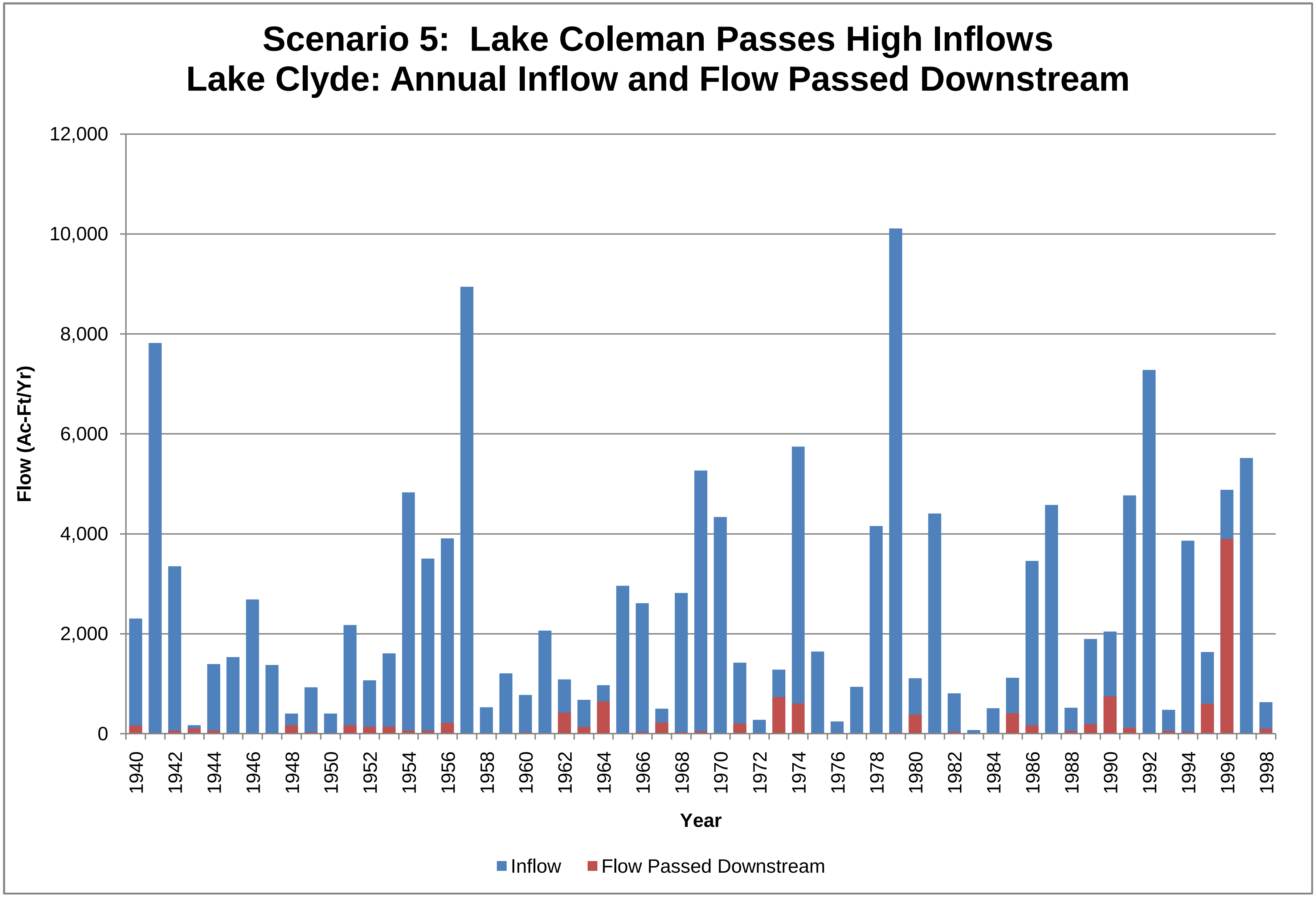

Scenario 5: Lake Coleman Passes High Inflows
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir



Scenario 5: Lake Coleman Passes High Inflows
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream


Scenario 5: Lake Coleman Passes High Inflows
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Clyde

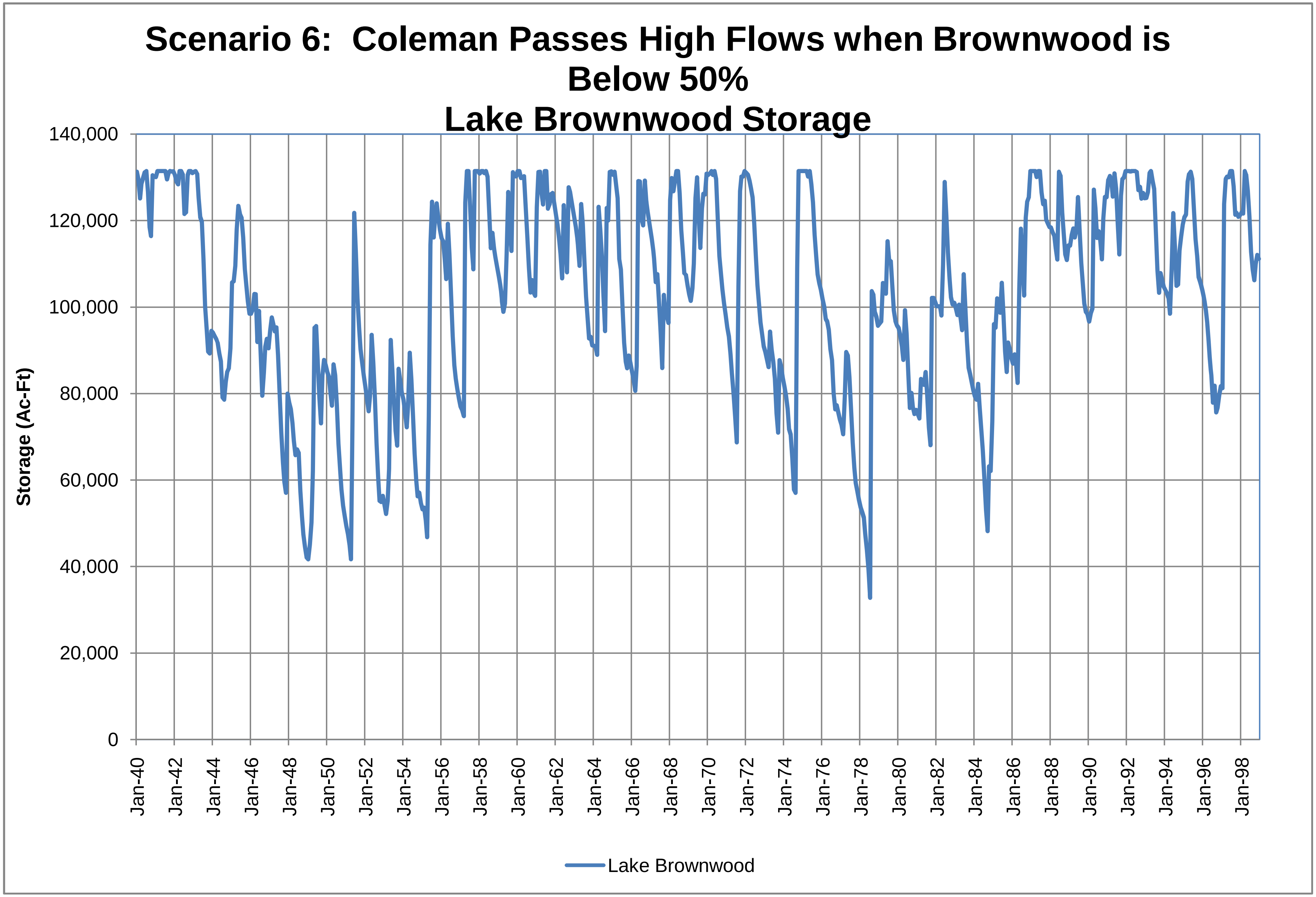

Scenario 5: Lake Coleman Passes High Inflows
Lake Clyde Storage
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde

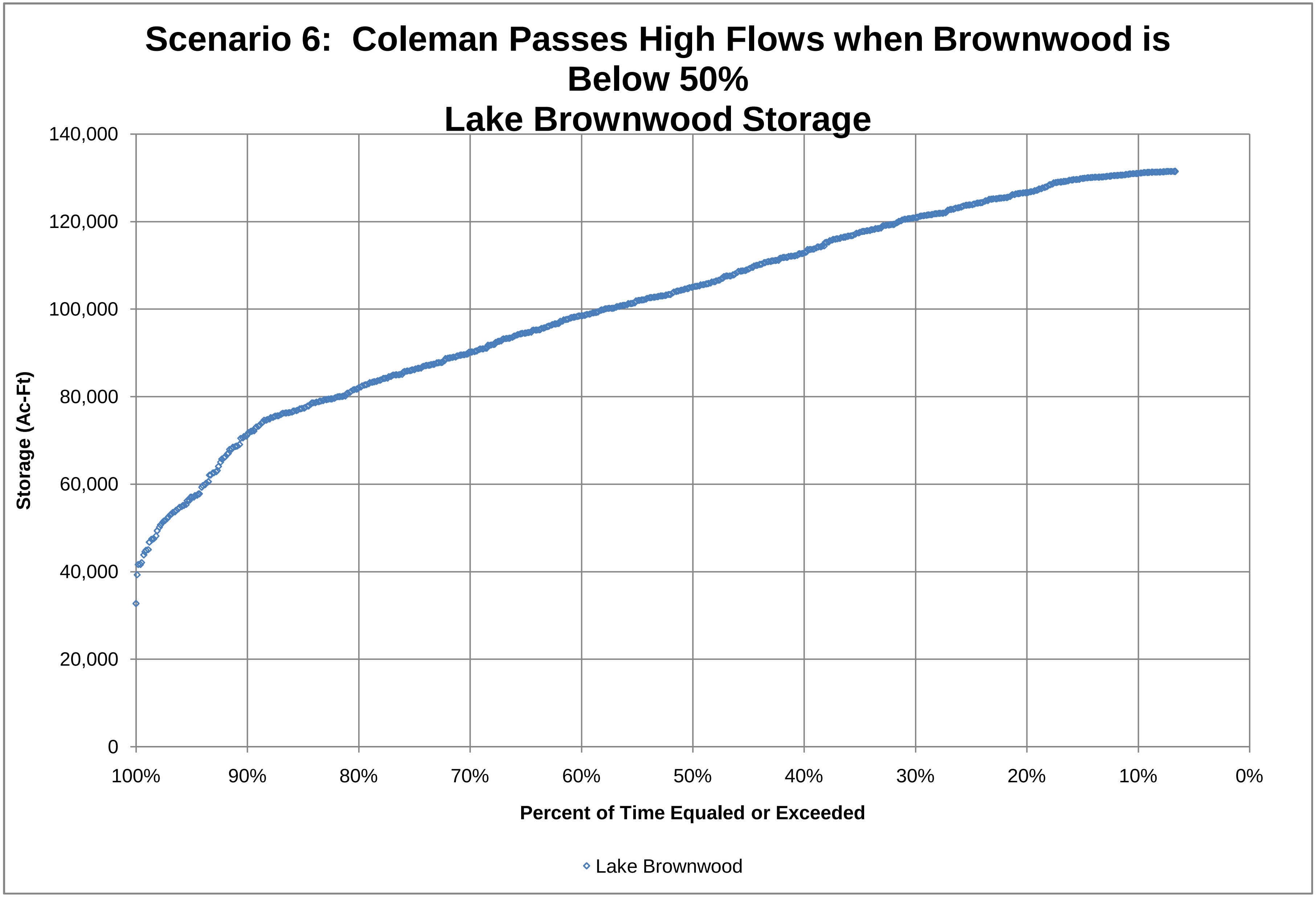


Scenario 5: Lake Coleman Passes High Inflows
Lake Clyde: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

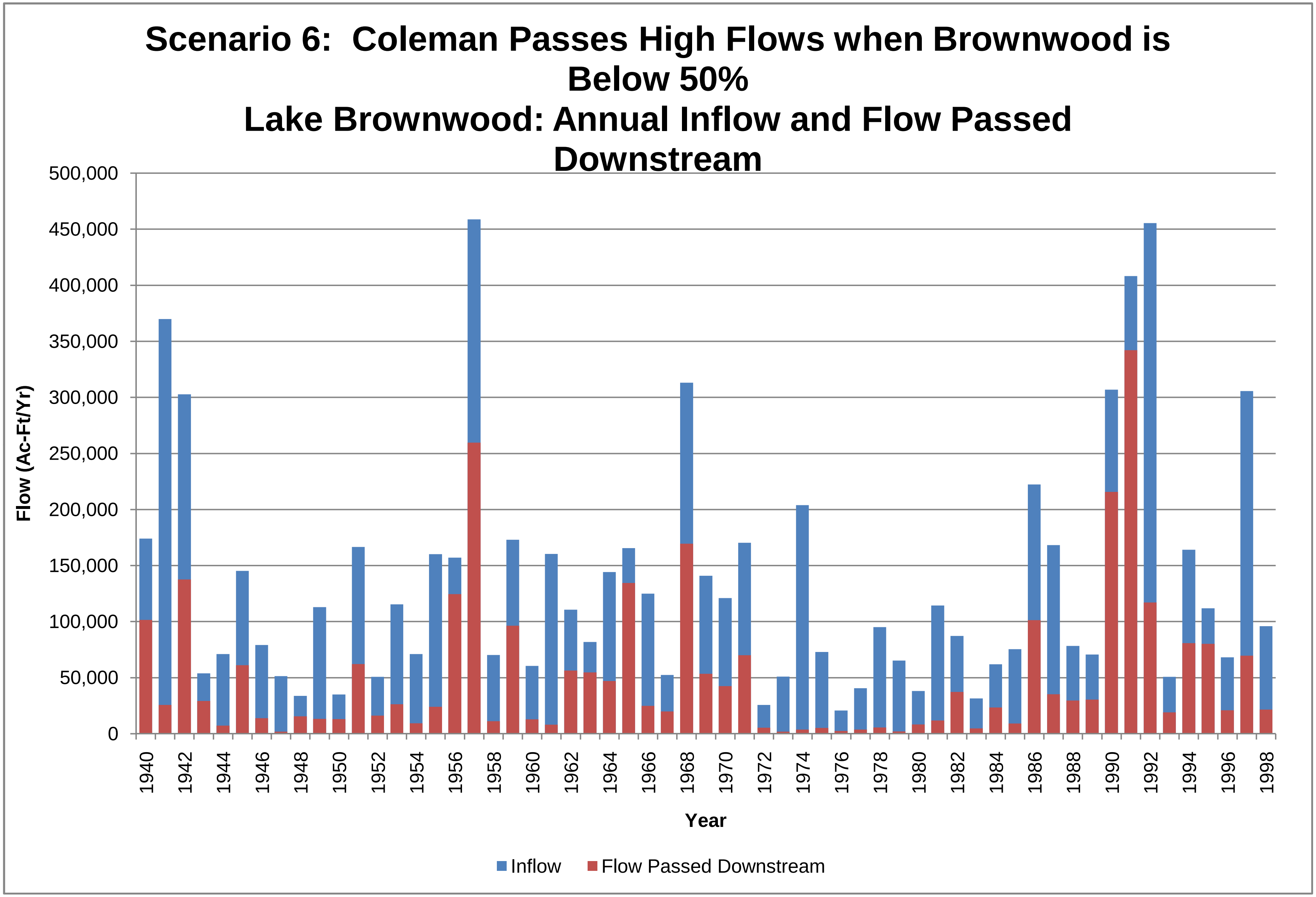
Scenario 6: Lake Coleman passes high flows when Lake Brownwood is below 50%

Simulated Reservoir Storage
Range of Storage
Volume of Water Passed Downstream

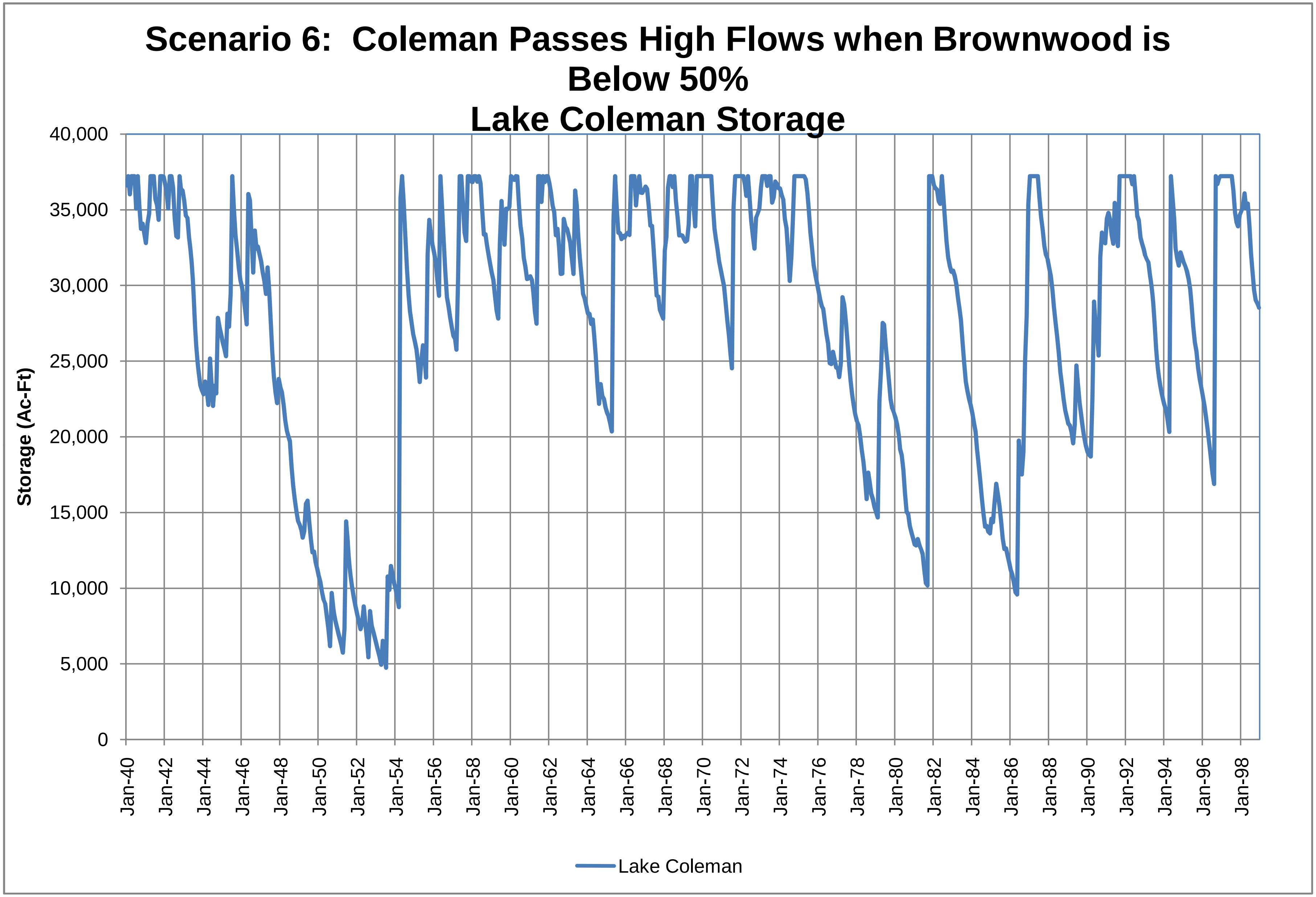

Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Brownwood



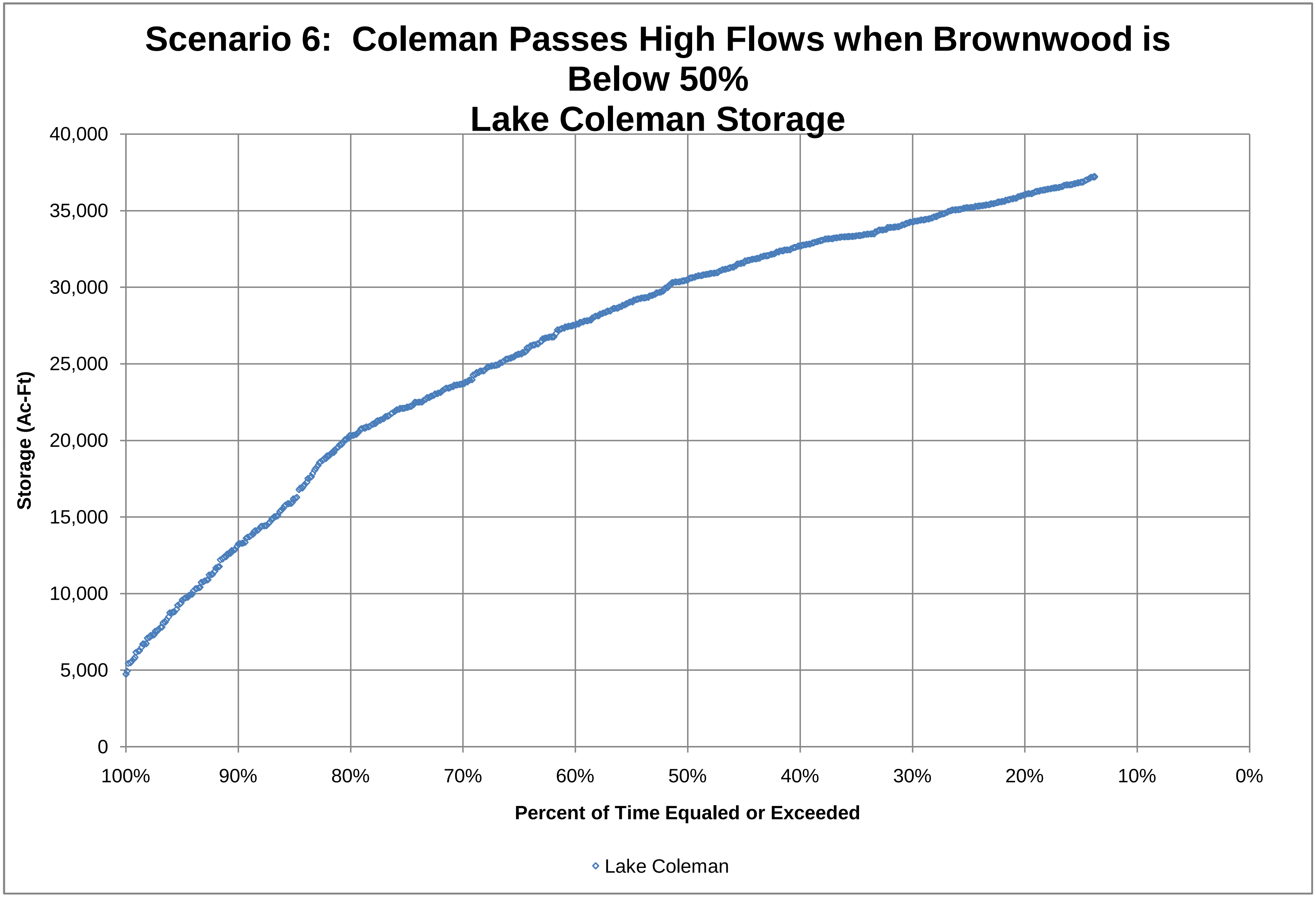
Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Brownwood Storage
Storage (Ac-Ft)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Brownwood



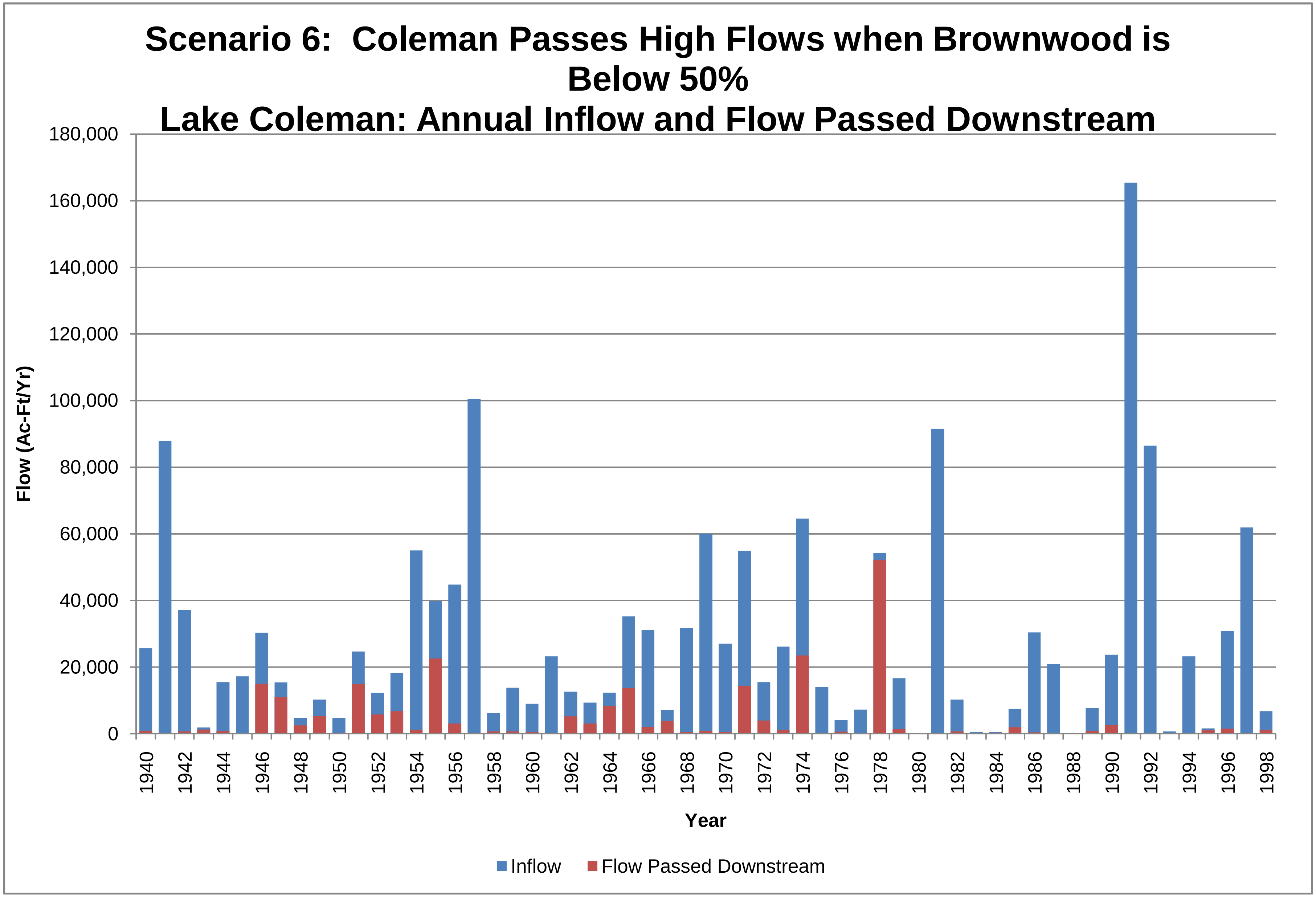
Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Brownwood: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream



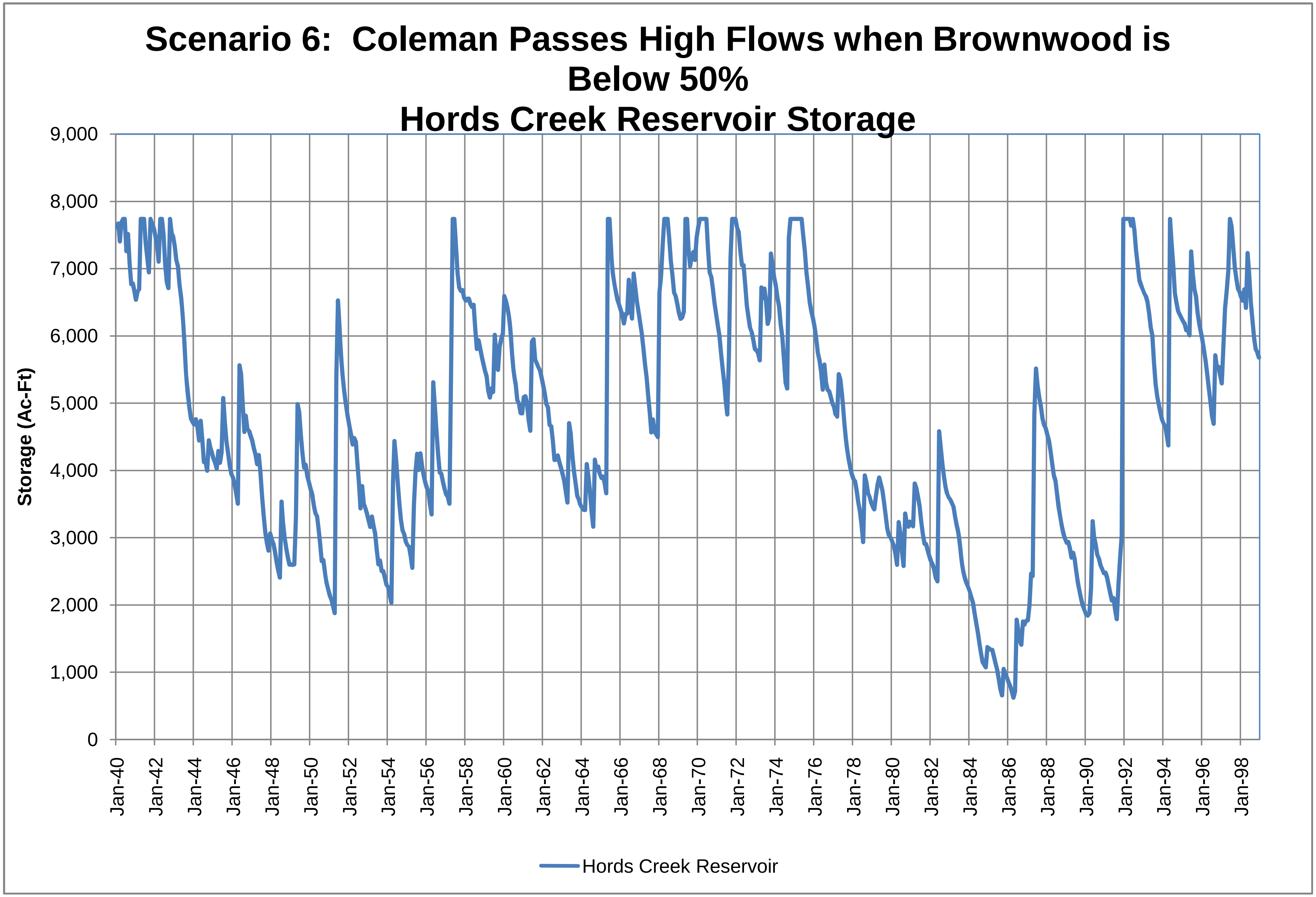
Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Coleman

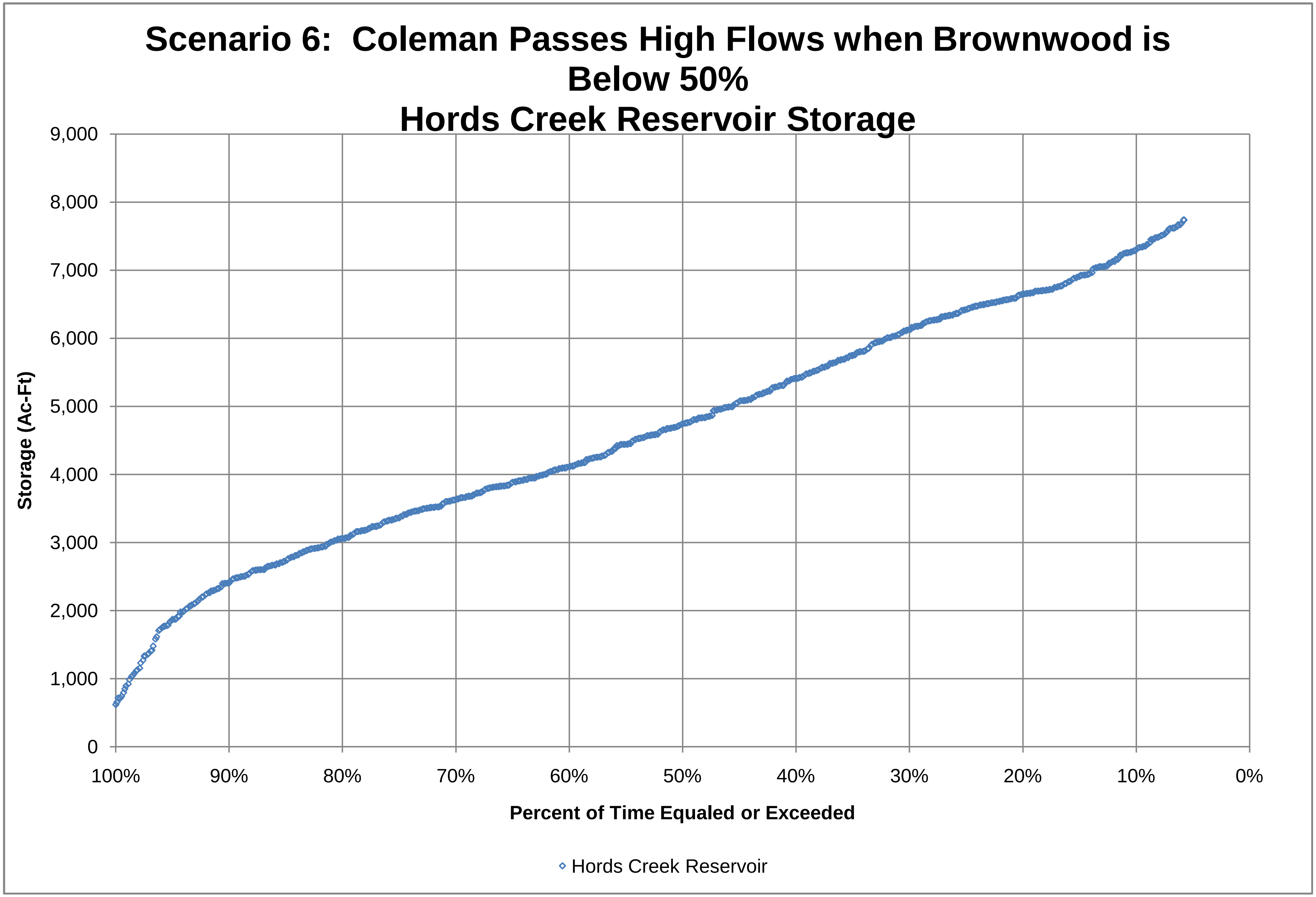


Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Coleman Storage
Storage (Ac-Ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Coleman

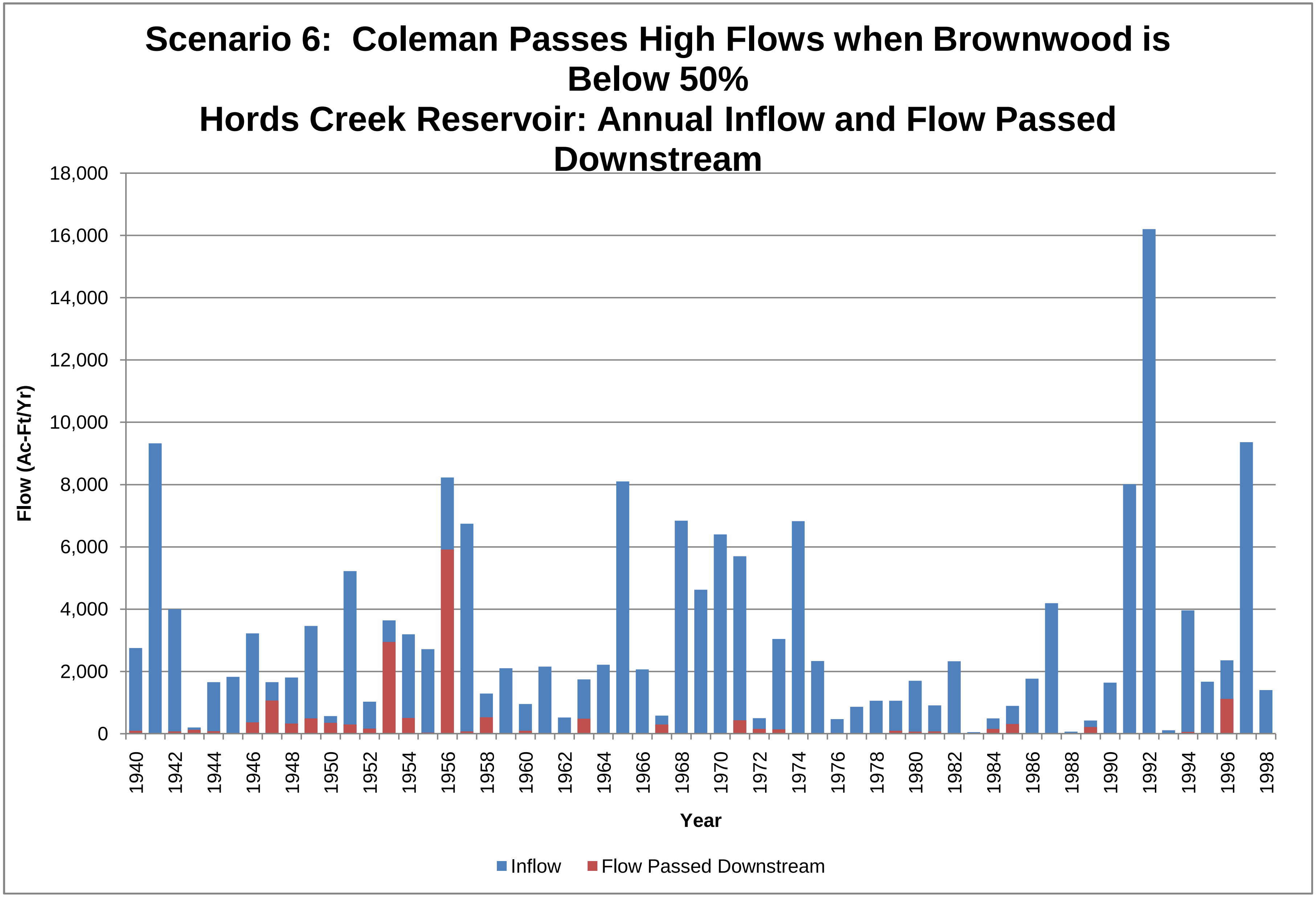


Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Coleman: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

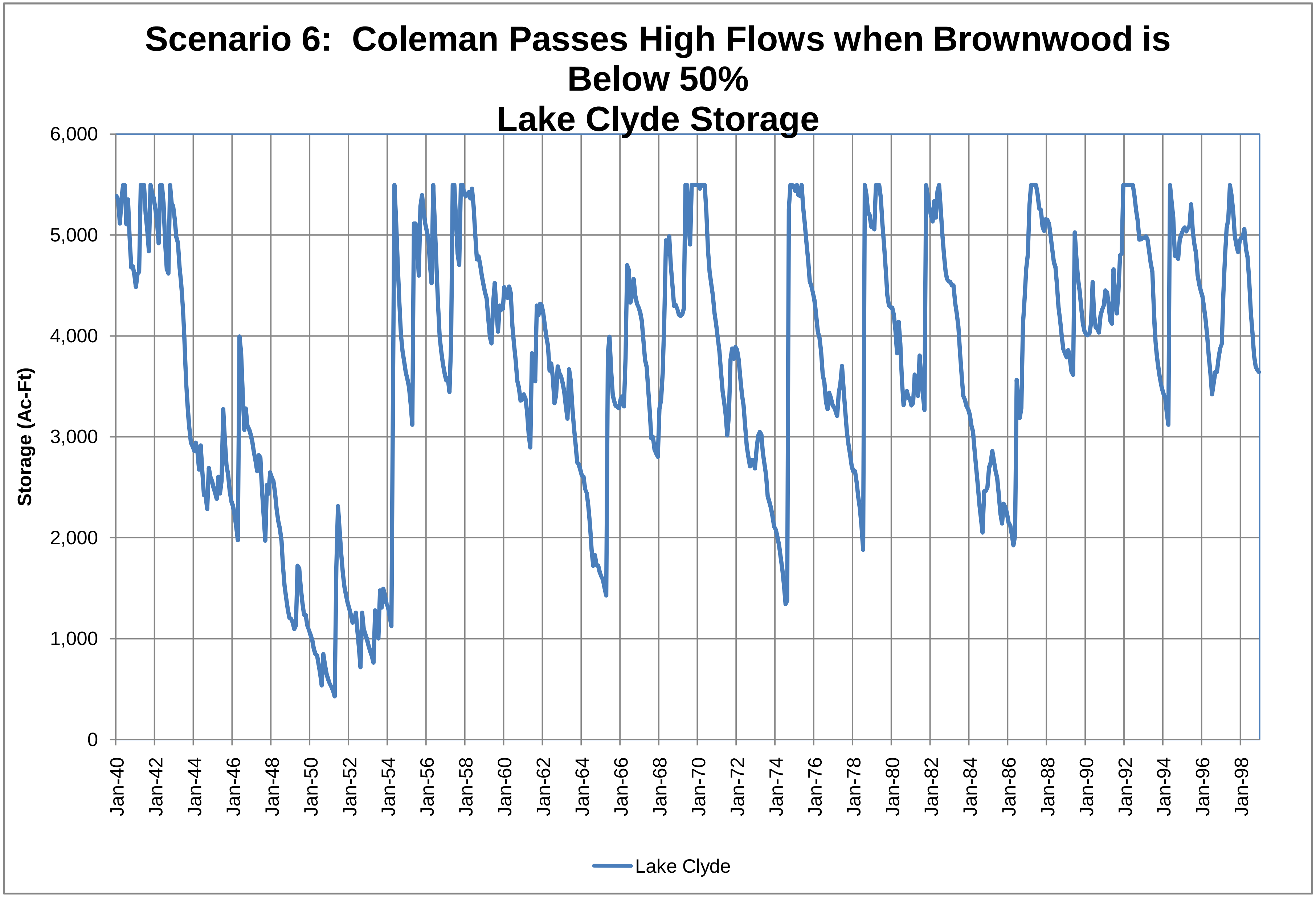

Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Hords Creek Reservoir Storage
Storage (Ac-Ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Hords Creek Reservoir

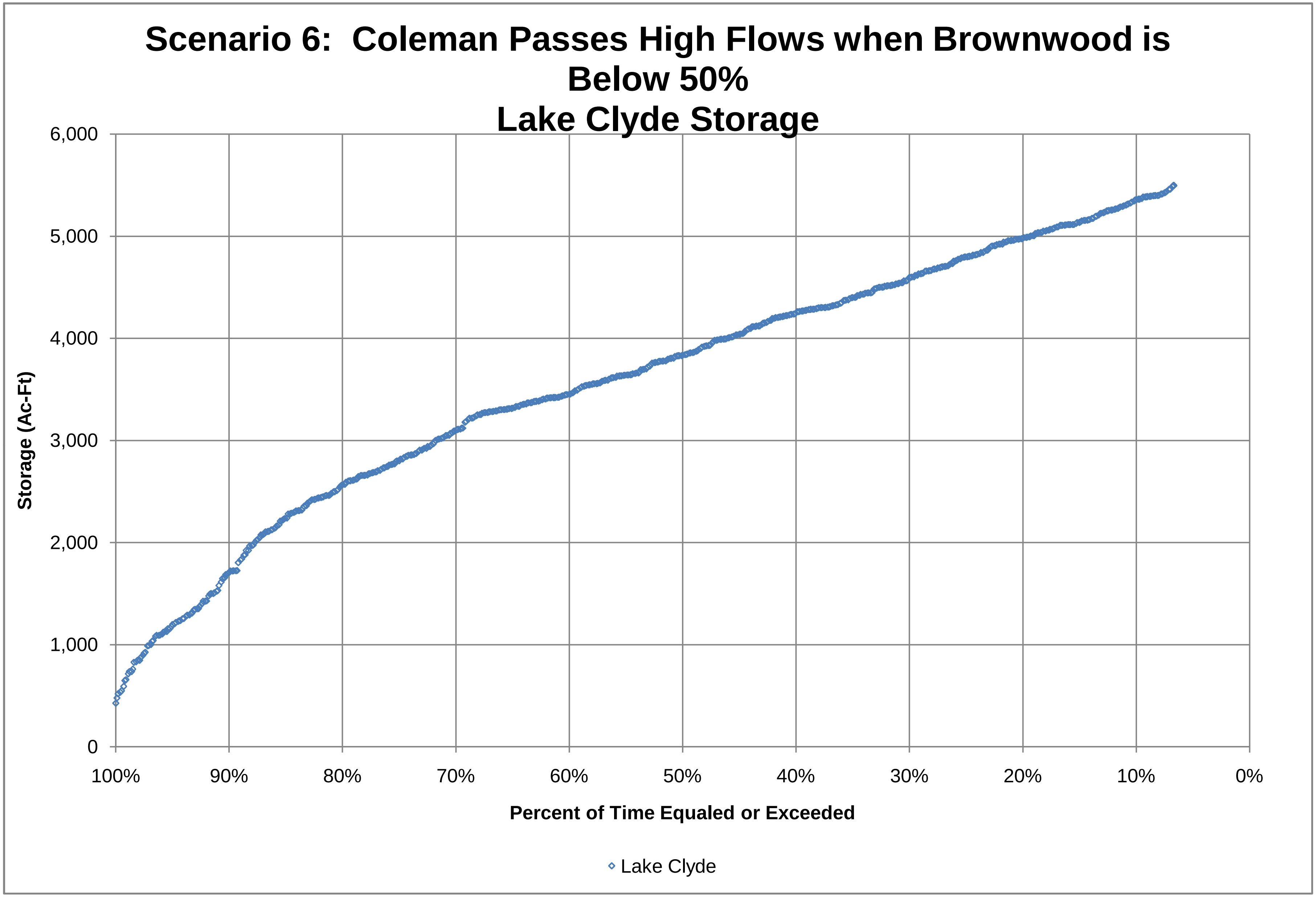


Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Hords Creek Reservoir Storage
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Hords Creek Reservoir

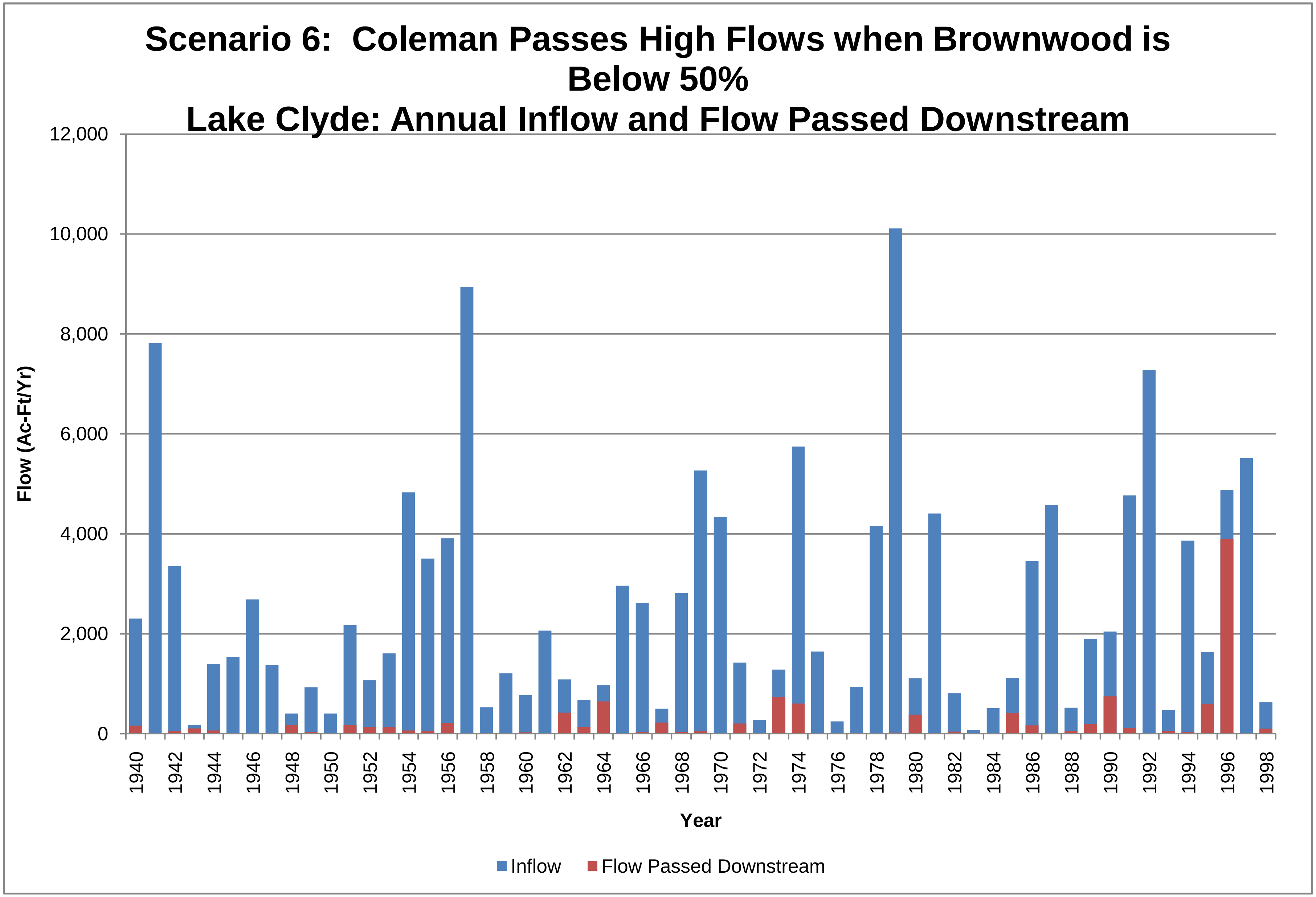


Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Hords Creek Reservoir: Annual Inflow and Flow Passed Downstream
Flow (Ac-Ft/Yr)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream


Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Clyde Storage
Storage (Ac-Ft)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Lake Clyde



Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Clyde Storage
6,000
5,000
4,000
3,000
2,000
1,000
0
Storage (Ac-Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Time Equaled or Exceeded
Lake Clyde


Scenario 6: Coleman Passes High Flows when Brownwood is Below 50%
Lake Clyde: Annual Inflow and Flow Passed Downstream
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (Ac-Ft/Yr)
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Inflow
Flow Passed Downstream

APPENDIX D
INTER-REGIONAL COORDINATION MEMORANDA

Freese and Nichols

MEMORANDUM

TO: Judge Dale Spurgin, Brazos G
Cc: David Dunn, P.E., HDR, Inc.

FROM: Jon S. Albright & Jeremy Rice, Freese and Nichols, Inc.

SUBJECT: Region F Pecan Bayou Modeling

DATE: February 4, 2009

One of the special studies conducted for Region F during this round of regional water planning was the Evaluation of Supplies in the Pecan Bayou Watershed. Figure 1 is a map showing the study area. This study was conducted to evaluate various operation scenarios for the reservoirs in the Pecan Bayou Watershed. These scenarios examined conditions under which Lake Coleman, Hords Creek Reservoir and Lake Clyde would pass water to Lake Brownwood, which has a senior water right. Lake Clyde, which is one of the reservoirs in the Pecan Bayou Watershed, is located in Region G. This memorandum presents a brief synopsis of this study and the potential impacts on Lake Clyde.

The study report was approved by the Region F Water Planning Group on Monday October 27, 2008. Region F will continue to work with the stakeholders to select the appropriate scenario for regional water planning purposes for the 2011 Regional Water Plans.

Background

One of the major recommended strategies in the *2006 Region F Water Plan* is the Subordination of Downstream Senior Water Rights in the Lower Colorado River Basin. This strategy was a joint modeling effort between Regions F and K using the Texas Commission on Environmental Quality's Colorado River Water Availability Model (Colorado WAM). This modeling effort was conducted for planning purposes only. The two most significant assumptions of this strategy are: 1) water rights in Region K do not make priority calls on major

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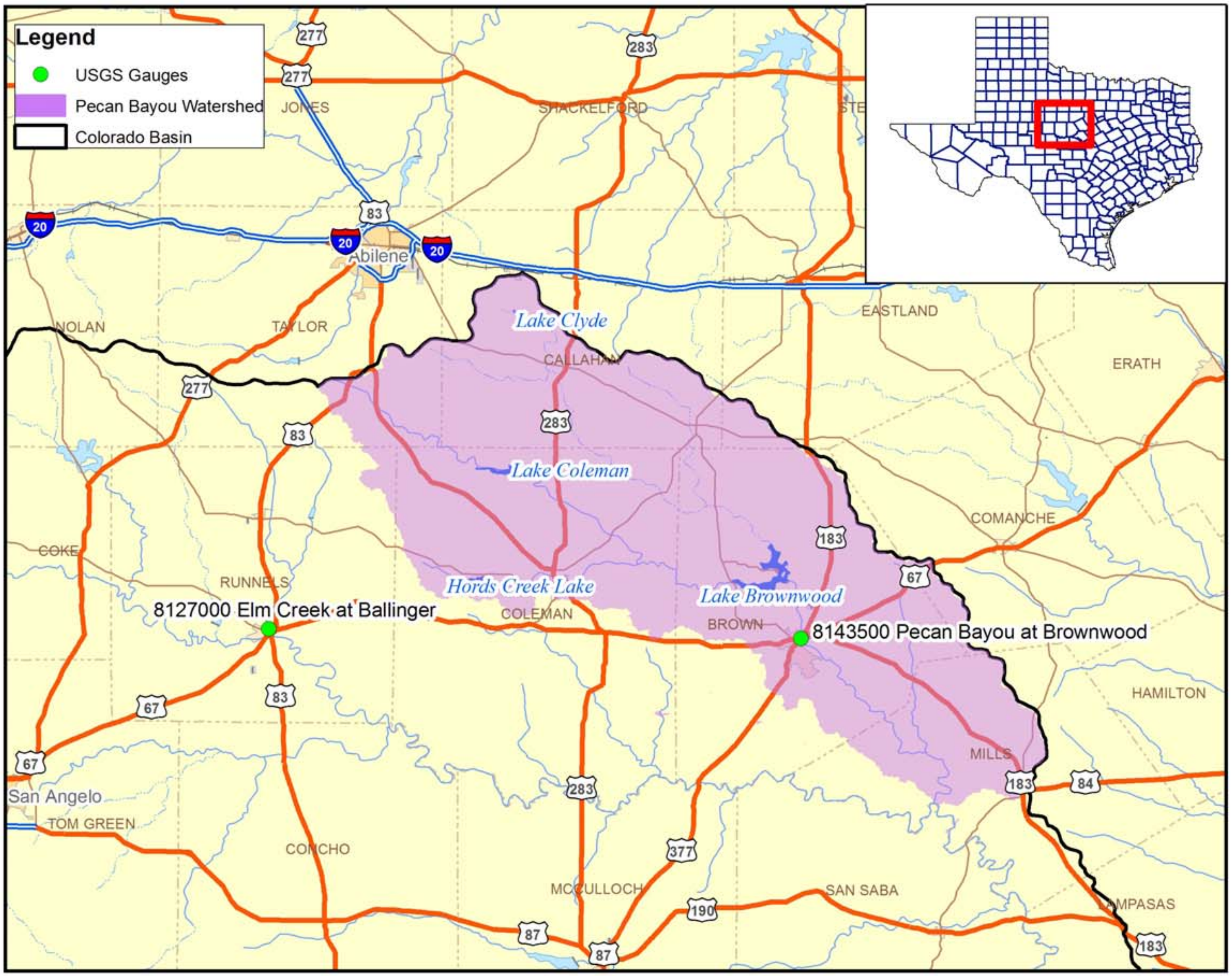
Region F Pecan Bayou Study

Location Map

FN JOB NO: CMD07215
FILE: Pecan Bayou
DATE: September 30, 2008
SCALE: 1:3,000
DESIGNED: JJR
DRAFTED: JJR

FIGURE 1



upper basin rights located in Region F and Brazos G, and 2) these Region F rights do not make priority calls on each other. These assumptions resulted in more realistic estimates of water availabilities for most of the major water rights in Region F, but may not have been appropriate for the Pecan Bayou Watershed.

The subordination strategy assumed Lake Brownwood, which is the senior water rights holder in the watershed, would not make priority calls on upstream junior reservoirs. While this assumption may be representative of basin operations much of the time, under drought conditions it is possible that Lake Brownwood would call on inflows from upstream junior reservoirs. As a result the 2006 plan may have overestimated water supplies from the upstream reservoirs and underestimated supplies from Lake Brownwood. Also, a comparison of historical inflows into Lake Coleman and Hords Creek Reservoir developed in previous studies to the inflows in the Colorado WAM indicates that the WAM flows may be overestimated. This study addresses these issues and evaluates several potential operating scenarios balancing water availability and use among users in the Pecan Bayou watershed.

Lake Clyde is in the Brazos G water planning region and supplies water to the City of Clyde and its customers. (The City of Clyde also purchases water from the Cities of Abilene and Baird.) Lake Clyde has an authorized diversion of 1,200 acre-feet per year. If Lake Brownwood fully exercises its senior priority right, Lake Clyde has no reliable supply. According to DB07, the 2006 Brazos G plan used a supply of 500 acre-feet per year from Lake Clyde, which would assume some level of subordination.

Study Results

Seven scenarios were developed that examined various conditions where a priority call is made by Lake Brownwood:

- *Base Scenario*: *Strict priority.* In this scenario Lake Clyde, Lake Coleman, and Hords Creek Reservoir continuously pass inflows to Lake Brownwood and other senior water rights as needed to fully satisfy diversion and storage rights. This scenario is identical to the assumptions used in the original TCEQ Colorado WAM.

- *Scenario 1: Holding All Inflow.* This scenario assumes that **all** water rights divert in upstream to downstream order and do not pass water to downstream senior water rights. No priority calls are made by any water right.
- *Scenario 2: No priority call by Lake Brownwood.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)
- *Scenario 3: Priority call when Lake Brownwood storage is below 50%.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 50% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)
- *Scenario 4: Priority call when Lake Brownwood storage is below 70%.* This scenario assumes that Lakes Clyde, Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 70% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)
- *Scenario 5: Lake Coleman passes high flows.* This scenario assumes that Lake Coleman would pass only high flows to Lake Brownwood. A high flow is defined as a volume above the average monthly flow of 2,300 acre-feet. Lake Coleman retains all flows that are less than the average monthly flow. Lake Clyde and Hords Creek Reservoir operate as in Scenario 2.
- *Scenario 6: Lake Coleman passes high flows when Lake Brownwood is below 50%.* This scenario is identical to Scenario 3 except that Lake Coleman passes only high flows to Lake Brownwood when Lake Brownwood is less than 50% of the conservation capacity

capacity instead of all flows.

The study also included a review of the hydrology used in the Colorado WAM. The WAM uses naturalized flows at the Pecan Bayou near Brownwood gage to calculated inflows into the reservoirs. This gage is located downstream of Lake Brownwood. A comparison of the WAM flows to historical flows shows that the WAM flows are overestimated for the three upstream reservoirs. In this study, new naturalized flows were developed based on the historical inflows into the reservoirs and naturalized flows from the Elm Creek near Ballinger gage. The recalculated inflows to Lake Clyde are about 28 percent lower than those used in the Colorado WAM. As a result, yields are somewhat lower than previous estimates.

Table 1 compares the firm yield and safe yields for Lake Clyde for each scenario. Table 2 shows the percentage of the months in the 59-year simulation period (1940 to 1998) that each reservoir is full in the safe yield simulations. Table 3 shows the minimum storage encountered in the safe yield simulations. Scenarios 1, 2, 5 and 6 have firm yields that are more than 500 acre-feet per year. The safe yield is less than 500 acre-feet per year in all scenarios. Of the alternative operation scenarios, Scenario 4 provides the least water for Lake Clyde.

Table 1
Firm Yield for Different Scenarios
(Values are Acre-Feet per Year)

Yield Type	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	Strict Priority	Holding all inflow	No priority call by Lake Brownwood	Priority call when Lake Brownwood storage is below 50%	Priority call when Lake Brownwood storage is below 70%	Lake Coleman passes high flows	Lake Coleman passes high flows when Lake Brownwood is below 50%
Firm Yield	0	620	580	330	50	580	580
Safe Yield	0	400	370	200	20	350	350

Table 2
Percentages of Time Lake Clyde is Full in Each Safe Yield Scenario

	Base Scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Lake Clyde	4.2%	8.5%	6.7%	6.4%	6.1%	6.7%	6.7%

Table 3
Minimum Storage in Each Safe Yield Scenario

	Base Scenario		**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**		**Scenario 6**	
	Storage (Ac-Ft)	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**	**Storage (Ac-Ft)**	**% Full**
Lake Clyde	47	1%	399	7%	384	7%	245	4%	49	1%	427	8%	427	8%

Freese and Nichols

MEMORANDUM

TO: John Burke, Chairman, Region K
Cc: David Parkhill, TCB

FROM: Jon S. Albright, Freese and Nichols, Inc.

SUBJECT: Region F Pecan Bayou Modeling

DATE: December 29, 2008

One of the special studies conducted for Region F during this round of regional water planning was the Evaluation of Supplies in the Pecan Bayou Watershed. Figure 1 is a map showing the study area. This study was conducted to evaluate various operation scenarios for the reservoirs in the Pecan Bayou Watershed. These scenarios examined conditions under which Lake Coleman, Hords Creek Reservoir and Lake Clyde would pass water to Lake Brownwood, which has a senior water right. This memorandum presents a brief synopsis of this study and the potential impacts on Region K.

The study report was approved by the Region F Water Planning Group on Monday, October 27, 2008. Region F will continue to work with the stakeholders to select the appropriate scenario for regional water planning purposes for the 2011 Region F Water Plan.

Table 1 compares average annual outflows from Lake Brownwood for the six scenarios identified in the study to the Colorado WAM operated in strict priority order (Base Scenario). The average annual flow for the entire period and for the period from 1950 to 1946 is included at the bottom of the table. The scenarios are described in detail later in this memorandum.

Under the strict priority assumptions of the Base Scenario (TCEQ-approved WAM), Lake Brownwood fills up and spills several times during the 1950s drought. The operation of the Pecan Bayou reservoirs could change the frequency of those spills depending on the operation scenario elected by the Region F Water Planning Group. This could potentially impact supplies

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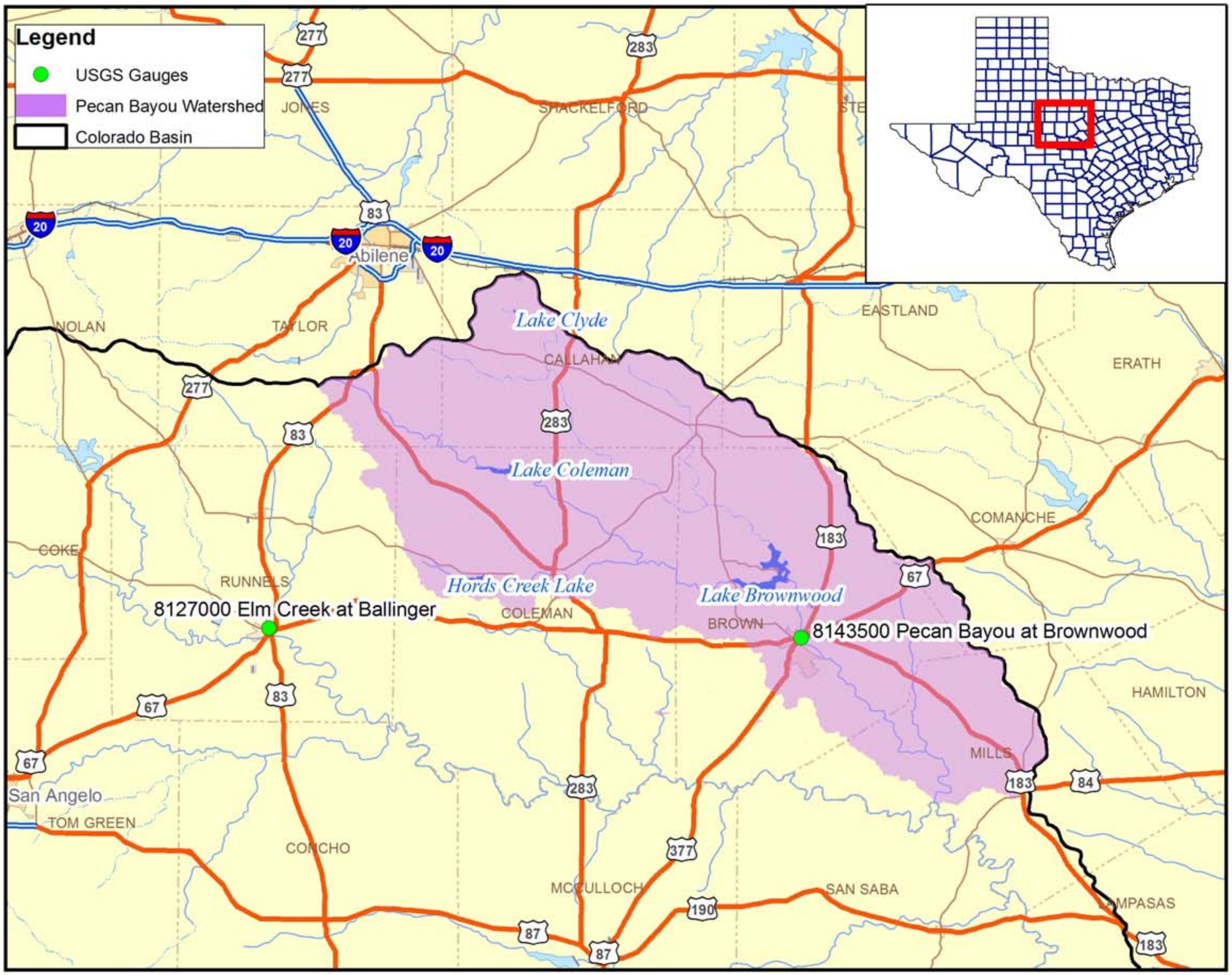

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Location Map

Region F Pecan Bayou Study

FN JOB NO	CMD07215
FILE	Pecan Bayou
DATE	September 30, 2008
SCALE	1:3,000
DESIGNED	JJR
DRAFTED	JJR

FIGURE 1

Table 1
Comparison of Annual Outflows from Lake Brownwood
(Values in Acre-Feet per Year)

Year	Base*	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1940	117,946	99,870	106,109	107,629	109,429	109,046	106,745
1941	302,986	301,115	318,806	318,806	318,806	318,248	318,806
1942	241,241	232,855	248,004	248,007	248,009	246,622	248,005
1943	29,796	2,716	29,195	29,195	29,195	29,195	29,195
1944	7,165	0	7,165	7,165	7,165	7,165	7,165
1945	80,981	61,098	61,139	61,139	79,741	68,828	61,139
1946	13,930	0	13,930	13,930	13,930	13,930	13,930
1947	1,951	0	1,951	1,951	1,951	1,951	1,951
1948	15,522	0	15,522	15,522	15,522	15,522	15,522
1949	13,159	0	13,159	13,159	13,159	13,159	13,159
1950	12,990	0	12,990	12,990	12,990	12,990	12,990
1951	97,248	52,170	45,771	75,859	84,852	69,883	62,260
1952	16,153	0	16,153	16,153	16,153	16,153	16,153
1953	26,405	0	26,405	26,405	26,405	26,405	26,405
1954	24,784	0	9,227	9,227	19,153	9,227	9,227
1955	73,859	35,650	16,295	31,111	48,937	53,906	23,953
1956	131,659	109,126	130,072	124,475	124,475	129,174	124,475
1957	326,839	357,571	361,057	357,802	357,887	337,341	359,149
1958	44,884	33,683	45,286	45,276	45,358	45,276	45,281
1959	106,678	92,194	96,254	96,254	98,597	100,467	96,254
1960	34,722	27,353	33,875	35,199	36,166	34,202	34,990
1961	78,844	74,432	89,608	89,356	89,558	83,468	89,449
1962	64,161	37,891	55,149	56,821	57,826	57,178	56,393
1963	60,362	36,960	54,755	54,755	54,834	56,732	54,755
1964	59,870	45,936	47,075	47,394	52,697	50,148	47,075
1965	137,633	114,827	134,522	134,522	134,522	134,522	134,522
1966	62,785	33,153	21,646	29,240	35,636	37,184	24,873
1967	19,817	0	19,817	19,817	19,817	19,817	19,817
1968	252,316	254,712	241,139	245,152	249,765	240,492	242,740
1969	74,179	44,451	51,917	56,069	60,413	56,450	53,483
1970	79,530	93,661	97,098	97,822	98,826	97,817	97,354
1971	90,113	66,036	69,961	73,214	77,480	79,370	71,337
1972	5,402	0	5,402	5,402	5,402	5,402	5,402
1973	1,818	0	1,818	1,818	1,818	1,768	1,768
1974	100,129	92,400	94,750	112,012	122,183	98,883	100,106
1975	47,884	45,085	49,425	49,601	49,764	49,648	49,498
1976	2,551	0	2,551	2,551	2,551	2,551	2,551
1977	3,714	0	3,714	3,714	3,714	3,714	3,714
1978	5,555	0	5,555	5,555	5,555	5,555	5,555
1979	19,150	0	2,025	2,025	2,025	2,025	2,025
1980	8,236	0	8,236	8,236	8,236	8,236	8,236
1981	30,486	0	2,435	13,951	25,571	19,050	11,870
1982	55,390	18,219	39,579	40,418	58,849	51,726	37,228
1983	4,720	0	4,720	4,720	4,720	4,720	4,720
1984	23,409	0	23,409	23,409	23,409	23,409	23,409
1985	9,109	0	9,109	9,109	9,109	9,109	9,109
1986	140,702	122,553	113,731	115,137	115,969	121,768	112,725
1987	111,925	123,886	136,459	136,727	136,725	128,548	136,519
1988	30,488	14,393	29,710	29,710	29,710	29,710	29,710
1989	33,335	15,710	30,522	30,522	30,522	30,522	30,522
1990	238,561	218,429	215,736	215,736	216,431	223,138	215,736
1991	335,436	336,775	338,579	345,915	355,335	345,922	342,027
1992	415,642	413,562	418,854	418,867	418,882	418,855	418,855
1993	22,459	8,458	20,602	20,602	20,602	20,602	20,602
1994	94,779	64,556	80,720	80,720	80,720	86,133	80,720
1995	92,753	66,714	78,626	82,494	87,208	88,935	80,162
1996	20,875	0	20,875	20,875	20,875	20,875	20,875
1997	215,313	241,689	211,934	217,152	225,449	214,230	214,398
1998	53,263	28,592	51,055	51,055	50,940	50,994	51,055
Average	81,756	68,110	76,122	77,957	80,534	78,608	76,909
Average 50-56	54,728	28,135	36,702	42,317	47,567	45,391	39,352

* TCEQ-approved WAM

in Region K determined with the Pecan Bayou watershed operated in strict priority order, as in the TCEQ WAM or the current Region K "Cutoff Model". The current analyses do not incorporate the "no call" assumptions used in either the 2006 Region F plan or the current Region K model, so a direct comparison to the current modeling is not possible. However, since the overall modeling currently used by Region K assumes that significantly less water is passed out of Lake Ivie[1], the difference in yield may not be significant. Future water supply analyses using consistent assumptions may be required to see if there are impacts on Region K supplies. This analysis can be performed once the Region F Water Planning Group elects a water supply scenario for the next water plan.

Background

One of the major recommended strategies in the *2006 Region F Water Plan* is the Subordination of Downstream Senior Water Rights in the Lower Colorado River Basin, also referred to as the "No Call" strategy. This strategy was a joint modeling effort between Regions F and K using the Texas Commission on Environmental Quality's Colorado River Water Availability Model (Colorado WAM). This modeling effort was conducted for planning purposes only. The two most significant assumptions of this strategy are: 1) water rights in Region K do not make priority calls on major upper basin rights located in Region F and Brazos G, and 2) these Region F rights do not make priority calls on each other. These assumptions resulted in more realistic estimates of water availabilities for most of the major water rights in Region F, but may not have been appropriate for the Pecan Bayou Watershed.

The no call strategy assumed Lake Brownwood, which is the senior water rights holder in the watershed, would not make priority calls on upstream junior reservoirs. While this assumption may be representative of basin operations much of the time, under drought conditions it is possible that Lake Brownwood would call on inflows from upstream junior reservoirs. As a result the 2006 plan may have overestimated water supplies from the upstream reservoirs and underestimated supplies from Lake Brownwood. Also, a comparison of historical inflows into Lake Coleman and Hords Creek Reservoir developed in previous studies to the inflows in the Colorado WAM indicates that the WAM flows may be overestimated. This study addresses these

1 Freese and Nichols, Inc.: Draft Memorandum to Region F: Region K Coordination, November 11, 2008.

issues and evaluates several potential operating scenarios balancing water availability and use among users in the Pecan Bayou watershed.

Study Results

Seven scenarios were developed that examined various conditions where a priority call is made by Lake Brownwood. All of the following scenarios were evaluated using the TCEQ-approved Colorado WAM with changes as noted:

- *Base Scenario*: *Strict priority.* In this scenario Lake Clyde, Lake Coleman, and Hords Creek Reservoir continuously pass inflows to Lake Brownwood and other senior water rights as needed to fully satisfy diversion and storage rights. This scenario is identical to the assumptions used in the original TCEQ Colorado WAM.

- *Scenario 1: Holding All Inflow.* This scenario assumes that **all** water rights divert in upstream to downstream order and do not pass water to downstream senior water rights. No priority calls are made by any water right.

- *Scenario 2: No priority call by Lake Brownwood.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 3: Priority call when Lake Brownwood storage is below 50%.* This scenario assumes that Lake Clyde, Lake Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 50% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 4: Priority call when Lake Brownwood storage is below 70%.* This scenario assumes that Lakes Clyde, Coleman, and Hords Creek Reservoir impound inflow that would have been passed **only to Lake Brownwood** under strict priority if Lake Brownwood is above 70% of the conservation capacity. (The scenario assumes that other water rights make priority calls on any of these reservoirs, and that these reservoirs make priority calls on other water rights.)

- *Scenario 5: Lake Coleman passes high flows.* This scenario assumes that Lake Coleman would pass only high flows to Lake Brownwood. A high flow is defined as a volume above the average monthly flow of 2,300 acre-feet. Lake Coleman retains all flows that are less than the average monthly flow. Lake Clyde and Hords Creek Reservoir operate as in Scenario 2.
- *Scenario 6: Lake Coleman passes high flows when Lake Brownwood is below 50%.* This scenario is identical to Scenario 3 except that Lake Coleman passes only high flows to Lake Brownwood when Lake Brownwood is less than 50% of the conservation capacity instead of all flows.

The study also included a review of the hydrology used in the Colorado WAM. The WAM uses naturalized flows at the Pecan Bayou near Brownwood gage to calculated inflows into the reservoirs. This gage is located downstream of Lake Brownwood. A comparison of the WAM flows to historical flows shows that the WAM flows are overestimated for the three upstream reservoirs. In this study, new naturalized flows were developed based on the historical inflows into the reservoirs and naturalized flows from the Elm Creek near Ballinger gage.

The modeling in this study does not include the “no call” option used in the 2006 Region F modeling or the recent Region K modeling. Therefore, except for Scenario 1, all water rights, including the four reservoirs in the Pecan Bayou watershed, are assumed to pass water to downstream senior water rights at least part of the time. (Lake Brownwood is senior to the Highland Lakes water rights, but is junior to most of the large run-of-the-river rights in Region K. The three upstream reservoirs are all junior to the major Region K water rights.) When water is retained by the three upstream reservoirs, it is simply subtracted from the storage in Lake Brownwood. Since there is little unappropriated water in the Colorado River Basin, there is often no water left to replace the water taken from Lake Brownwood under a strict priority assumption.

The potential impact on Region K would be the reduction in the frequency that Lake Brownwood is full and spilling during the critical drought period of the 1950s. An analysis using consistent assumptions with the Region K model may be required to identify potential impacts on Region K supplies (if any). This analysis can be performed once the Region F Water Planning Group elects a water supply scenario for the next water plan.