5. MODEL CALIBRATION

In order to increase the reliability of hydrologic impact predictions, the groundwater flow model was calibrated. Although aquifer tests were conducted within the Project area, few wells were utilized for testing and the data are not suitable for regional model calibration. Therefore, the model was calibrated to steady-state pre-mining (pre-1970) water level elevations reported in the SEO wells database. Based on a review of the available data, 12 wells were determined to be suitable as calibration targets. The water level data are considered to contain significant uncertainty associated with variable measurement dates, seasonal fluctuations, well completion depths, and approximate land surface elevation (e.g. +/- 20 feet). However, given the regional scale of the model and the wide range of water level elevations (e.g., up to approximately 1,500 feet over the model domain) the accuracy of the water levels are considered acceptable for use in calibration.

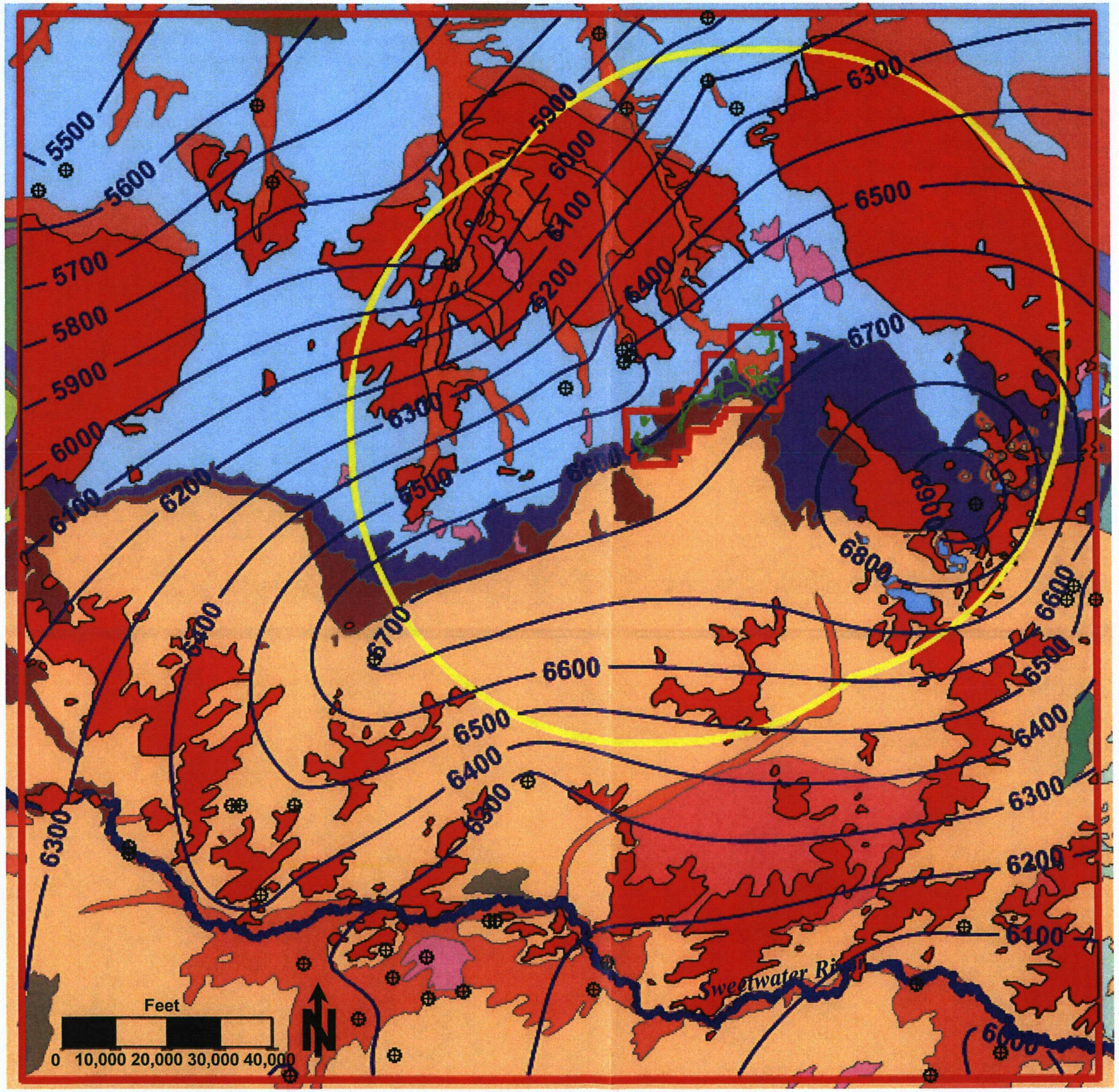
Figure 5-1 illustrates the approximate water-table configuration prior to mining. Based on these data, there is a regional groundwater flow divide that corresponds to the location of the Beaver Rim Escarpment and recharge area. To the north of the escarpment, groundwater generally flows to the northwest towards the Boysen Reservoir and the Wind River discharge areas. To the south of the escarpment, groundwater generally flows to the south towards the Sweetwater River discharge area.

Table 5-1 summaries the results of the regional model calibration based on the static water elevation in the target wells. **Figure 5-2** shows a plot of observed verses computed (modeled) heads. The scaled residual error between the observed and computed water levels is just slightly greater than 1 percent, which is considered acceptable given the regional scale of the model and uncertainty associated with water level measurements representing variability over several decades. Model calibrated flow direction and gradients are consistent with measured regional water level elevations in **Figure 5-1**.

Table 5-1 – MODFLOW Model Calibration Results

ID	Permit #	Date of Measurement	Easting (X)	Northing (Y)	Layer	Observed Groundwater Elevation (feet amsl)	Computed Groundwater Elevation (feet amsl)	Residual (feet)
4	P12441P	10/20/1964	761160.05	725584.96	1	6718	6718	0
17	P7013P	7/20/1948	745831.71	697772.72	1	6488	6467	20
21	P7438P	4/25/1929	805472.45	668069.40	1	6180	6178	2
33	P12331P	9/11/1964	894086.01	736576.10	1	6605	6633	-27
35	P3021W	9/10/1969	876755.29	754757.10	1	6990	7026	-36
39	P11151P	12/21/1942	733945.80	697680.50	1	6456	6479	-23
44	P12439P	4/14/1965	790361.48	702225.25	1	6267	6286	-20
57	P439G	5/1/1956	810532.49	783202.95	2	6503	6485	18
58	P2661P	12/21/1942	825530.78	847588.19	2	5956	5967	-11
59	P5281P	6/27/1960	697159.79	814598.51	2	5537	5520	17
60	P5282P	6/28/1960	702386.20	818646.82	2	5498	5508	-10
63	P5285P	5/12/1958	739060.00	830942.80	2	5614	5639	-25

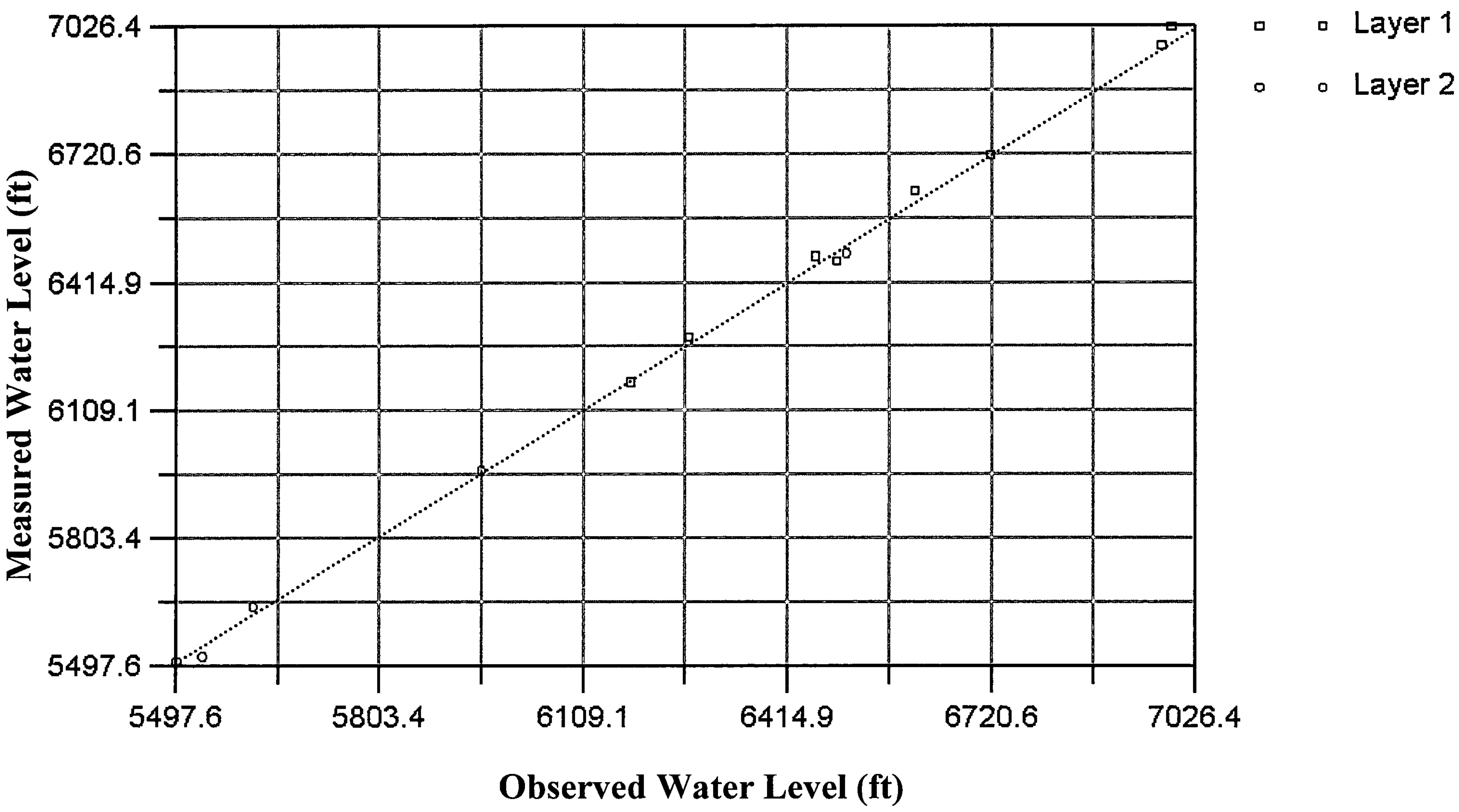
Residual Mean	-7.935969
Abs. Res. Mean	16.634352
Res. Std. Dev.	17.714935
Sum of Squares	4898.380998
RMS Error	19.411299
Min. Residual	-36.05543
Max. Residual	20.276093
Number of Observations	13
Range in Observations	1492.74
Scaled Std. Dev.	0.011867
Scaled Abs. Mean	0.011144
Scaled RMS	0.013004



Legend

- ⊕ Stock/Domestic Well
- 6600 Groundwater Elevation (feet amsl)
- Permit Boundary
- Model Domain
- 10-mile Buffer
- Pre-Tertiary and Other No-Flow Outcrops

AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**Pre-1970 (Pre-Mining) Water Table Surface**	Hydrologic Impact Assessment – Gas Hills Facility Natrona and Fremont Counties, Wyoming Cameco	FIGURE: **5-1**



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Observed vs. Modeled Water Levels
Steady-State Calibration

Hydrologic Impact Assessment
Gas Hills Facility
Natrona and Fremont Counties, Wyoming

Cameco

FIGURE:
5-2

6. HYDROLOGIC IMPACT SIMULATIONS

Hydrologic impacts due to the operation of the Project were simulated over an estimated 20 year development and restoration period beginning in 2014 and continuing through 2033. The Gas Hills ISR facility will include development of five Mine Units (MU-1 through MU-5) as shown on **Figure 2-2**.

6.1.1 Gas Hills ISR Operations

The mining and restoration schedule and water balance assumptions for the Project are provided in **Attachment A**. Mining is planned to proceed sequentially in numerical order, beginning with Mine Unit 1 and ending with the development of Mine Unit 5.

Economically recoverable uranium is present in the 30 through 80 Sands. These sand units are semi-continuous and are treated as a single production aquifer for purposes of this impact assessment. Therefore, all Project groundwater withdrawals are taken from model Layer 3, which includes all production sands. Groundwater withdrawals were simulated using a series of 3 to 5 pumping centers (wells) per Mine Unit depending on the relative size of the unit.

Groundwater withdrawals due to ISR production are assumed to be 1 percent of total wellfield production (1 percent bleed). The ISR production bleed is expected to vary from a minimum of 10 gallons per minute (gpm) to a maximum of 119 gpm. Production bleed generally increases from Development Year 1 to a maximum in Development Year 8.

Groundwater withdrawals due to ISR restoration are assumed to be 20 percent of total restoration flow (20 percent bleed). The 20 percent restoration bleed is assumed to be equivalent to the Reverse Osmosis (RO) brine reject volume for disposal (e.g. 80 percent RO efficiency). The simulated ISR restoration bleed therefore varies from 40 to 240 gpm over the life of the mine. In practice, groundwater withdrawals during restoration are likely to be reduced substantially (e.g. 5 percent restoration bleed) by recovery of condensate from a planned forced evaporation treatment system.

6.1.2 Initial Conditions

Prior to conducting the hydrologic impact simulation, initial conditions were established that correspond to the approximate current hydrologic conditions at the site. Pre-mining water level elevations (**Figure 5-1**) used for model calibration did not include the important impact of legacy pit lake dewatering and evaporation (drawdown) on the aquifer system. Therefore, evaporation from pit lakes was simulated using a free water surface evaporation rate of 40 inches per year, minus the average annual direct precipitation rate of 9.4 inches, resulting in a net pit lake evaporation rate of 2.55 feet per year (WRCC, 2012 and WRDS, 2012). The rate of evaporation was multiplied by the estimated surface area of the Buss Pit, Lucky Mc Pit, and PC Pit, resulting in pit lake groundwater withdrawal rates of 15, 51, and 4 gpm, respectively.

The modified flow model was run to steady-state to establish initial conditions for the impact simulation. **Figures 6-1 through 6-3** illustrate the resulting initial water level elevations used for the impact simulation. The simulated initial water level elevation for the production aquifer (**Figure 6-3**) closely approximates recent water level elevations observed in the production aquifer at the site (Cameco, 2010).

6.1.3 Gas Hills Impact Assessment Results

In general, maximum drawdown impacts are predicted to occur around Development Year 9, corresponding to the time of maximum groundwater withdrawals. Maximum on-site drawdown impacts are predicted to be approximately 10-feet at the permit boundaries within the production sand aquifer, as shown by **Figure 6-4**. Drawdowns of greater than 1-foot were only observed on-site and to the north of the site in model Layer 3 (production aquifer). As show by **Figure 6-4,** the drawdown cone in the production sand aquifer is attenuated to the south by the recharge boundary along the Beaver Rim Escarpment, and elsewhere by the presence of pit lakes that act as recharge boundaries. Drawdowns are also less significant in the eastern portion of the Project area, where the East Canyon Conglomerate is in hydraulic communication with the overlying production aquifer, resulting in increased aquifer transmissivity.

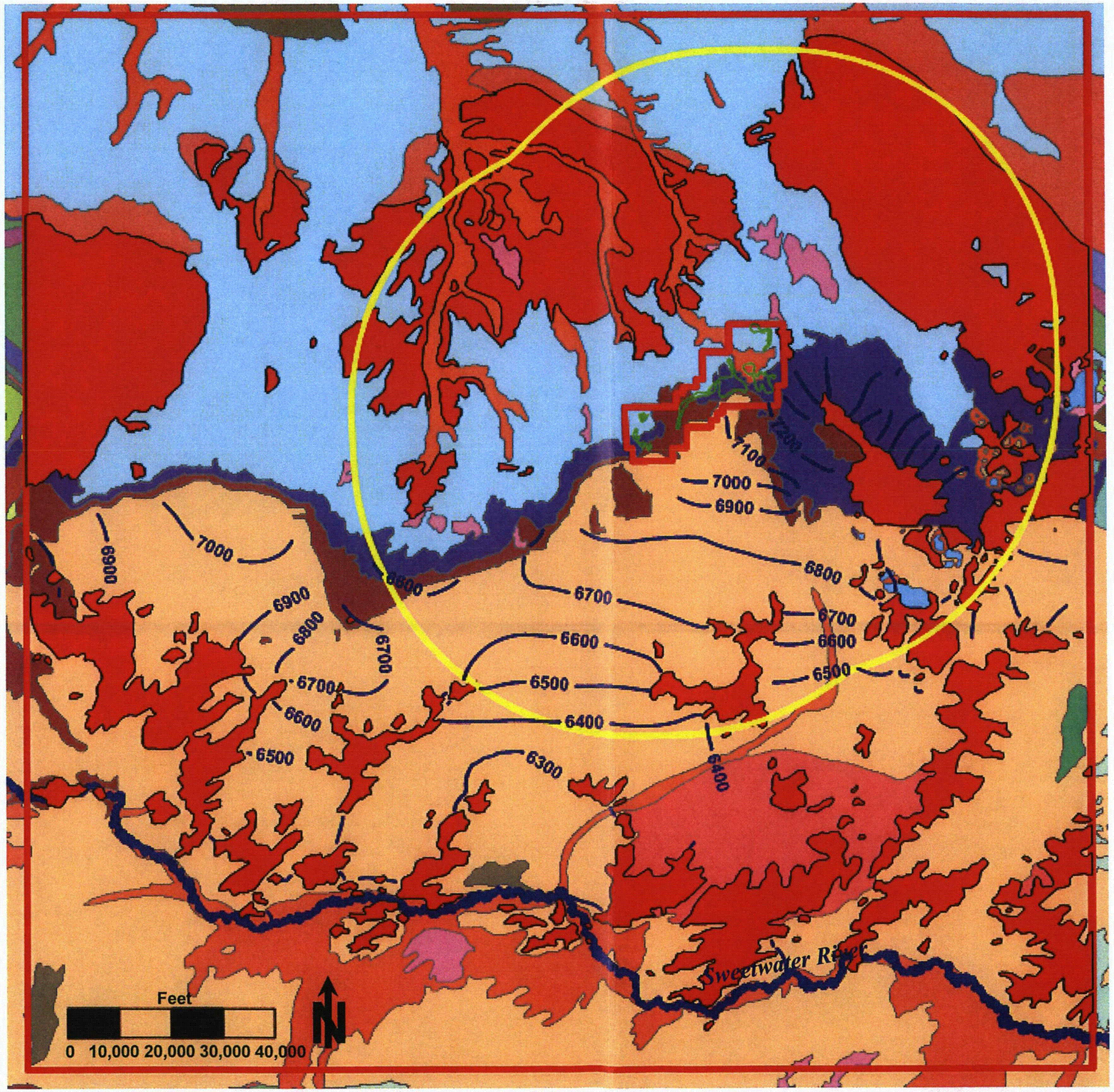
Maximum drawdown impacts are predicted to be less than 1-foot at all domestic and stock well locations. No measurable impact was observed in the Cameron Spring, which is located on-site in model Layer 1. Drawdown impacts to stock and domestic wells are limited largely because these wells are installed in the shallow water-table aquifer and are separated vertically from the production aquifer by a thick sequence of lower permeability sediments.

6.2 SUMMARY AND CONCLUSIONS

Hydrologic impacts associated with Cameco's Gas Hills ISR Project were evaluated over an estimated 20 year ISR development and restoration period. The drawdown impact computed by the groundwater flow model was evaluated at 45 water well and spring locations within a 10-mile radius of the Gas Hills facility.

In general, maximum drawdown impacts are predicted to occur around Development Years 8 and 9, corresponding to the period of maximum groundwater withdrawals. Maximum on-site drawdown impacts are predicted to be approximately 10-feet at the Project boundaries within the production sand aquifer. Impacts to all domestic and stock wells are predicted to be less than 1-foot over the life of the mine development, with no measurable decrease in spring flows. Drawdown impacts are predicted to be relatively small primarily because stock and domestic wells are installed in the shallow water-table aquifer and are hydraulically isolated from the underlying production sand aquifer by lower permeability sediments. Drawdown in the production sand aquifer is also limited by the presence of pit lakes with large storage capacity, areas of higher transmissivity across the eastern portion of the facility, and the location of the facility adjacent to the Beaver Rim Escarpment groundwater recharge area.

There are a number of assumptions incorporated into the impact assessment that render model drawdown predictions conservative (e.g. the model is likely to over-estimate drawdown impacts). These include the absence of legacy underground mine workings in the groundwater model, and the use of conservative (maximum) groundwater withdrawal rates for the ISR Project development (1 percent production bleed and 20 percent restoration bleed).



Legend

6600 Model Groundwater Elevation (feet amsl)

Permit Boundary

Model Domain

10-mile Buffer

Pre-Tertiary and Other No-Flow Outcrops

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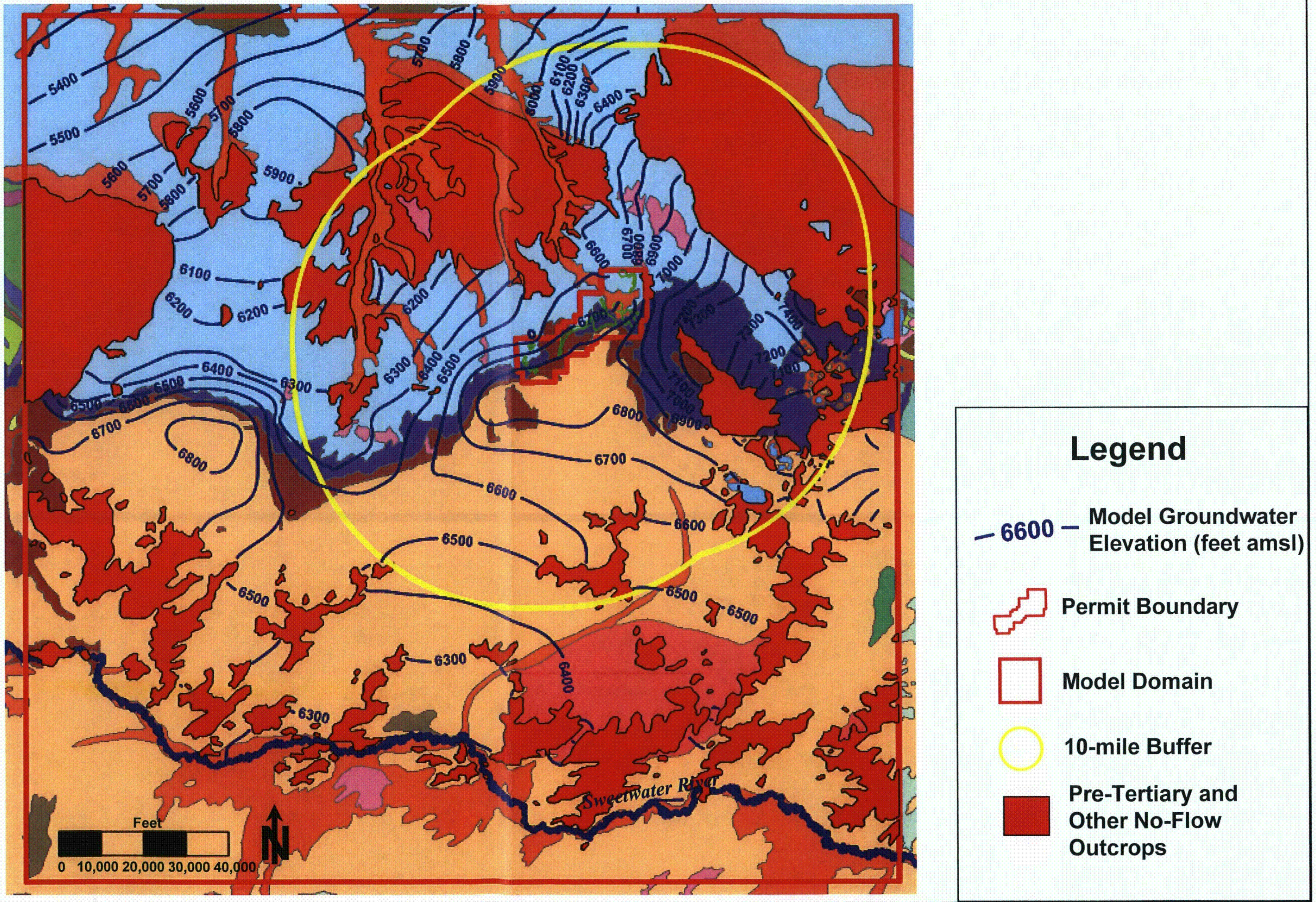
MODFLOW Initial Water Level Elevation – Layer 1

Hydrologic Impact Assessment – Gas Hills Facility
Natrona and Fremont Counties, Wyoming

Cameco

FIGURE:

6-1



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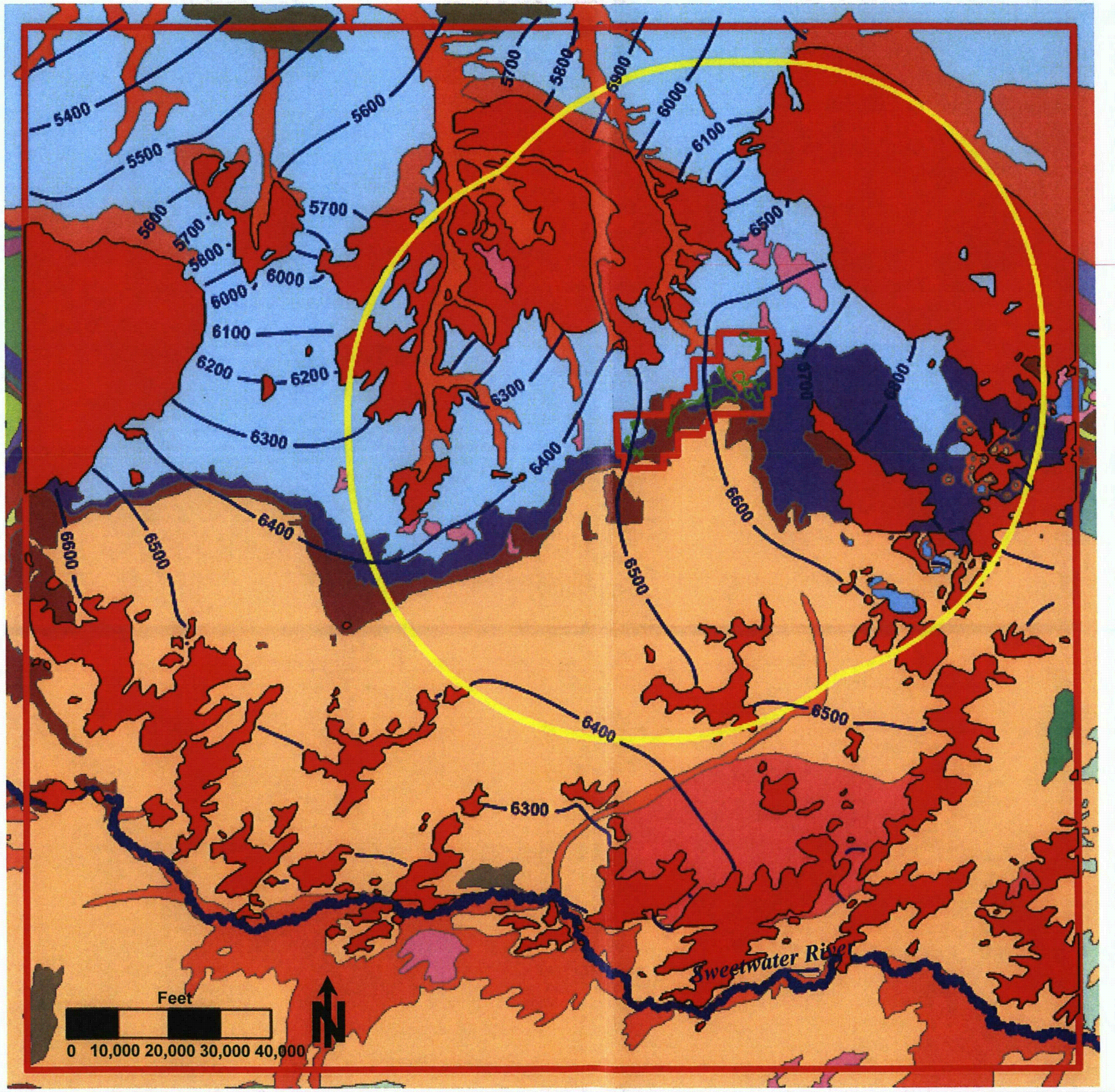
MODFLOW Initial Water Level Elevation – Layer 2

Hydrologic Impact Assessment – Gas Hills Facility
Natrona and Fremont Counties, Wyoming

Cameco

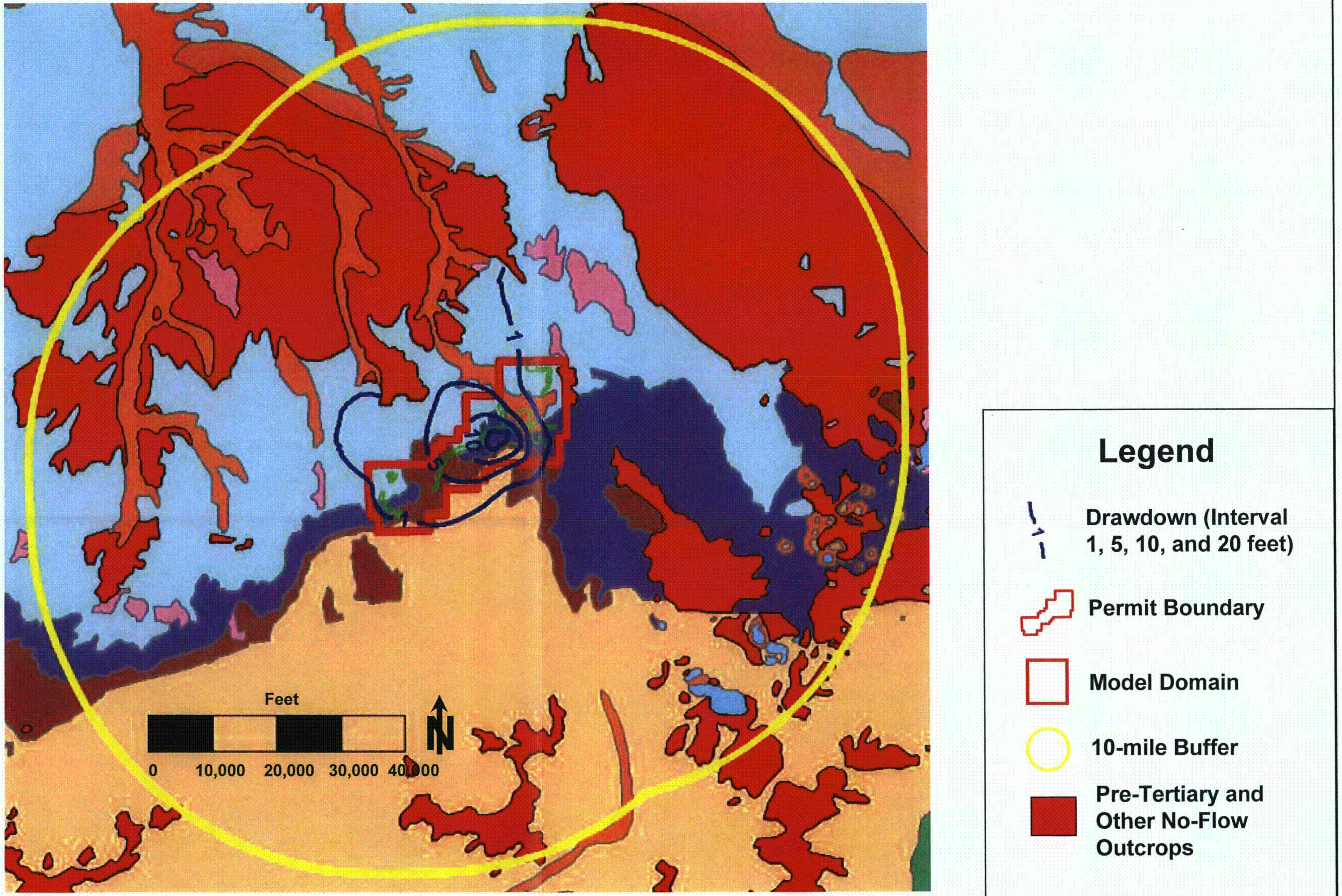
FIGURE:
6-2



Legend

- 6600 — Model Groundwater Elevation (feet amsl)
- Permit Boundary
- Model Domain
- 10-mile Buffer
- Pre-Tertiary and Other No-Flow Outcrops

AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**MODFLOW Initial Water Level Elevation – Layer 3**	Hydrologic Impact Assessment – Gas Hills Facility Natrona and Fremont Counties, Wyoming Cameco	FIGURE: **6-3**



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Maximum Drawdown Layer 3 – Development Year 9

Hydrologic Impact Assessment – Gas Hills Facility
Natrona and Fremont Counties, Wyoming

Cameco

FIGURE: **6-4**

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ATTACHMENT A

Gas Hills ISR Project Schedule and Water Balance

Gas Hills Production Water Balance

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production																					
Mine Unit Flow (gpm)		2800	5600	7100	8500	9500	9900	11500	11900	11400	10800	10300	10000	9700	7760	6208	4346	3042	2129	1491	1043
Operation Timeframe																					
Mine Unit One																					
Mine Unit Two																					
Mine Unit Three																					
Mine Unit Four																					
Mine Unit Five																					
Production Bleed (gpm) (Assume 1% bleed)		28	56	71	85	95	99	115	119	114	108	103	100	97	78	62	43	30	21	15	10
Restoration (Assume nine CPV of treatment)																					
Mine Unit 1 (gpm)	1CPV=	180	Mgal.			550	1000	1000	750												
Total (Mgal.) (Annually)						285	518	518	389												
Total Cumulative Treated (Mgal.)						285	804	1322	1711												
Mine Unit 2 (gpm)	1CPV=	293	Mgal.					200	450	1200	1200	1200	1000								
Total (Mgal.) (Annually)								104	233	622	622	622	518								
Total Cumulative Treated (Mgal.)								104	337	959	1581	2203	2722								
Mine Unit 3 (gpm)	1CPV=	148.5	Mgal.										200	1200	1000	200					
Total (Mgal.) (Annually)													104	622	518	104					
Total Cumulative Treated (Mgal.)													104	726	1244	1348					
Mine Unit 4 (gpm)	1CPV=	160	Mgal.												200	1000	1200	500			
Total (Mgal.) (Annually)															104	518	622	259			
Total Cumulative Treated (Mgal.)															104	622	1244	1503			
Mine Unit 5 (gpm)	1CPV=	180	Mgal. (est.)															700	1200	1200	200
Total (Mgal.) (Annually)																		363	622	622	104
Total Cumulative Treated (Mgal.)																		363	985	1607	1711
Restoration Bleed (gpm) (Assume 20% bleed)						110	200	240	240	240	240	240	240	240	240	240	240	240	240	240	40

Definitions

Mine Unit 1
Mine Unit 2
Mine Unit 3
Mine Unit 4
Mine Unit 5*

gpm = gallons per minute
CPV = Contacted Pore Volume
Mgal= Million Gallons