Proposed Groundwater Model Conversion and Update (2024)

Prepared for Spokane Aquifer Joint Board

Prepared by John Porcello, LHG

November 16, 2023

GSI Water Solutions, Inc.

Topics

- Objectives
- Study methods (scope of work)
  - Groundwater flow model setup
  - Wellhead protection update
  - Climate-change analysis
  - Documentation
- Details of the budget estimate
- Recent City of Spokane work
  - Provides a starting point in two regards
    - New groundwater flow model
    - Climate-change study (nearing completion)

Objectives

1. Update wellhead protection area capture zones to incorporate 20+ years of information obtained since the original capture zones were delineated in the late 1990s
   - Changes to well network
   - Improved understanding of lithology and aquifer properties in the eastern portion of the City of Spokane
   - Aquifer and river studies
     - SAJB, City of Spokane, USGS, Idaho DWR
   - Improved groundwater modeling tools

Objectives

2. Use new climate models and a groundwater model to understand implications of growth and climate change on groundwater levels and pumping capacities in individual wells
   - Climate projections show changes in:
     - Natural recharge to aquifer
     - Temperatures and length of growing season (which affects demands)
   - Many wells are shallow, with little room to maintain yields if water levels decline
     - Particular concern in summer

Study Methods

Step 1

- Develop an updated groundwater flow model
  - Use knowledge from prior modeling studies (SAJB, City, USGS)
  - Use new software, with refined gridding and layering
    - MODFLOW-USG (the core groundwater modeling code)
    - Groundwater Vistas (graphical user interface)
  - Regional-scale calibration to data from prior studies
    - Spokane River gains/losses
    - Groundwater elevation contours
  - First step to a modern model; not the model to end all models

Status: Essentially completed (by City of Spokane)

Key Assumption: Model is sufficiently calibrated for use by SAJB

Remaining Work: Conduct grid refinements at SAJB wells

Study Methods

Step 2

- Change hydrologic inputs in the groundwater flow model using published climate change factors from a publicly available source (https://climatetoolbox.org)
  - Simulate multiple possibilities for the period 2070-2099
    - Low and high scenarios for future greenhouse gas emissions
      - RCP 4.5: a somewhat optimistic scenario (emissions decline by ~2050)
      - RCP 8.5: a pessimistic scenario ("business as usual")
    - Low, medium, and high amounts of change for each emissions scenario
  - Simulate changes to the aquifer and to monthly demands
    - Climate-change influences on aquifer recharge terms
    - Climate-change influences on timing and magnitude of monthly demand curve
    - Increased demand (50-year projections)

Status: Completed (by City of Spokane)

Remaining Work: Develop pumping demand details for each SAJB member well

Study Methods

Step 3

- Run the groundwater flow model with climate change applied to the aquifer and to the demand curve, then analyze results against baseline (current) conditions
  - Total of 7 simulations
    - Baseline = Current conditions (2015-2020 average)
    - Six climate-change scenarios
  - The comparison of each climate-change scenario to baseline conditions evaluates the effect of three influences:
    - Increased demand due to growth
    - Climate-influenced changes on seasonal demands
    - Climate-influenced changes in the aquifer and Spokane River

Status: City of Spokane has defined two critical inputs

- Climate-change inputs for aquifer recharge and Spokane River
- 50-year demand projection for City of Spokane wells (with climate change)

Remaining Work: For all SAJB member wells

- Define 50-year demand (with climate change)
- Run and analyze model results for all SAJB member wells

Study Methods

Step 4

- Select a simulation to use for conducting updated delineations of wellhead protection areas
- Use same delineation approach and methods as before
  - Pumping rates are based on annual water rights volume
  - Delineate Special Wellhead Protection Areas (SWHPAs) for a travel time of 1 year multiplied by an importance factor
  - The importance factors are related to the response time to a contamination event:
    - Importance factor = Response Time in Months / 12 months
    - Ranges in value from 0.1 to 5.0
  - Original delineations used 15 scenarios for importance factors
    - Three types of well uses (primary, secondary, or peaking supply)
    - Availability of water from other purveyors (via interties)
    - Ability of distribution system to accommodate higher flow at specific wells

Importance Factor Table (Derivation in 1990s)

TABLE 1
Methodology and Rationale for Response Times and Importance Factors
SAJB Wellhead Protection Program

Scenario	Well Use [a]	Is The Necessary Flow Obtainable From Other Wells? [b]	Can The Necessary Flow Be Obtained From Other Purveyors? [c]	Distribution System Capabilities [d]	Response Time or Planning Time (months)	Importance Factor [e]
1	Primary	Yes	---	Capable	$\leq$ 12	1.0
2	Primary	Yes	---	Limited	12 - 36	1.0 - 3.0
3	Primary	Yes	---	Incapable	24 - 60	2.0 - 5.0
4	Primary	No	No	Limited or Incapable	24 - 60	2.0 - 5.0
5	Primary	No	Yes	Capable	12 - 24	1.0 - 2.0
6	Secondary	Yes	---	Capable	9 - 12	0.75 - 1.0
7	Secondary	Yes	---	Limited	12 - 36	1.0 - 3.0
8	Secondary	Yes	---	Incapable	24 - 60	2.0 - 5.0
9	Secondary	No	No	Limited or Incapable	18 - 60	1.5 - 5.0
10	Secondary	No	Yes	Capable	6 - 12	0.5 - 1.0
11	Peaking	Yes	---	Capable	3 - 6	0.25 - 0.5
12	Peaking	Yes	---	Limited	6 - 36	0.5 - 3.0
13	Peaking	Yes	---	Incapable	12 - 36	1.0 - 3.0
14	Peaking	No	No	Limited or Incapable	6 - 36	0.5 - 3.0
15	Peaking	No	Yes	Capable	1 - 12	0.1 - 1.0

Footnotes to Importance Factor Table

(a) Well uses are defined as follows:
  - Primary: Used on a year-round (or nearly year-round) basis
  - Secondary: Helps with summer peak demands, but also used at other times.
  - Peaking: Used exclusively for peak demand periods.

(b) It is assumed that the lost pumping volume needs to be replaced.

(c) Dashes indicate that this question is not relevant (i.e., capacity is available at other wells). "Yes" entry assumes that agreements and facilities are in place and that supply is available.

(d) Distribution system capabilities are defined as follows:
  - Capable: Pumping loss at this well can be replaced by pumping from another well without exceeding capacity of distribution system at other wells.
  - Limited: Pumping increases may not be possible at other wells without exceeding capacity of distribution system. May depend on season during which pumping needs to be increased at other wells.
  - Incapable: System would require capital improvements before increasing pumping at other wells.

(e) Equals response time divided by one year.

Study Methods

Step 5

- Documentation
  - WHP Updates: Technical memorandum
    - Provides documentation for SAJB members and DOH
  - Climate change analysis: Presentation
    - Assume presentation is sufficient
      (cost savings by avoiding a technical memorandum)

Cost Estimate Details *(For Budget Planning Purposes)*

Four tasks

1. Data gathering
2. Model simulations
   - Setting up and running 7 simulations
     - Baseline conditions
     - 6 different climate scenarios
   - Analyzing climate change model results
   - Updating SWHPAs (using 1 simulation)
3. Presentation of results
4. SWHPA delineation report

Cost Estimate Details *(For Budget Planning Purposes)*

Estimated cost: $75,000

Activity	Estimated Cost
Data gathering, deciding on importance factors	$9,000
Set up, run, and QC flow simulations (7 model runs)	$20,000
Delineate SWHPAs	$10,000
Analyze climate-change effects on production wells	$14,000
Presentation of results	$7,000
SWHPA delineation report	$15,000
Total	**$75,000**

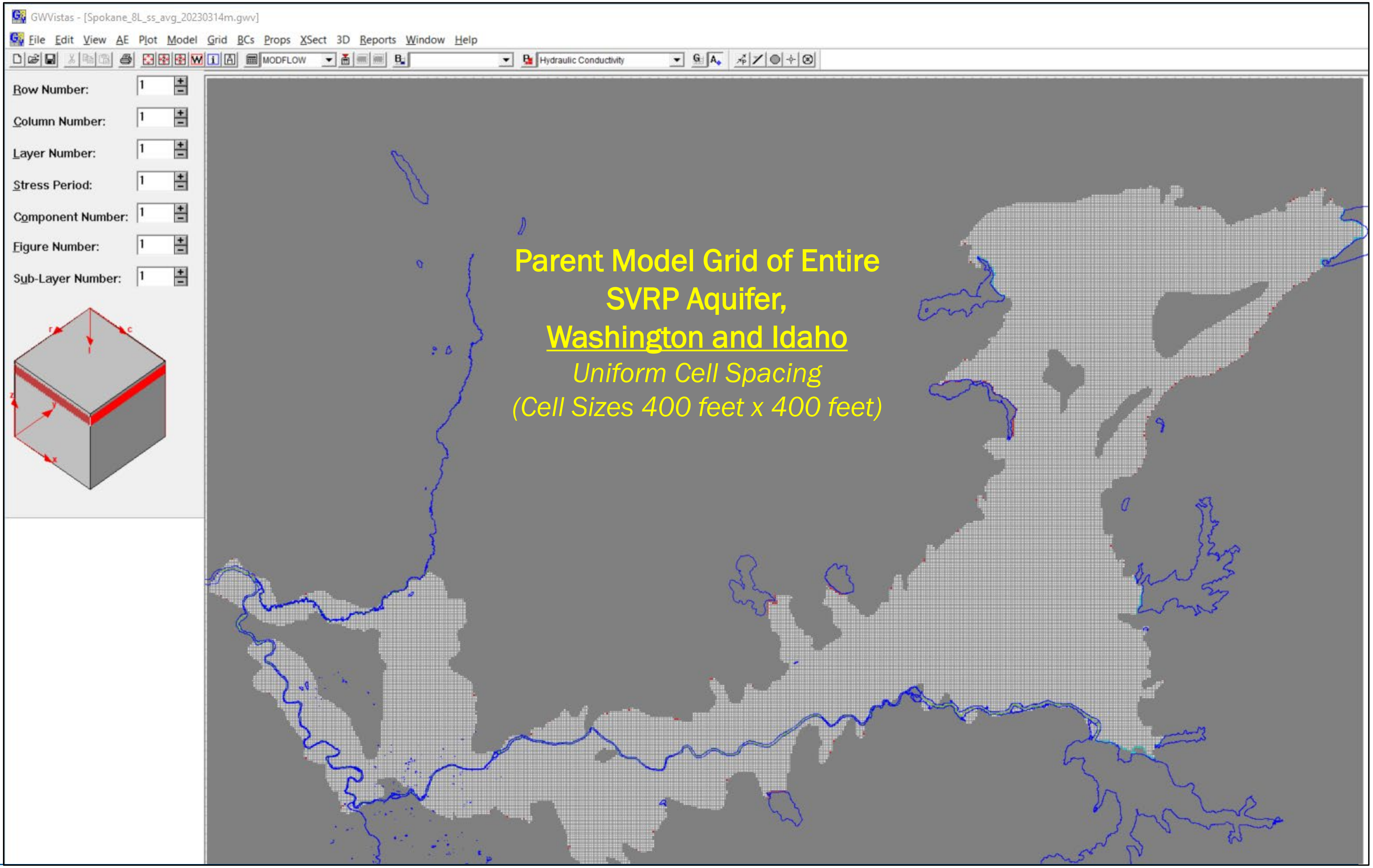
Without the work already conducted by the City of Spokane, the cost would be ~$40,000 greater

Background/Supporting Information

Groundwater Flow Model Development Activities Conducted to Date

(Grid Design, Model Calibration)

Grid Design



GWVistas - [Spokane_8L_ss_avg_20230314m.gwv]
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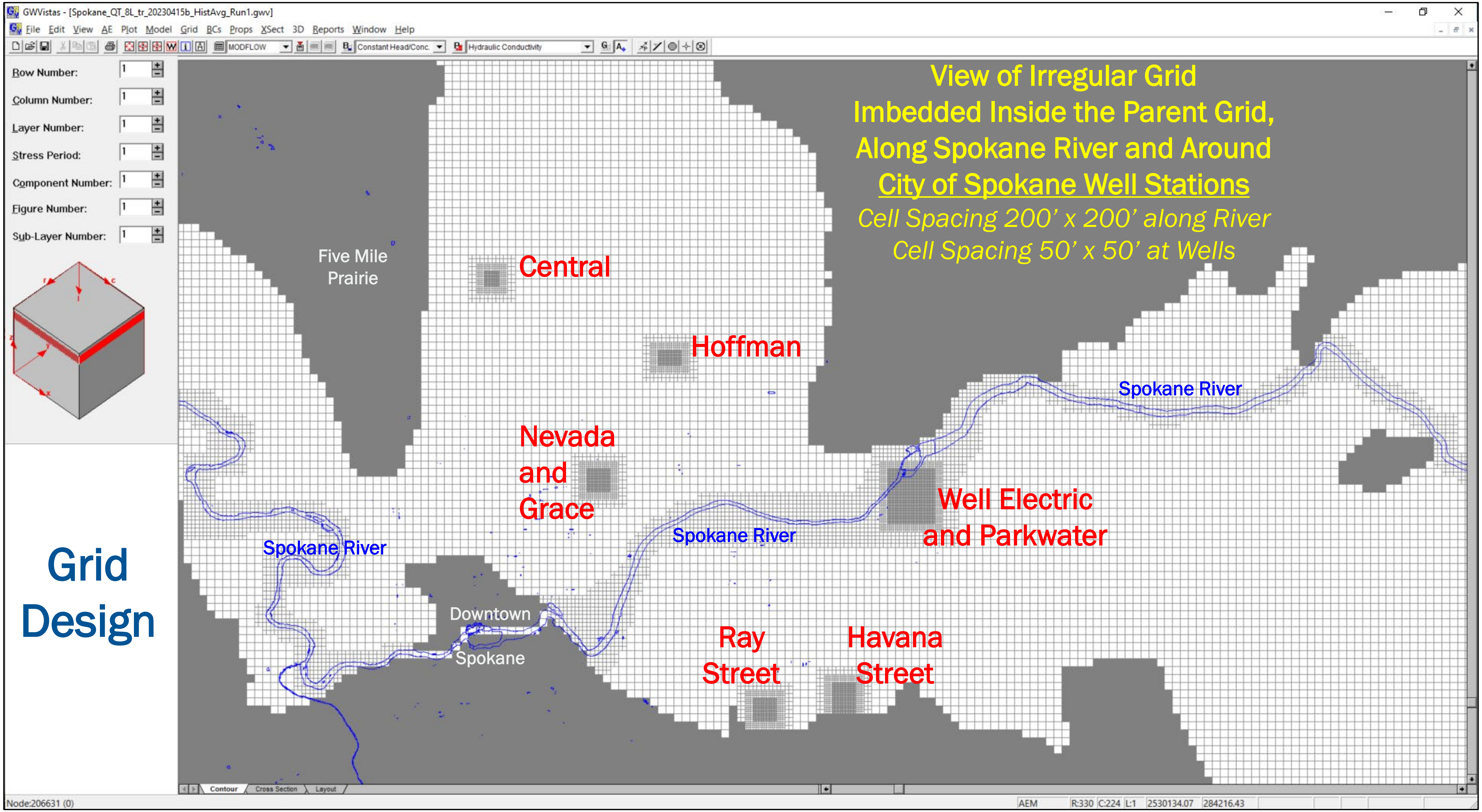
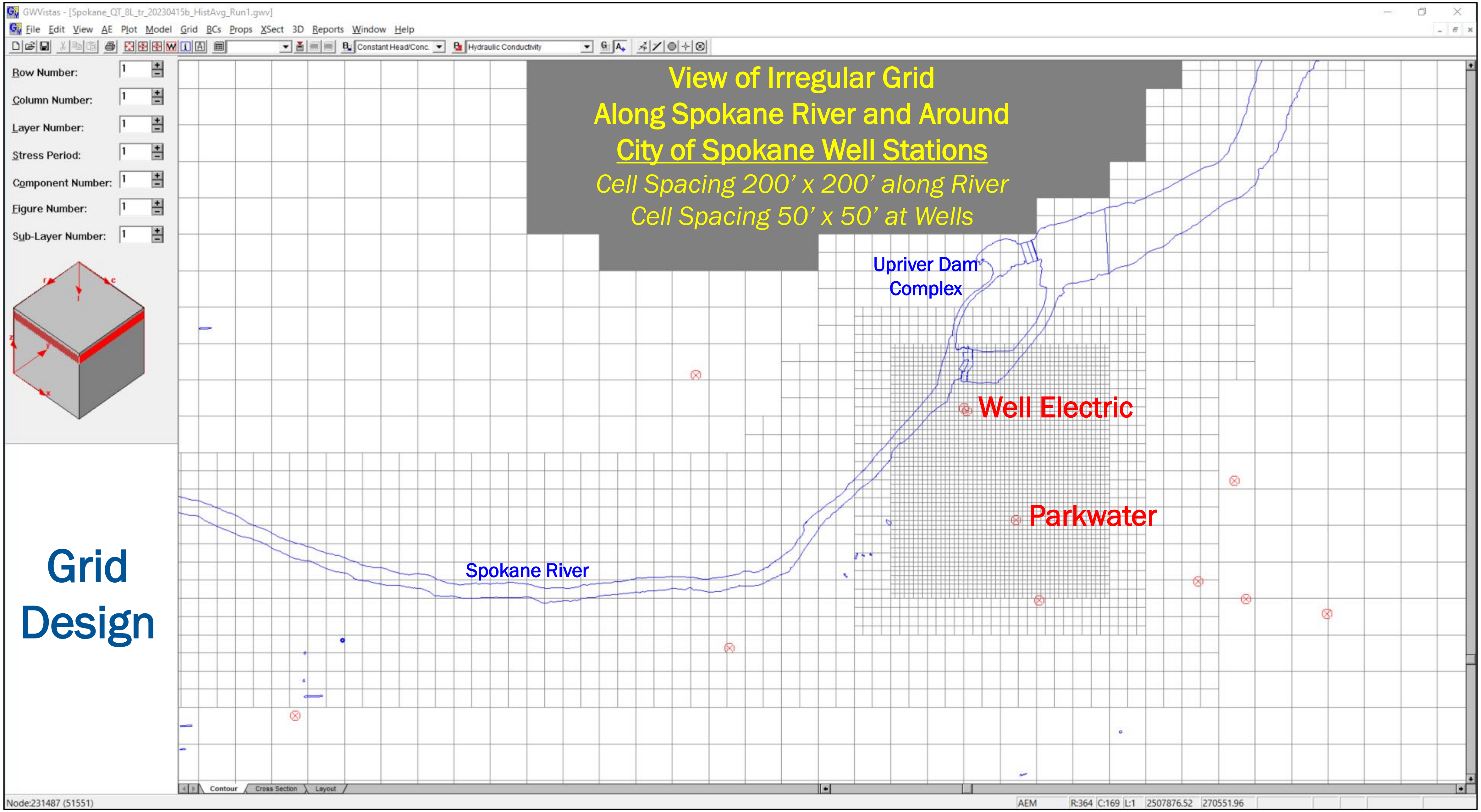
MODFLOW
Hydraulic Conductivity
Row Number: 1
Column Number: 1
Layer Number: 1
Stress Period: 1
Component Number: 1
Figure Number: 1
Sub-Layer Number: 1
Parent Model Grid of Entire
SVRP Aquifer,
Washington and Idaho
Uniform Cell Spacing
(Cell Sizes 400 feet x 400 feet)

Grid Design


GWVistas - [Spokane_QT_8L_tr_20230415b_HistAvg_Run1.gwv]
File Edit View AE Plot Model Grid BCs Props XSect 3D Reports Window Help
MODFLOW
Constant Head/Conc.
Hydraulic Conductivity
Row Number:
Column Number:
Layer Number:
Stress Period:
Component Number:
Figure Number:
Sub-Layer Number:
View of Irregular Grid
Imbedded Inside the Parent Grid,
Along Spokane River and Around
City of Spokane Well Stations
Cell Spacing 200' x 200' along River
Cell Spacing 50' x 50' at Wells
Five Mile
Prairie
Central
Hoffman
Nevada
and
Grace
Spokane River
Spokane River
Spokane River
Well Electric
and Parkwater
Downtown
Spokane
Ray
Street
Havana
Street
Contour
Cross Section
Layout
Node:206631 (0)
AEM
R:330 C:224 L:1 2530134.07 284216.43

Grid Design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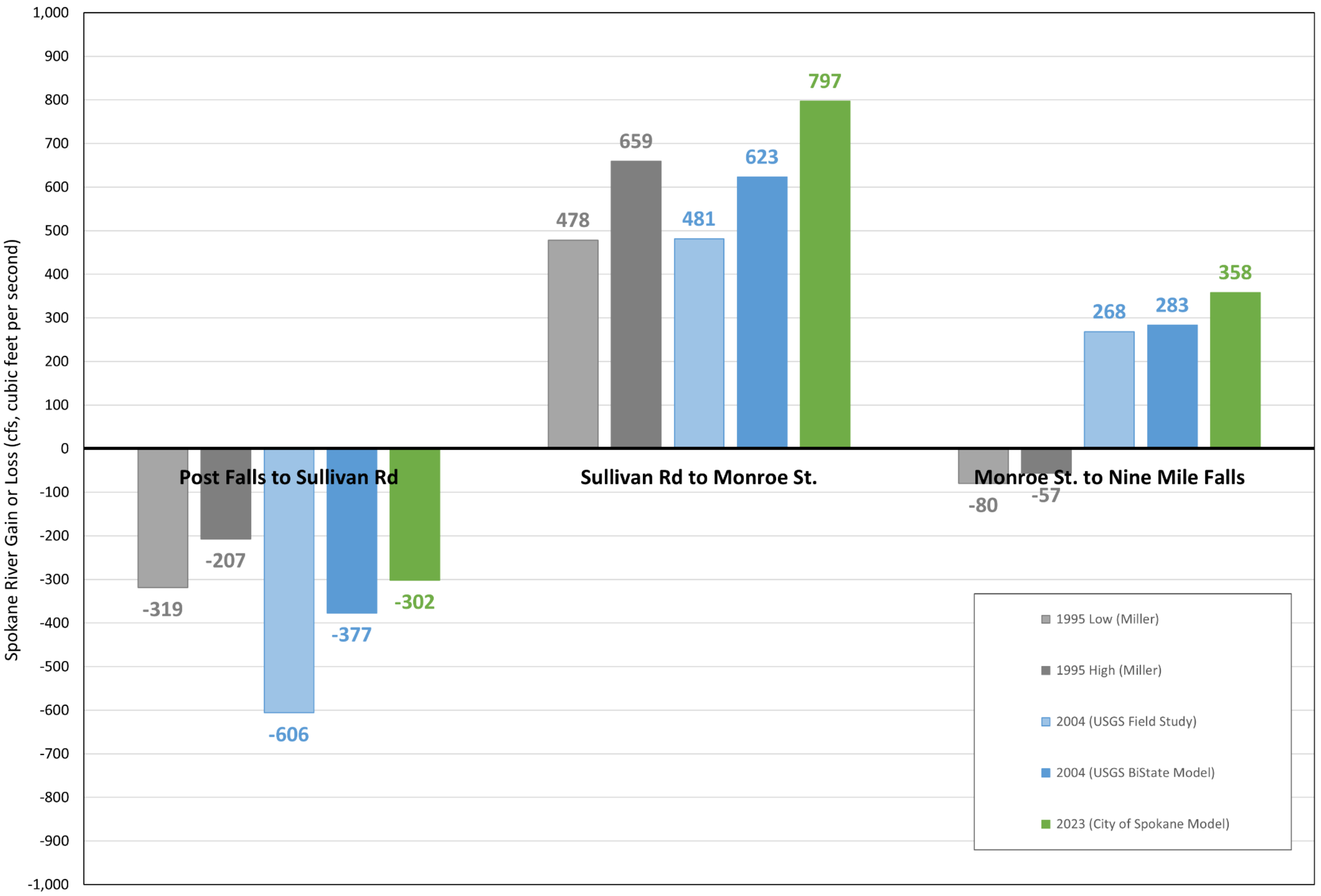
Constant Head/Conc.
Hydraulic Conductivity
Row Number: 1
Column Number: 1
Layer Number: 1
Stress Period: 1
Component Number: 1
Figure Number: 1
Sub-Layer Number: 1
View of Irregular Grid
Along Spokane River and Around
City of Spokane Well Stations
Cell Spacing 200' x 200' along River
Cell Spacing 50' x 50' at Wells
Upriver Dam Complex
Well Electric
Parkwater
Spokane River
Contour
Cross Section
Layout
Node:231487 (51551)
AEM
R:364 C:169 L:1
2507876.52 270551.96

Model Calibration to Spokane River Gains/ Losses (cfs) During Low-Flow Month (August)

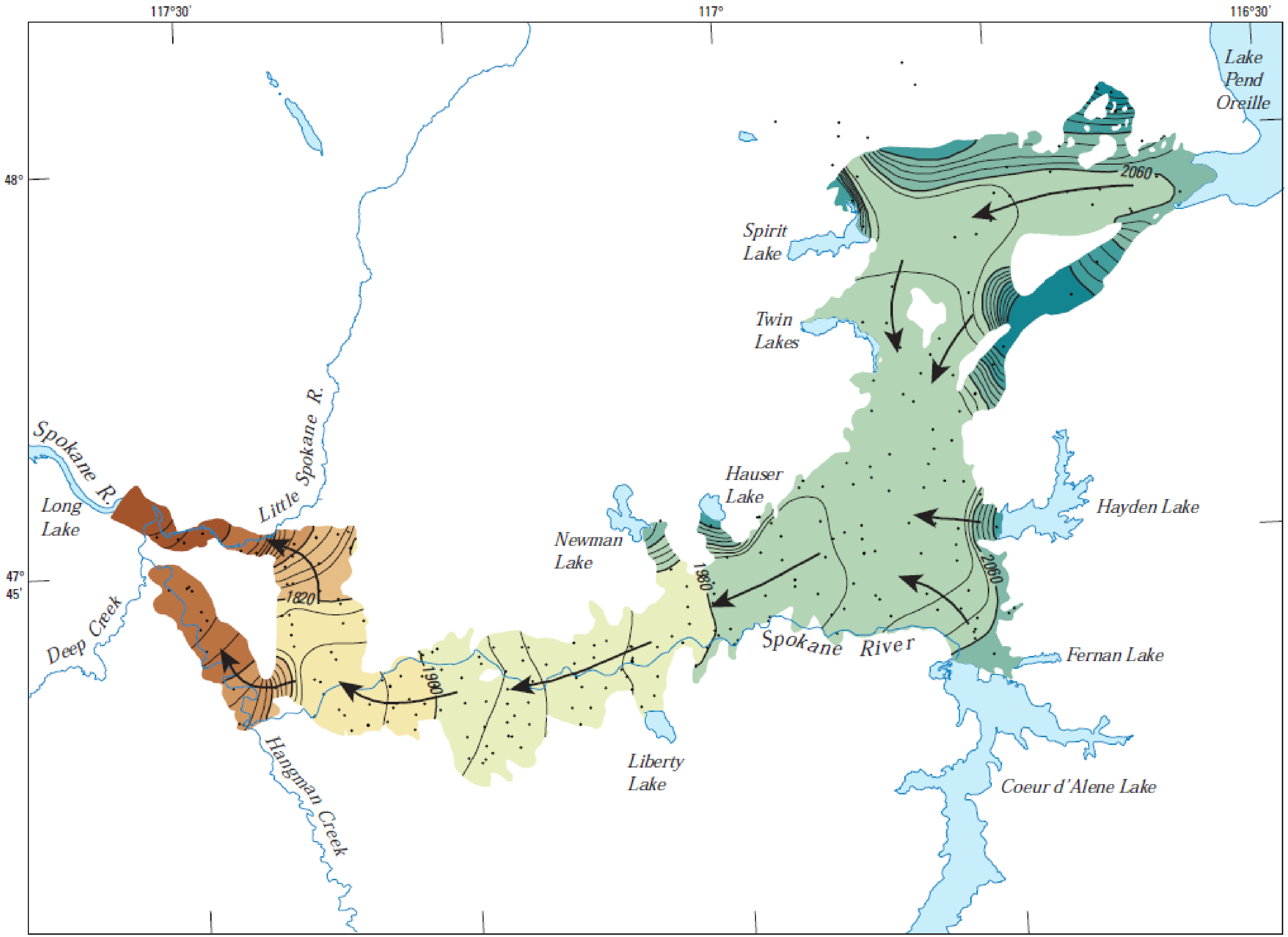
<table>
<tr><th>Reach</th><th>April 2023 Version of New City Model</th><th>May 2023 Version of New City Model</th><th>USGS Bi-State Model: Losses for Sept 2004</th><th>USGS Field-Measured Losses for Sept 2004</th><th>Miller 1995 Field Study</th></tr>
<tr><td>Post Falls to Sullivan Road</td><td>-409</td><td>-302</td><td>-377</td><td>-606</td><td>-207 to -319</td></tr>
<tr><td>Sullivan Road to Greene Street</td><td>+905</td><td>+760</td><td rowspan="2">+623</td><td>+593</td><td>+415 to +537</td></tr>
<tr><td>Greene Street to Monroe Street</td><td>+278</td><td>+37</td><td>-112</td><td>+63 to +122</td></tr>
<tr><td>Monroe Street to 9-Mile Falls</td><td>+103</td><td>+358</td><td>+283</td><td>+268</td><td>-57 to -80</td></tr>
</table>

Model Calibration to Spokane River Gains/ Losses (cfs) During Low-Flow Month (August)



USGS Published Map of Groundwater Elevation Contours

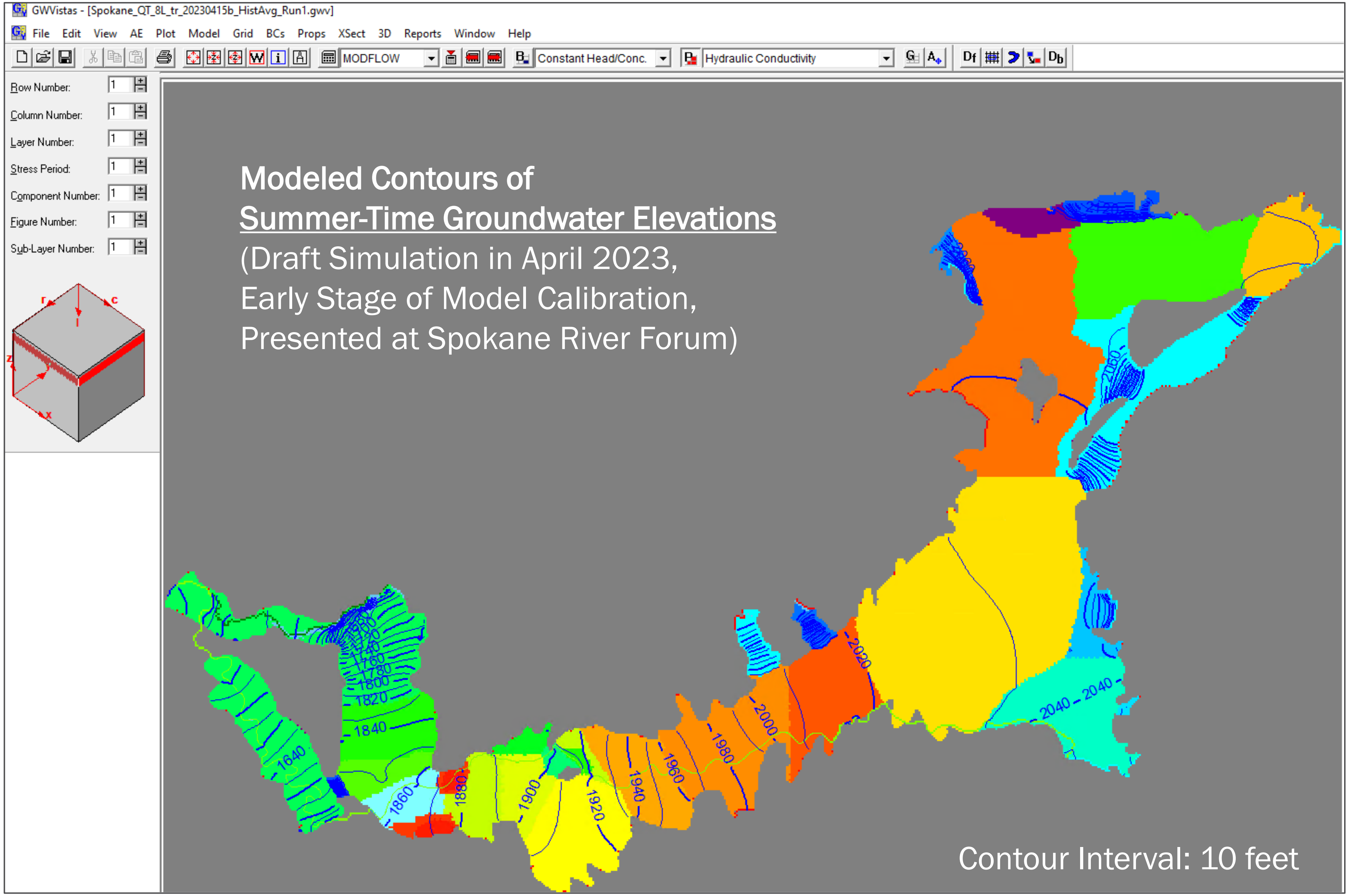
(Field Data)
(September 2004)



Contour Interval: 20 feet

Source:
Kahle, S.C., and Bartolino, J.R., 2007. *Hydrogeologic Framework and Ground-Water Budget of the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho.* U.S. Geological Survey Scientific Investigations Report 2007-5041, 48 p., 2 pls.

Model Calibration to Groundwater Elevations



Model Calibration to Groundwater Elevations