



An investigation of ground water-surface water interaction in the Flint Creek Valley, Granite County, Montana  
by Martha Hoffman Kauffman

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences  
Montana State University  
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**Abstract:**

Closure of several basins in Montana to new surface-water allocations has created a higher demand for ground-water resources. Concerns have been raised regarding the impact these actual and planned withdrawals may have on existing water rights and dry-season surface flows needed for fisheries and irrigation. This investigation characterizes the interaction of surface water, irrigation, and ground water in the Flint Creek valley, Granite County, Montana, using MODFLOW, a numerical ground-water flow model. The model was calibrated to ground-water and surface-water measurements collected by the Department of Natural Resources and Conservation and the U.S. Geological Survey for the Flint Creek Return Flow Study.

Reasonable ranges for transmissivity and storage values that could be assigned during model calibration were determined from aquifer test results, analysis of specific capacity data, examination of surface water gains and changes in ground-water storage, and published tables. Acceptable ranges for net recharge on sprinkler irrigated, flood irrigated and unirrigated lands were established using precipitation, irrigation, and crop evapotranspiration information. The model was calibrated to five quantitative and qualitative targets. Problems that had to be addressed during model development included heterogeneous stratigraphy, abrupt topographic changes, limited data, and realistic calibration targets.

The model calibrated best when elevated benches in the field area were treated as one hydrostratigraphic unit with transmissivity values of 15,000 gpd/ft (186 m<sup>2</sup>/d) on the majority of the benches and 1,500 gpd/ft (19 m<sup>2</sup>/d) where the gravels thin to the north. The alluvial areas were best modeled as three units with transmissivity values ranging from 10,500 gpd/ft (130 m<sup>2</sup>/d) to 29,900 gpd/ft (370 m<sup>2</sup>/d). Specific yield values ranged from 0.1 to 0.2 for layer one. Net recharge was best modeled at eight inches (20 cm) per summer season for sprinkler irrigation, 18 inches (46 cm) per season for flood irrigation, and one inch (2.5 cm) per season for unirrigated areas.

Using the calibrated model, several example simulations were performed to test the effect of ground-water withdrawals on streamflow. These examples show that well position in the valley (valley width) and distance from the stream influence the timing of greatest impact on streamflow and whether well water is drawn primarily from storage or from streamflow. The farther the well is from the stream, the more the timing of impact on streamflow is delayed from summer until fall, and the more water is drawn from storage rather than from streamflow. Many other simulations could be explored with this model. The choice of simulations should be constrained by input from a variety of perspectives such as those represented by the members of the Upper Clark Fork Basin Steering Committee.

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INTERACTION IN THE FLINT CREEK VALLEY,  
GRANITE COUNTY, MONTANA

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Martha Hoffman Kauffman

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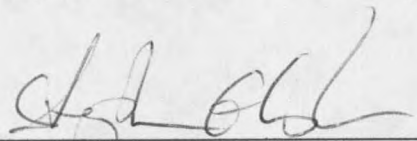
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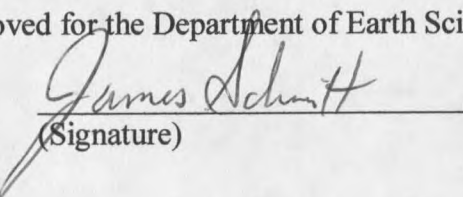
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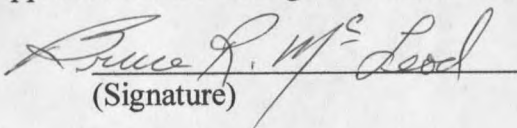
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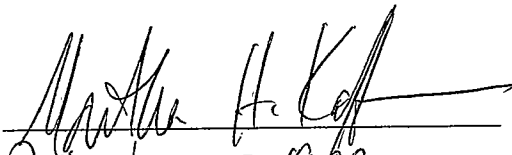
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## TABLE OF CONTENTS

	Page
LIST OF TABLES.....	viii
LIST OF FIGURES.....	xi
ABSTRACT.....	xiii
CHAPTER 1. INTRODUCTION.....	1
Study Area.....	2
Geology.....	8
Regional Tectonic Setting.....	8
Flint Creek Valley Stratigraphy.....	11
Previous Hydrogeologic Investigations.....	18
CHAPTER 2. HYDROGEOLOGIC SETTING AND CONCEPTUAL MODEL.....	21
Hydrostratigraphy.....	21
Aquifer Parameters.....	25
Hydraulic Conductivity and Transmissivity.....	25
Storage.....	37
Alluvial Aquifer Storage.....	38
Gravel Cap Aquifer Storage.....	41
Clay Aquitard Storage.....	42
Deep Aquifer Storage.....	42
Flow System.....	43
Hydraulic and Physical Boundaries.....	45
Water Budget.....	47
Field-Estimated Water Budget.....	47
Ground-Water Recharge.....	51
Ground-Water Recharge from Precipitation.....	52
Ground-Water Recharge from Irrigation.....	54
Ground-Water Recharge from Surface Water.....	58
Ground-Water Recharge from Ground Water.....	62

TABLE OF CONTENTS – Continued

	Page
CHAPTER 3. MODEL DESIGN .....	64
Model Selection.....	64
Model Input Requirements.....	65
Model Design.....	69
Grid.....	69
Physical Boundaries.....	71
Hydrologic Parameters .....	74
Time Discretization.....	77
Recharge and Discharge Boundaries.....	79
Constant Head Boundaries.....	79
River Boundaries.....	81
Drain Boundaries.....	83
Recharge Boundaries.....	84
Calibration Process.....	86
CHAPTER 4. MODEL RESULTS.....	88
Model Design Revisions.....	88
Conceptual Model Revision.....	88
Layer Thickness.....	88
Layer Conceptualization.....	90
No-Flow Boundaries.....	92
Calibrated Hydrologic Parameters.....	95
Calibration Results.....	101
Sensitivity Analysis.....	111
Verification.....	116
Predictive Simulations.....	116
CHAPTER 5. MODEL LIMITATIONS.....	135
Assumptions Made and Limitations of Modeling Effort.....	135
Uncertainty in Predictions.....	137
Appropriate Use of Modeling Results.....	138
CHAPTER 6. SUMMARY AND CONCLUSIONS.....	140
Conclusions.....	140
Recommended Future Work.....	142
REFERENCES CITED.....	145

TABLE OF CONTENTS – Continued

	Page
APPENDICES.....	152
Appendix A – Ground-Water Chemistry Data for the Flint Creek Valley.....	153
Water Chemistry data for wells located in the Flint Creek valley.....	154
Plot of Stiff diagrams for wells with water chemistry data.....	155
Wilcox diagram for wells with water chemistry data.....	156
Piper diagram for wells with water chemistry data.....	157
Appendix B – Lithologic Logs.....	158
Appendix C – Cross Sections.....	167
Appendix D – Mean Daily Inflows and Outflows for the Flint Creek Valley....	171
Appendix E – Curve Number Calculations.....	186
Appendix F – Flint Creek and Allendale Canal flows measured by DNRC and USGS .....	190
Flint Creek flows measured by DNRC and USGS in the Flint Creek valley.....	191
Measured changes in flow along Flint Creek.....	192
Allendale Canal flows measured by DNRC.....	193
Appendix G – Observed and simulated heads.....	194



## LIST OF TABLES

Table	Page
1. Hydrostratigraphic units in the Flint Creek valley.....	21
2. Transmissivity and specific capacity results from DNRC aquifer tests conducted for the Flint Creek Return Flow Study.....	27
3. Transmissivity values calculated from specific capacity using equation derived from DNRC aquifer tests.....	32
4. Comparison of transmissivity value for screened versus unscreened wells in each aquifer.....	34
5. Transmissivity values for the alluvial, gravel cap and deep aquifers for the Flint Creek valley and for Tertiary deposits in the Deer Lodge valley.....	35
6. Range of acceptable transmissivity values that can be assigned during model calibration.....	37
7. Storage parameter results from DNRC aquifer tests conducted for the Flint Creek Return Flow Study.....	38
8. Specific yield values for the alluvial aquifer using three different approaches.....	41
9. Storativity, specific storage, and specific yield values for the gravel cap aquifer.....	42
10. Storativity and specific storage values for the deep aquifer.....	43
11. Summary of acceptable specific yield and specific storage values for the four hydrostratigraphic units in the Flint Creek valley.....	43
12. Net recharge based on consumptive use for Climatic Zone 5.....	56
13. Average consumptive use from sites similar to the Flint Creek valley from the Montana Irrigation Guide.....	57
14. Net irrigation recharge based on consumptive use from sites similar to the Flint Creek valley.....	57
15. Range of acceptable net irrigation recharge values for the Flint Creek valley.....	58
16. Difference in flow at gaging locations along Flint Creek during pre-irrigation, irrigation, and post-irrigation months.....	62
17. Initial values of hydraulic parameters estimated to calibrate the model in English units.....	74

LIST OF TABLES -- Continued

Table	Page
18. Initial values of hydraulic parameters estimated to calibrate the model in metric units.....	74
19. Stress periods assigned in ground-water model.....	79
20. Recharge rates assigned to each stress period in the initial model.....	86
21. Results of changing well layer assignments on simulations of changes in seasonal water level.....	91
22. Acceptable range, initial estimate and calibrated values of parameters assigned in the model.....	96
23. Results of error measurements from the calibrated model.....	106
24. Comparison of simulated and measured changes in river flow over four reaches of Flint Creek.....	109
25. Calculated drawdown at different pumping rates using the Cooper-Jacob method.....	120
26. Pumping rates used for predictive simulations.....	120
27. Model generated river leakage and storage for the calibrated model in which there are no pumping wells.....	121
28. Model generated river leakage and storage for the predictive simulation which well PW-1 is place 0.25 mile from Flint Creek and is pumping at 300 gpm.....	122
29. Reduction in return flow to Flint Creek when well PW-1 is placed 0.25 mile from Flint Creek and pumped at 100 gpm, 200 gpm, and 300 gpm.....	123
30. Reduction in return flow to Flint Creek when well PW-1 is placed 0.5 mile from Flint Creek and pumped at 100 gpm, 200 gpm, and 300 gpm.....	124
31. Reduction in return flow to Flint Creek when well PW-1 is placed 0.75 mile from Flint Creek and pumped at 100 gpm, 200 gpm, and 300 gpm.....	125
32. Summer flows in Flint Creek measured at the Flint-Creek-near-Drummond gage.....	128
33. Reduction in return flow to Flint Creek when well PW-3 is placed 1 mile from Flint Creek and pumped at 100 gpm and 200 gpm.....	130
34. Reduction in return flow to Flint Creek when well PW-3 is placed 0.75 mile from Flint Creek and pumped at 100 gpm and 200 gpm.....	131
35. Model-generated drain leakance out of the aquifer, change in storage, and amount removed by well for the predictive simulation in which well PW-2 is placed on west bench and pumped at 100 gpm and 200 gpm during the irrigation seasons. ....	134

LIST OF TABLES – Continued

Table	Page
A-1. Water chemistry data for wells located in the Flint Creek valley.....	154
D-1. Mean daily inflows and outflows for the Flint Creek valley.....	172
F-1. Flint Creek flows measured by DNRC and USGS in the Flint Creek valley.....	191
F-2. Measured changes in flow along Flint Creek.....	192
F-3. Allendale Canal flows measured by DNRC.....	193
G-1. Observed and simulated heads for wells located in the Flint Creek valley.....	195

## LIST OF FIGURES

Figure	Page
1. Location of study area in southwestern Montana.....	3
2. Flint Creek drainage showing the Philipsburg and Flint Creek valleys.....	5
3. Flint Creek valley study area.....	7
4. Regional tectonic features and principal plutons of southwestern Montana.....	9
5. Geologic map of the Flint Creek valley.....	12
6. Cenozoic strata in the Flint Creek basin.....	14
7. Basins included in the Clark Fork basin depositional area.....	15
8. Location of wells in study area.....	22
9. Cross sections A-A' and F-F' generalized to show hydrostratigraphic units.....	23
10. Duration of specific capacity tests performed by drillers in the Flint Creek valley.....	29
11. Log-log plot of transmissivity versus specific capacity for the Flint Creek valley with fitted regression lines.....	29
12. Log-log plot of transmissivity versus specific capacity for the Gallatin valley, the Flint Creek valley and the Deer Lodge valley with fitted regression lines.....	31
13. Streamflow gaging and measurement locations.....	40
14. Generalized potentiometric surface for August, 1995.....	44
15. Shaded relief and contour map of the Flint Creek valley.....	46
16. Relationship of streamflow at Flint-Creek-below-Douglas-Creek gage and Flint-Creek-below-Allendale-Canal-diversion gage.....	48
17. Flint Creek valley inflow and outflow hydrographs, April, 1995 through December, 1996.....	50
18. Schematic drawing of ground-water recharge budget in the Flint Creek valley.....	52
19. Division of Flint Creek into four reaches between gages.....	60
20. Required inputs for MODFLOW.....	66
21. Grid layout for ground-water model.....	70
22. Cross-sectional view of the model from west to east along cross section line A-A'.....	72
23. Distribution of initial transmissivity, hydraulic conductivity, and storage values for layer one.....	76
24. Cell boundaries assigned in layer one of initial model.....	80
25. Irrigation status used for recharge in the initial conceptual model for the Flint Creek valley.....	85

LIST OF FIGURES – Continued

Figure	Page
26. Schematic cross-sectional view of model demonstrating the problem created by insufficient overlap.....	89
27. Cross sections A-A' and F-F' revised to show clay layer as non-continuous.....	93
28. Cell boundaries assigned in layer one of revised model.....	94
29. Distribution of calibrated transmissivity values for layer one.....	97
30. Photograph of gravel pit in Flint Creek alluvium (southwest) .....	98
31. Potentiometric surface for simulated heads, stress period three ending August 25, 1995.....	102
32. Observed and simulated heads of wells over the entire two-year period.....	104
33. Calculated versus observed heads for each stress period.....	108
34. Sensitivity analysis for specific yield.....	112
35. Sensitivity analysis for recharge.....	112
36. Sensitivity analysis for horizontal hydraulic conductivity.....	113
37. Sensitivity analysis for the ratio of horizontal to vertical hydraulic conductivity...	113
38. Sensitivity analysis for streambed conductivity.....	114
39. Location of pumping wells for predictive simulations.....	118
40. Reduction in return flow to Flint Creek when well PW-1 is placed at different distances from the stream.....	126
41. Impact of wells on streamflow, depending on distance of well from stream; wells located in Flint Creek alluvium (northeast) and pumping at 300 gpm.....	128
42. Reduction of return flow to Flint Creek when well PW-3 is placed at different distances from the stream and pumped at 100 and 200 gpm.....	132
A-1 Plot of Stiff diagrams for wells with water chemistry data.....	155
A-2 Wilcox diagram for wells with water chemistry data.....	156
A-3 Piper diagram for wells with water chemistry data.....	157

## ABSTRACT

Closure of several basins in Montana to new surface-water allocations has created a higher demand for ground-water resources. Concerns have been raised regarding the impact these actual and planned withdrawals may have on existing water rights and dry-season surface flows needed for fisheries and irrigation. This investigation characterizes the interaction of surface water, irrigation, and ground water in the Flint Creek valley, Granite County, Montana, using MODFLOW, a numerical ground-water flow model. The model was calibrated to ground-water and surface-water measurements collected by the Department of Natural Resources and Conservation and the U.S. Geological Survey for the Flint Creek Return Flow Study.

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The model calibrated best when elevated benches in the field area were treated as one hydrostratigraphic unit with transmissivity values of 15,000 gpd/ft (186 m<sup>2</sup>/d) on the majority of the benches and 1,500 gpd/ft (19 m<sup>2</sup>/d) where the gravels thin to the north. The alluvial areas were best modeled as three units with transmissivity values ranging from 10,500 gpd/ft (130 m<sup>2</sup>/d) to 29,900 gpd/ft (370 m<sup>2</sup>/d). Specific yield values ranged from 0.1 to 0.2 for layer one. Net recharge was best modeled at eight inches (20 cm) per summer season for sprinkler irrigation, 18 inches (46 cm) per season for flood irrigation, and one inch (2.5 cm) per season for unirrigated areas.

Using the calibrated model, several example simulations were performed to test the effect of ground-water withdrawals on streamflow. These examples show that well position in the valley (valley width) and distance from the stream influence the timing of greatest impact on streamflow and whether well water is drawn primarily from storage or from streamflow. The farther the well is from the stream, the more the timing of impact on streamflow is delayed from summer until fall, and the more water is drawn from storage rather than from streamflow. Many other simulations could be explored with this model. The choice of simulations should be constrained by input from a variety of perspectives such as those represented by the members of the Upper Clark Fork Basin Steering Committee.

## CHAPTER 1

## INTRODUCTION

Streams, lakes and reservoirs supply most of the water used for irrigation, industry, drinking water, and recreation in Montana. As demand grows, there is increasing competition for a finite resource. In several basins, surface-water allocations have exceeded supply and these basins have been closed to future allocations. Closures have occurred in the Clark Fork River Basin, the Upper Missouri and parts of the main stem of the Missouri. As basins are closed, there is an increasing demand for ground-water resources. Concerns have been raised regarding the impact these actual and planned ground-water withdrawals may have on existing water rights and dry-season surface flows needed for fisheries and irrigation. Important questions include: How close to the stream can a withdrawal occur before it produces important deleterious effects? Are there areas where ground-water withdrawal will likely have no effect on the stream? If such areas exist, how are they recognized and where are they? What impact do irrigation return flows via ground water have on stream flow?

These questions are important but difficult to answer because of the complexity of irrigated intermontane valley systems and a lack of data. Flint Creek, a tributary to the Clark Fork River, which flows through an irrigated intermontane valley, was closed to

new surface water allocations in 1991. The Upper Clark Fork Basin Steering Committee, with representatives from agriculture, fisheries, recreation, industry, county planning agencies and regulatory bodies initiated the closure and are currently grappling with the difficult issue of water management for the Upper Clark Fork Basin. Several agencies have recognized the need for more information on which to base management decisions. The Montana Department of Natural Resources (DNRC) Water Management Bureau, in cooperation with the U.S. Geological Survey (USGS) initiated the Flint Creek Return Flow Study, which was conducted from 1994-1997. The study focused on the Flint Creek basin, a major tributary to the Clark Fork River in Granite County, Montana (Fig. 1). The purpose of the DNRC study was to analyze aquifer recharge from irrigation and to quantify the amount and timing of irrigation return flows (Voeller and Waren, 1997). Although the U.S. Bureau of Reclamation is developing a surface water model to analyze reservoir operations and irrigation timing, no ground water modeling was planned to test the linkage between ground water and surface water. The purpose of this study is to develop a calibrated numerical ground-water model that characterizes stream-aquifer interactions in the Flint Creek valley so that questions regarding management of water in the basin can be explored.

### Study Area

Flint Creek, a tributary to the Clark Fork River in Western Montana, is part of the Upper Columbia River basin. The confluence of Flint Creek with the Clark Fork River is



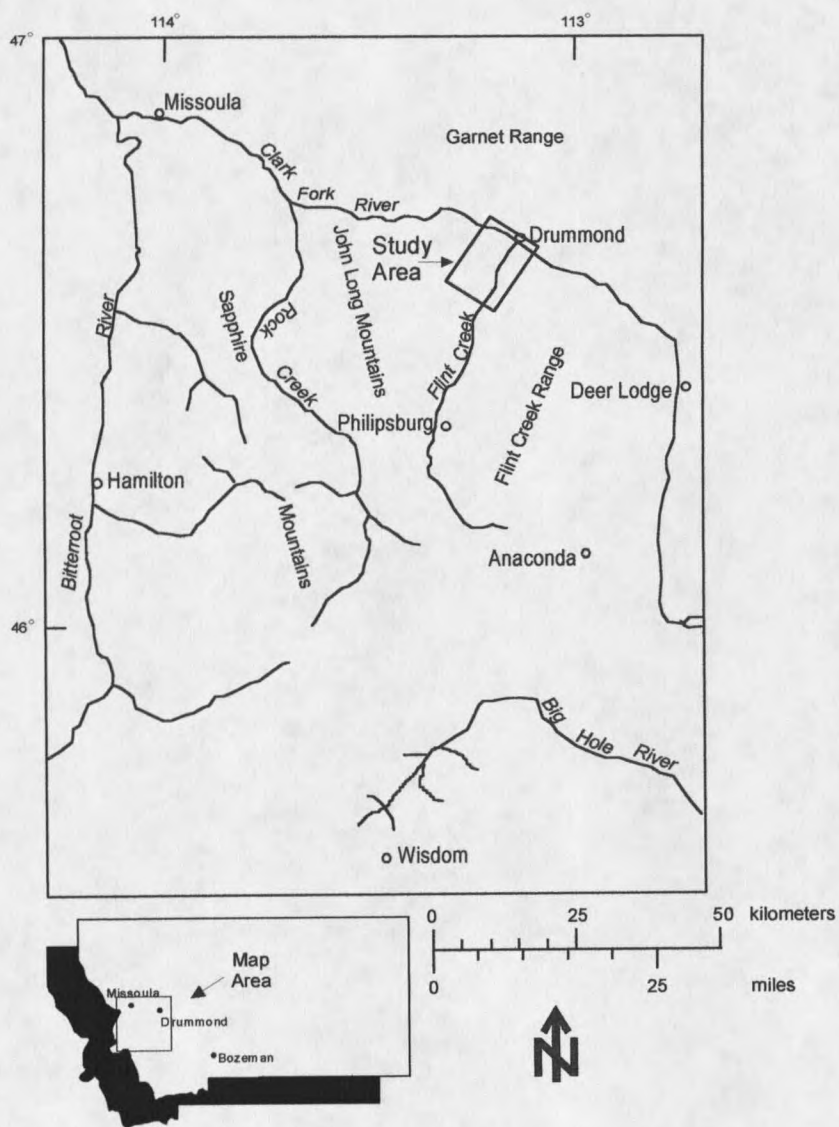


Figure 1. Location of study area in southwestern Montana (modified from Wallace et al., 1989)

near the town of Drummond, approximately 25 miles (40 kilometers (km)) northwest of Deer Lodge and 40 miles (60 km) southeast of Missoula (Fig. 1). Flint Creek flows north, and has a drainage area of approximately 500 square miles (1,300 km<sup>2</sup>) (Voeller and Waren, 1997).

Two large valleys lie within the drainage area, which is surrounded by mountainous terrain (Fig. 2). The Philipsburg valley is located in the upper reaches of Flint Creek near Philipsburg, while the Flint Creek valley is located in the lower reaches near Drummond. A narrow canyon separates the two basins. Flint Creek enters the Flint Creek valley at an elevation of approximately 4,360 feet (1,329 meters (m)), and exits at the confluence with the Clark Fork River at an elevation of approximately 3,950 feet (1,204 m). The local physiography of the Flint Creek valley is dominated by the alluvial floodplains of Flint Creek and Lower Willow Creek. The floodplains are flanked by elevated benches, which rise 100 to 300 feet (30 to 91 m) above the alluvium.

Flint Creek is the largest stream in the drainage basin. The average annual flow of Flint Creek is 137 cubic feet per second (cfs) (4 m<sup>3</sup>/s) near its confluence with the Clark Fork River (U.S. Geological Survey, 1999). Flows can range from four cfs (0.1 m<sup>3</sup>/s) in August to 1,100 cfs (31 m<sup>3</sup>/s) during a snowmelt event (usually in June, although high flow events occasionally occur during winter thaws). Flow in Flint Creek originates from reservoir storage, unregulated tributaries (Boulder Creek and Fred Burr Creek), regulated tributaries (Lower Willow Creek), and ground water (Fig. 2). Georgetown Lake, in the headwaters of Flint Creek, has active storage of 31,000 acre-feet (ac-ft)

















































































































































































































































































































































































































































