# Effects of On-site Sewage Disposal Facilities on Ground Water Within the Wood River Valley

Submitted in Partial Fulfillment of the Requirements for Graduation With Honors to the Department of Biology and Chemistry at Carroll College, Helena, Montana

by

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April 3, 1992

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## ACKNOWLEDGEMENTS

I could never have written this thesis without the help of Terry Schultz, my father. His assistance in my choosing this subject and during research was invaluable. Also, he arranged to have the Idaho State Laboratories do the chemical analysis of the samples.

I also thank the people at Idaho State Laboratories, Idaho State University, who were responsible for both the sample and error analysis. Their work allowed me to obtain more accurate results than I could have achieved on my own. Their promptness in returning results is still greatly appreciated.

Third I would like to congratulate S. P. Luttrell and C. E. Brockway on the thoroughness of their 1984 study. The amount of work and research they used in their project helped me to research and understand the ground water of the Wood River Valley.

Fourth I must thank all the landowners in the Wood River Valley who allowed their wells to be sampled. Without their cooperation no samples could have been obtained and no thesis written.

Finally I'm grateful to Dr. John Christenson for his patience and humor in reading and correcting this paper, over and over again. His work has improved this thesis immensely, from an original compilation of confusion to a readable paper.

ABSTRACT

Quality of well water is an indicator of ground water quality. Chloride and nitrate-N concentrations, from May to December of 1991, were determined in water samples obtained from 48 different wells, located in four different hydrologic areas of the Wood River Valley. Results of the first set of these tests were contrasted to a previous study. The comparison indicates no degradation of ground water quality has occurred since 1982. The second set of tests studied three other areas near the Wood River. These tests provided information about ground water in these areas and will create base-line data for further studies.

## LIST OF ILLUSTRATIONS

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# INTRODUCTION

Ground water provides 95% of the drinking water in Idaho (Burnell, 1991). Septic tank effluent is the most common cause of ground water contamination (Yates, 1985). In rural areas, the dependance on ground water for human use is often threatened by the necessity of on-site sewage disposal. This contamination can include nitrogenous or chloride compounds (Close, 1989).

The population of the Wood River Valley has increased 120% since 1980 (Blaine County Assessor, oral communication, 1991). Rural development primarily uses on-site sewage disposal, incorporating both septic tank and drainage field (Bicki et al., 1991). The effects of on-site sewage disposal on the water resources of the Wood River Valley were studied by Luttrell and Brockway. They found mean nitrate-N concentrations of 0.53 mg/L, and chloride at 2.4 mg/L. Both of these values fell within recommended USEPA levels (Luttrell and Brockway, 1984).

The Big Wood River Valley is located in south-central Idaho. The study area includes the valley of the Big Wood River, and its tributaries: the East Fork, Lower Broadford, and Warm Springs. The towns of Ketchum, Sun Valley, Hailey and Bellevue are found within this study area.

Earlier studies of the water resources of the Big Wood

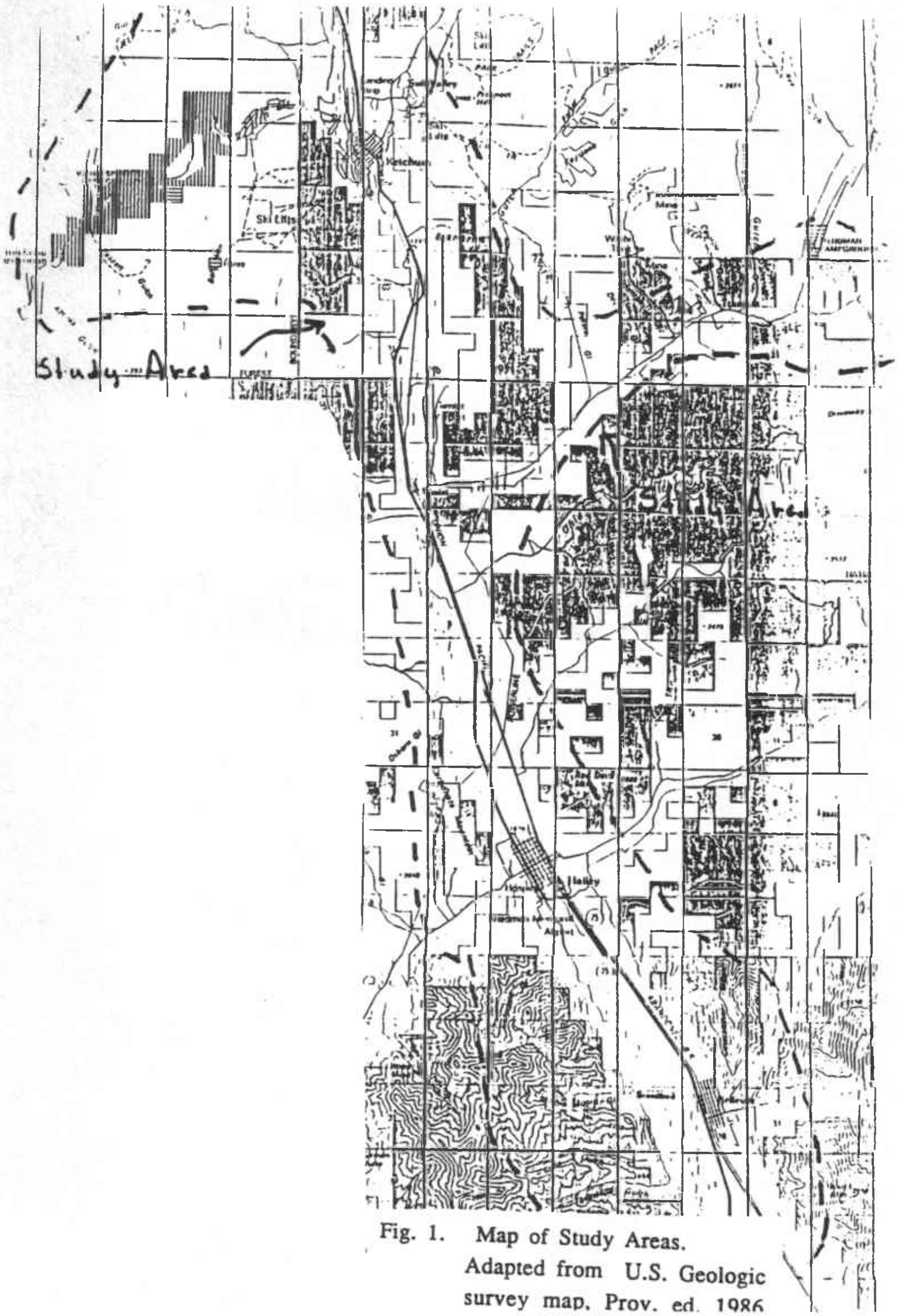


Fig. 1. Map of Study Areas.
Adapted from U.S. Geologic
survey map, Prov. ed. 1986

River Valley include sections of U. S. Geologic Survey Water-Supply Papers 774 (Stearns et al., 1938) and 1654 (Mundorff et al., 1964). In 1975 Castelin and Winner studied urbanization effects on the water resources in this area. The 1982 study by Luttrell and Brockway determined the effects of building densities in the study area on ground water (Luttrell and Brockway, 1984).

The geology of the study area can be divided into two distinct forms: consolidated sedimentary and igneous rocks, or unconsolidated fluvioglacial and alluvial material. Consolidated rocks comprise the mountains surrounding the valley floors. Sedimentary rocks, such as sandstone, limestone, and shale, arise from the Pennsylvanian and Mississippian eras. The igneous rocks are formed from extrusive lava flows of andesite, basalt and latite during the Tertiary era, and diorite and granite from the Cretaceous era. Complex stratigraphy and structure is due to extensive faulting and folding within the area (Umpleby et al.,1930).

Usually consolidated rocks are very poor hydraulic conductors, acting as barriers between major water yielding zones. When these rocks are fractured, jointed springs may occur providing large quantities of water (Smith, 1959). Several springs, some geothermic, are found in the study area.

Unconsolidated materials of coarse sand, gravel, clay, and silt constitute the valley fill. These valley fill deposits comprise the major aquifer of the study area (Stearns et al., 1938). Wells in this area can provide up to 2000 gpm. The transmissivity of the aquifer in the Hailey vicinity is approximately 950,000 gpd/ft (Smith, 1959).

Ground water is not confined in the fill deposits of the Wood River Valley, as it is present in a single aquifer. This ground water is found at varying depths, from a few ft in portions of the flood plain, to more than 100 ft on the alluvial fans and river terraces. Ground water underflow near Hailey is estimated to be 34,000 acre-ft/yr. The hydraulic potential of this aquifer does not vary with depth, so the ground water flow within the study area is essentially horizontal. The aquifer is recharged from precipitation, percolation, tributary valley underflow, and canal or stream seepage (Smith,1959).

This study was to determine the quality of ground water in the Wood River Valley. This objective will be met by two methods. First, ground water sample data obtained in this study is compared with the results of Luttrell and Brockway's 1984 report. This will determine whether an increase in ground water contamination has occurred. Second, information on the quality of ground water surrounding tributaries of the Wood River will be compiled. This will build a data pool of water quality which can be compared to results of both the 1982 and 1991 studies. These comparisons will help to determine ground water contamination patterns.

# MATERIALS AND METHODS

## SAMPLE SITES

To begin the process of data gathering for this thesis, the sample sites were first located. This was achieved through two methods. First data appropriate for comparison with the 1984 Luttrell and Brockway study was obtained by using the same sample wells as those of the 1984 study. Although this eliminated the possibility of random samples, it allowed for a more accurate comparison of data between the two studies.

Data sheets of the 1982 samples contained the names of the owners of the wells. In the simple instances, the same people owned and used the same well. At other times, new owners would be traced through tax notices and legal descriptions. Occasionally it was necessary to confirm the location of the well site using the U. S. Geological Survey numbering system (Luttrell and Brockway, 1984).

This process provided 18 of the 26 wells sampled in 1982-1983. The location of these sample sites is shown in Fig. 2-4. Since 1983, four of the wells were discontinued due to expansion of city water systems. Two wells had been driven deeper which would diminish the sample accuracy. Two of the wells have been abandoned since 1982.

The second method of acquiring sample wells was a random sample. The well logs of all wells within the Warm Springs, East Fork, and Lower Broadford tributary areas were obtained from the Idaho Department of Water Resources. Ten wells from each of these three areas were then randomly chosen. The location of these sample sites can be seen in Fig. 6-9.

Since all of these wells were privately owned, the next step was obtaining permission to sample them. The well owners were first contacted by telephone, informed about the survey, and asked if they wished to participate. Next a letter was sent to the well owners. This letter contained two parts. The first explained the study again. The second part was a permission slip which the owner filled out and mailed back. A space was included in the permission slip that allowed the owners to diagram their property indicating the most convenient site for well sampling. Usually the sample sites were located outside, but some sites were found indoors.

## SAMPLE SCHEDULE

The wells for the first set of tests were sampled in odd-numbered months beginning with May. The remaining 30 wells were sampled on even-numbered months beginning with August.

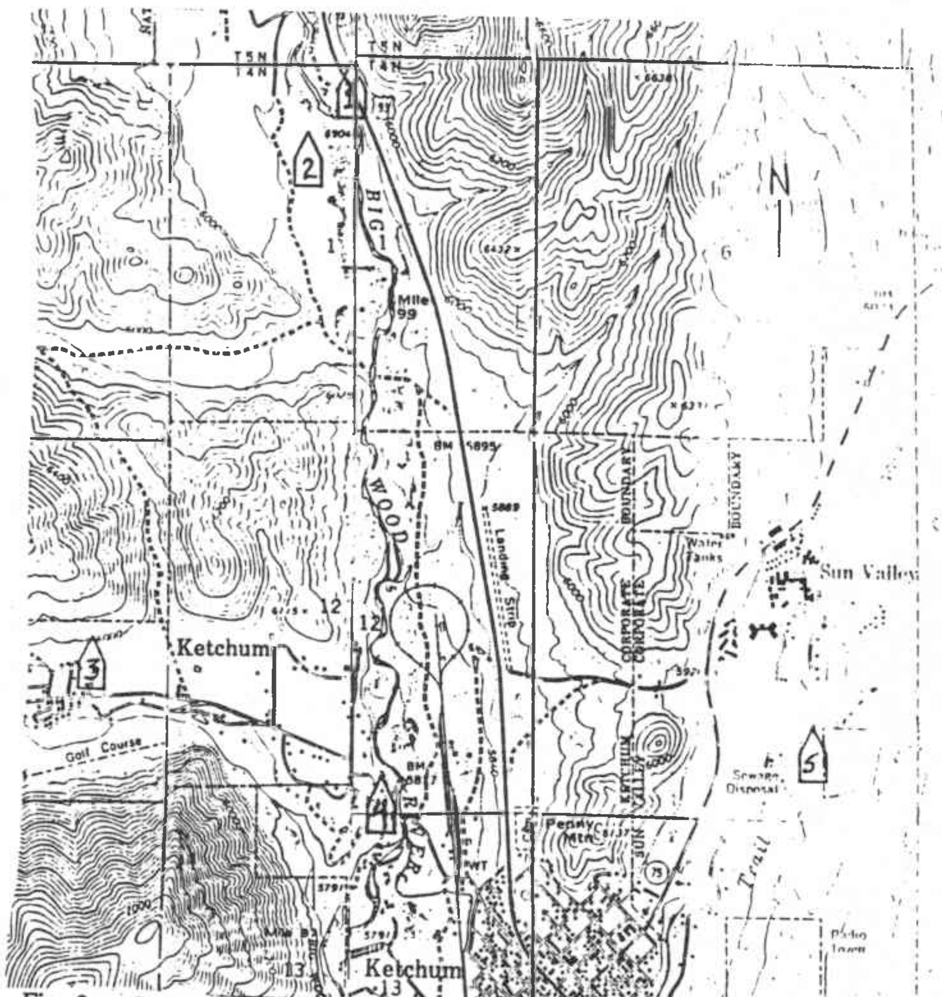


Fig. 2. Contour map of Wood River study area indicating sample sites 1-5. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

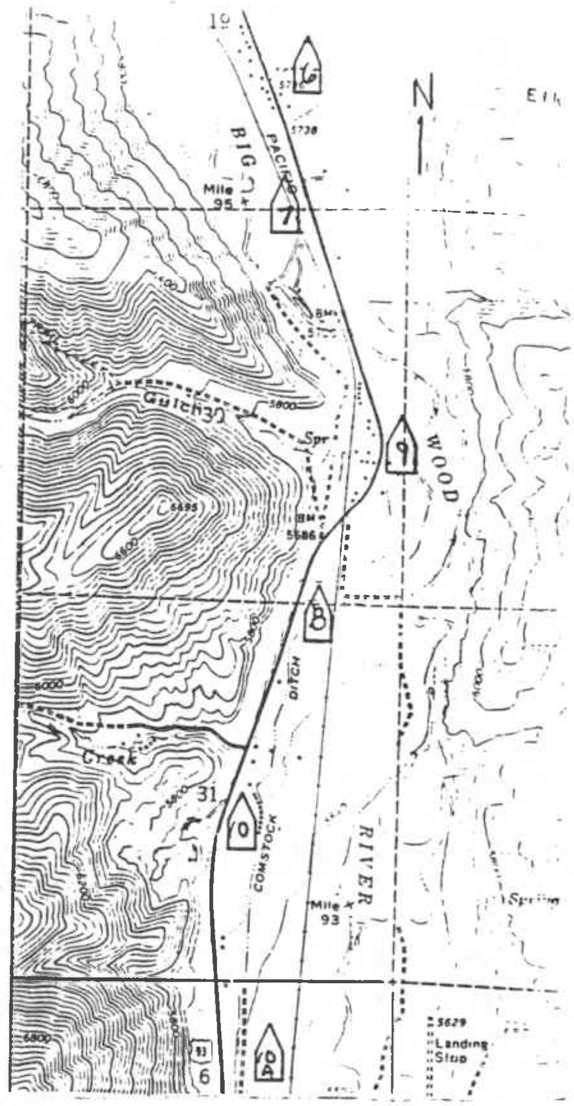

Fig. 3. Contour map of Wood River study area indicating sample sites 6-10A. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

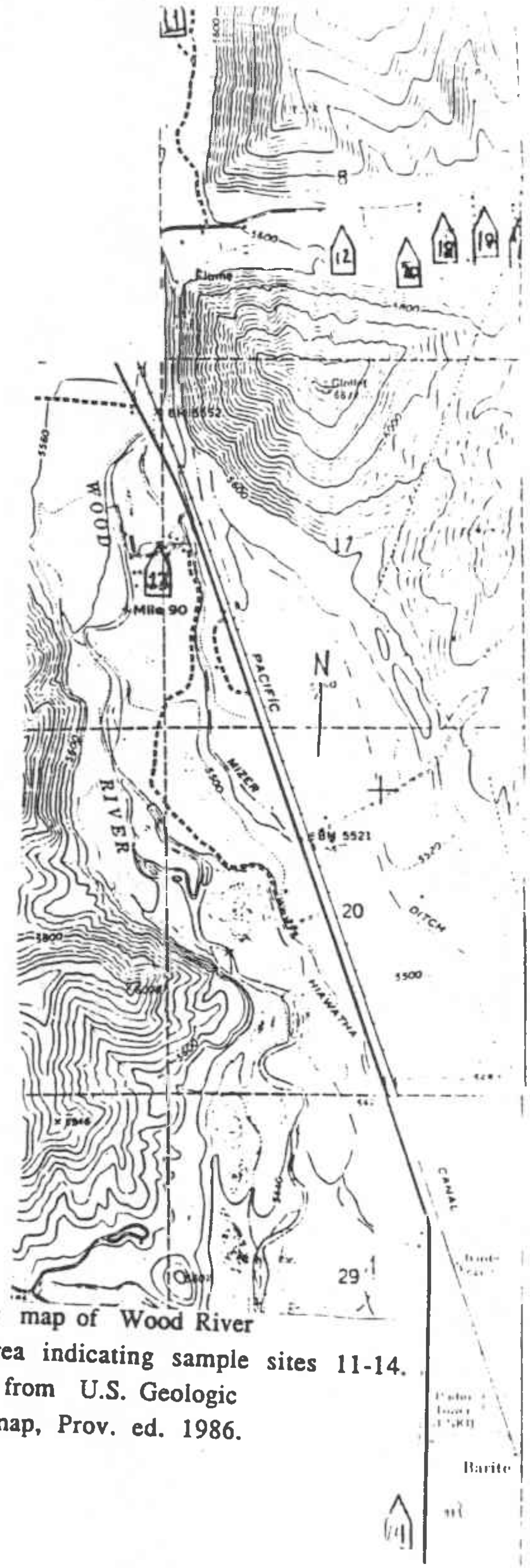


Fig. 4. Contour map of Wood River study area indicating sample sites 11-14. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

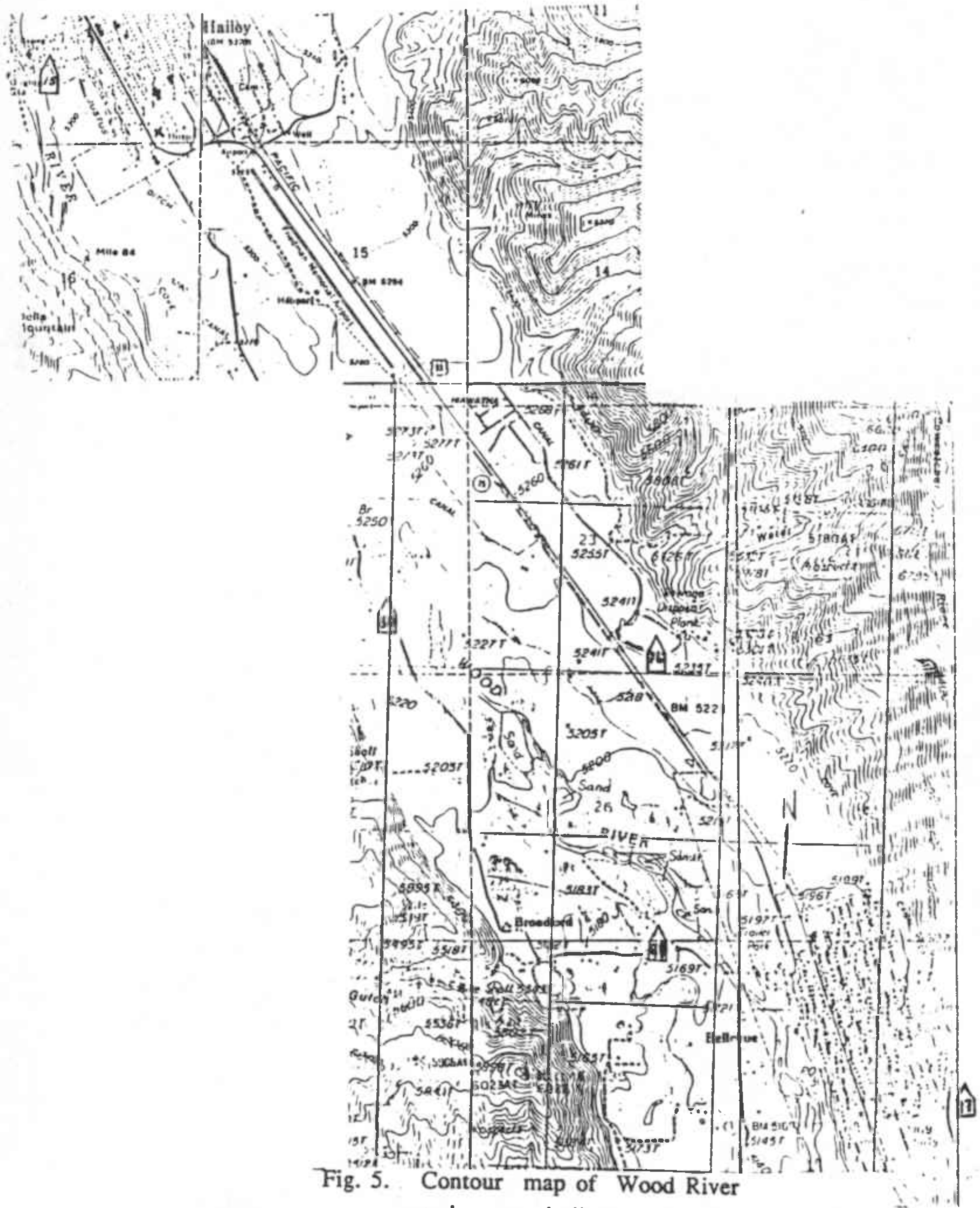


Fig. 5. Contour map of Wood River study area indicating sample sites 15-17. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

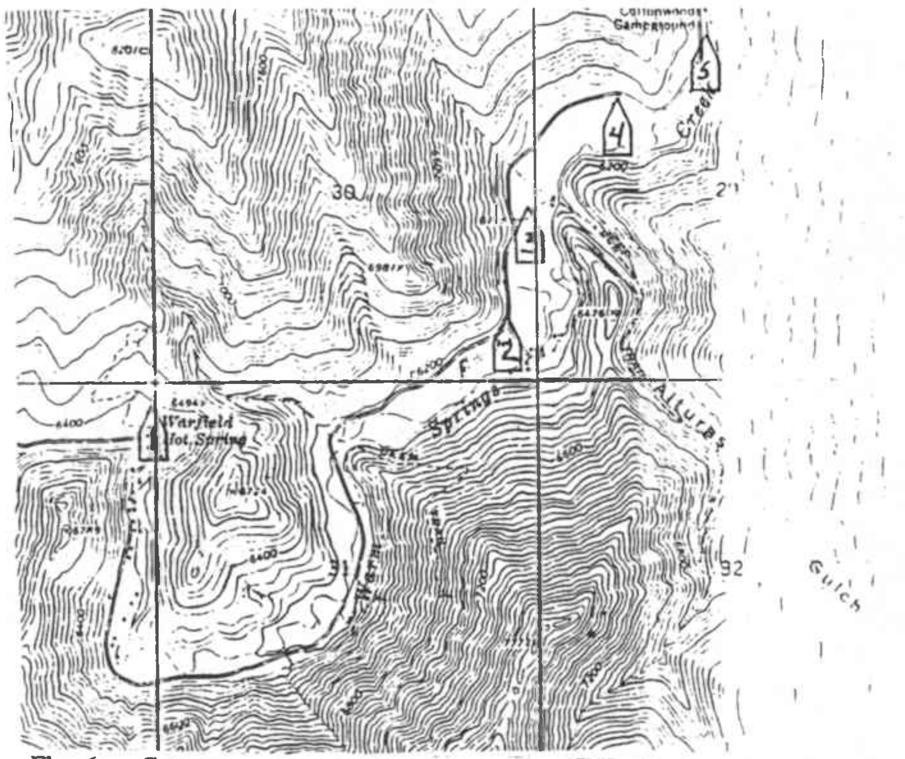


Fig. 6. Contour map of Warm Springs study area indicating sample sites 1-5. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

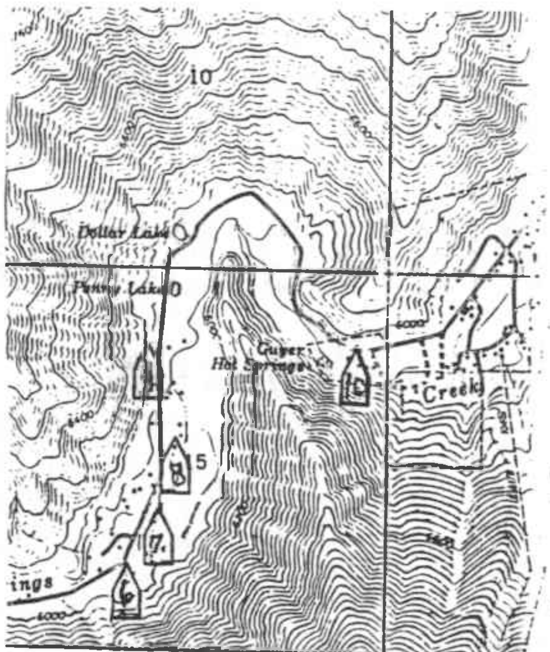

Fig. 7. Contour map of Warm Springs study area indicating sample sites 6-10. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

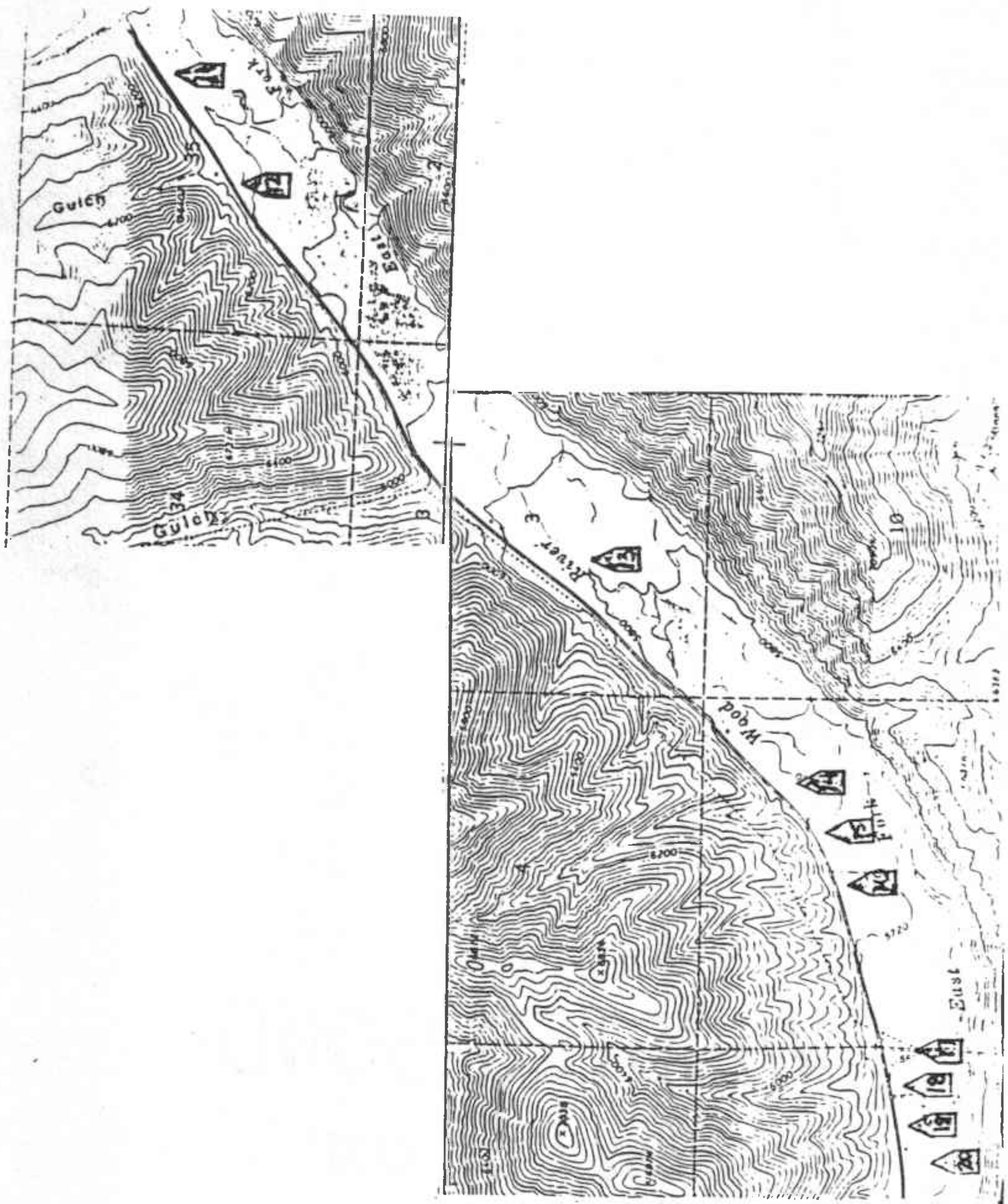

Fig. 8. Contour map of East Fork study area indicating sample sites 11-20. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

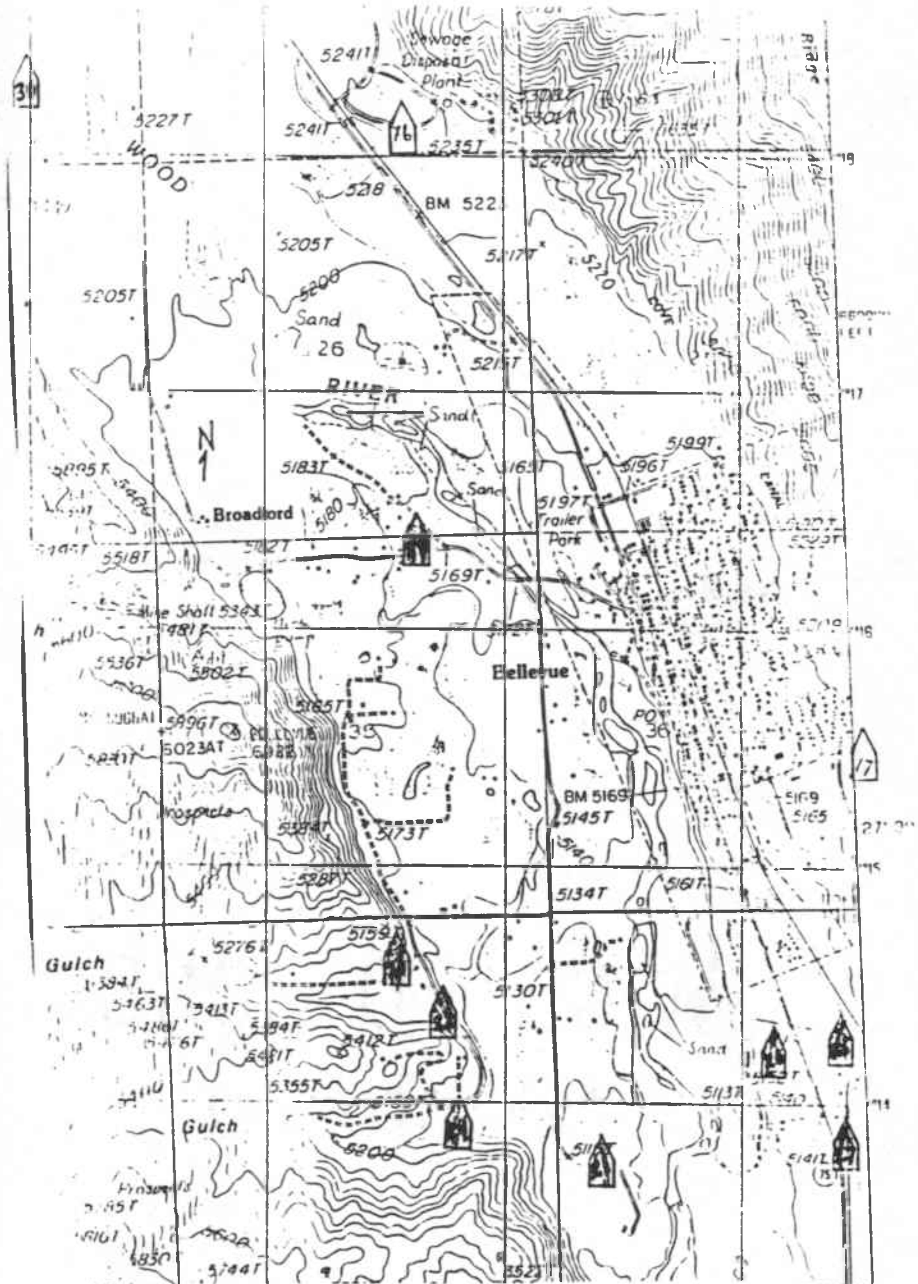


Fig. 9. Contour map of Lower Broadford study area indicating sample sites 21-30. Adapted from U.S. Geologic survey map, Prov. ed. 1986.

SAMPLE METHODS

Obtaining samples from prechosen sample sites was simple. If the sample site was indoors, then the filter mechanism of the faucet, such as a mechanical screen or water softener, was disconnected from the water's path. When the site was outdoors no precautions were necessary since filter mechanisms were not used. Next the water was turned on and allowed to run for approximately 15 min or until the well pump turned on. This assured that water was coming directly from the well, because water from the well casing and distribution system had been flushed out.

A chloride sample of water was collected by filling a 1-L plastic cubitainer with water running from the well. This sample was then dated and labeled.

A nitrate-N sample of water was obtained in much the same way. One L of water running from the well was used to fill a 1-L plastic cubitainer. Next 1 mL of concentrated sulfuric acid was added to preserve the sample. This sample was dated and labeled. These samples were then sent to Idaho State Laboratories in Boise, Idaho for analysis.

To assure quality in sampling methods, 10 percent of the chloride and nitrate-N samples were duplicated. Later when the samples were analyzed, the duplicates were used to measure variation between the samples which should be identical. These duplicates were randomly chosen and used in error analyses.

Another method of quality control used was a spiked sample. Ten percent of the chloride and nitrate-N samples also contained a spike. This spike was a substance received from the analyzing lab which was placed in the sample so the percent of recovery could be determined. The composition of this substance and its amount were unknown to the sampler. The spike contained no materials that would affect chloride or nitrate-N concentration. The spikes were placed in random samples and labeled. Trip blanks and transfer blanks were also used to assure quality control. Once each month the analyzing lab sent out a sample, the transfer blank, which contained a known concentration of chloride and nitrate-N. Along with the transfer blank a trip blank was sent. The trip blank contained no nitrates or chlorides. These known samples were sent back to the analysis lab along with all of the unknown samples obtained from the wells. These different samples were used to calibrate the analysis of unknown chloride and nitrate concentrations.

SAMPLE ANALYSIS

The samples were analyzed by Idaho State Laboratories to determine the concentrations of chloride or nitrate-N. Chloride concentrations were found by the argentometric method (APHA, 1971). Nitrate-N concentrations were determined with an ion specific electrode (Milham et al., 1970).

# RESULTS

## NITRATE-N

The mean nitrate-N concentration found in the ground water of the study area was 0.612 mg/L. Data obtained in 1991 was contrasted to comparable information from 1983 (Fig. 10). The mean nitrate-N concentrations of each sample site in the three tributary areas are found in Fig. 12, 14, and 16. The concentration and sampling data of each site are listed in Tables 1, 2.

The Wood River Valley itself had nitrate-N concentrations that varied from 0.005 mg/L to 1.53 mg/L. The mean nitrate-N concentration of this area was 0.453 mg/L. Ground water around the Warm Springs tributary of the Wood River had a low nitrate-N concentration of 0.005 mg/L and a high of 0.786 mg/L. The mean concentration of nitrate-N in ground water around Warm Springs Creek was 0.205 mg/L. The ground water of the East Fork of the Wood River had a mean nitrate-N concentration of 0.686 mg/l. The low nitrate-N concentration was 0.006 mg/L. The high concentration was 3.48 mg/L. The Lower Broadford tributary of the Wood River had the highest nitrate-N concentrations. Its lowest concentration was 0.072 mg/L, and its highest was 6.75 mg/L. The mean concentration for this area was 1.23 mg/L.

CHLORIDE

The mean chloride concentration of ground water in the study area was 3.3 mg/L. Information from the Lutrell and Brockway study is compared to data compiled in 1991 (Fig. 11). The mean chloride concentrations of each sample site are indicated in Fig. 13, 15, and 17. The chloride concentrations are compiled in Tables 1,2.

The Wood River Valley ground water had a low chloride concentration of 0.4 mg/L and a high concentration of 5.4 mg/L. The mean concentration was 2.5 mg/L. The ground water of Warm Springs Creek had a low chloride concentration of 1.2 mg/L, and a high concentration of 4.5 mg/L. The mean concentration in the Warm Springs area was 2.1 mg/L. The East Fork ground water had a low chloride concentration of 0.9 mg/L and a high of 12.2 mg/L. The mean concentration of the East Fork was 3.7 mg/L. Lower Broadford area had the highest mean chloride concentration, 5.4 mg/L. The lowest chloride concentration in this area was 1.6 mg/L and the highest 14.4 mg/L.

Table 1. Nitrate-N and Chloride concentrations in water samples from the Wood River Valley

| Sample Site | Sample Date | Nitrate-N Concentrations (mg/L) | Chloride Concentrations (mg/L) |
|---|---|---|---|
| 1. 205 S. Aspen | 5/20/91 | 0.287 | 0.4 |
| | 7/23/91 | 0.332 | 0.9 |
| | 9/9/91 | 0.305 | 1.8 |
| | 11/13/91 | 0.24 | 1.7 |
| 2. 741 Paintbrush | 5/20/91 | 0.216 | 0.4 |
| | 7/23/91 | 0.099 | 0.5 |
| | 9/9/91 | 0.115 | 1.5 |
| | 11/13/91 | 0.311 | 2.2 |
| 3. 2107 Warm Springs Rd. | 5/20/91 | 0.789 | 4.8 |
| | 7/23/91 | 0.605 | 3.3 |
| | 9/9/91 | 0.545 | 4.2 |
| | 11/13/91 | 0.492 | 5.4 |
| 4. 1204 Warm Springs Rd. | 5/20/91 | 0.982 | 3 |
| | 7/23/91 | 1.36 | 4.9 |
| | 9/9/91 | 1.26 | 3.9 |
| | 11/13/91 | 1.53 | 4.9 |
| 5. 121 Dollar Rd. | 5/20/91 | 0.222 | 1.3 |
| | 7/23/91 | 0.539 | 2.1 |
| | 9/9/91 | 0.34 | 2.1 |
| | 11/13/91 | 0.28 | 1.9 |
| 6. 8 Elkhorn Rd. | 5/20/91 | 0.353 | 1.3 |
| | 7/23/91 | 1.13 | 1.7 |
| | 9/9/91 | 0.83 | 2.9 |
| | 11/13/91 | 0.195 | 2.4 |
| 7. 124 Birdseye Rd. | 5/20/91 | 0.289 | 1.3 |
| | 7/23/91 | 0.239 | 1.6 |
| | 9/9/91 | 0.29 | 2.8 |
| | 11/13/91 | 0.25 | 3.2 |
| 8. 25 Hailey Ave. | 5/20/91 | 0.521 | 3 |
| | 7/23/91 | 0.415 | 2.4 |
| | 9/9/91 | 0.36 | 2.9 |
| | 11/13/91 | 0.356 | 2.8 |
| 9. Ketchum Highway | 5/20/91 | 0.334 | 1.3 |
| | 7/23/91 | 0.005 | 1.9 |
| | 9/9/91 | 0.325 | 2.6 |
| | 11/13/91 | 0.293 | 2.8 |
| 10. Ketchum Highway | 5/20/91 | 0.577 | 1.3 |
| | 7/23/91 | 0.838 | 3.1 |
| | 9/9/91 | 0.635 | 3.1 |
| | 11/13/91 | 0.502 | 3.5 |
| 11. 106 Rail Rd. | 5/20/91 | 0.21 | 2.1 |
| | 7/23/91 | 0.152 | 1.7 |

| | | | |
|---|---|---|---|
| | 9/9/91 | 0.24 | 2.8 |
| | 11/13/91 | 0.233 | 2.2 |
| 12. 409 Martin Water Way | 5/20/91 | 0.614 | 2.1 |
| | 7/23/91 | 1.34 | 3.8 |
| | 9/9/91 | 0.51 | 4.6 |
| | 11/13/91 | 0.24 | 3.2 |
| 13. 105 Magic Mountain | 5/20/91 | 0.115 | 1.3 |
| | 7/23/91 | 0.149 | 0.9 |
| | 9/9/91 | 0.155 | 1.5 |
| | 11/13/91 | 0.068 | 2.2 |
| 14. 113 Abbey Rd. | 5/20/91 | 0.165 | 1.3 |
| | 7/23/91 | 0.166 | 1.4 |
| | 9/9/91 | 0.188 | 2.6 |
| | 11/13/91 | 0.22 | 3 |
| 15. 218 N. Aspen Rd. | 5/20/91 | 0.976 | 3 |
| | 7/23/91 | 0.419 | 2.4 |
| | 9/9/91 | 0.455 | 2.8 |
| | 11/13/91 | 0.229 | 2.8 |
| 16. 415 W. Bullion Way | 5/20/91 | 0.329 | 2.1 |
| | 7/23/91 | 0.318 | 2.6 |
| | 9/9/91 | 0.32 | 2.9 |
| | 11/13/91 | 0.25 | 2.4 |
| 17. N. Bellevue Industrial Pl | 5/20/91 | 0.442 | 2.1 |
| | 7/23/91 | 1.16 | 3.5 |
| | 9/9/91 | 0.425 | 2.8 |
| | 11/13/91 | 0.998 | 4.7 |
| 18. 110 Bayhorse Rd. | 5/20/91 | 0.682 | 3 |
| | 7/23/91 | 0.555 | 2.6 |
| | 9/9/91 | 0.29 | 2.8 |
| | 11/13/91 | 0.391 | 3.4 |

Table 2. Nitrate-N and Chloride concentrations in water samples from the Warm Springs, East Fork, and Lower Broadford

| Sample Site | Sample Date | Nitrate-N Concentrations (mg/L) | Chloride Concentrations (mg/L) |
|---|---|---|---|
| Warm Springs, Sample Sites | | | |
| 1. 983 Warm Springs Rd. | 8/5/91 | 0.056 | 1.6 |
| | 10/8/91 | 0.067 | 1.8 |
| 2. 109 Sandy Lane | 8/5/91 | 0.005 | 1.2 |
| 3. 520 Warm Springs Rd. | 8/5/91 | 0.126 | 1.2 |
| | 10/8/91 | 0.104 | 1.6 |
| | 12/4/91 | 0.126 | 2.5 |
| 4. 690 W. Warm Springs Rd. | 8/5/91 | 0.076 | 2 |
| | 10/8/91 | 0.133 | 2 |
| | 12/4/91 | 0.102 | 2.3 |
| 5. 780 W. Warm Springs Rd. | 8/5/91 | 0.239 | 1.6 |
| | 10/8/91 | 0.255 | 1.6 |
| | 12/4/91 | 0.253 | 2.2 |
| 6. 125 Broad Loop | 8/5/91 | 0.568 | 2.2 |
| | 10/8/91 | 0.734 | 4.5 |
| | 12/4/91 | 0.786 | 3.2 |
| 7. 102 W. Warm Springs Rd | 8/5/91 | 0.254 | 2.8 |
| | 10/8/91 | 0.251 | 2.5 |
| | 12/4/91 | 0.244 | 3.8 |
| 8. 396 W. Warm Springs Rd. | 8/5/91 | 0.127 | 2.3 |
| | 10/8/91 | 0.156 | 1.8 |
| | 12/4/91 | 0.159 | 2 |
| 9. 106 Carriage Lane | 8/5/91 | 0.155 | 1.8 |
| | 10/8/91 | 0.177 | 2 |
| | 12/4/91 | 0.166 | 2.9 |
| 10. 320 Carriage Lane | 8/5/91 | 0.024 | 2.1 |
| | 10/8/91 | 0.025 | 1.8 |
| | 12/4/91 | 0.016 | 3.4 |
| East Fork Creek Sample Sites | | | |
| 11. 201 Meadowbrook | 8/5/91 | 0.011 | 3.7 |
| | 10/8/91 | 0.211 | 4 |
| | 12/4/91 | 0.01 | 4.8 |
| 12. 102 Meadowbrook | 8/5/91 | 0.779 | 4.4 |
| | 10/8/91 | 0.851 | 3.6 |
| | 12/4/91 | 0.818 | 5.4 |
| 13. 134 Hyndman View | 8/5/91 | 0.511 | 2.5 |
| | 10/8/91 | 0.178 | 1.8 |
| | 12/4/91 | 0.168 | 2.7 |
| 14. 117 Pioneer Rd. | 8/5/91 | 0.032 | 1.1 |
| | 10/8/91 | 0.019 | 1.4 |
| | 12/4/91 | 0.024 | 2.7 |

| | | | |
|---|---|---|---|
| 15. 106 Cobb Circle | 8/5/91 | 1.49 | 12.2 |
| | 10/8/91 | 0.362 | 10.1 |
| | 12/4/91 | 1.3 | 5.2 |
| 16. 906 Canyon Rd. | 8/5/91 | 0.293 | 2.5 |
| | 10/8/91 | 0.318 | 2.2 |
| | 12/4/91 | 0.3 | 2.5 |
| 17. 209 Timberline Rd. | 8/5/91 | 0.062 | 1.4 |
| | 10/8/91 | 0.071 | 1.4 |
| | 12/4/91 | 0.06 | 2 |
| 18. 121 Timberline Rd. | 8/5/91 | 2.79 | 4.4 |
| | 10/8/91 | 2.41 | 4.2 |
| | 12/4/91 | 3.48 | 1.8 |
| 19. 105 Timberline Rd. | 8/5/91 | 1.09 | 3.7 |
| | 10/8/91 | 2.53 | 10.7 |
| | 12/4/91 | 0.855 | 3.8 |
| 20. 113 Magic Mountain | 8/5/91 | 0.006 | 0.9 |
| | 10/8/91 | 0.029 | 1.4 |
| | 12/4/91 | 0.033 | 2.5 |
| Lower Broadford Creek Sample Sites | | | |
| 21. 126 Hurst Lane | 8/5/91 | 0.165 | 2.5 |
| | 10/8/91 | 0.146 | 2.4 |
| | 12/4/91 | 1.58 | 4.1 |
| 22. 48 Townsned Gulch | 8/5/91 | 3.61 | 7.8 |
| | 10/8/91 | 4.04 | 8.7 |
| | 12/4/91 | 3.71 | 9.7 |
| 23. 100 Lee's Gulch | 8/5/91 | 0.551 | 4.3 |
| | 10/8/91 | 0.518 | 5.1 |
| | 12/4/91 | 0.523 | 10.3 |
| 24. 90 Townsend Gulch | 8/5/91 | 6.75 | 11.2 |
| | 10/8/91 | 5.7 | 12.5 |
| | 12/4/91 | 5.54 | 14.4 |
| 25. 50 Gannet Rd. | 8/5/91 | 0.541 | 2.5 |
| | 10/8/91 | 0.523 | 2.5 |
| | 12/4/91 | 0.506 | 3.4 |
| 26. 11052 Hwy 75 | 8/5/91 | 0.113 | 1.6 |
| | 10/8/91 | 0.127 | 2.2 |
| | 12/4/91 | 0.179 | 2.7 |
| 27. 11037 Hwy 75 | 8/5/91 | 0.505 | 2.7 |
| | 10/8/91 | 0.53 | 2.5 |
| | 12/4/91 | 0.538 | 3.4 |
| 28. 10964 Hwy 75 | 8/5/91 | 0.209 | 2 |
| | 10/8/91 | 0.168 | 2.4 |
| | 12/4/91 | 0.159 | 3.1 |
| 29. 385 Broadford Rd. | 8/5/91 | 0.072 | 2.3 |
| | 10/8/91 | 0.089 | 2.2 |
| | 12/4/91 | 0.171 | 3.4 |
| 30. Lower Broadford Rd. | 8/5/91 | 0.297 | 2.1 |
| | 10/8/91 | 0.559 | 2.9 |
| | 12/4/91 | 0.67 | 5.8 |

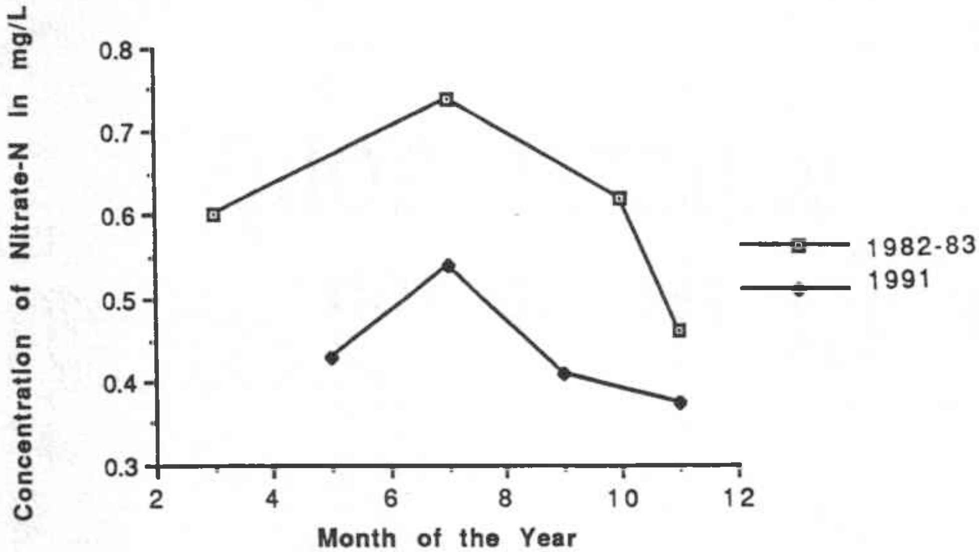


Fig. 10. Comparison of mean nitrate-N in Wood River Valley wells in 1982-83 and 1991.

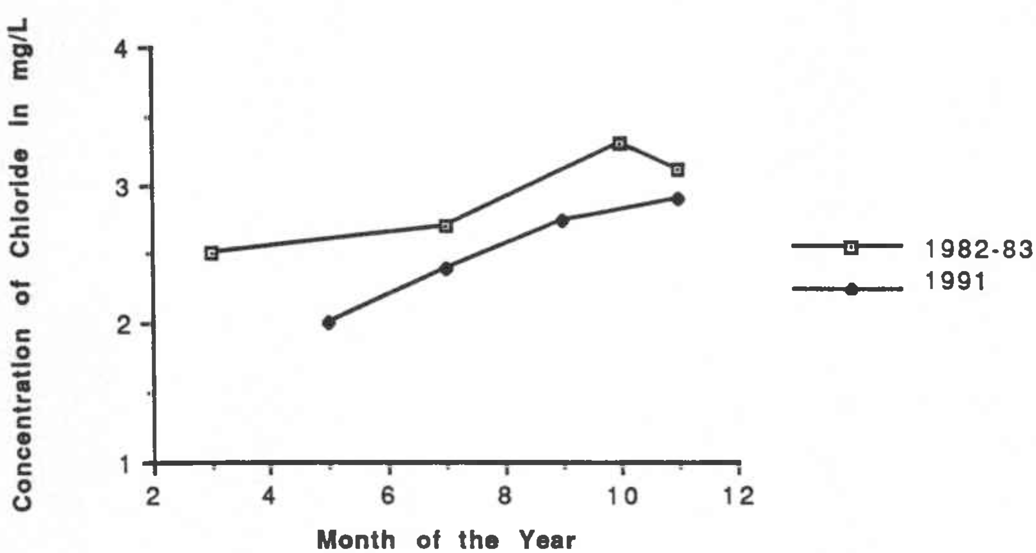


Fig. 11. Comparison of mean chloride in Wood River Valley wells in 1982-83 and 1991.

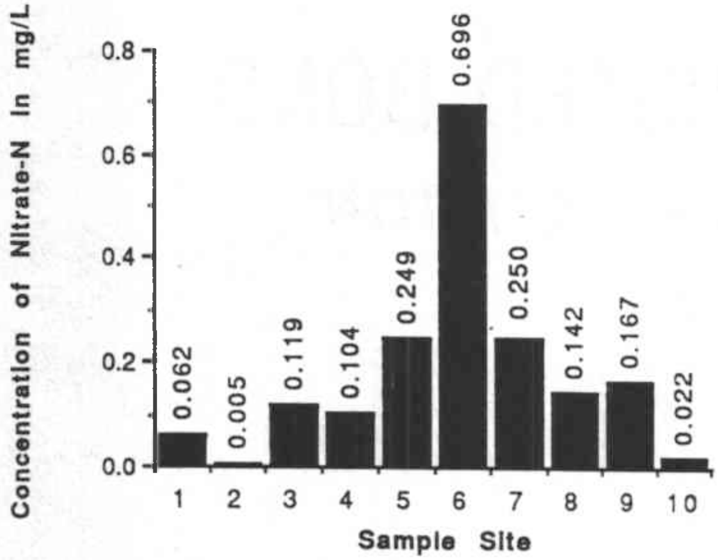


Fig. 12. Mean nitrate-N concentrations versus individual sample sites within the Warm Springs hydrologic area.

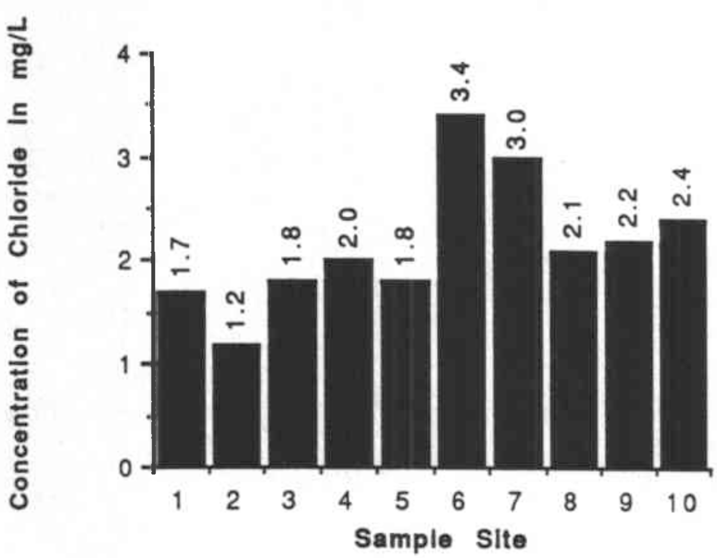


Fig. 13. Mean chloride concentrations versus individual sample sites within the Warm Springs hydrologic area.

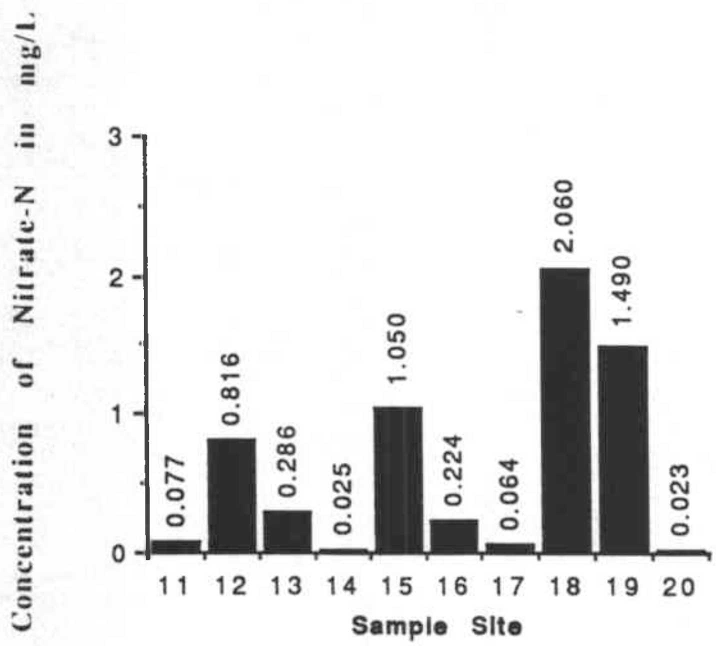


Fig. 14. Mean nitrate-N concentrations versus individual sample sites within the East Fork hydrologic area.

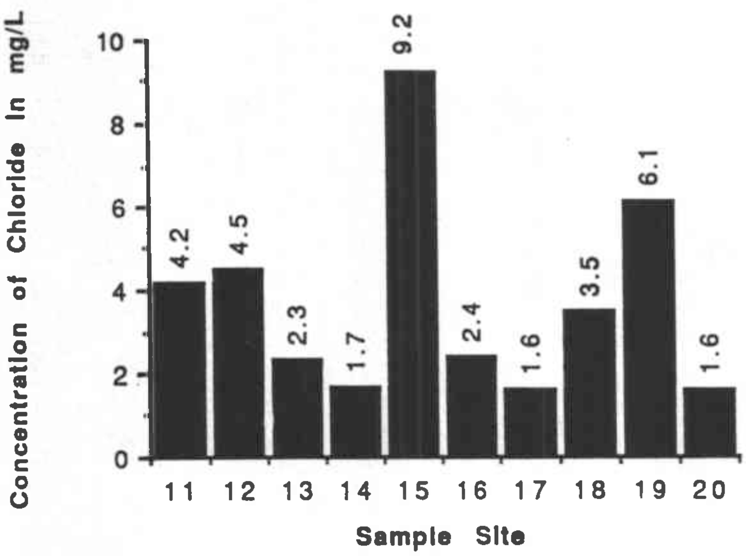


Fig. 15. Mean chloride concentrations versus individual sample sites within the East Fork hydrologic area.

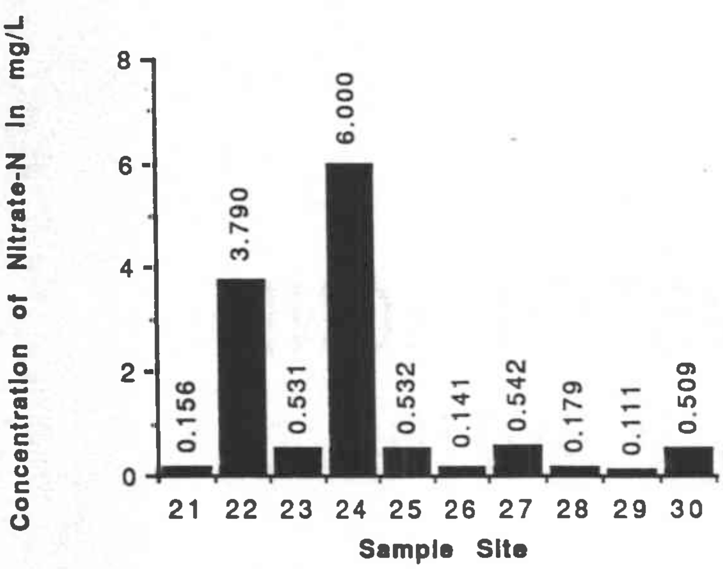


Fig. 16. Mean nitrate-N concentrations versus individual sample sites within the Lower Broadford hydrologic area.

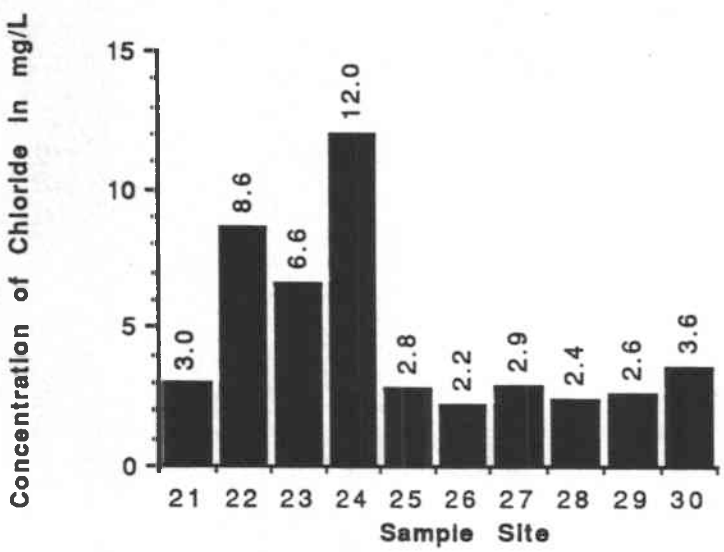


Fig. 17. Mean Chloride concentrations versus individual sample sites within the Lower Broadford hydrologic area.

# DISCUSSION

Nitrate-N concentration is used as the primary indicator of ground water contamination from on-site sewage disposal systems (Luttrell and Brockway, 1984). Presence of chloride ions in ground water is also a sign of on-site sewage system contamination (Canter et al., 1985).

In the eight years since Luttrell and Brockway gathered information on ground water in the Wood River Valley, the population of the area has greatly expanded. Also, some people continue to use on-site sewage disposal (Burnell, 1991). However, in this interval the quality of ground water in the Wood River Valley has improved. This trend is observable by comparing both nitrate-N and chloride levels between 1983 and 1991 (Fig. 1, 2). It is apparent that at all times during the year, nitrate-N and chloride concentrations were lower in 1991 than 1983.

Differences between the current and previous studies and an overview of possible errors are presented below. Also possibilities of why the ground water quality has improved, and a discussion of the impacts of ground water quality are included. Understanding the information gained on the ground water quality of the tributaries of the Wood River will follow.

The results of the duplicate samples for error analysis indicate accurate sampling and analysis, since the mean deviation between all duplicates was less than 0.01. The spiked samples indicated that the percent recovery for all samples was greater than 99 percent, a high percentage of recovery.

The samples were gathered as accurately possible, but deviation could result from the sample schedule. The contaminant levels of ground water fluctuate from month to month. My sample schedule was set on odd-numbered months, like July; whereas, Luttrell and Brockway used even-numbered months (Fig 1, 2). This discrepancy may explain the apparent improvement of ground water quality even with the substantial population increase.

The data suggest that ground water quality has improved. Valley fill deposits could not be filtering and aerating the ground water better in 1991 than 1983 (Burnell, 1991). These features are not responsible for the improvement of ground water quality, but how people are currently disposing of their sewage may explain the improvements.

Most people moving into the Wood River Valley settle in the towns of Hailey, Ketchum, and Bellevue (Blaine County Assessor, oral communication, 1991). These towns use public sewer systems and sewage treatment plants. Most people currently living in the Wood River Valley use these public systems which are designed to reduce environmental contamination (Burnell, 1991). The increased use of public sewage systems is probably the biggest reason ground water quality has improved.

The information gained in this study supports the use of a public sewer system and treatment plant, as compared to on-site disposal of sewage, to better preserve ground water quality. Protecting ground water will improve human life by decreasing disease and illness caused by drinking contaminated water (APHA, 1971). However, protecting ground water requires further study of ground water systems.

The second set of tests investigated ground water quality in areas not covered by the 1983 study. Discussing the results of these tests focuses on why different contaminant levels were found in the three different hydrologic areas.

Ground water is not confined within the Wood River Valley. This characteristic allows contaminants to diffuse from one hydrologic area to the next. The fill deposit of the Wood River Valley is uniform, indicating subsurface filtration and aeration is the same in the three different areas. Soil and geologic characteristics cannot explain the ground water quality differences between the three areas.

Elevation of the three areas differs. The mean elevation of the Warm Springs sample sites is approximately 6200 ft above sea level. The mean altitude of the wells in the East Fork area is around 5700 ft above sea level, and wells in the Lower Broadford are near 5100 ft above sea level.

Ground water flows downhill flushing contaminants away from the high and into the low elevations. The area with the lowest elevation, the Lower Broadford, also has the highest concentrations of both nitrate-N and chloride. The Warm Springs area has the highest elevation and the lowest nitrate-N and chloride concentrations.

Population in the Lower Broadford is twice as dense as that of the East Fork area. The East Fork is more populous than the Warm Springs area (Blaine County Assessor, oral communication, 1991). More people results in more waste, and in each of these areas on-site sewage disposal is the only method of sewage management.

The largest population coupled with the lower elevation is probably the best explanation for the highest contaminant concentrations in the Lower Broadford area. Likewise, the best ground water quality is due to the lowest population and highest elevation found in the Warm Springs area.

Ground water use increases as the population increases. In the Wood River Valley, a need exists for better management of the ground water resources in those areas with both high population densities and low elevation. Because of the continuing influx of people in the valley, better methods of sewage management than on-site disposal are needed. Without utilizing these methods, higher levels of contamination are inevitable.

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