GAM Run 06-33a

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Groundwater Availability Modeling Section
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After we delivered this GAM run, staff at the Texas Commission on Environmental Quality noted that they also needed spring flow at Hueco Springs to complete their surface water analysis. Therefore, we modified the modeling code with an empirical formula to estimate springflow at Hueco Springs. For all runs flows at Comal Springs changed no more than 10 cubic feet per second and heads at J-17 changed no more than three feet as a result of the addition of Hueco Springs. Hueco Springs are not discussed in this report because they were not part of the original request.

EXECUTIVE SUMMARY:

We used a numerical groundwater flow model, GWSIM-IV, to evaluate three pumping scenarios for the San Antonio Segment of the Edwards (Balcones Fault Zone) Aquifer. The scenarios included:

1. pumping with permits capped at 450,000 acre-feet per year under constraints of current critical period management rules,

2. pumping with permits capped at 400,000 acre-feet per year under constraints of current critical period managements rules, and

3. pumping with permits totaling 542,000 acre-feet per year under constraints of proposed critical period management rules from Senate Bill 24 of the First-Called Special Session of the 79th Legislature.

GWSIM-IV is a model developed by Texas Water Development Board and is one of the groundwater availability models for the San Antonio Segment of the Edwards (Balcones Fault Zone) Aquifer.

Model results suggest that having permitted pumping capped at 400,000 acre-feet per year under current critical period management rules (Scenario 2) will allow an average of 24 cubic feet per second more flow from Comal Springs over the 56-year simulation period than the other two scenarios. During a drought similar to the drought of the 1950s, all three scenarios predict that Comal Springs may go dry for at least 25 months. The model shows that flow at Comal Springs would be similar for Scenarios 1 and 3. The average difference in flow at Comal Springs between Scenarios 1 and 3 over the 56-year simulation period is about 1.5 cubic-foot per second. The model suggests that spring flow at San Marcos Springs is not sensitive to the different pumping scenarios.

REQUESTOR:

Representative Patrick M. Rose, Texas State House District 45.

DESCRIPTION OF REQUEST:

Representative Patrick M. Rose asked the Texas Water Development Board and the Texas Commission on Environmental Quality to simulate the effects on Comal and San Marcos springflow and flows in the Guadalupe River due to various pumping scenarios in the San Antonio Segment of the Edwards (Balcones Fault Zone) Aquifer. The groundwater portion of the request included the following five tasks to be evaluated using the GWSIM-IV groundwater flow model:

1. Confirm the calibration of GWSIM-IV by confirming that Comal Springs had no flow for five months in 1956 and San Marcos had a minimum flow close to 46 cubic feet per second during the same year.

2. Simulate the effect of pumping an annual amount of approximately 450,000 acre-feet per year given constraints of current Edwards Aquifer Authority critical period management rules (withdrawal reductions up to 23 percent).

3. Simulate the effect of pumping an annual amount of approximately 400,000 acre-feet per year given constraints of current Edwards Aquifer Authority critical period management rules (withdrawal reductions up to 15 percent).

4. Simulate the effect of pumping an annual amount of approximately 549,000 acre-feet per year given constraints of Edwards Aquifer Authority critical period management rules as proposed in Senate Bill 24 of the First-Called Special Session of the 79th Legislature (withdrawal reductions of up to 40 percent in the San Antonio Pool and up to 30 percent in the Uvalde Pool).

5. Compare spring flows at Comal and San Marcos springs for Tasks 2, 3, and 4, including the number of months with no flow, and determine the percentage of months that water rights holders would be subject to critical period management restrictions by stage in the San Antonio and Uvalde pools.

A sixth task is a surface water rights assessment to be performed by the Texas Commission on Environmental Quality. We will provide electronic copies of the results of Tasks 1, 2, 3, and 4 to Texas Commission on Environmental Quality staff for them to complete their analyses. In addition to flows at Comal and San Marcos Springs, modeled flows at Hueco, San Pedro, and San Antonio Springs will be provided to TCEQ because they are required for the surface water analysis.

METHODS:

We selected the GWSIM-IV groundwater flow model of the San Antonio Segment of the Edwards (Balcones Fault Zone) Aquifer because it is relatively simple and quick to adjust the model for implementing and comparing different critical period management strategies. The model does a good job of reproducing spring flow at Comal Springs and water levels at the points required for this analysis; however, the model underestimates spring flow at San Marcos Springs. This is because San Marcos Springs is fed by a regional component of groundwater flow and a local component of groundwater flow, with the local component of flow being the more important component. The model includes the regional component of flow but only approximates the local component of flow.

We first ran the model using U.S. Geological Survey estimates of historical recharge and using historical pumping amounts to confirm the calibration of the model. We then implemented the existing critical period management rules (Tables 1 and 2) in the model and simulated permitted pumping capped at 450,000 acre-feet per year and 400,000 acre-feet per year. The 450,000 acre-feet per year scenario included senior permitted amounts (the senior and the junior permitted amounts total 542,000 acre-feet per year). The 400,000 acre-feet per year included senior permitted amounts reduced proportionally by about 11 percent. Finally, we implemented the critical period management rules as proposed in Senate Bill 24 of the First-Called Special Session of the 79th Legislature (Table 3) with permitted pumping capped at 542,000 acre-feet per year, the total amount contained in the latest (2005) permitted pumping file available for the model. All scenarios also included an additional 15,300 acre-feet per year for exempt pumping.

We compared the monthly flow volumes for Comal and San Marcos springs for the scenarios, and we compared the simulated percentage of months subject to drought restrictions for each of the scenarios.

PARAMETERS AND ASSUMPTIONS:

For the historical simulation (Task 1) the simulation period is 1934 through 1989. The historical recharge distribution is based on U.S. Geological Survey estimates. The pumping for each of the 56 years is based on estimates of historical pumping. The original request asked for a calibration confirmation between 1934 and 1957; however, we confirmed the calibration for 1947 through 1959 because this was the actual calibration period for the model.

For the predictive scenarios (Tasks 2, 3, and 4) the simulation period was 56 years using recharge representing the years 1934 through 1989. The recharge is based on historical U.S. Geological Survey estimates. The pumping distribution is based on permit information from 2005, the latest year available for the GWSIM-IV model. The total amount of permitted pumping in the latest version of the pumping input is approximately 542,000 acre-feet per year. The senior permits total about 447,000 acre-feet per year. The annual pumping is distributed spatially based on permit information and it is distributed monthly based on factors developed from historic monthly pumpage estimates.

Critical period management reduction factors are applied to municipal, industrial, and irrigation pumping according to the rules listed in Tables 1, 2, and 3. Reduction factors are not applied to domestic pumping. Also, the San Marcos Springs trigger was not implemented in the model because the modeled discharge at San Marcos Springs is not sensitive to pumping and recharge over most of the model area and because the model tends to underestimate discharge at San Marcos Springs.

RESULTS:

The results of the calibration confirmation run (Figures 1 through 4) closely replicate the original calibration runs of the model (Thorkildsen and McElhaney, 1992). Very slight differences occur between these results and the original calibration run because the original calibration started with 1947 whereas this run begins in 1934 using estimated historical pumpage. Consequently, in 1947 the modeled water levels are slightly different than the initial water levels used in the original model calibration. The model simulates Comal Springs with no flow for four calendar months in 1956, consistent with measurements made at the time (Figure 1; measurements show that the springs went dry from June 13, 1956, through November 3, 1956), and the minimum flow simulated at San Marcos springs is 53 cubic feet per second (Figure 2). The water levels at the San Antonio index well (Figure 3) also closely match the results from the original model calibration (Thorkildsen and McElhaney, 1992).

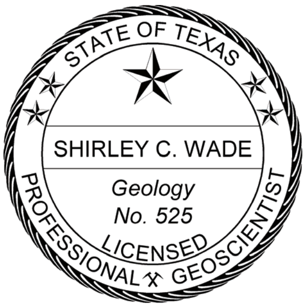
Annual pumping rates for the scenarios in Tasks 2, 3, and 4 vary in response to drought triggers (Figure 4). Results for all three scenarios indicate that during a drought similar to the 1950s water levels will drop below Stage 4 triggers at both J-17 (Figure 5) and J-27 (Figure 6) and that Comal Springs will go dry (Figure 7). The simulations indicate that, except during extreme drought conditions, flow from Comal Springs will be greater with permitted pumping capped at 400,000 acre-feet per year (Task 3) than for the other two scenarios (Figures 7 and 8). The average difference in Comal Springs discharge between 400,000 and 542,000 acre-feet per year is 24 cubic feet per second (Figure 8). The total number of months with no spring flow at Comal Springs for the 400,000 acre-feet per year scenario is 25 months. Only 12 percent of the simulation months are spent in stage 4 drought for this scenario, while 33 percent of the months are not in drought stage (Table 4).

The 450,000 and 542,000 acre-feet per year scenarios produce similar results (Figure 8). In some cases discharge from Comal Springs will be greater with the 450,000 acre-feet per year scenario (Task 2) than with the 542,000 acre-feet per year scenario (Task 4). In other cases the discharge at Comal Springs is greater for the 542,000 acre-feet per year scenario (Figures 7 and 8). The average difference in Comal Springs discharge between these two scenarios is 1.5 cubic foot per second. However, with the 450,000 acre-feet per year scenario, Comal Springs goes dry for 30 months while Comal Springs goes dry for only 25 months with the 542,000 acre-feet per year scenario due to the higher reductions during critical periods. On the other hand, the 542,000 acre-feet per year scenario results in the greatest percentage of time spent in drought stages (Table 4).

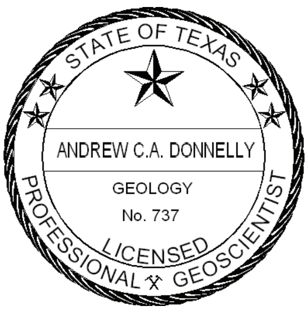
Simulated spring flow at San Marcos Springs (Figure 9) does not seem to be sensitive to the different pumping scenarios.

REFERENCES:

Thorkildsen, D., and McElhaney, P.D., 1992, Model refinement and applications for the Edwards (Balcones Fault Zone) aquifer in the San Antonio region, Texas: Texas Water Development Board Report 340, 33 p.



The seal appearing on this document was authorized by Shirley C. Wade, P.G. 525, on February 12, 2007.



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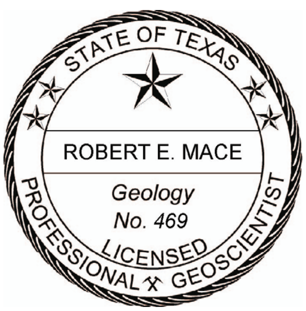

The seal appearing on this document was authorized by Robert E. Mace, Ph.D., P.G. 469, on February 13, 2007.

Table 1. Current critical period management rules if permitted pumping is capped at 450,000 acre-feet per year.

Stage	*J-17 water level (feet)*	*J-27 water level (feet)*	*Comal Springs discharge (cfs)*	*San Marcos Springs[1] discharge (cfs)*	*Permitted irrigation reduction factor*	*Permitted non-irrigation reduction factor*
			San Antonio Pool			
1	< 650	na[2]	< 220	< 110	0.0	0.05
2	< 640	na	< 154	< 96	0.0	0.1
3	< 630	na	< 86	< 80	0.15	0.15
4	< 627	na	na	na	0.23	0.23
			Uvalde Pool			
1	na	na	na	na	na	na
2	na	na	na	na	na	na
3	na	< 845	na	na	0.15	0.15
4	na	< 842	na	na	0.23	0.23

1. San Marcos Springs were not included in the model rules because the simulated spring flow is not sensitive to regional pumping in the model
2. na: Not applicable
3. cfs = cubic feet per second

Table 2. Current critical period management rules if permitted pumping is capped at 400,000 acre-feet per year.

Stage	*J-17 water level (feet)*	*J-27 water level (feet)*	*Comal Springs discharge (cfs)*	*San Marcos Springs[1] discharge (cfs)*	*Permitted irrigation reduction factor*	*Permitted non-irrigation reduction factor*
San Antonio Pool						
1	< 650	na[2]	< 220	< 110	0.0	0.05
2	< 640	na	< 154	< 96	0.0	0.1
3	< 630	na	< 86	< 80	0.15	0.15
4	< 627	na	na	na	0.15	0.15
Uvalde Pool						
1	na	na	na	na	na	na
2	na	na	na	na	na	na
3	na	< 845	na	na	0.15	0.15
4	na	< 842	na	na	0.15	0.15

1. San Marcos Springs were not included in the model rules because the simulated spring flow is not sensitive to regional pumping in the model
2. na: not applicable
3. cfs = cubic feet per second

Table 3. Critical period management rules proposed in Senate Bill 24 of the First-Called Special Session of the 79th Legislature.

Stage	*J-17water level (feet)*	*J-27water level (feet)*	*Comal Springs discharge (cfs)*	*Total pumpage reduction factor*
		San Antonio Pool		
1	< 665	na[1]	na	0.1
2	< 650	na	na	0.2
3	< 640	na	< 150	0.3
4	< 630	na	< 100	0.4
		Uvalde Pool		
1	na	na	na	na
2	na	na	na	na
3	na	< 845	na	0.15
4	na	< 842	na	0.3

1. na: not applicable
2. cfs = cubic feet per second

Table 4. Number of months spent in each drought stage for Tasks 2, 3, and 4.

Task	*Stage*	*San Antonio Pool (percent)*	*Uvalde Pool (percent)*	*Number of dry months for Comal Springs*
2	No drought	20	54	na[1]
2	1	24	0	na
2	2	28	0	na
2	3	10	3	na
2	4	18	42	30
3	No drought	33	63	na
3	1	26	0	na
3	2	22	0	na
3	3	7	4	na
3	4	12	33	25
4	No drought	2	47	na
4	1	18	0	na
4	2	25	0	na
4	3	29	4	na
4	4	27	48	25

1. na: not applicable

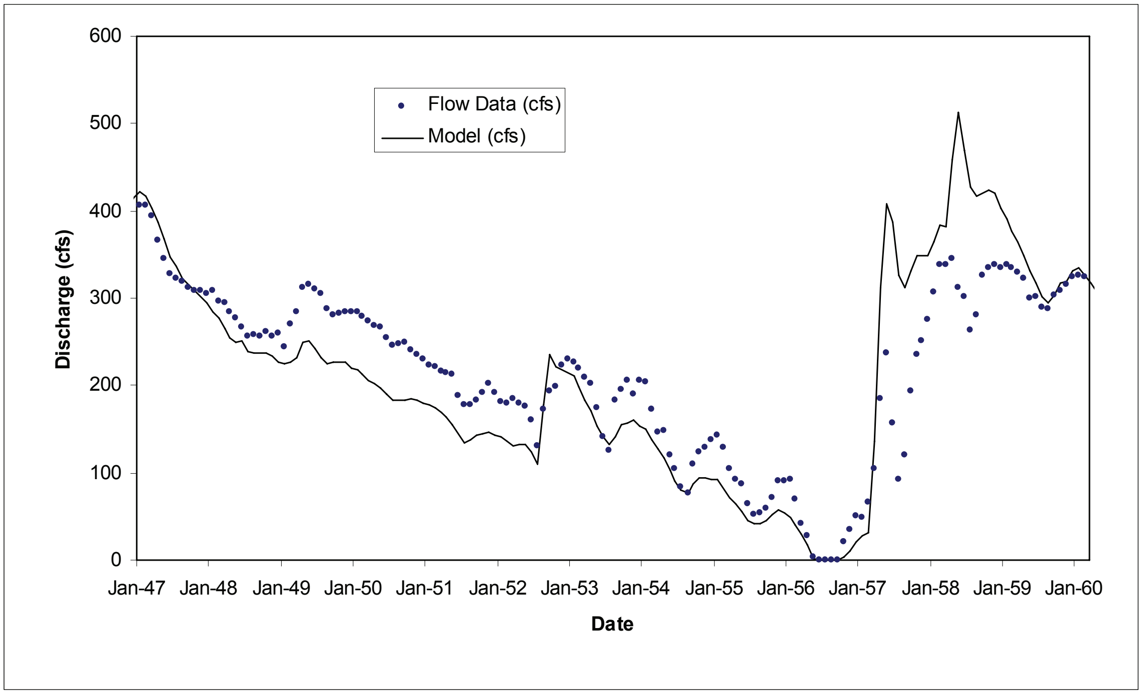

Figure 1. **Simulated and measured flow at Comal Springs over the model calibration period (1947 through 1959; cfs = cubic feet per second).**

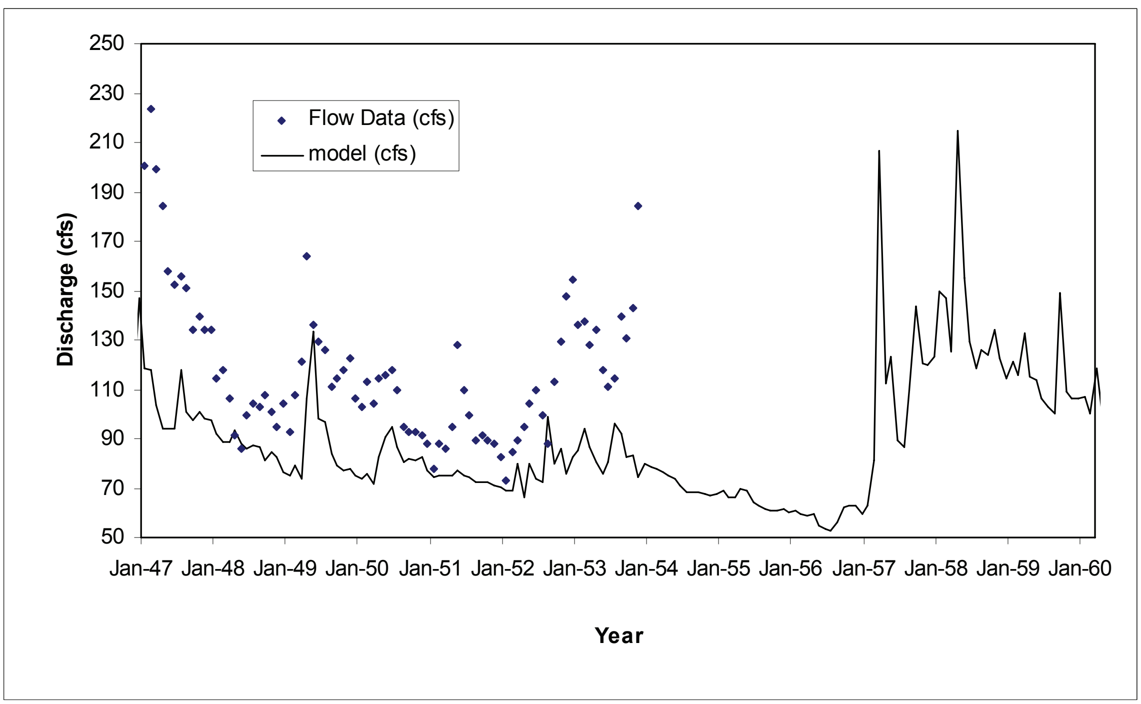

Figure 2. **Simulated and measured flow at San Marcos Springs over the model calibration period (1947 through 1959; cfs = cubic feet per second; we were not able to find measured flow data after January 1954).**

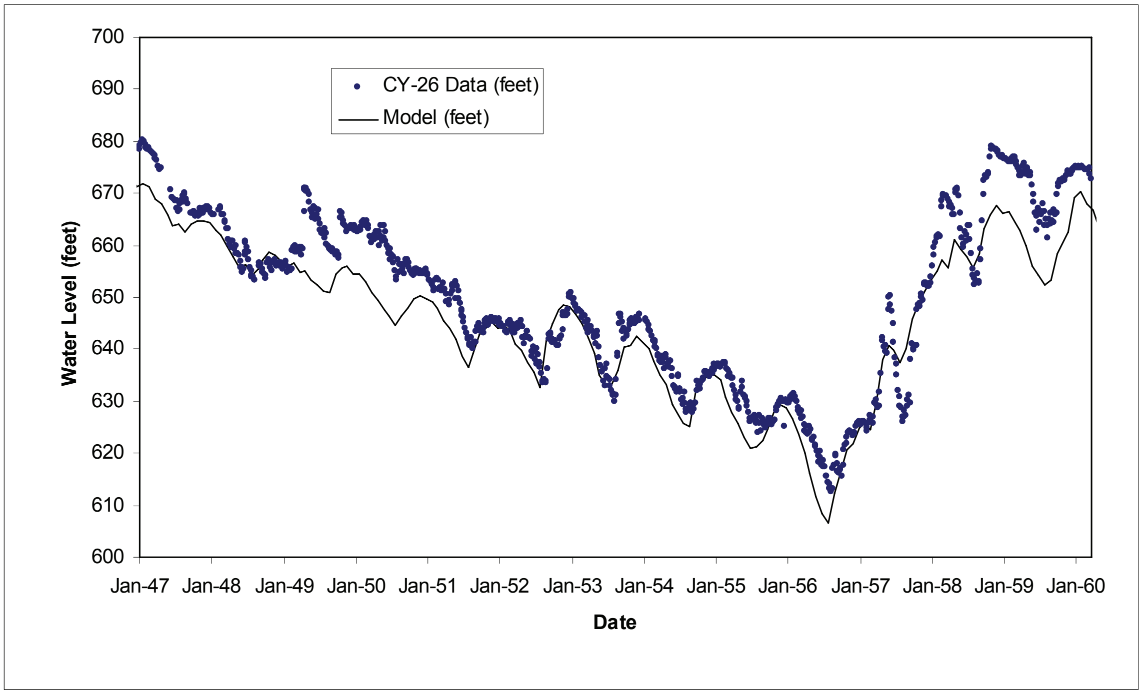

Figure 3. Simulated and measured water levels at the Bexar County Index Well (CY-26) over the model calibration period (1947 through 1959).

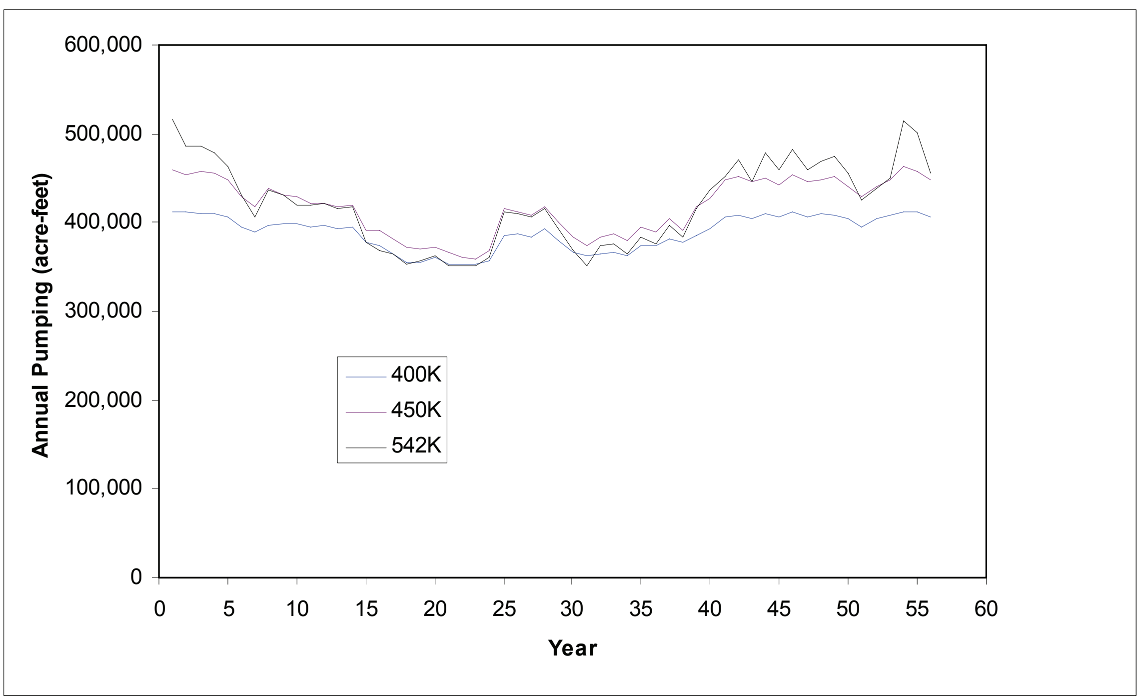

Figure 4. Annual pumping for the 56 year predictive period. Pumping varies according to the application of critical period management rules. Total pumping may be greater than the capped amount due to exempt use.

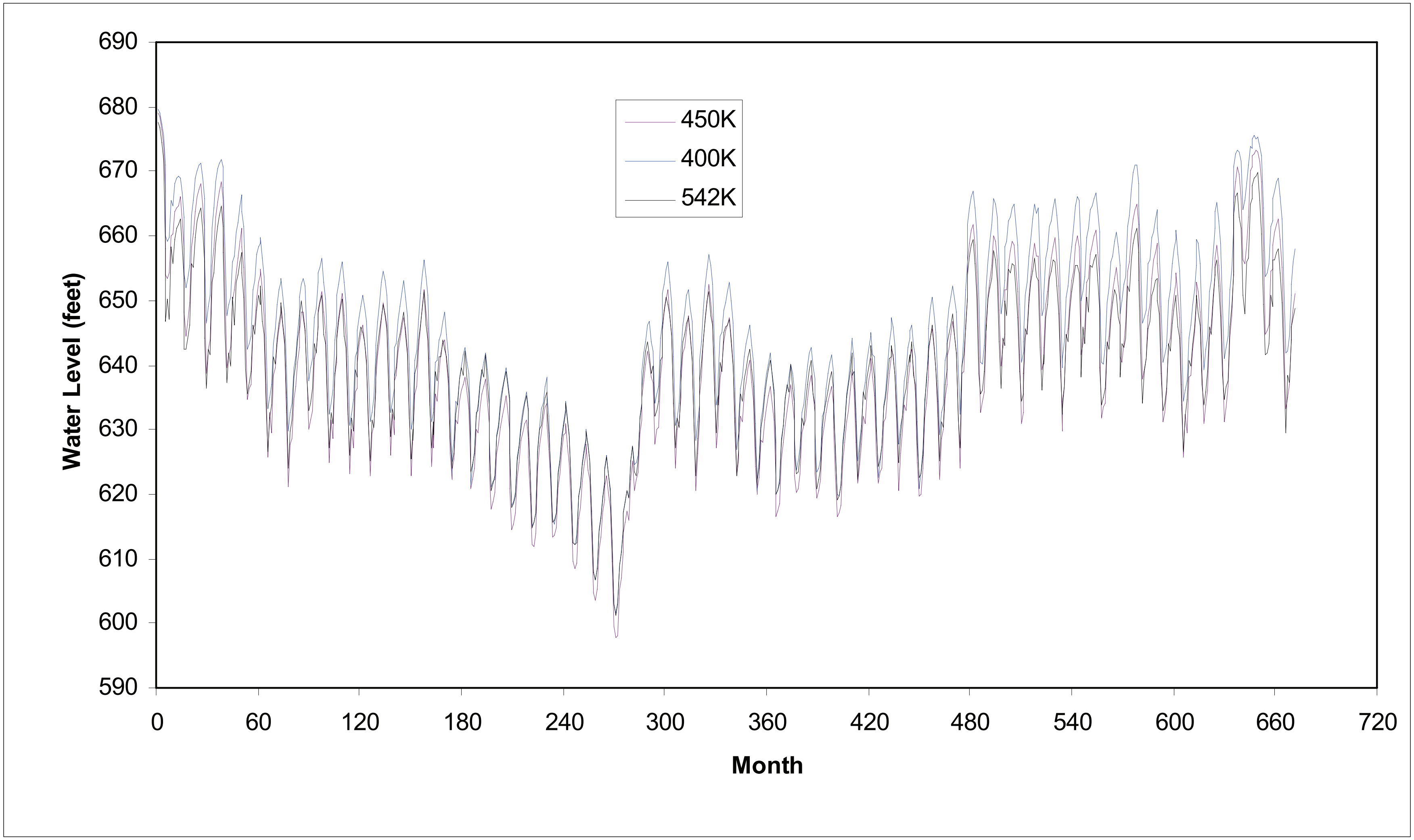

Figure 5. Simulated water levels at J-17 for the three predictive scenarios.

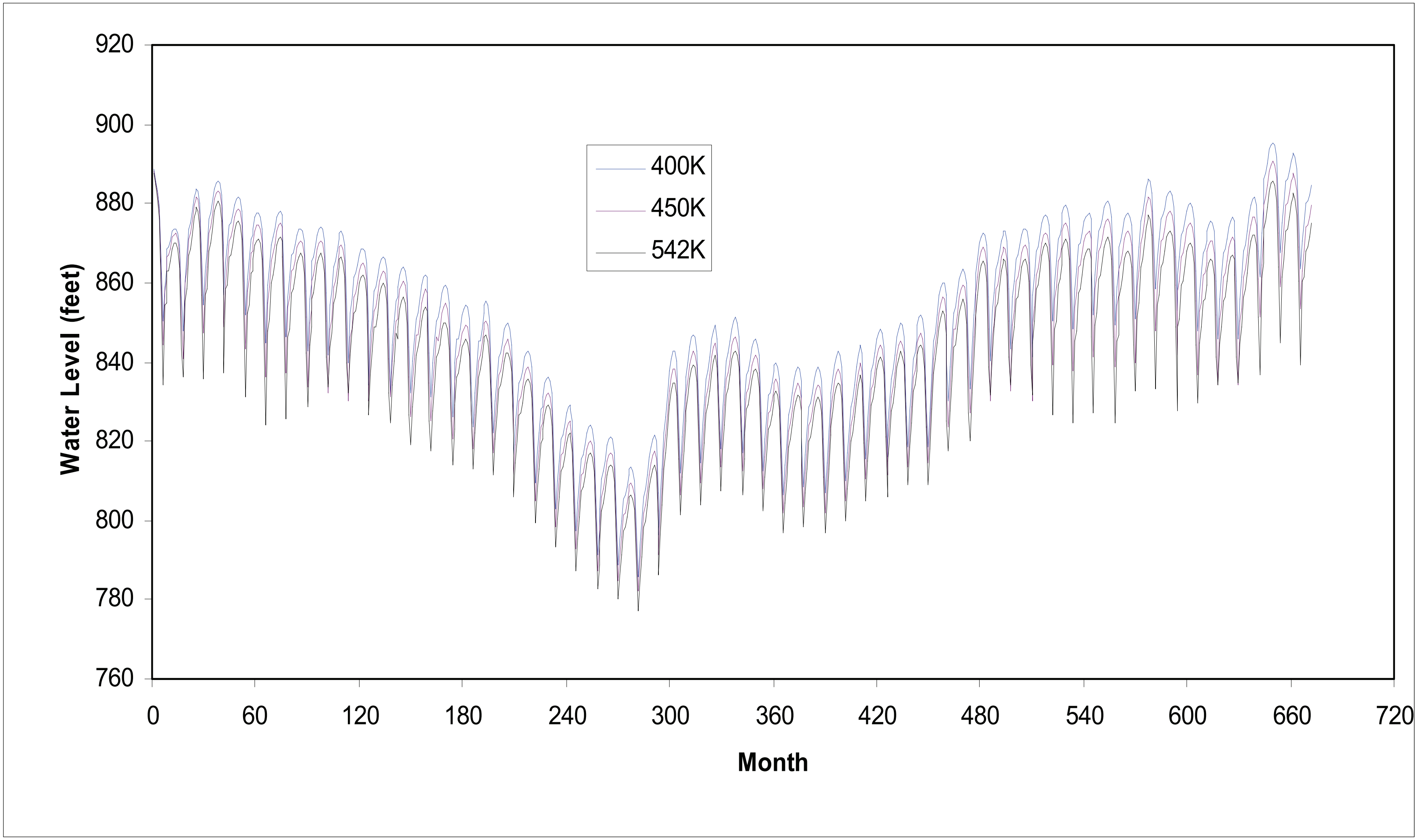

Figure 6. Simulated water levels at J-27 for the three predictive scenarios.

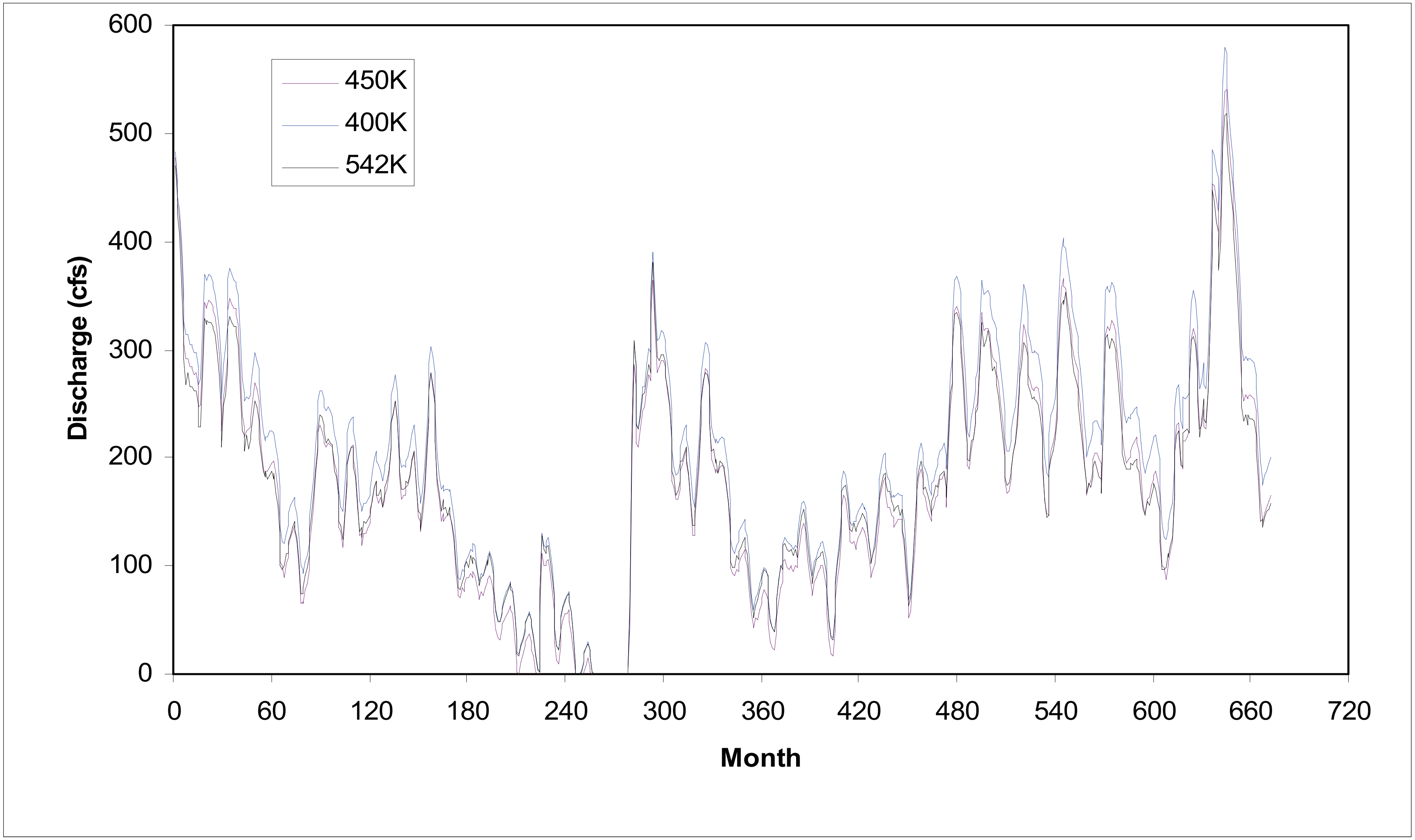

Figure 7. Simulated discharge at Comal Springs for the three predictive scenarios.

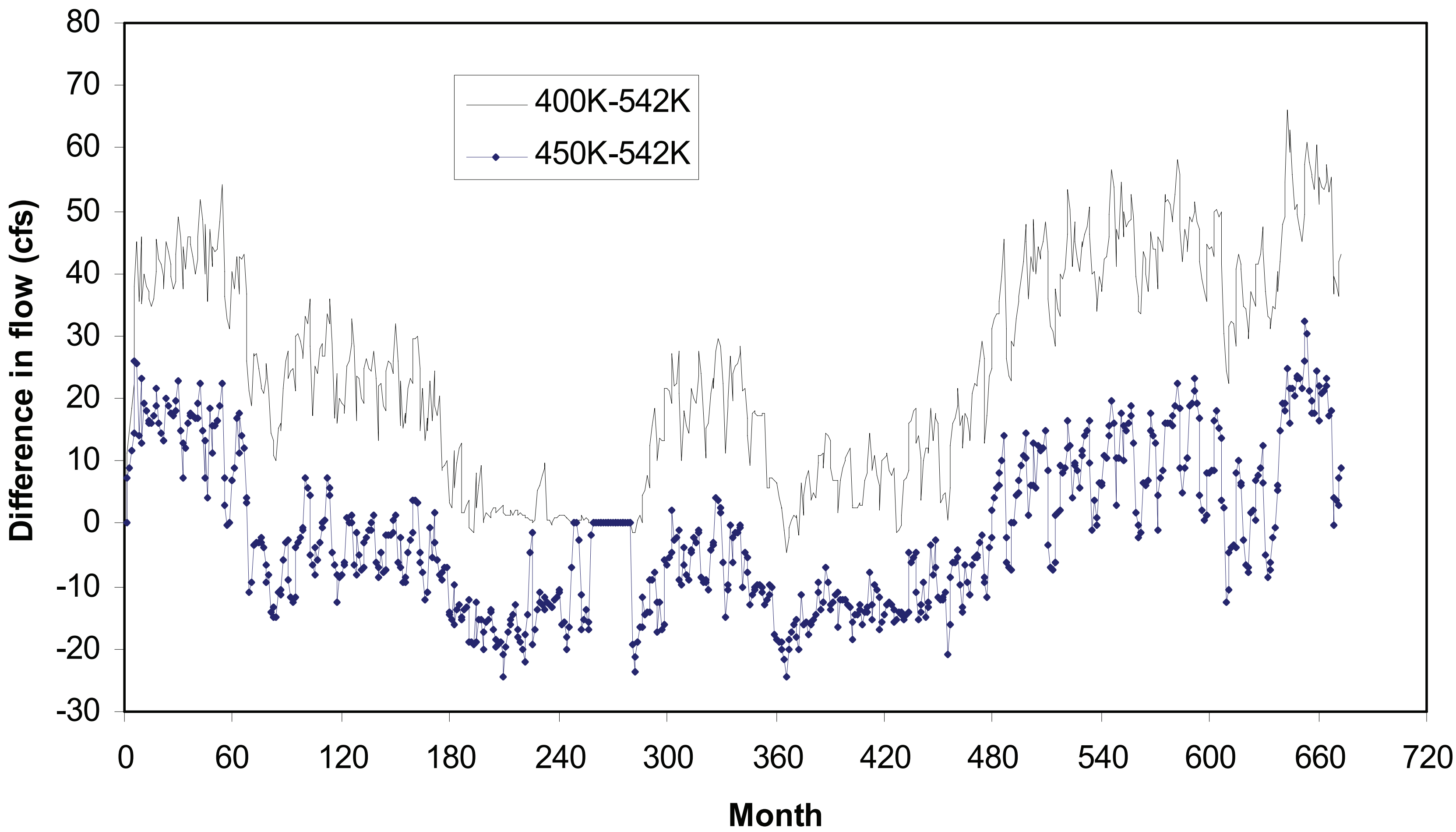

Figure 8. Difference in spring flow at Comal Springs between 400,000 acre-feet per year scenario and the 542,000 acre-feet per year scenario and the 450,000 acre-feet per year scenario and the 542,000 acre-feet per year scenario.

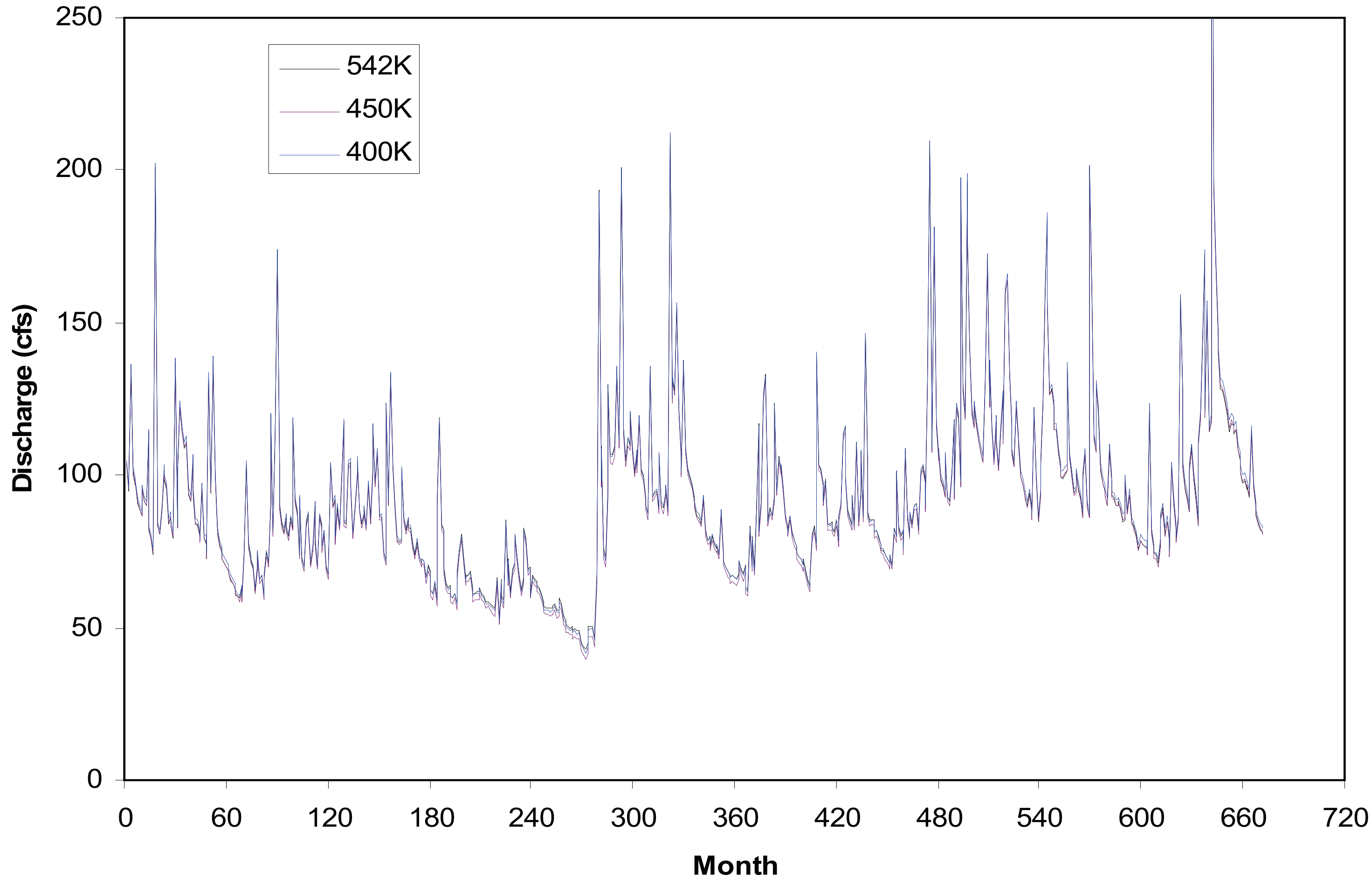

Figure 9. Simulated discharge at San Marcos Springs for the three predictive scenarios.