Report for 2004MI47B: Studying the Quantative Water Withdrawal Effects on Michigan's Water Supply and Distributing the Conclusions

There are no reported publications resulting from this project.

Report Follows

Project Number: 2004MI47B FY 2004 Federal Funds: $15,000
FY 2004 Non-Federal Funds: $31,653
Start Date: 03/01/04 **End Date:** 02/28/05
Title: Studying the Quantitative Water Withdrawals Effects on Michigan's Water Supply and Distributing the Conclusions
Investigators: William J. Northcott, Asst. Professor, Dept. Ag Engineering
Co-PI: Steve Miller, Specialist, Institute of Water Research and Dept. Ag Engineering
Other PI's: Pam Hunt, Visiting Specialist, Institute of Water Research
Focus Categories: Water Quantity, Water Use, Education
Congressional District: Eighth
Descriptors: Hydrology, Water Use Conflicts, GIS, Groundwater

Studying the Quantitative Water Withdrawals Effects on Michigan's Water Supply and Distributing the Conclusions

Problem and Research Objectives

The public perception of a bountiful water supply and viable water resources is being altered by published events of conflicting water uses. Due to continued media coverage on conflicting water withdrawals from industry, mining operations and irrigators, past drought conditions, and water diversion, the public is now acutely aware of potential water conflict issues regarding quantity and quality of the water source. In accordance with protecting the water supply, the state of Michigan has recently passed legislation, Public Act 148 of 2003, to manage and protect the water resources with respect to water withdrawals. One of the mandates is to produce a Groundwater Inventory and Map to guide the policy makers to enact appropriate legislation. Through the compilation and integration of data and information resulting from the inventory and the subsequent map and combining the ongoing and proposed studies, outreach and educational opportunities will be developed and made accessible concerning hydrologic principles including water use, availability, quantity, and quality to legislators, policy makers and the nonscientific community. By utilizing existing technological and standard models, these educational materials can be maximized for dissemination to target audiences.

Methodology, Principal Findings, Significance

Recent high profile water use conflict issues have renewed the interest in water quantity management issues in Michigan. The focus of efforts in the FY 2004 grant was on developing and information on the impact of water use on groundwater and surface water. A number of meetings were held with MDEQ, MDA, and USGS. The meetings in the first part of the grant were to receive input on information outreach needs and in later part of the grant to provided information derived from this project and other related projects. An important tool in educating the nonscientific community on complex groundwater flow issues is the graphical capabilities of the Interactive Groundwater Model (IGW). A number of scenarios have been developed with the focus on large volumes of water withdrawal (PowerPoint presentations are attached).

Initiated in early 2004, the development of a web site, which focused on reporting water use data compiled by the Michigan Department of Environmental Quality into a county and watershed format maintained by IWR-MSU was updated for the water year 2002 and will be updated in the future for 2003. Michigan water use data can be retrieved by years, 1997-2003, for the five major sectors of water withdrawal: Thermoelectric Power Generation, Public Water Supply, Self Supplied Industrial, Agricultural Irrigation, and Golf Course Irrigation. This site sorts the water withdrawal data by location and then respectively by category and years. The URL address is http://www.hydra.iwr.msu.edu/iwr/wateruse/index.html. A future goal of this web site is to enhance the data with graphical charts to illustrate the water withdrawal rates for the retrieved county or watershed.

In addition the following opportunities provided a forum to augment the delivery of outreach materials or gather comments for the distribution of the conclusions.

- GIS Training in March facilitated the understanding needed for the basic development of the web site to house the data inventory, query formula options, and projections of the map series required by the legislation.
- The State Science Olympiad in April was an avenue to teach and test middle and high school students on hydrogeological parameters. The Olympiad also provided feedback to what elements needed to be expanded for outreach initiatives, such as highlighting the State's groundwater and surface water resources locally and regionally.
- A half-day symposium with MDA to share with them our perspectives, information, and modeling efforts to aid in their deliberations to policy options related to the recent GW legislation and the proposed Water Legacy Act. The last agenda item was to solicit the educational needs - integration/system studies/education.
- Ag Expo is an annual event sponsored by Michigan State University (MSU) and is largest farm show in the State scheduled in July. Educational exhibits highlighting MSU research and extension have always been the mainstay of the expo. IWR featured two interactive web sites, EZ-Mapper and Know Your Watershed to illustrate imagery available by the internet. Additionally, a color printout of their farm or another point of interest was printed for the visitors depicting aerial photography presenting water bodies, topography and land use features. IWR-MSU brochures were made available to the expo participants emphasizing the education components of protecting one's water resources.
- In November, the MSU extension group, Area of Expertise (AOE) Water requested a presentation on the mandated requisites of Public Act 148. Through discussions with the group, materials needed at this time for the public audience are informational bulletins explaining base flow and water use in Michigan. Presently, the base flow brochure is in the review process.
- In January, through a focus group meeting, participants identified different techniques to employ to reach various target audiences.
- At the annual conferences for the Association of Townships and Michigan Association of Counties, respectively in January and February, the booth showcased digital watershed and watershed mapping. Watershed mapping tools were shown to over 250 people. Although water-related issues varied between the urban and rural settings, several water-related issues had common interest, wetland location, access to updated photos, and DEQ violations. The attendees expressed a need to access and utilizing GIS data for decision-making policy.

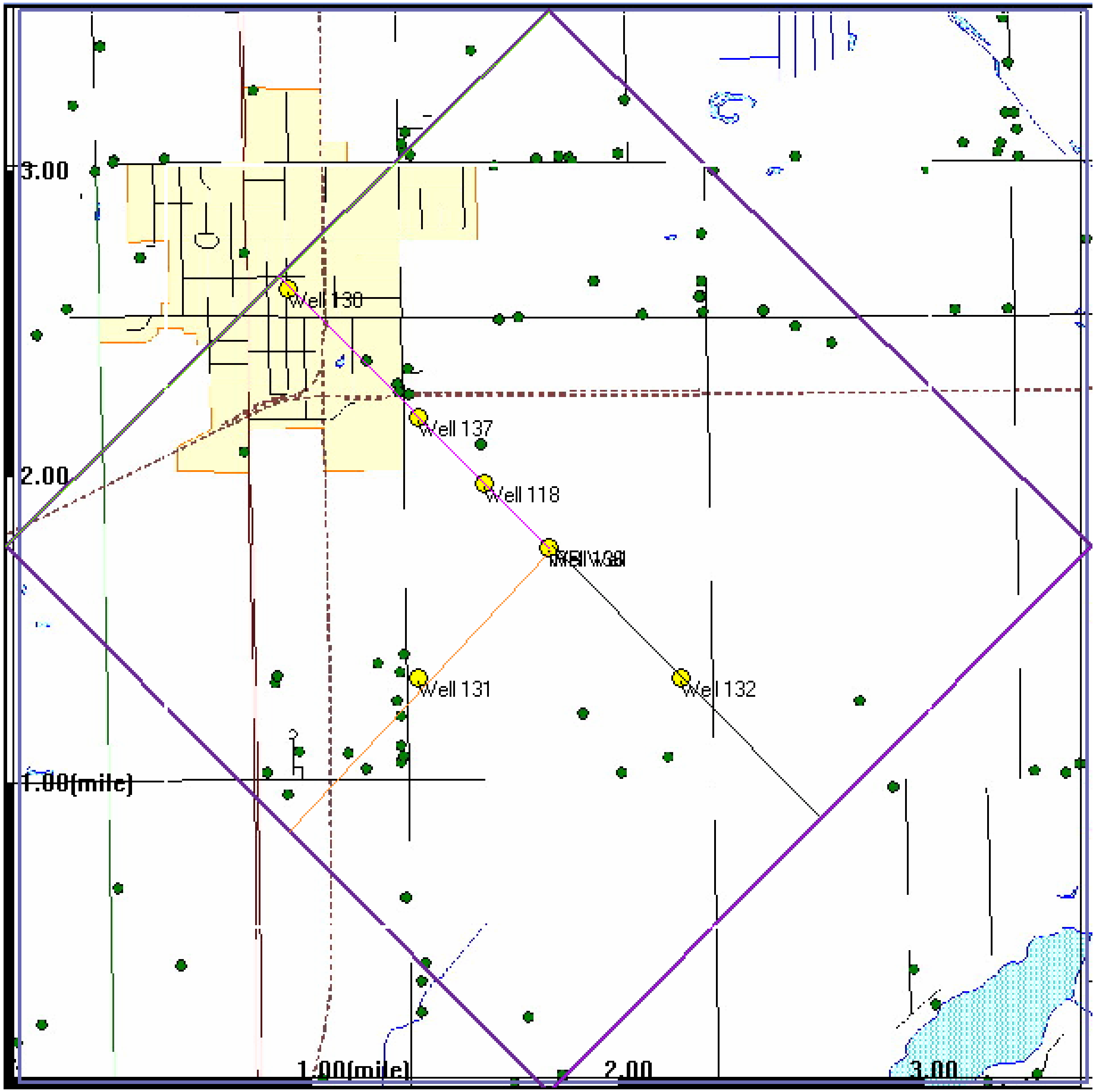

Well 130
Well 137
Well 118
Well 131
Well 132
3.00
2.00
1.00(mile)
1.00(mile)
2.00
3.00

Table 1: Drawdown at MW located 500m from the pumping well (1000 GPM)

Unconfined Aquifer (K=141 ft/day)					
Recharge 4 in/yr			Recharge 9 in/yr		
dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr	dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr
5.926	3.297	0.326	4.485	2.004	-0.924

Unconfined Aquifer (K=300 ft/day)					
Recharge 4 in/yr			Recharge 9 in/yr		
dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr	dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr
2.777	2.085	0.053	2.729	2.061	0.05

Confined Aquifer (K=141 ft/day)					
Recharge 4 in/yr			Recharge 9 in/yr		
dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr	dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr
5.958	3.306	0.328	5.743	3.243	0.308

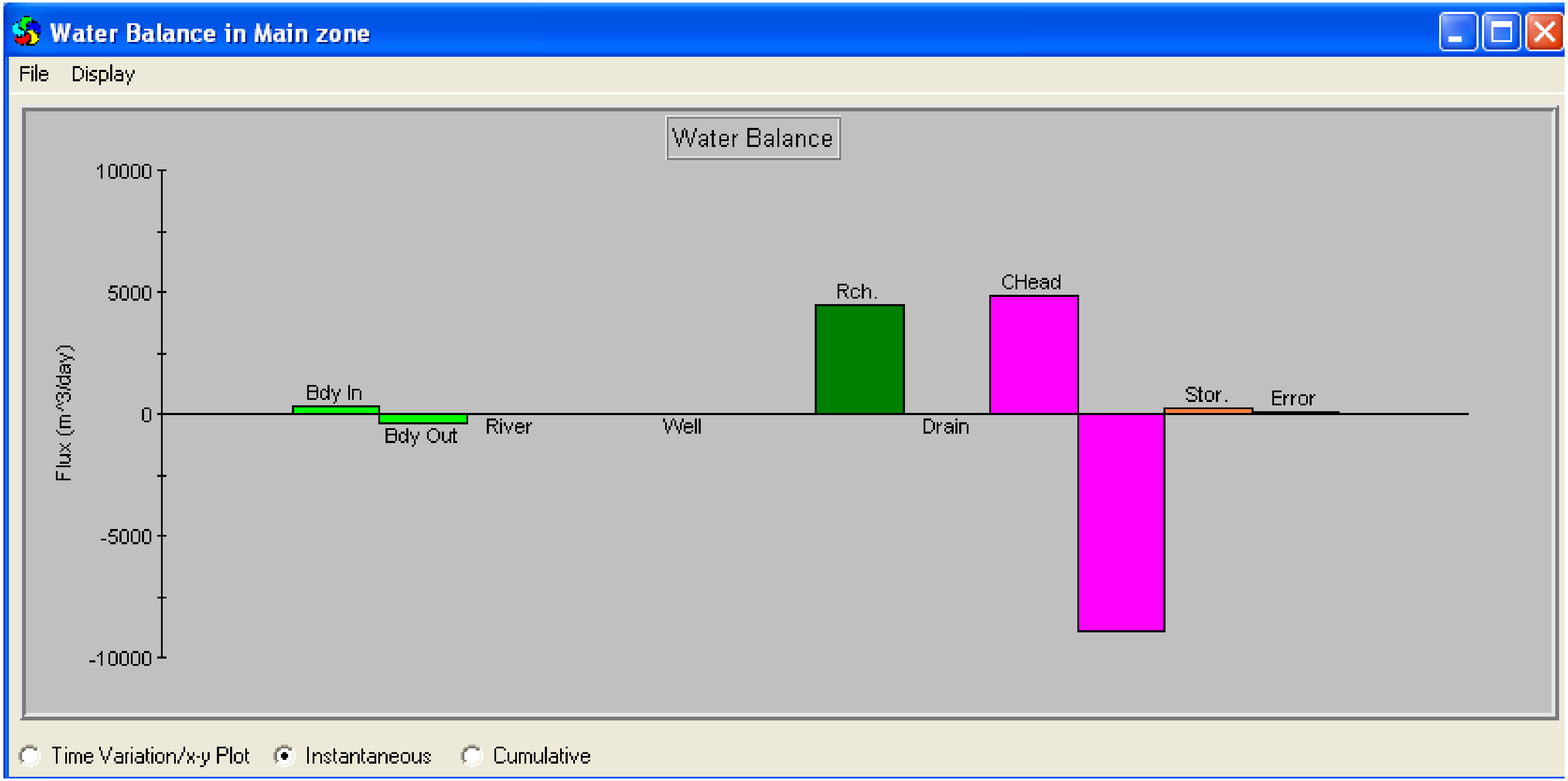
*Aquifer thickness is 84ft

Confined Aquifer (K=300 ft/day)					
Recharge 4 in/yr			Recharge 9 in/yr		
dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr	dd at Steady State	dd at 90 days pumping	dd at 90 days pumping w/recovery for total time of 1 yr
2.776	2.085	0.053	2.729	2.061	0.05

Mass Balance for Unconfined Case

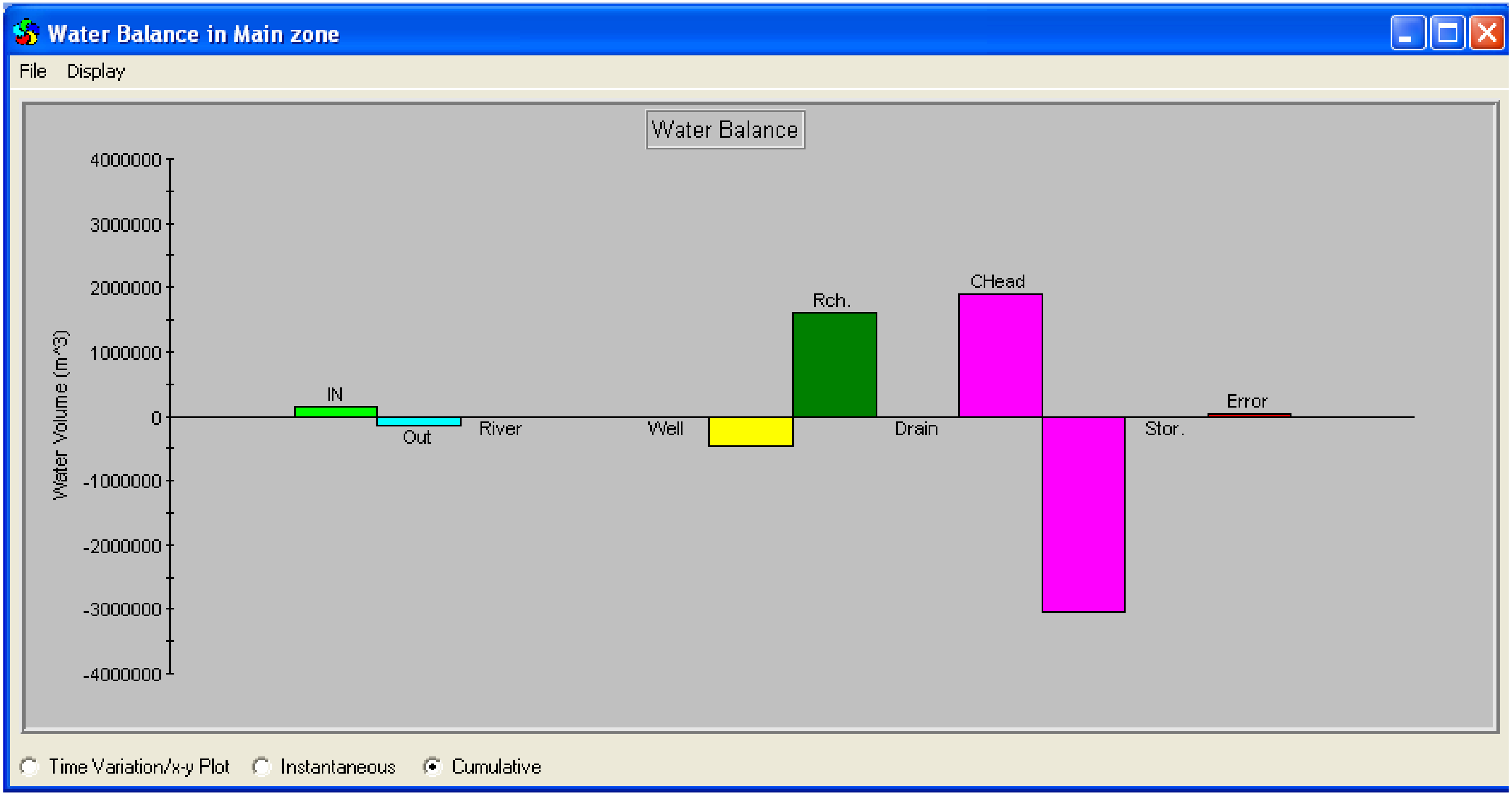
with 4in/yr of Recharge and K=300 ft/day

instantaneous



Mass Balance for Unconfined Case
with 4in/yr of Recharge and K=300 ft/day

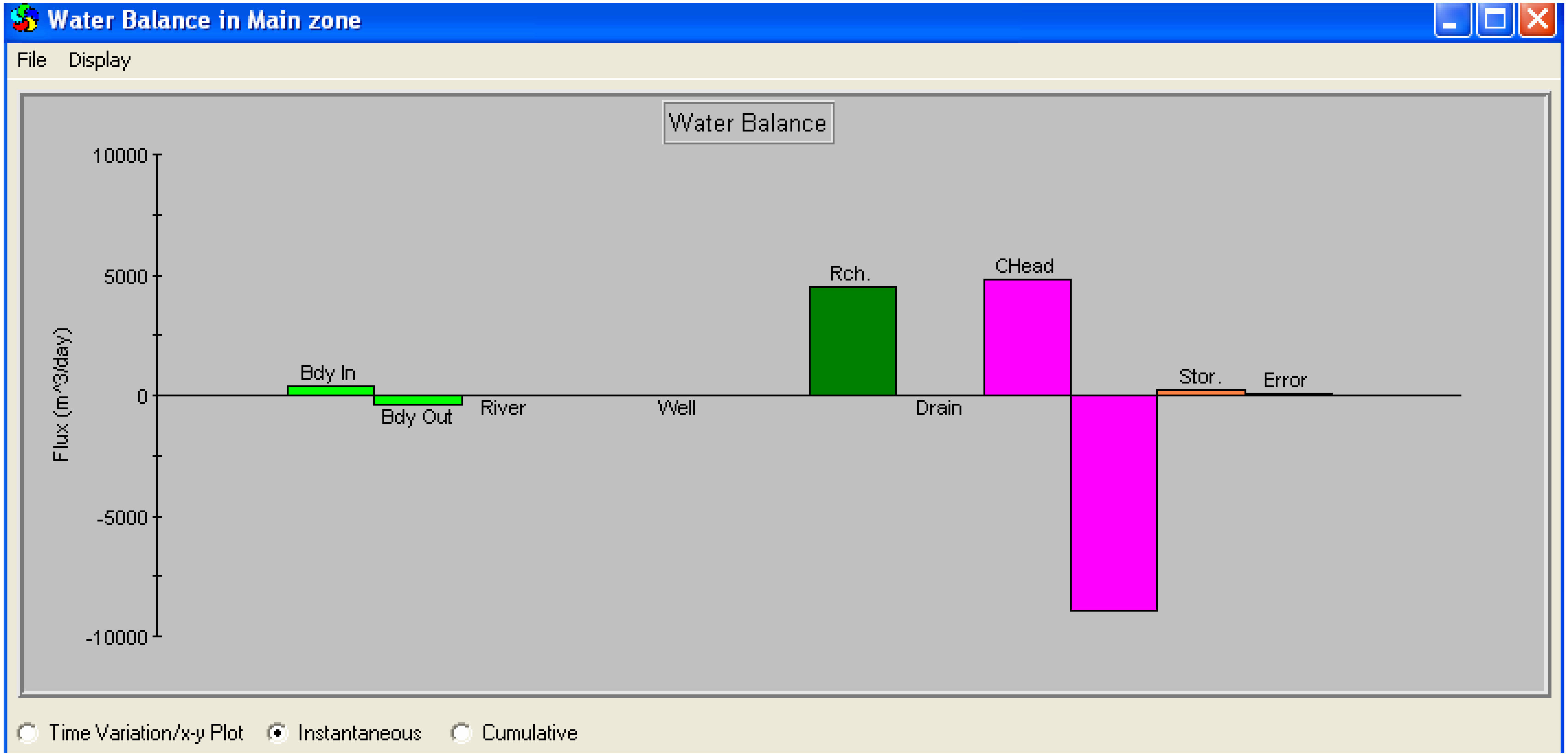
cumulative



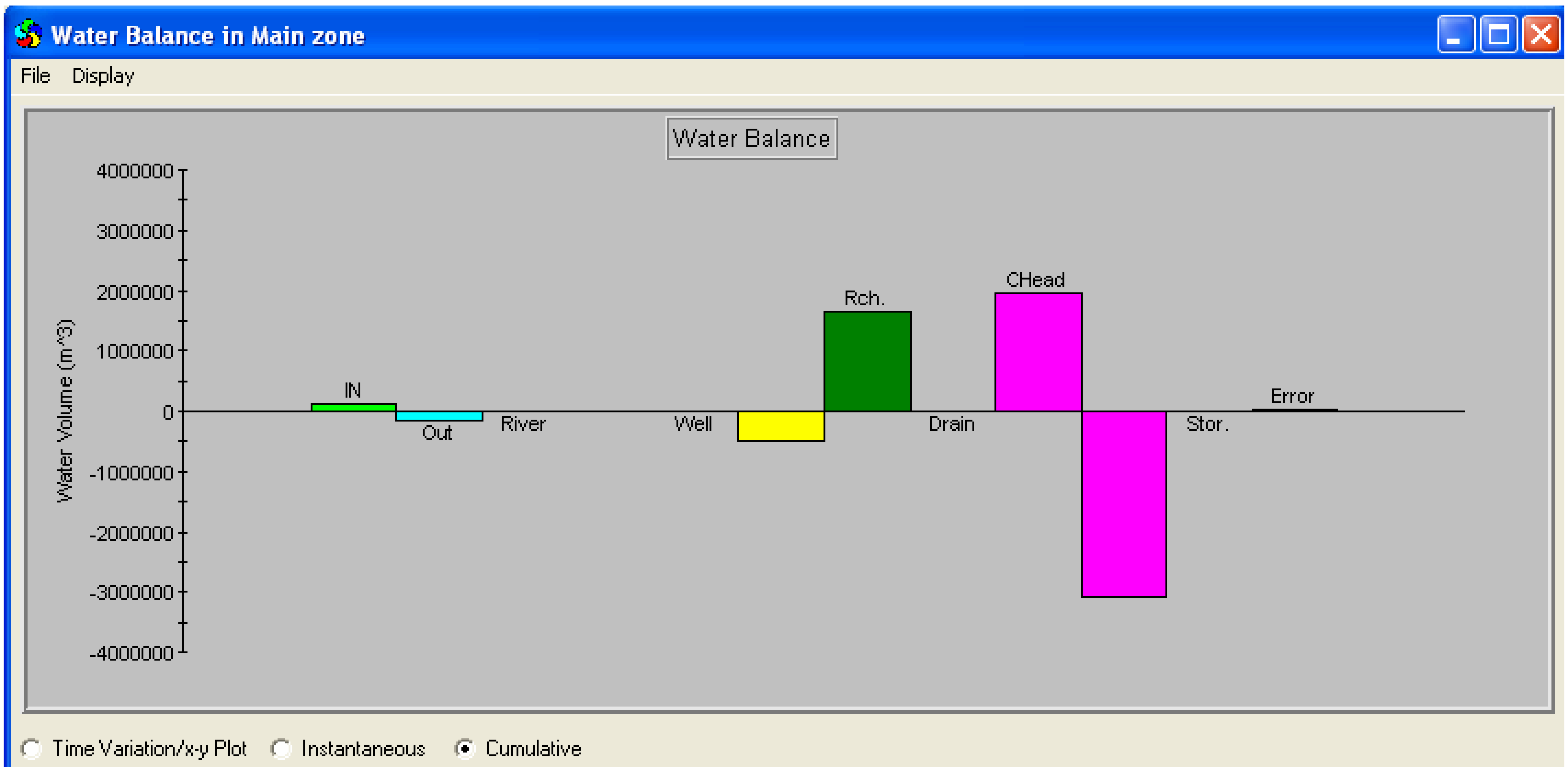
Mass Balance for Confined Case

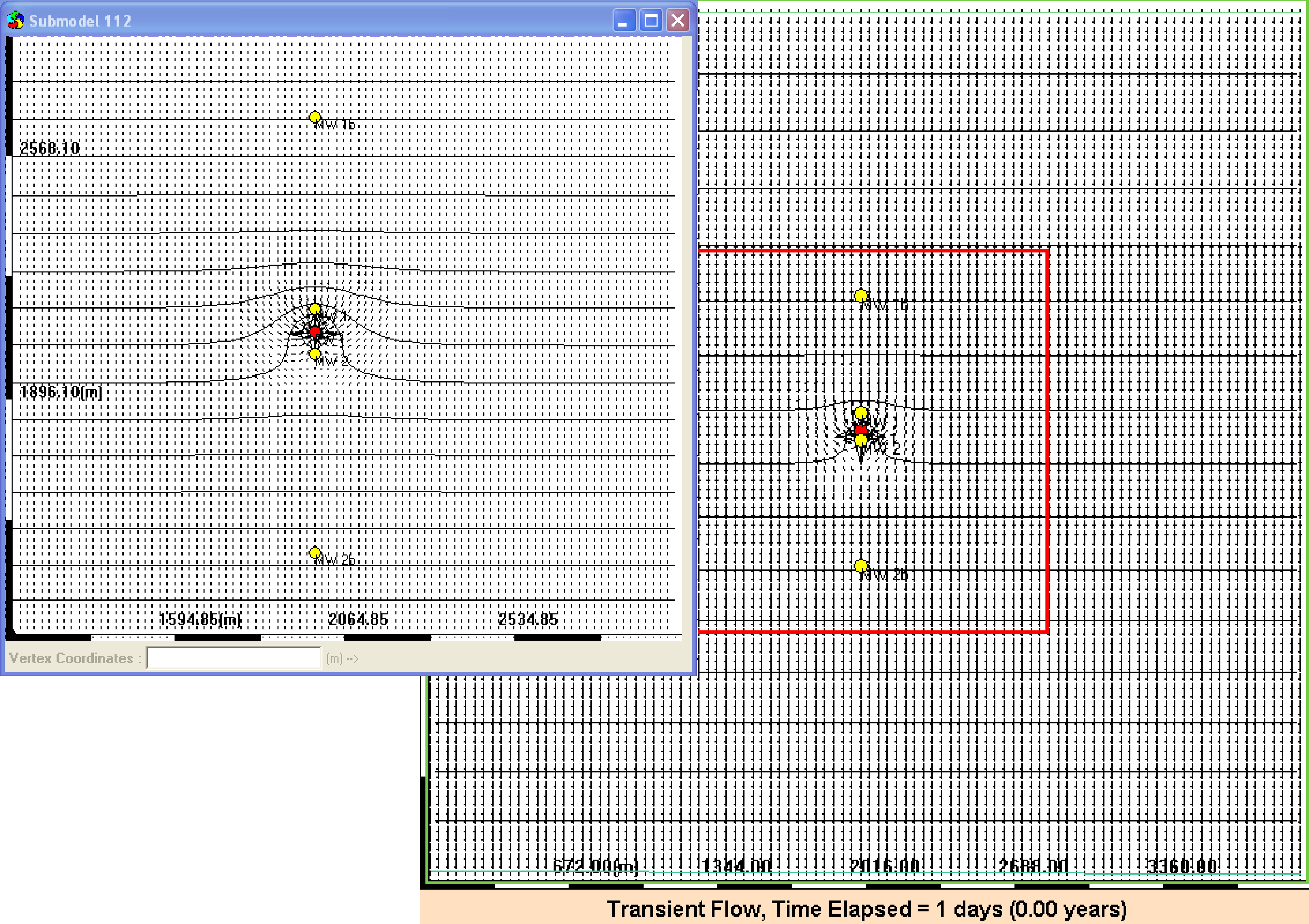
with 4in/yr of Recharge and K=300 ft/day

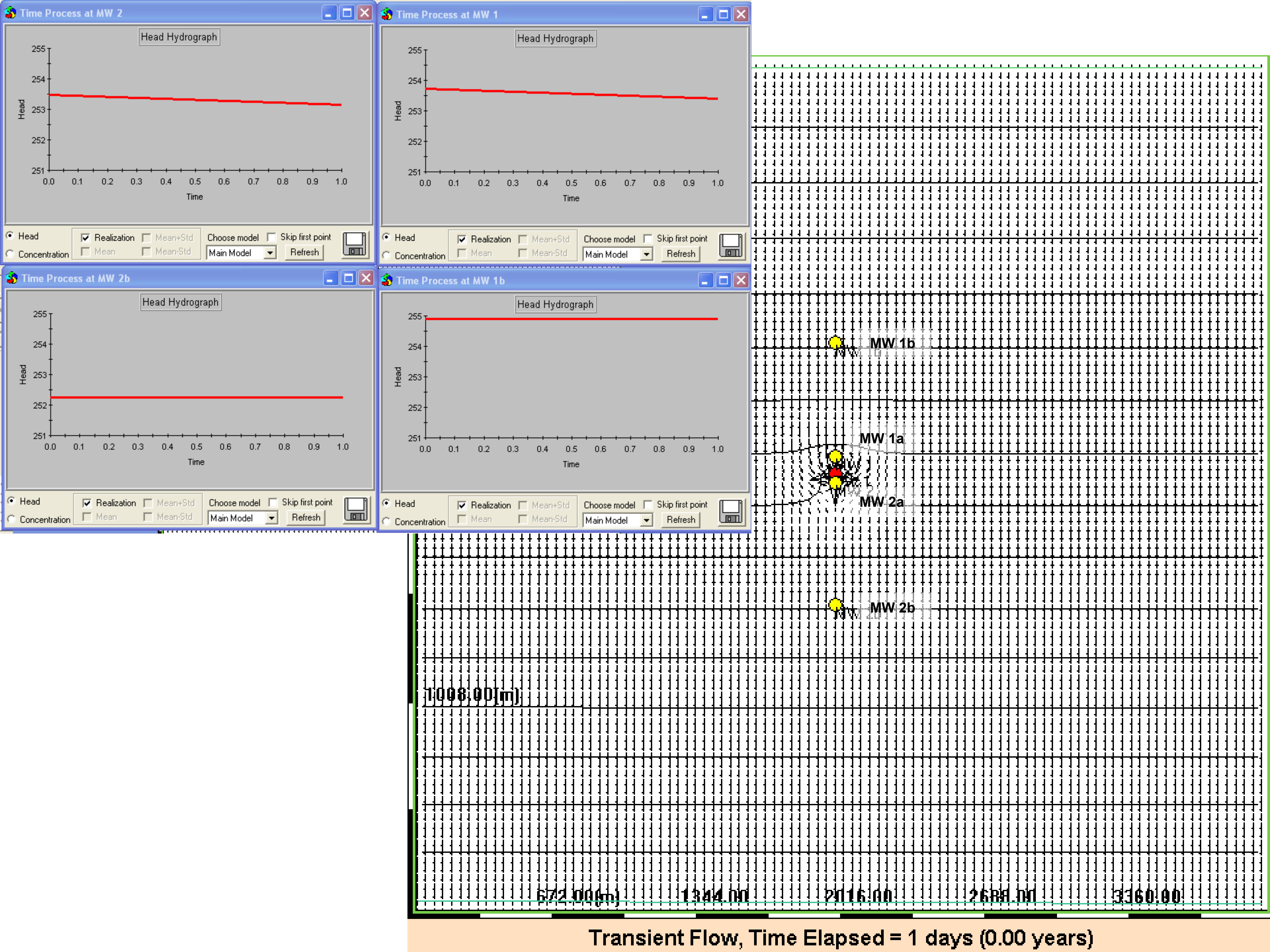
instantaneous



Mass Balance for Confined Case
with 4in/yr of Recharge and K=300 ft/day
cumulative




Submodel 112
MW 1b
2568.10
MW 2
1896.10(m)
MW 2b
1594.85(m)
2064.85
2534.85
Vertex Coordinates :
(m) -->
MW 1b
MW 2
MW 2b
672.000(m)
1344.00
2016.00
2688.00
3360.00
Transient Flow, Time Elapsed = 1 days (0.00 years)

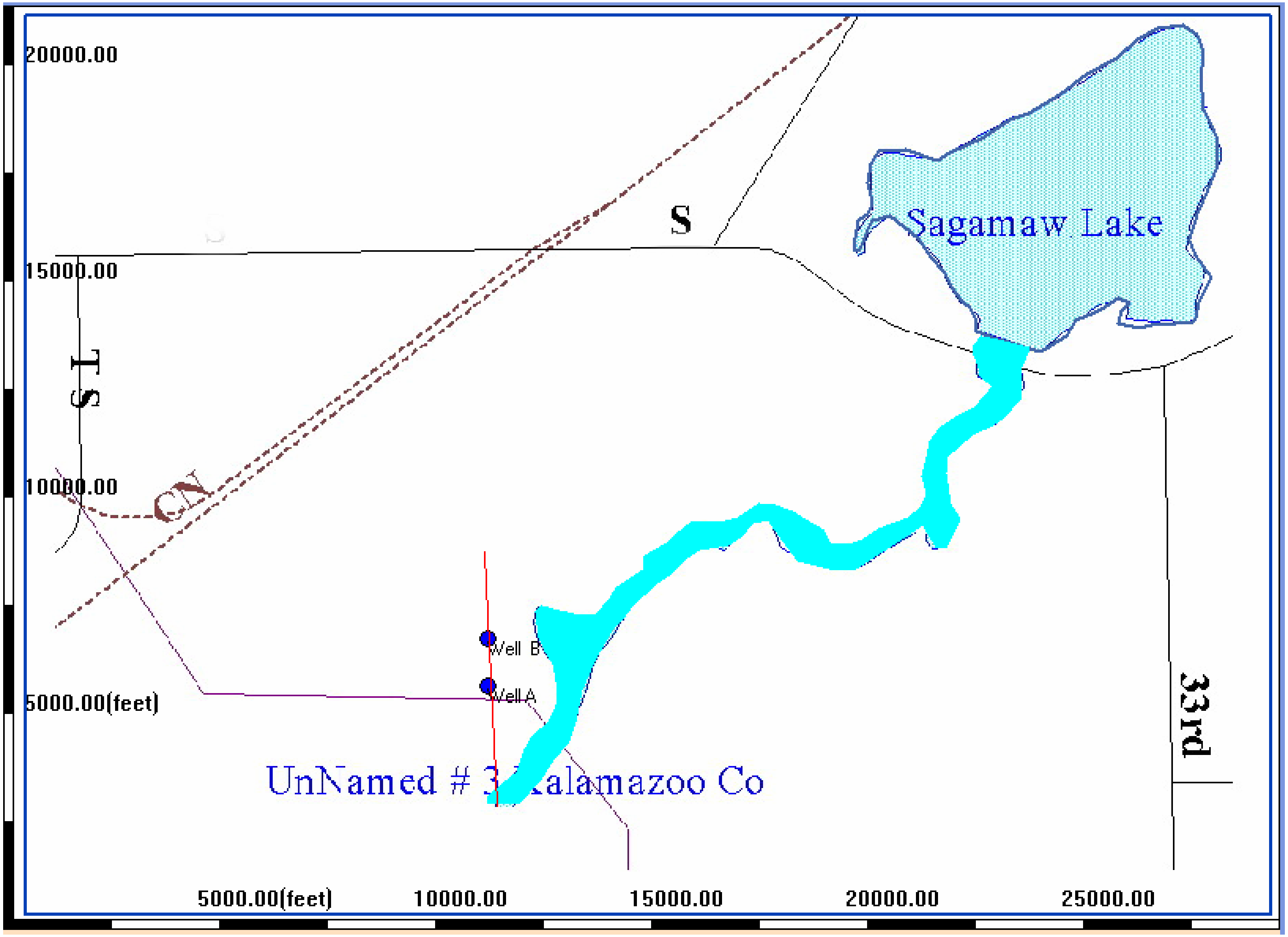


Time Process at MW 2
Head Hydrograph
Head
Time
Time Process at MW 1
Head Hydrograph
Head
Time
Time Process at MW 2b
Head Hydrograph
Head
Time
Time Process at MW 1b
Head Hydrograph
Head
Time
Head
Concentration
Realization
Mean+Std
Mean
Mean-Std
Choose model
Main Model
Skip first point
Refresh
MW 1b
MW 1a
MW 2a
MW 2b
1008.00[m]
672.00[m]
1344.00
2016.00
2688.00
3360.00
Transient Flow, Time Elapsed = 1 days (0.00 years)

Use of water harvesting technique to enhance aquifer recharge and associated water supply

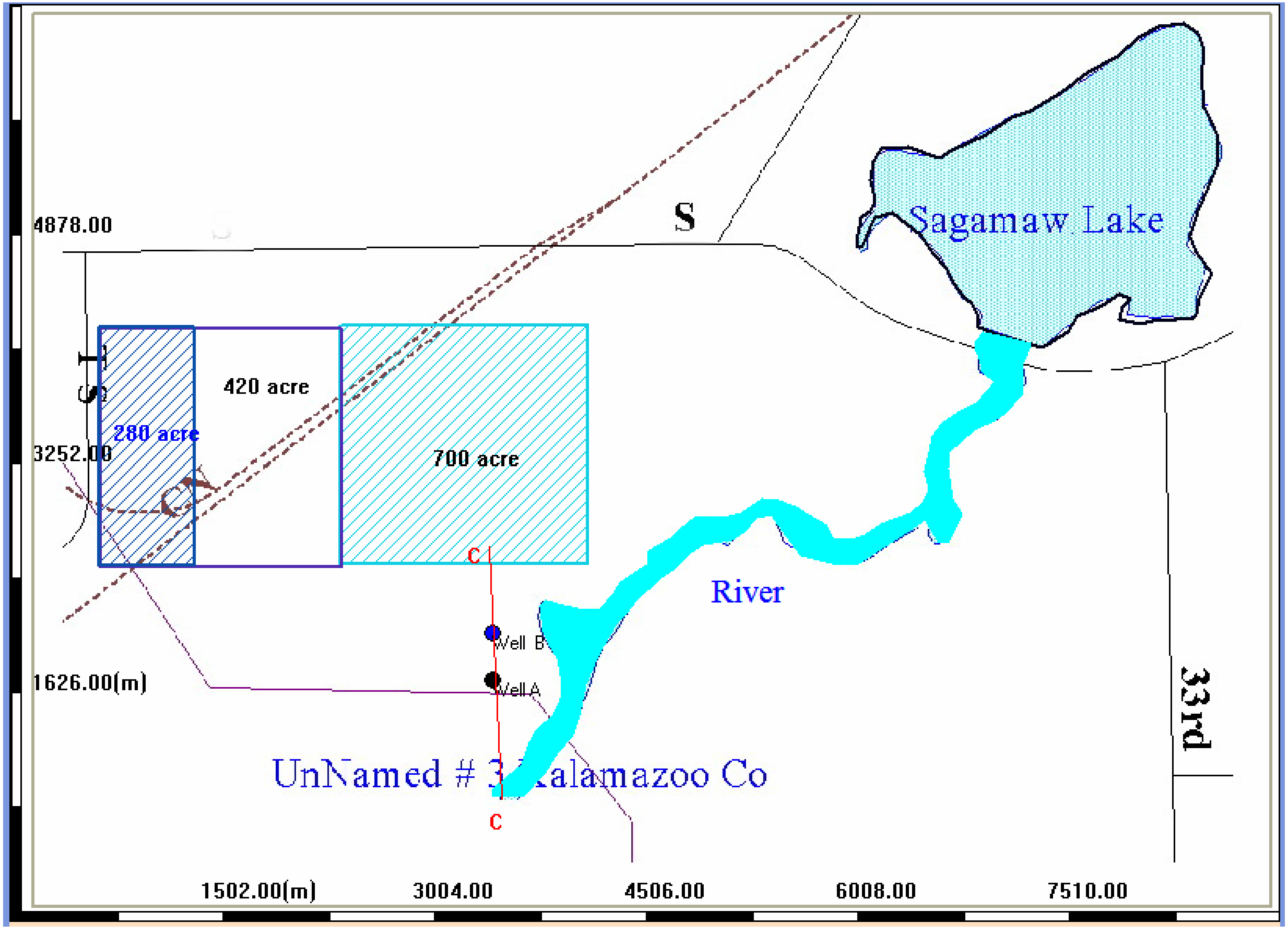
July 29, 2004

Modeling domain



No-flow boundary

No-flow boundary



No-flow boundary

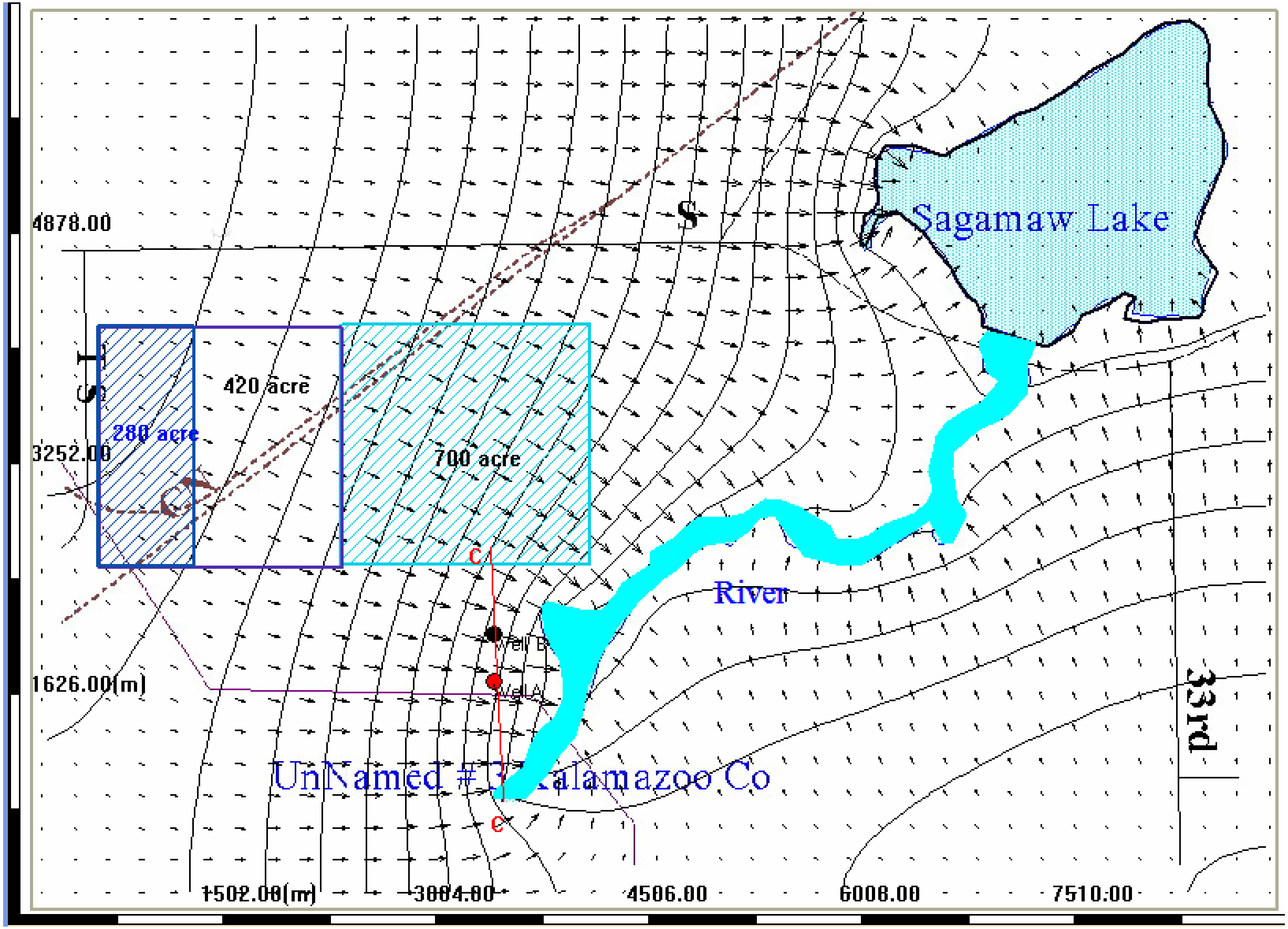
No-flow boundary

Physical parameters	Value (unit)
Ground Surface elevation	+32 (ft)
Aquifer top elevation (unconfined)	+32 (ft)
Aquifer bottom elevation	-164 (ft)
Hydraulic conductivity K_x	32(ft/day)
Ratio of anisotropy in horizontal direction K_x / K_y	1 (-)
Effective recharge	5 (in/year)
Specific yield	0.1 (-)

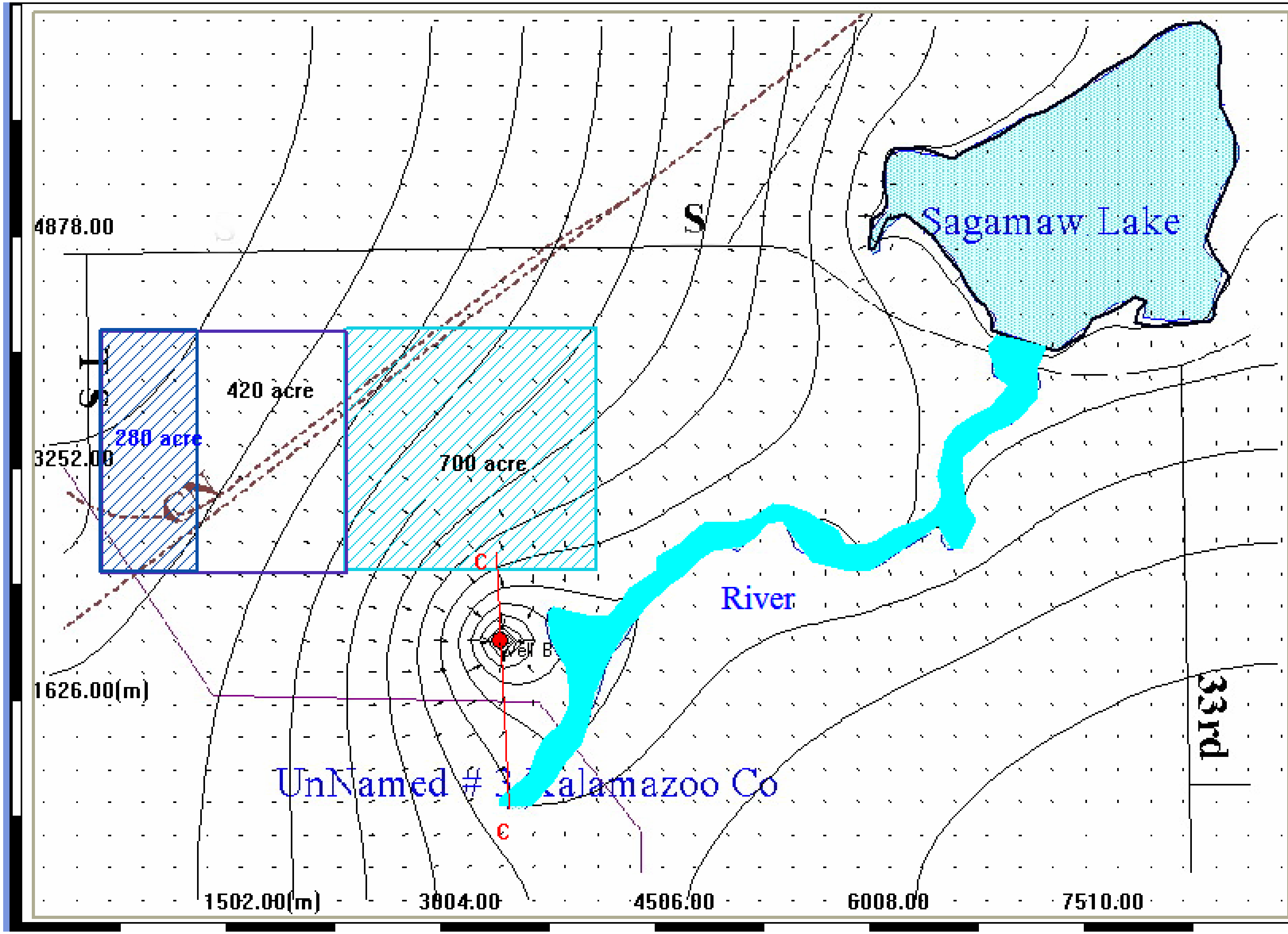
Lake parameters	Value (unit)
Water Elevation	0.00(ft)
Leakance	5 (1/day)
Bottom elevation	-98 (ft)
Area	1.118 (E+10) (ft^2)

River parameters	Value (unit)
Elevation	0.32 (ft)
Leakance	0.01 (1/day)
Width, Length	Given (basemap)

Pumping well parameters	Value (unit)
Top screen Elevation	-32 (ft)
Top screen Elevation	-98 (ft)
Well A Pumping rate	-1000 (gpm)
Well B Pumping rate	-1000 (gpm)
Pumping duration	90 (days)



Sagamaw Lake
4878.00
3252.00
1626.00(m)
420 acre
280 acre
700 acre
River
Well B
Well A
UnNamed # 3 Kalamazoo Co
33rd
1502.00(m)
3004.00
4506.00
6008.00
7510.00



Transient case at the end of 30 days

Sensitivity analysis for different recharge rates
Water balance for whole modeling domain

	Case 1 No additional recharge		Case 2 700 acre field with additional 2in/yr recharge		Case 3 700 acre field with additional 4in/yr recharge	
	Steady state regional recharge 5 in/yr	after 30 days pumping with 1000 gpm	Steady state	after 30 days pumping with 1000 gpm	Steady state	after 30 days pumping with 1000 gpm
Recharge	18000(m^3/day)	18000	18200	18200	18700	18700
Lake	-6500	-6000	-6500	-5700	-6500	-6000
River	-11500	-6500	-11700	-7000	-12200	-7200
Pumping well	0	-5500	0	-5500	0	-5500

Sensitivity analysis for different recharge rates
Water balance for whole modeling domain

	Case 1 No additional recharge		Case 2 280 acre field with additional 2in/yr recharge		Case 3 280 acre field with additional 4in/yr recharge	
	Steady state regional recharge 5 in/yr	after 30 days pumping with 1000 gpm	Steady state	after 30 days pumping with 1000 gpm	Steady state	after 30 days pumping with 1000 gpm
Recharge	18000(m^3/day)	18000	18100	18100	18500	18500
Lake	-6500	-6000	-6500	-5800	-6500	-5800
River	-11500	-6500	-11600	-6800	-12000	-7200
Pumping well	0	-5500	0	-5500	0	-5500

Modeling domain

x direction $2.9527559 \cdot 10^4 \cdot ft = 5.592mi$

y direction $2.1325459 \cdot 10^4 \cdot ft = 4.039mi$

$1 \cdot acre = 4.047 \times 10^3 m^2$

$1 \cdot acre = 4.356 \times 10^4 ft^2$

Pumping rate 1000 gpm:

$$1000 \cdot \frac{gal}{min} = 5.451 \times 10^3 m^3 \cdot day^{-1}$$

$$1000 \cdot \frac{gal}{min} \cdot 30 \cdot day = 1.635 \times 10^5 m^3$$

$$700 \cdot acre \cdot 2 \cdot \frac{in}{yr} \cdot 1yr = 1.439 \times 10^5 m^3$$

$$700 \cdot acre \cdot 4 \cdot \frac{in}{yr} \cdot 1yr = 2.878 \times 10^5 m^3$$

$$280 \cdot acre \cdot 2 \cdot \frac{in}{yr} \cdot 1yr = 5.756 \times 10^4 m^3$$

$$280 \cdot acre \cdot 4 \cdot \frac{in}{yr} \cdot 1yr = 1.151 \times 10^5 m^3$$

For one year

$$\frac{1.635 \times 10^5 m^3}{2 \cdot in} = 795.31 acre$$

$$\frac{1.635 \times 10^5 m^3}{4 \cdot in} = 397.655 acre$$

$$600 \cdot \frac{\text{gal}}{\text{min}} \cdot 30 \cdot \text{day} = 9.812 \times 10^{4}\,\text{m}^{3}$$

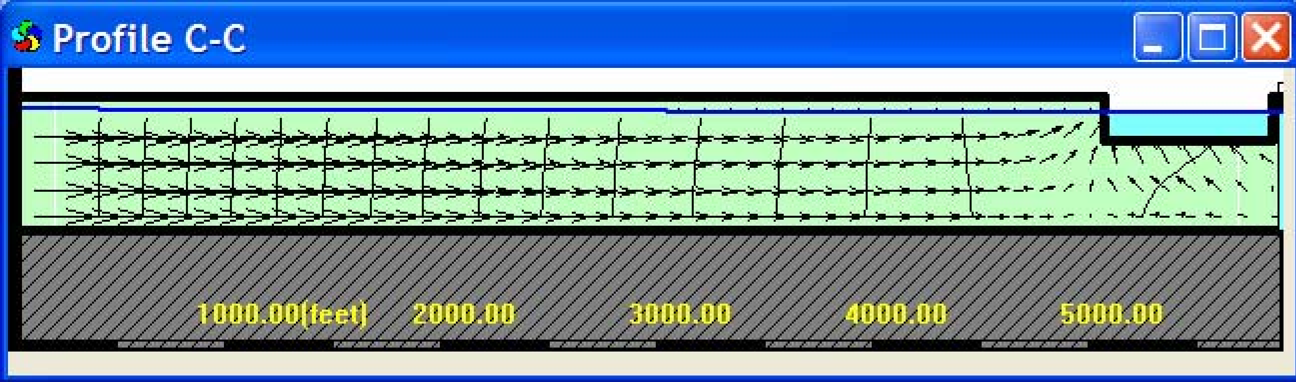
$$900 \cdot \frac{\text{gal}}{\text{min}} \cdot 30 \cdot \text{day} = 1.472 \times 10^{5}\,\text{m}^{3}$$

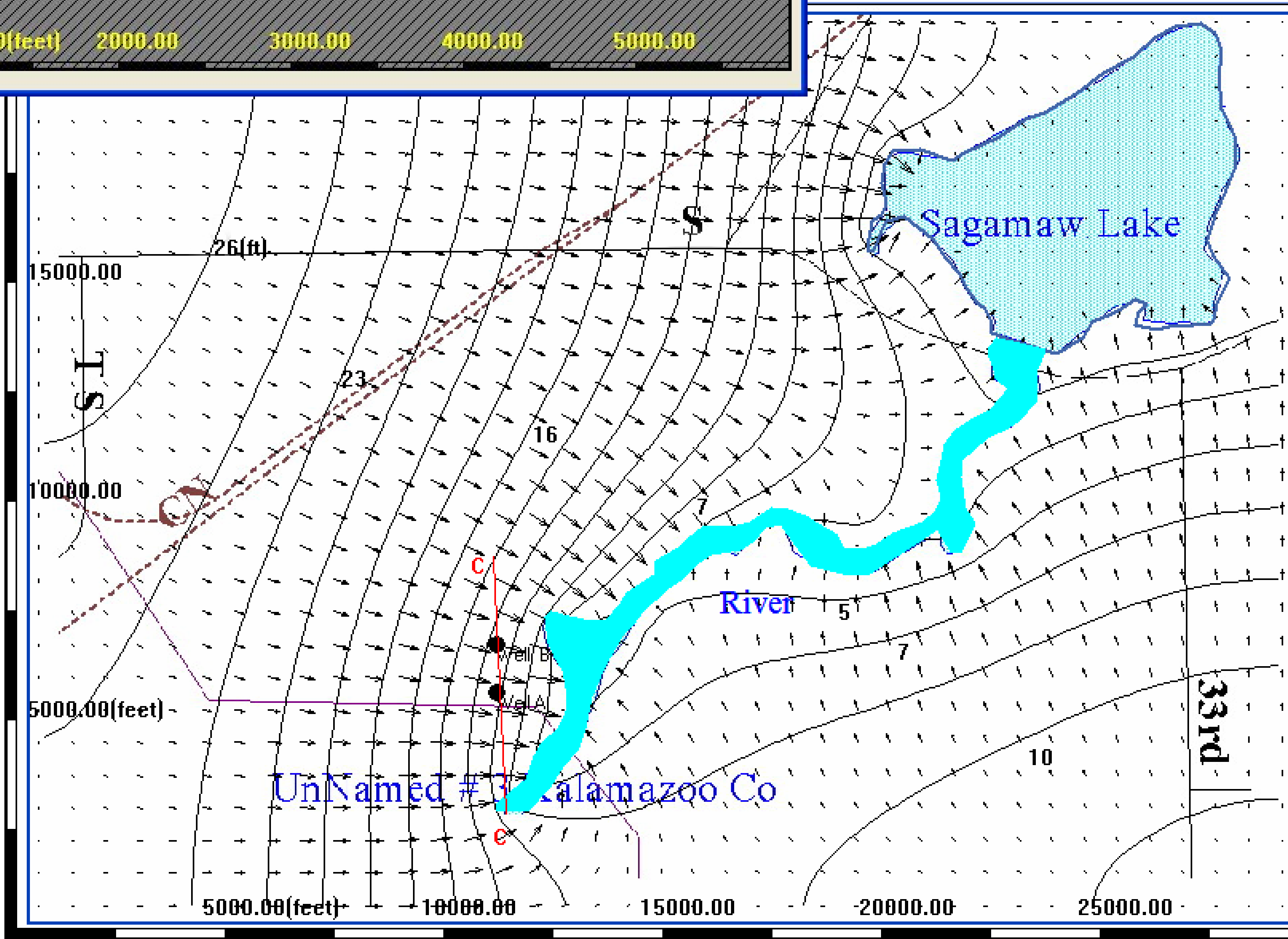
$$\frac{9.812 \times 10^{4} \cdot \text{m}^{3}}{40 \cdot \text{acre}} = 23.864\text{in}$$

$$\frac{1.472 \times 10^{5} \cdot \text{m}^{3}}{40 \cdot \text{acre}} = 35.801\text{in}$$

END

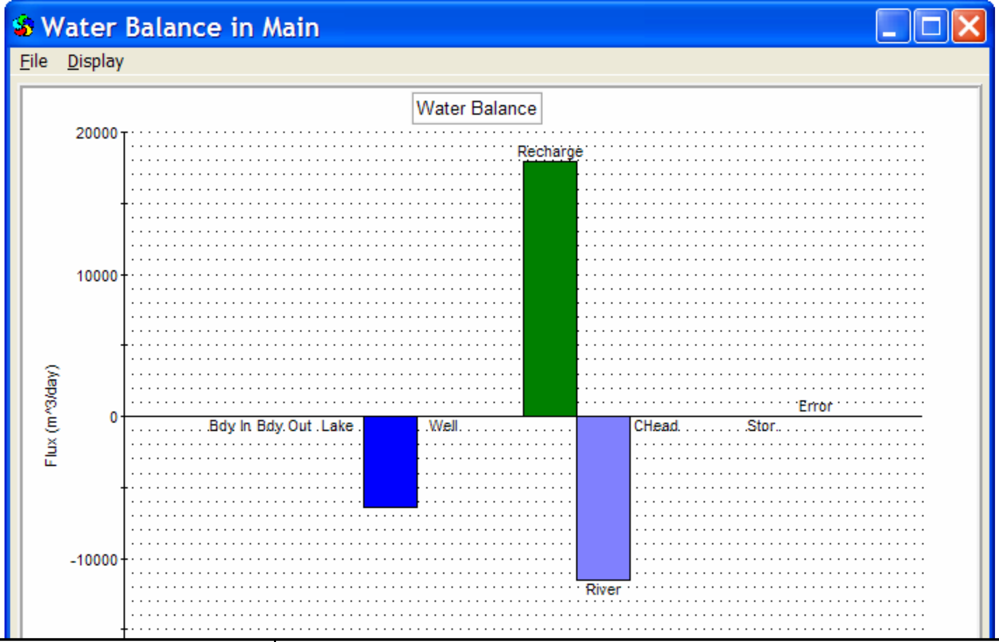
Head contour map for steady state condition



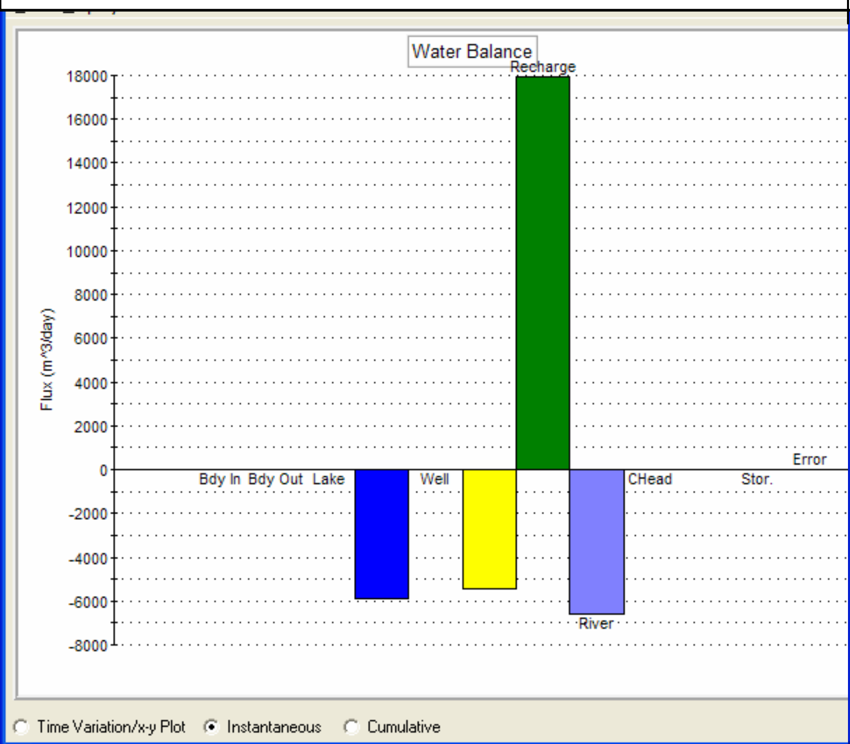


- Unconfined Aquifer
- Constant aquifer thickness
- Constant recharge
- No-flow boundaries from all sides

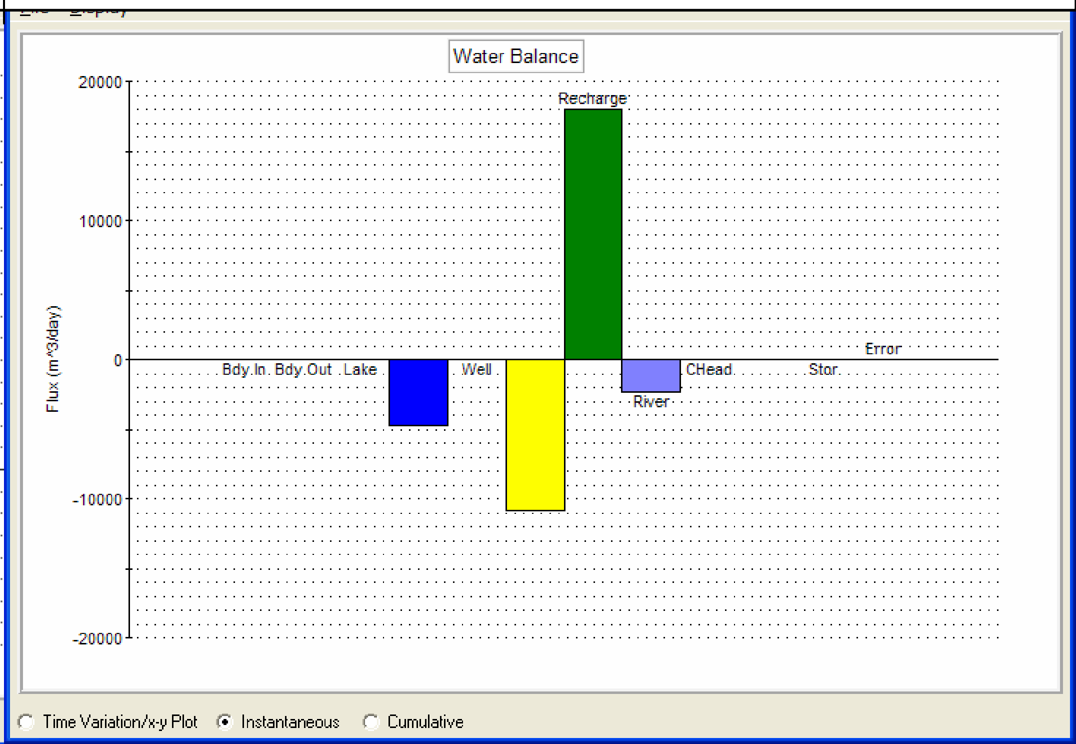
Water balance for the main modeling domain. Steady state condition no pumping wells

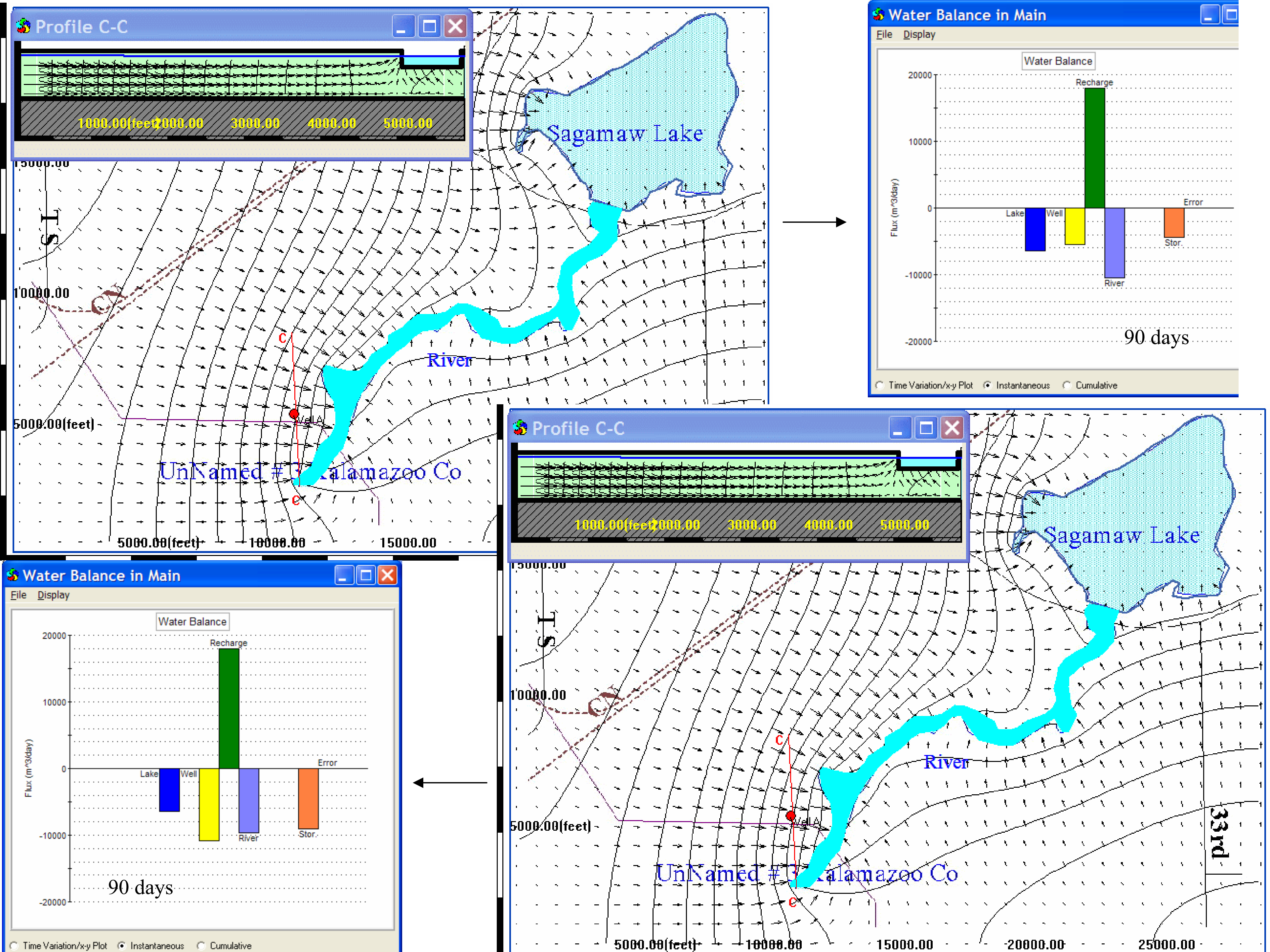


Steady state condition with one pumping wells

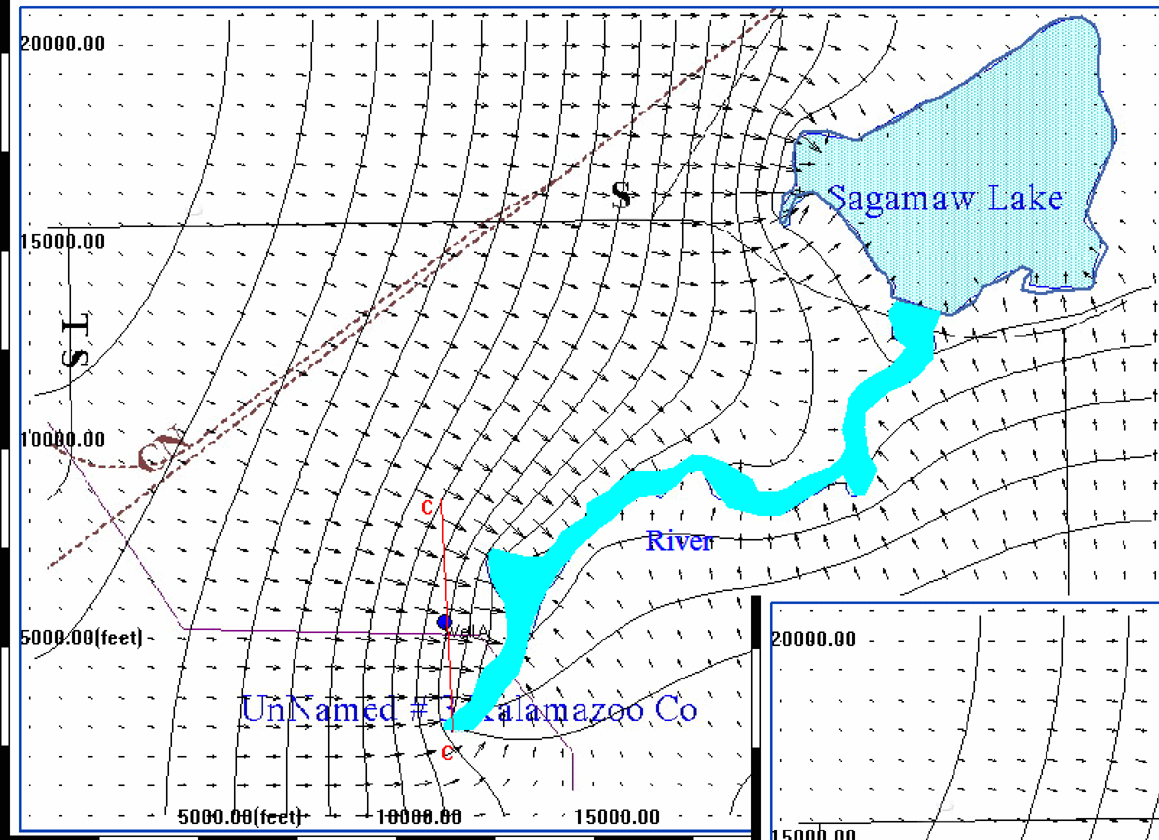


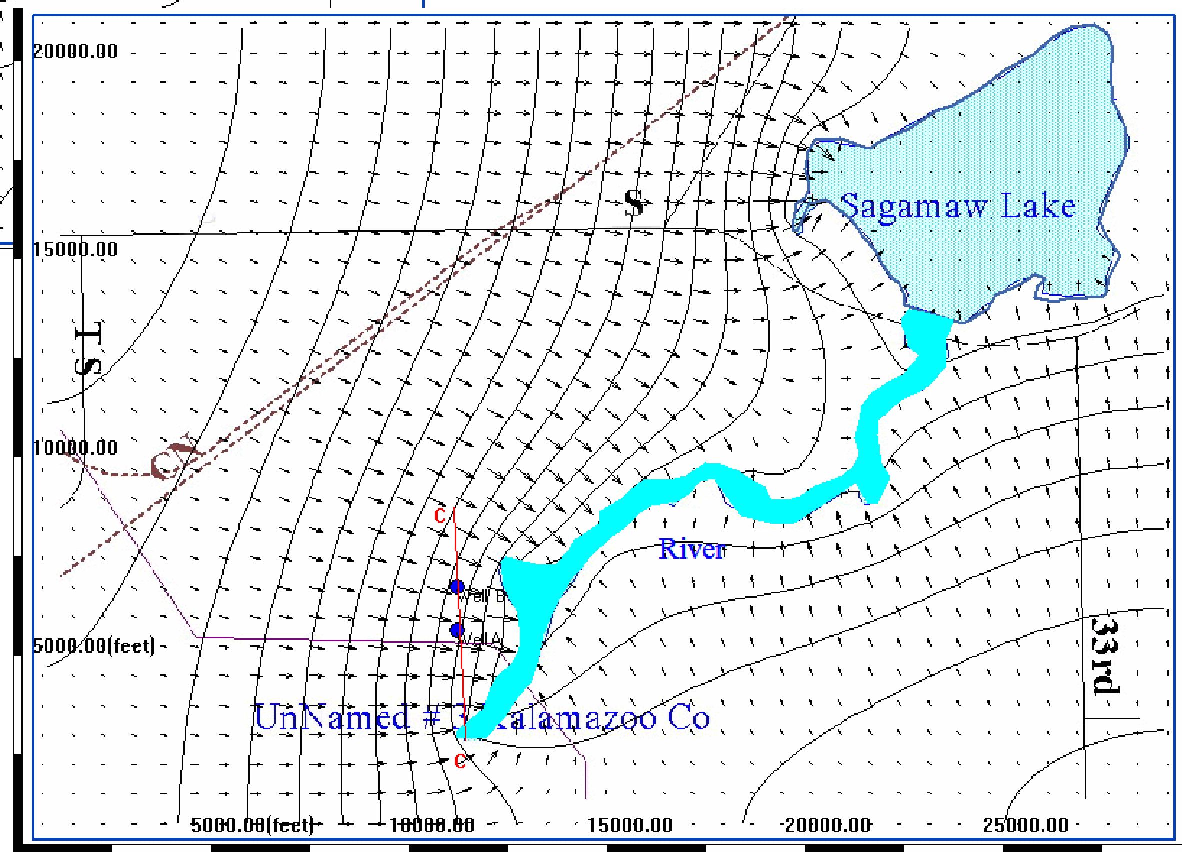
Steady state condition with two pumping wells





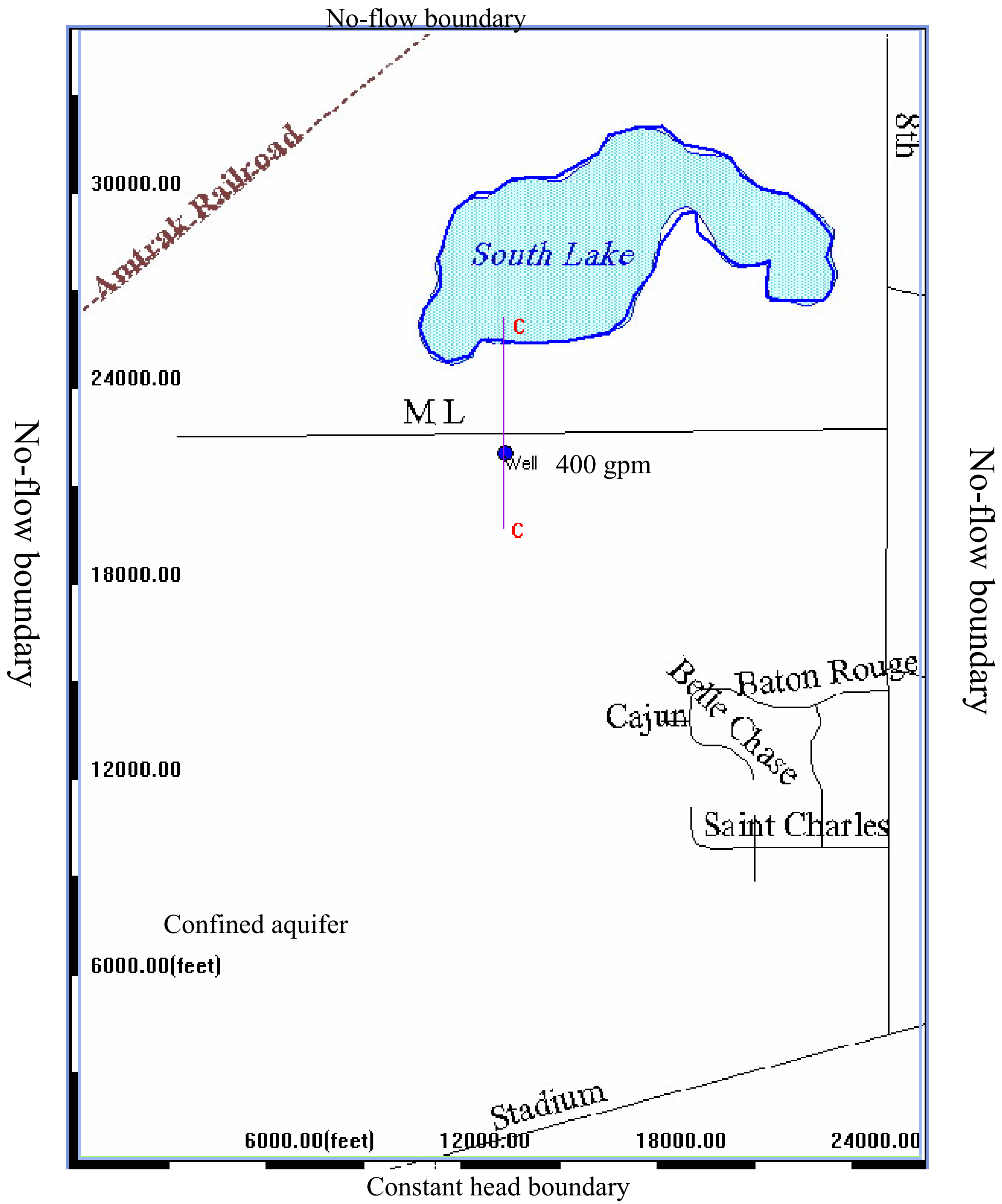
Profile C-C
1000.00(feet) 2000.00 3000.00 4000.00 5000.00
Sagamaw Lake
River
UnNamed #3 Kalamazoo Co
5000.00(feet)
10000.00
15000.00
20000.00
25000.00
Well A
33rd
Water Balance in Main
File Display
Water Balance
Recharge
Lake
Well
River
Error
Stor.
Flux (m^3/day)
20000
10000
0
-10000
-20000
90 days
Time Variation/x-y Plot
Instantaneous
Cumulative


20000.00
15000.00
10000.00
5000.00(feet)
5000.00(feet)
10000.00
15000.00
Sagamaw Lake
S
S T
River
UnNamed #3 Kalamazoo Co
c
c
Well A


20000.00
15000.00
10000.00
5000.00(feet)
5000.00(feet)
10000.00
15000.00
20000.00
25000.00
Sagamaw Lake
S
S T
River
UnNamed #3 Kalamazoo Co
c
c
Well B
Well A
33rd

Pumping near a lake

- Lakes are one of the water surface bodies that can interact with aquifers.
- Depending on connection of lake to aquifer and other stresses, lake can gain or loose water to the aquifer.
- In this example we illustrate impact of pumping near a lake and its influence on steady state ground water flow.



Modeling domain

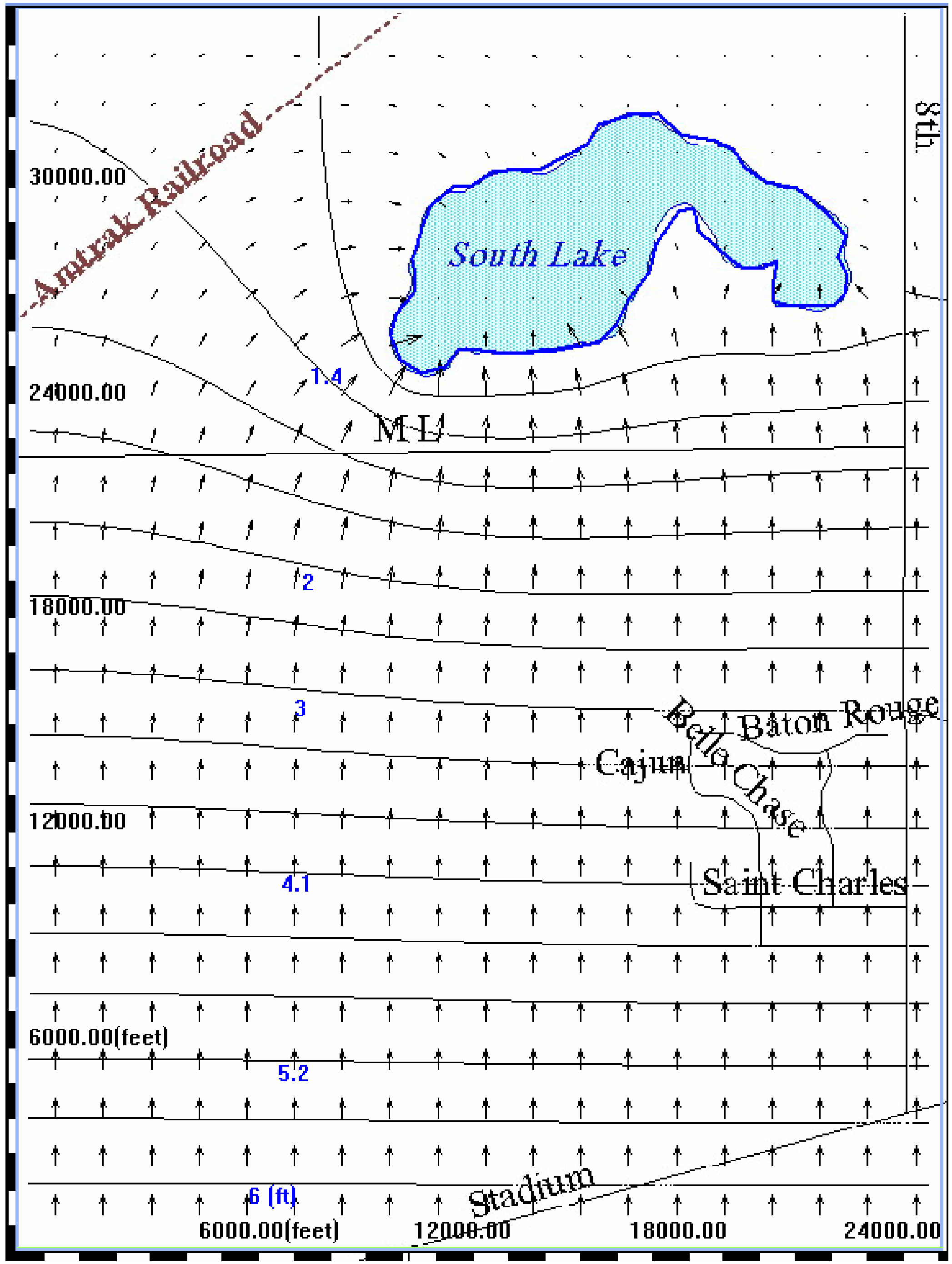
Physical parameters of aquifer

Physical parameters	Value (unit)
Ground Surface elevation	+32 (ft)
Aquifer top elevation (confined)	-32 (ft)
Aquifer bottom elevation	-164 (ft)
Hydraulic conductivity K_x	164(ft/day)
Ratio of anisotropy in horizontal direction K_x / K_y	1 (-)
Specific storage	3.048e-6 (1/ft)

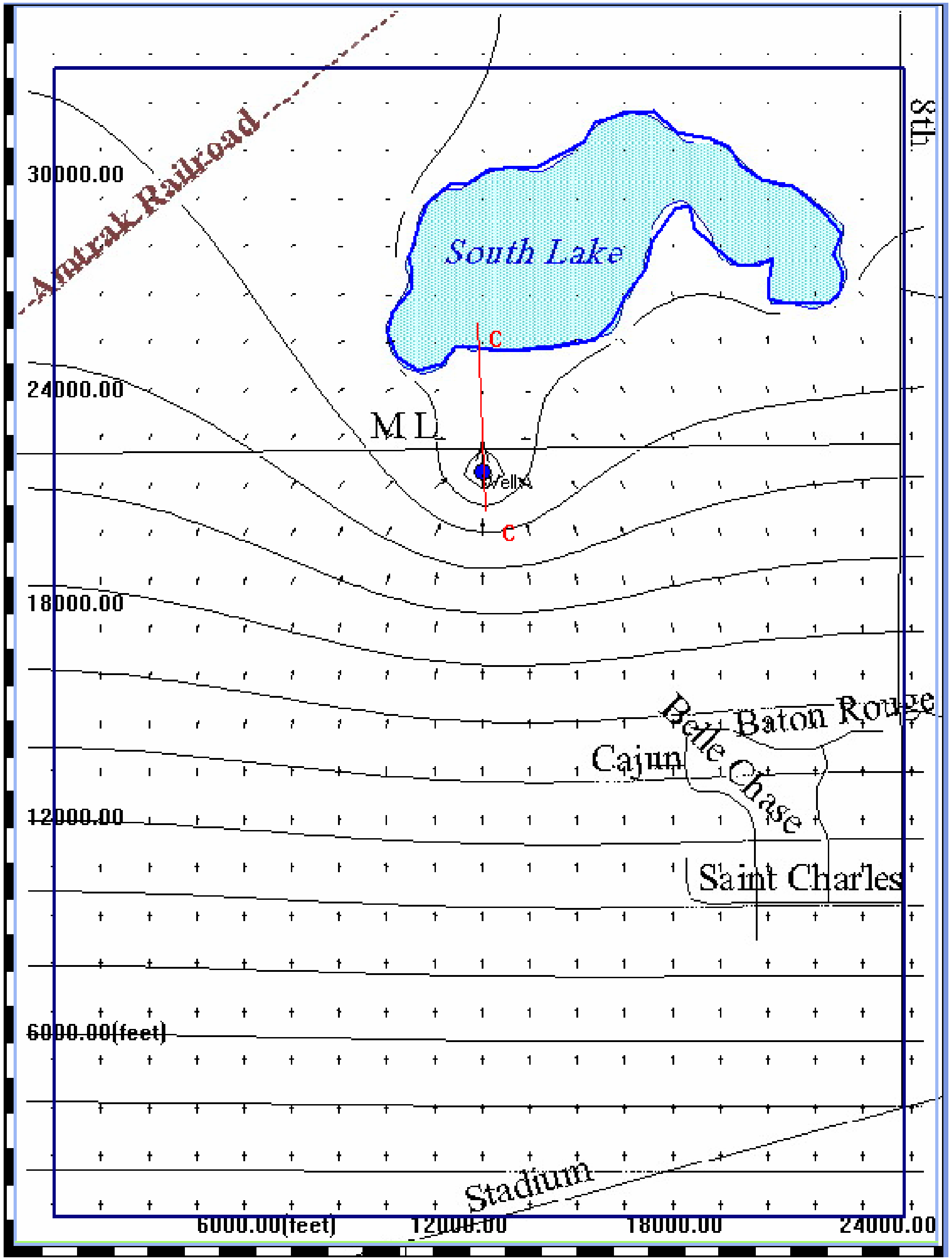
Lake parameters	Value (unit)
Water Elevation	0.00(ft)
Leakance	5 (1/day)
Bottom elevation	-98 (ft)
Area	4.894(E07) (ft^2)

Parameters for pumping wells

Pumping well parameters	Value (unit)
Top screen Elevation	-76 (ft)
Top screen Elevation	-120 (ft)
Well A Pumping rate	-400 (gpm)
Well B Pumping rate	-500 (gpm)

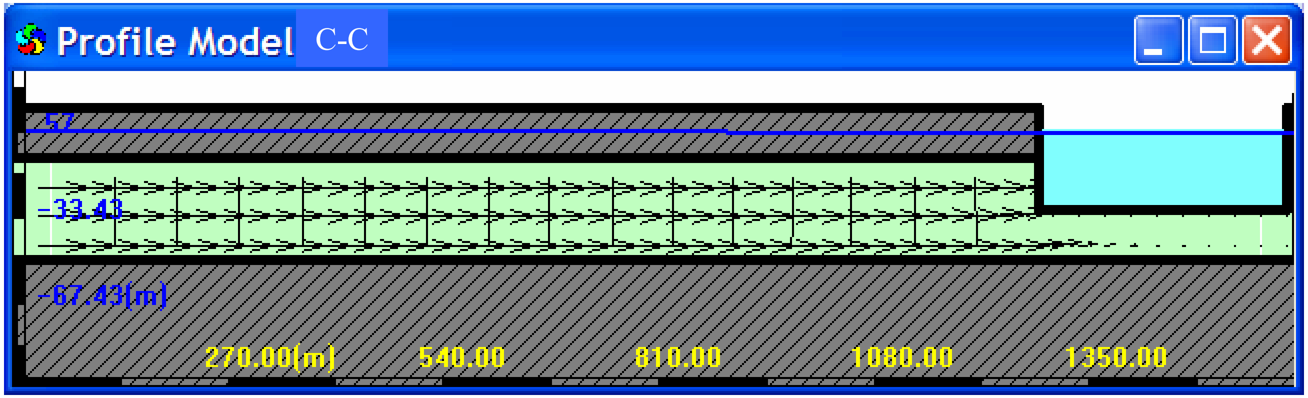


Steady state ground water flow prior to pumping

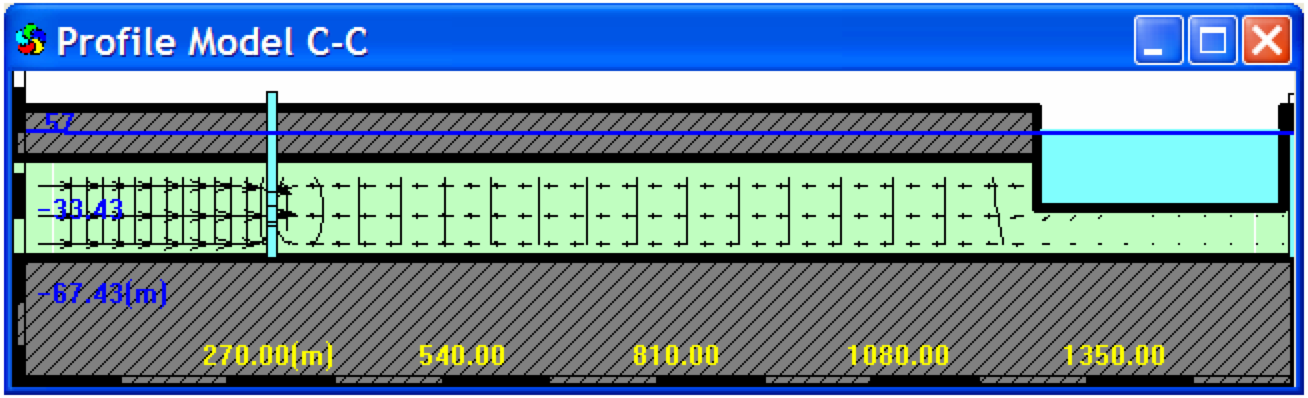


Steady state ground water flow after pumping

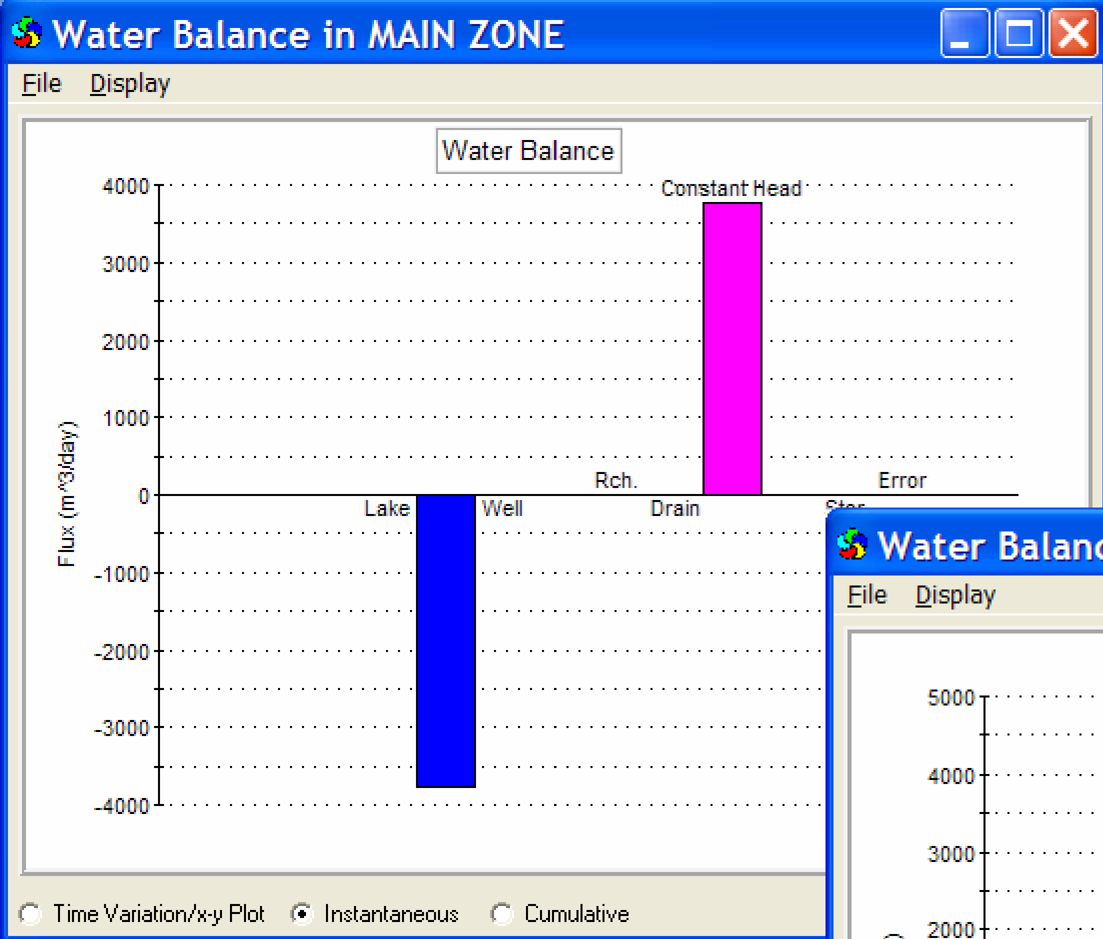
Flow cross section prior to pumping



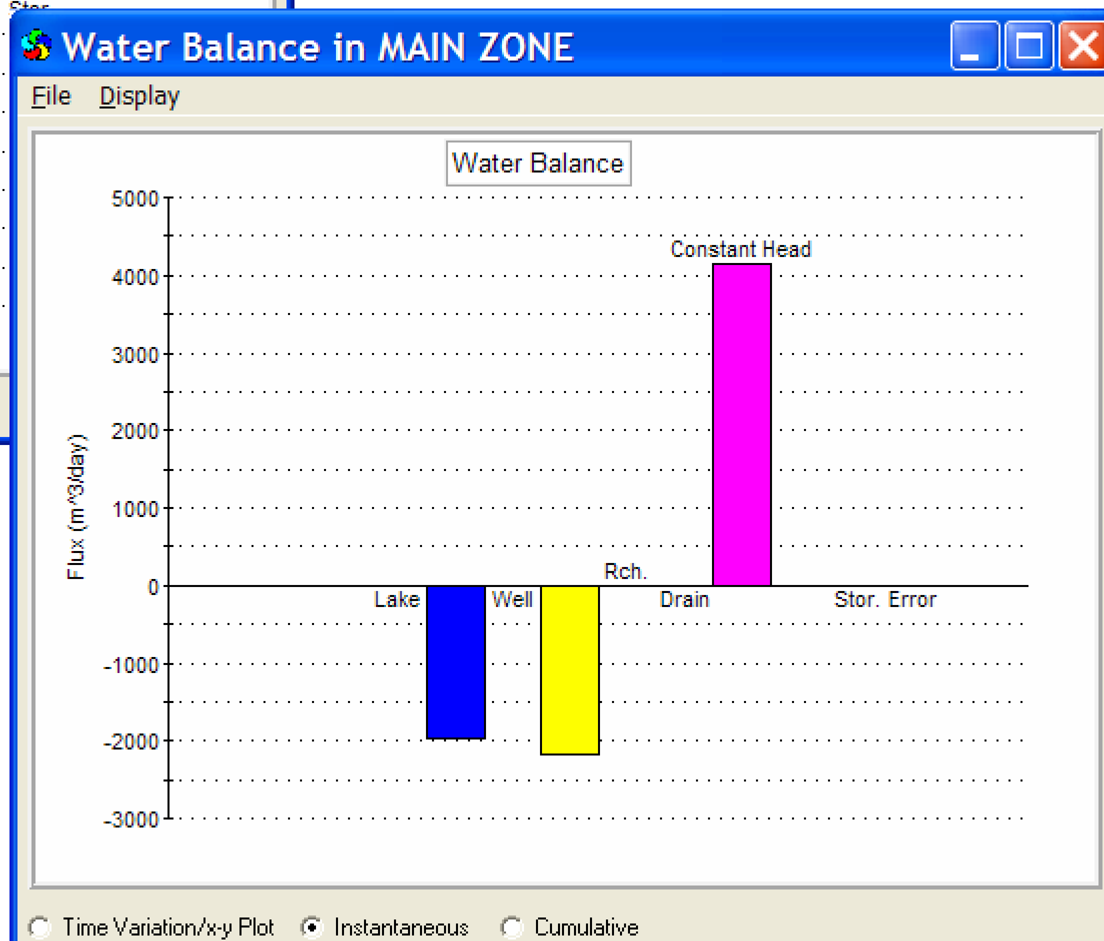
Flow cross section after pumping



Steady state condition

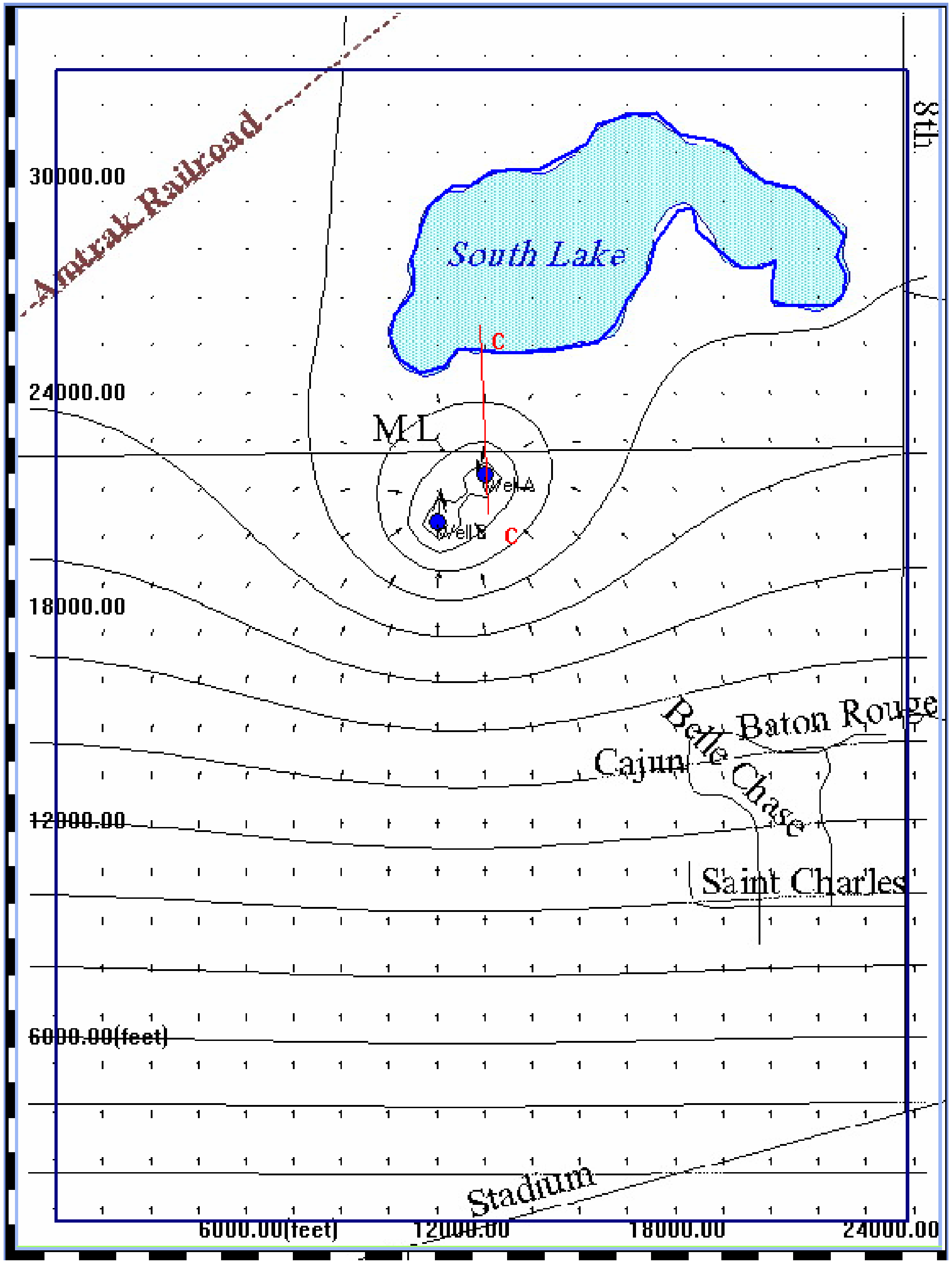


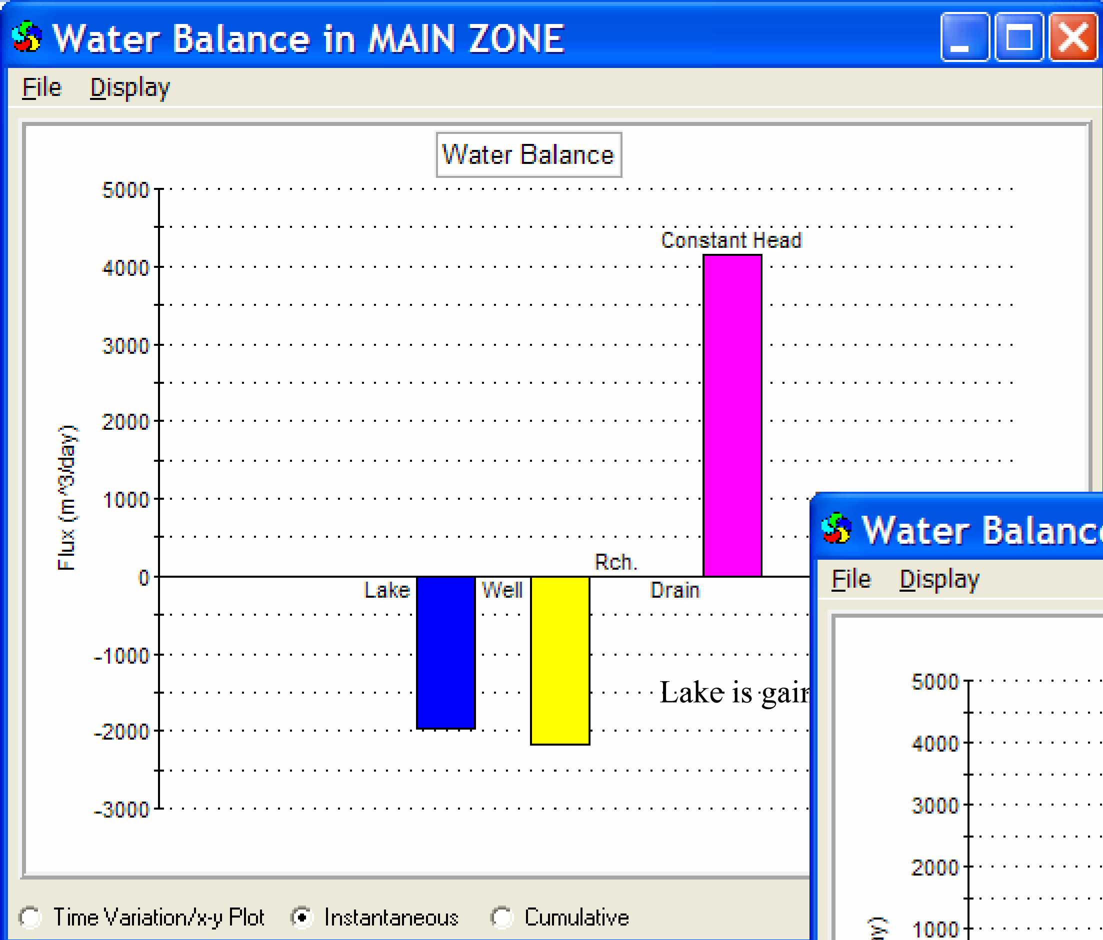
Water balance for whole modeling domain prior to pumping.



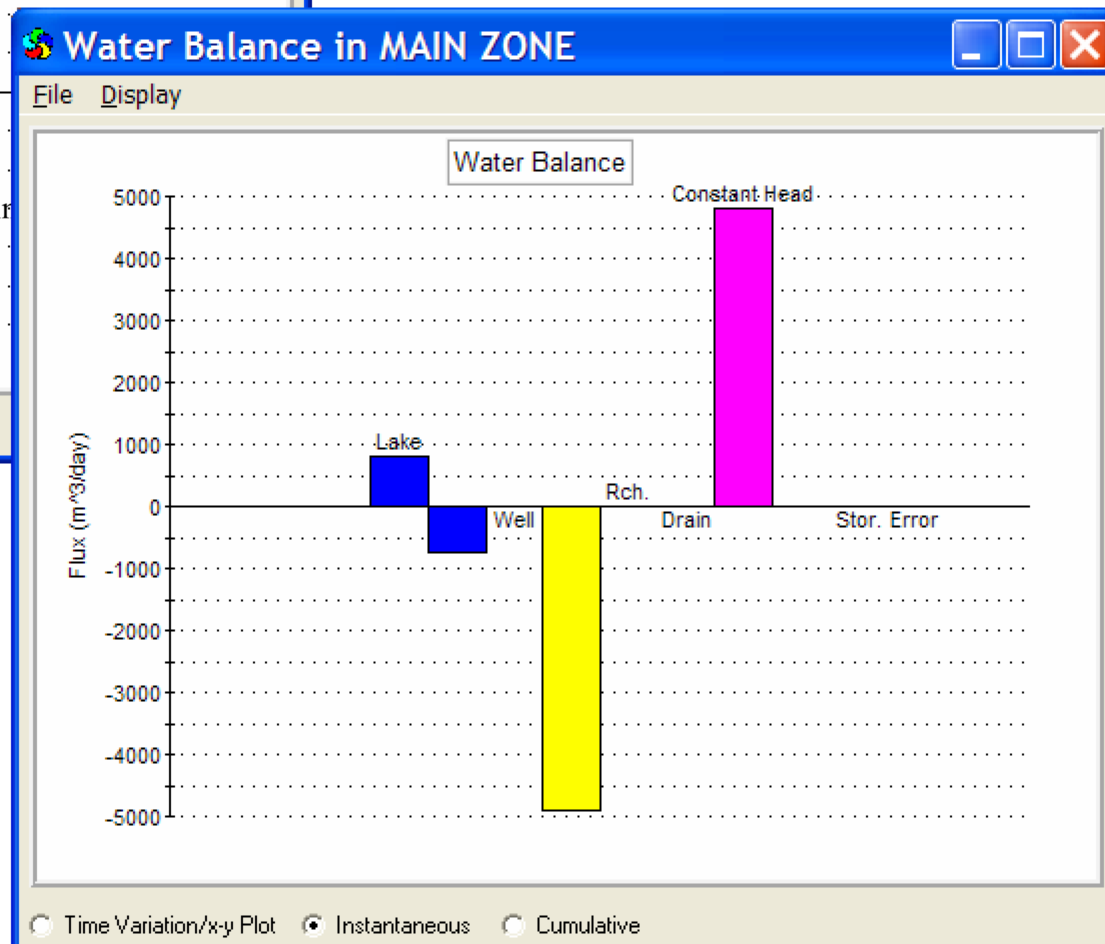
Water balance for whole modeling domain after pumping. Surface water level in the lake drops by 3.031 in.

Steady state ground water flow with **two** pumping wells

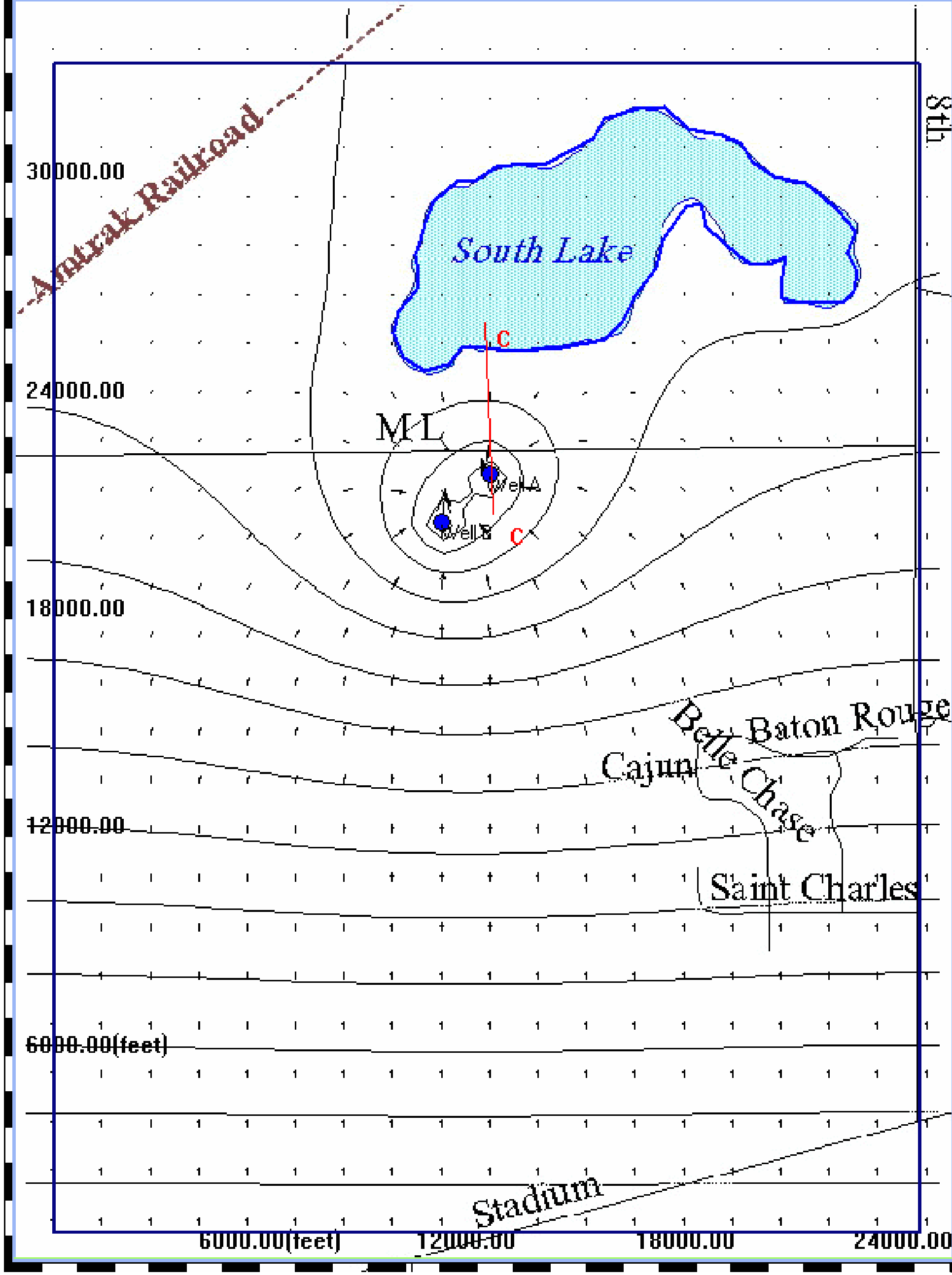


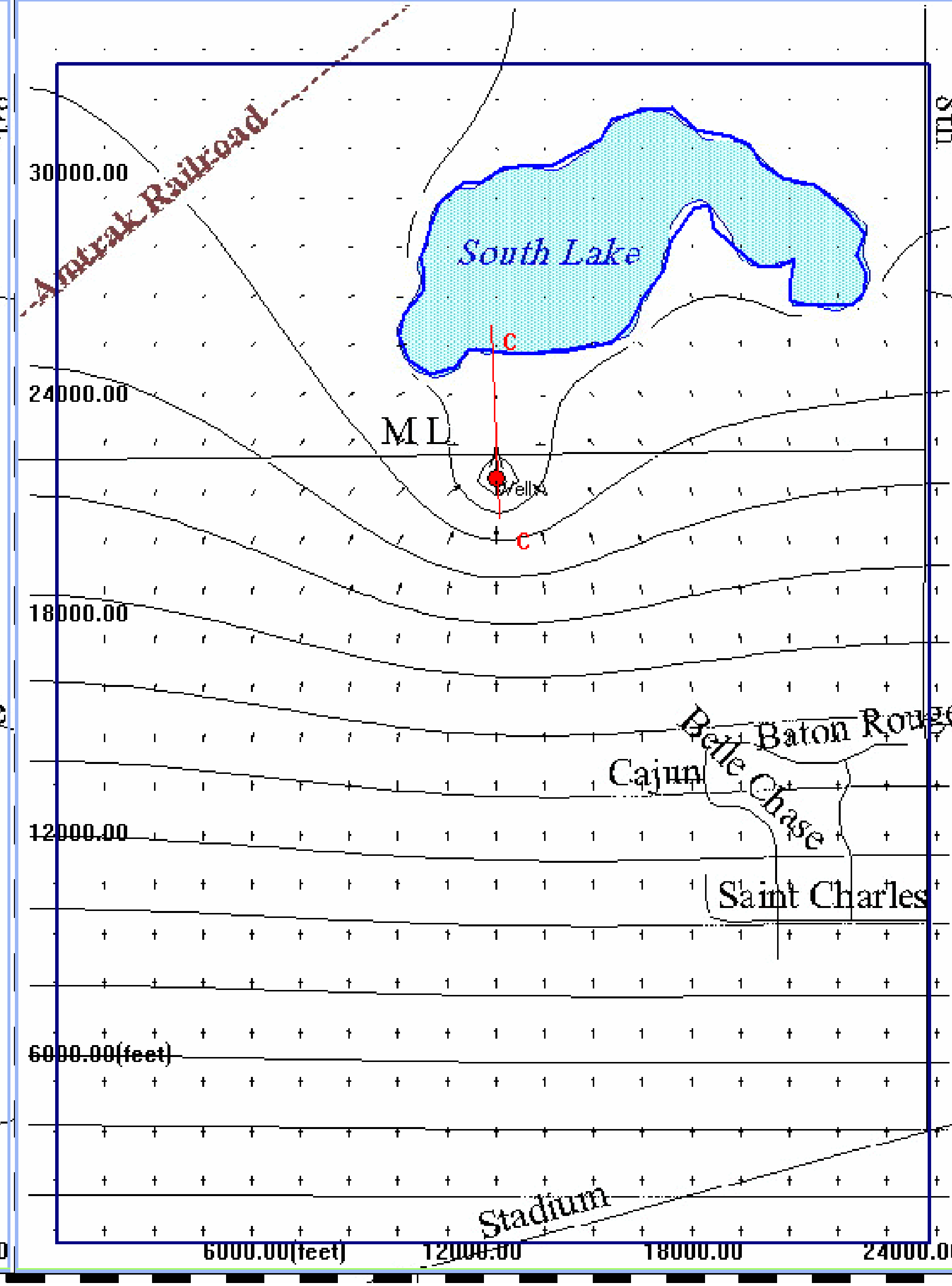


Water balance for whole modeling domain with **one** pumping well

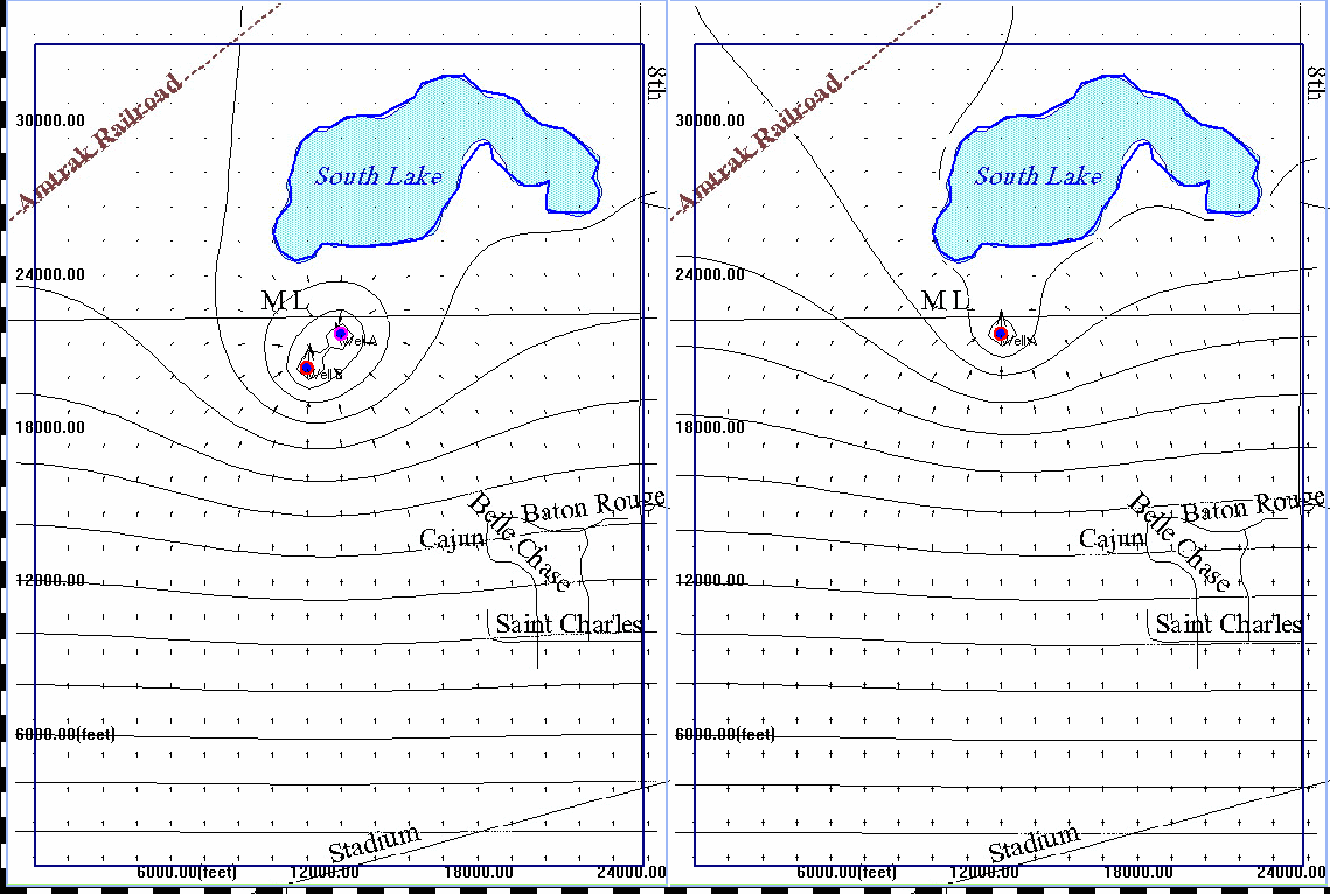


Water balance for whole modeling domain with **two** pumping well





Transient head for 30 days



WHPA for 30 years