Water-Quantity, Water-Quality, Soil, and Sediment Data Collected at Goose Egg Spring, Natrona County, Wyoming, May and July 1992

By George F. Ritz and Breton W. Bruce

U.S. GEOLOGICAL SURVEY
Open-File Report 93-476

Prepared in cooperation with the
WYOMING GAME AND FISH COMMISSION

Cheyenne, Wyoming

1993

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
nanometer	3.3937×10^{-8}	inch
millimeter	0.03937	inch
centimeter	0.3937	inch
meter	3.281	foot
kilometer	0.6214	mile
liter	1.057	quart
cubic meter per second	35.31	cubic foot per second
gram	0.03527	ounce, avoirdupois
kilogram	2.205	pound, avoirdupois

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 9/5\ (°C) + 32.$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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Abstract

Recent, apparent increases in sedimentation in Goose Egg Spring, southwest of Casper, Wyoming, may have been the result of natural environmental processes or quarry operations near the spring in late 1991. Goose Egg Spring is the sole source of water for the Dan Speas Fish Rearing Station. This facility is operated by the Wyoming Game and Fish Commission, and produces about 77,000 kilograms of stockable fish annually. Samples of the spring water, surrounding soils, and bottom sediment were collected. Methods used in obtaining all samples are discussed. Results of chemical analyses of the spring water, stratigraphic description of core samples, particle-size distribution analysis, visual mineralogical assessment, and X-ray diffraction analysis were used to characterize Goose Egg Spring and the immediately surrounding area in May and July 1992.

INTRODUCTION

Goose Egg Spring in Natrona County, Wyoming, is the sole source of water for the Dan Speas Fish Rearing Station, operated by the Wyoming Game and Fish Commission. This is the largest fish rearing station in Wyoming, producing about 77,000 kilograms of fish annually. The spring is located on the eastern side of Bessemer Mountain, approximately 20 kilometers southwest of Casper, Wyoming (fig. 1). Beginning in October 1991, a local mining and construction company began quarrying limestone outcrops on the west side of Bessemer Mountain, about 2 kilometers west of the spring. Blasting operations at the quarry started in October and continued through December 1991. Personnel at the Dan Speas Station observed an apparent increase in sediment accumulation and delta formation in the spring shortly thereafter. Increased sediment accumulation within the spring could damage pumps that supply spring water to the Dan Speas Fish Rearing Station, while chemical changes in the spring water might be harmful to fish production. In response to the observations of increased sediment accumulation, the physical and chemical characteristics of Goose Egg Spring and immediately surrounding area were studied in cooperation with the Wyoming Game and Fish Commission.

Purpose and Scope

This report describes the physical and chemical characteristics in and around Goose Egg Spring during May and July 1992. Continuous records of stage were obtained beginning in June 1992, while periodic discharge measurements were made beginning in October 1991 (Druse and others, 1993). Spring water was sampled and analyzed for common ions, trace metals, and nutrients during May and July 1992. A water sample was collected for tritium analysis in July. Stratigraphic descriptions, particle-size distribution analyses, and visual mineralogical determinations were used to characterize the soils around, and depositional material in, the spring. X-ray diffraction analysis was used to provide a qualitative assessment of minerals present in selected soil samples and sediment cores.

Location and Site Description

Goose Egg Spring is located on the eastern slope of Bessemer Mountain at an elevation of about 1,600 meters above sea level, approximately 20 kilometers southwest of Casper (fig. 1). The spring is in the SE1/4 NE1/4 NW1/4 Sec.15, T. 32 N., R. 81 W. at latitude 42°44'40", longitude 106°31'56". Surficial geology around the spring is comprised of material from the Goose Egg Formation of Permian to Lower Triassic age, Chugwater Group of Triassic age, and nearby Quaternary alluvial deposits. Water from Goose Egg Spring has been identified as originating

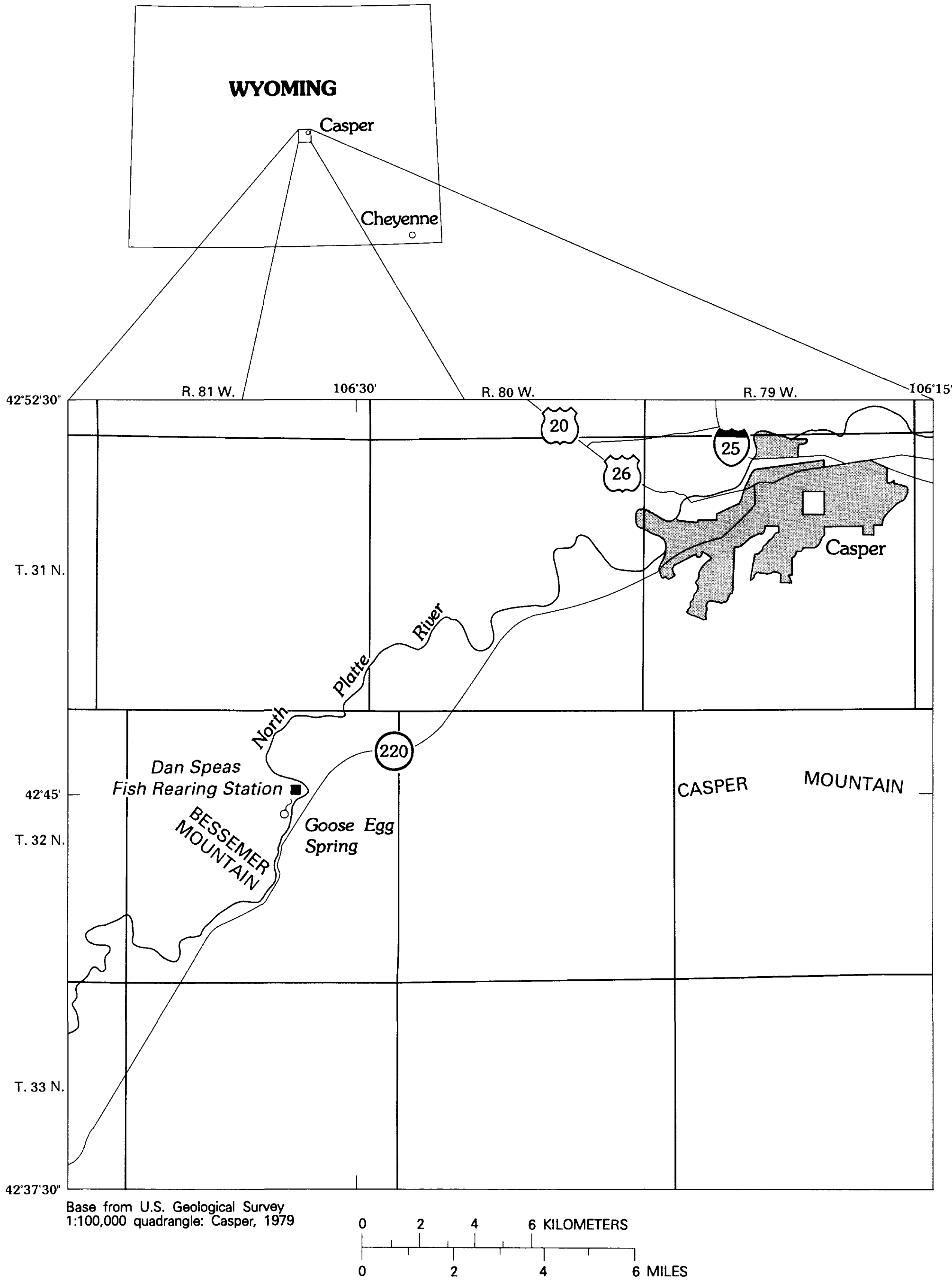

Figure 1.--Location map showing Goose Egg Spring, southwest of Casper, Wyoming.

from the Casper Formation of Middle to Upper Pennsylvanian or Lower Permian age and classified as a calcium bicarbonate type by Crist and Lowry (1972, p. 47-49).

The spring is divided into an upper and lower pool by a dam constructed of steel sheet piling (fig. 2). The dam was installed in 1958 (Steve Gnagy, Superintendent, Dan Speas Fish Rearing Station, oral commun., 1993). Water flows from the upper pool into the lower pool through a cut-out section in the sheet piling, which acts as a weir. The upper pool contains three main areas of upwelling water; the lower pool contains one small area of upwelling water. Maximum depth of water measured in the upper pool was 2.2 meters; water depth in the lower pool was not measured. Most of the spring water is routed about 1.5 kilometers through a concrete pipe, northeast to the Dan Speas Fish Rearing Station. A small diversion from the lower pool carries about 0.03 cubic meter per second (1 cubic foot per second) of water to a private user. In addition, the water from two smaller springs discharges into the upper pool of Goose Egg Spring (fig. 2). The spring discharge from the west was smaller than the discharge from the southwest spring. Inflow from the west spring enters Goose Egg Spring by a hillside rivulet while water from the southwest spring is piped along the hillside to Goose Egg Spring through a semicircular steel conduit about 0.6 meter in diameter, covered by galvanized steel roofing material. Reddish gravel, sand, and mud, visually similar to the surrounding soil, were observed on the cover of the conduit during the May and July 1992 sampling. The discharges from the two small inflow springs were not measured for this study.

Acknowledgments

The authors wish to thank Steve Gnagy, Superintendent of the Dan Speas Fish Rearing Station, for his substantial assistance in all aspects of this project and Karen McCormack, Department of Geology and Geophysics, University of Wyoming, for X-ray diffraction analysis of soil samples and sediment-core layers.

SAMPLING TECHNIQUES

Water samples were collected over the three major areas of upwelling water in the upper pool of Goose Egg Spring during the May and July 1992 sampling using a 1 liter, acrylic, Kemmerer sampler. Samples were collected from a canoe. The Kemmerer sampler was lowered to a position directly above the refluxing sand, a depth of about 2.2 meters, and samples were collected. Prior to this study, grab samples were collected from the lower pool near the grated entrance to the pipe leading to the Dan Speas Fish Rearing Station using the equal-width increment (EWI) method with a polyethylene DH-81, hand-held sampler.

Prior to sampling, all sampling equipment used in May and July 1992 was soaked in a chlorine bleach solution for about 30 minutes for disinfection, and, while wet, wrapped in cellophane at the Cheyenne office of the U.S. Geological Survey (USGS). This process ensured that the sampling equipment would not contaminate Goose Egg Spring with pathogens that cause disease in fish. At Goose Egg Spring, the Kemmerer sampler was rinsed three times in native water to remove any residual chlorinated species before samples were collected. The churn splitter used in the compositing of samples from Goose Egg Spring was first cleaned with an Alconox solution, rinsed three times with tap water, rinsed with a 5 percent (by volume) hydrochloric acid solution, and then rinsed three times with deionized water. To prevent contamination during transport, the lid to the churn splitter was taped to the body of the churn, and the spigot was wrapped in a plastic bag, which then was taped closed over the spigot. At the spring, the churn was rinsed three times with native water. Eleven, 1-liter samples were collected over the three main areas of upwelling water in the upper pool and composited in the churn splitter. Representative aliquots were obtained for chemical analyses.

One tritium sample was collected from the upper pool of the spring in July 1992 using the Kemmerer sampler, although compositing through the churn splitter was not done. Instead, the 1-liter water sample was transferred directly to a 1-liter, polyethylene bottle, and the bottle was sealed with electrical tape. Atmospheric contact was minimized during transfer to the sample bottle by draining the Kemmerer sampler through a small stopcock in the bottom of the sampler rather than opening the top of the Kemmerer sampler and pouring the sample into the polyethylene sample bottle.

Nine soil samples of surficial material from the hillslopes around Goose Egg Spring and the small feeder springs were collected in May 1992 (fig. 2). Samples were collected to a depth of about 5 centimeters. Approximately 400 grams of soil were collected in each sample and placed in small plastic bags which were labeled according to location. Soil-sample sites were located to characterize surficial material on the hillslopes surrounding the upper pool of

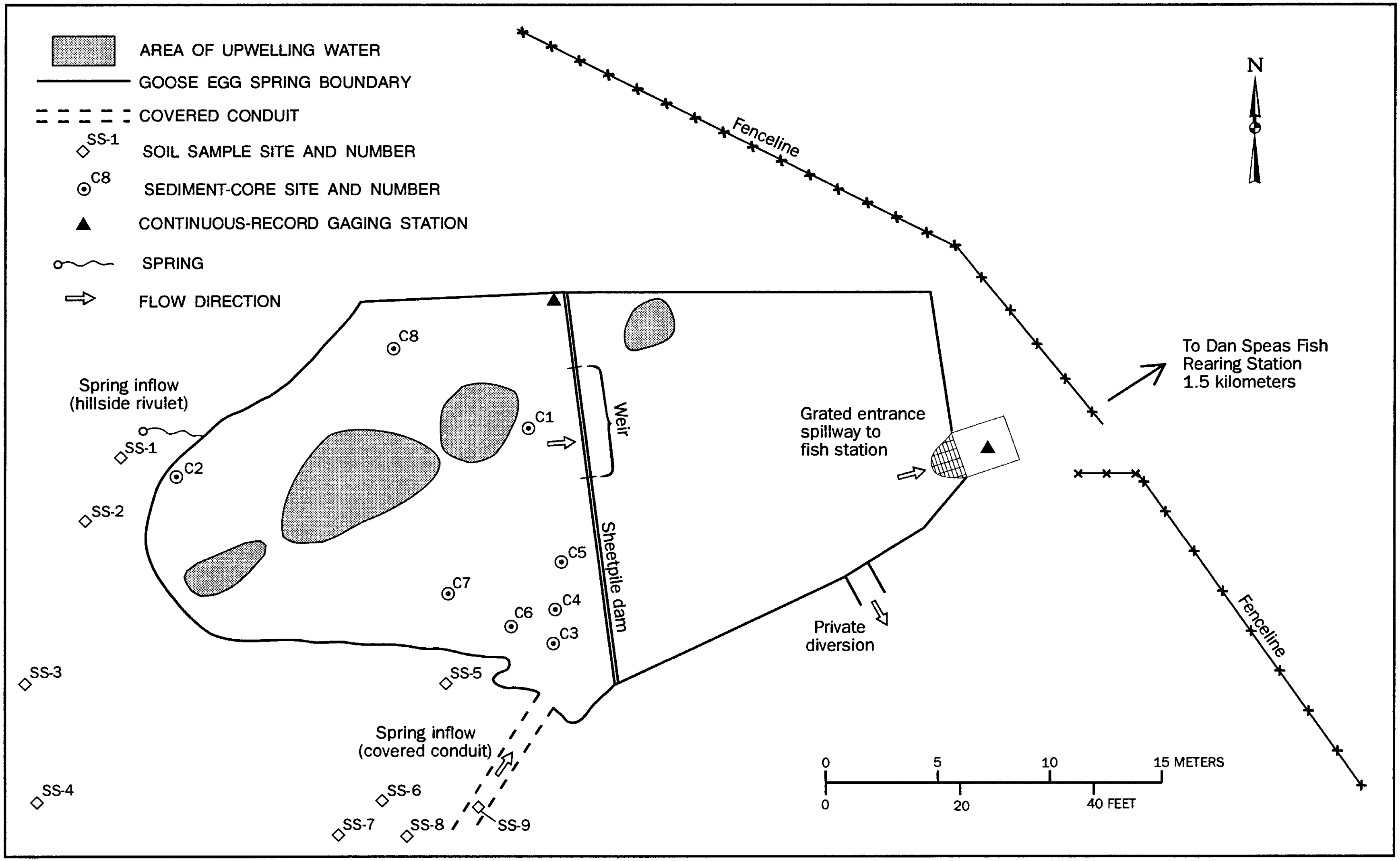

Figure 2.--Diagram of Goose Egg Spring showing spring boundaries, covered conduit, private diversion, sediment-core sites, location of continuous-record gaging stations, approximate location of soil sample sites, and areas of upwelling water, May 1992.

the spring and areas where slopewash into the spring appeared likely. Approximate locations of soil-sample sites are shown in figure 2.

Sediment-core samples were collected from eight sites in the upper pool of Goose Egg Spring in May 1992 (fig. 2). Sampling sites were located to characterize deltas and side deposits in the spring. A modified Livingstone sampler was used to collect the sediment cores. The sampler was intruded into the bottom material by hand until downward progress was completely stopped. To retain the stratigraphic character of the cores, the Livingstone sampler was not twisted to achieve greater core depth. The cores were extruded from the sampler and wrapped in cellophane. These wrapped cores then were wrapped again with heavy-duty aluminum foil, labeled, and placed in a 6.35-centimeter diameter, polyvinyl chloride (PVC) tube that had been cut lengthwise to accept the cores. The two halves of the PVC pipe then were closed together with duct tape around the sediment-core samples for transportation to Cheyenne.

Locations where sediment-core samples were collected from the upper pool of Goose Egg Spring were determined using a Hilger-Watts optical surveying level. The outline of the spring pools and relevant reference marks and structures also were surveyed to produce a diagram of the site at the time of sampling in May 1992 (fig. 2).

WATER QUANTITY

Initially, stage-discharge information was collected at the grated entrance to the circular pipe that supplies the Dan Speas Fish Rearing Station with water from Goose Egg Spring. A USGS gagehouse was built at this location in April 1992 (fig. 2); however, the resulting stage record at this site was extremely complex because of the operation of pumps at the fish rearing station and the constant shifting of headboards. A second measurement gage was installed in June 1992 in the upper pool, adjacent to the steel, sheetpile dam (fig. 2). Both gages were of the stilling-well type and were equipped with graphical, continuous-stage recorders. Discharge from the spring was measured monthly using a Price AA or pygmy flow meter.

On agreement with the Wyoming Game and Fish Commission, stage and discharge data from the gage in the upper pool were published in the 1992 USGS Annual Data Report for Wyoming (Druse and others, 1993, p. 547-549), and are not included in this report. Data is listed under "Goose Egg Spring (upper pool) near Goose Egg, Wyoming," station identification number is 424440106315601.

WATER QUALITY

Water samples collected from the upper pool of Goose Egg Spring in May and July 1992 were analyzed for common ions, trace elements, and nutrients at the USGS National Water Quality Laboratory in Arvada, Colorado. A separate water sample collected in July 1992 was analyzed for tritium by the Rosensteil School of Marine and Atmospheric Science Tritium Laboratory at the University of Miami in Florida. The results are listed in table 1 along with analyses of water samples collected from Goose Egg Spring prior to the start of this study. During the May and July 1992 sampling, specific conductance, water temperature, barometric pressure, dissolved oxygen concentrations, and field alkalinities also were measured.

SOIL AND SEDIMENT

Particle-Size Distribution

Three soil samples, SS-2, SS-6, and SS-9 were analyzed for particle-size distribution. Soil material was mixed inside the original plastic collection bag until visually homogeneous, then a subsample was removed from the bag and weighed. The subsample was then placed in a shaker sieve and shaken for approximately 30 minutes. Ten screens were used in the sieve, from a 32-millimeter screen opening to 0.062-millimeter opening. Material retained on each screen after shaking was weighed, as well as the material which passed through the 0.062-millimeter screen (labelled "pan"), then the individual weights were summed and compared to the initial subsample weight. Analysis weights which differed from the initial subsample weight by 3 percent or less were accepted, otherwise the analysis was rejected, screens were cleaned, and the process repeated with another subsample of soil.

If the analysis was accepted, the weight of material retained on each screen was converted to a percentage of the final analyzed weight. Cumulative percentages of original subsample retained on screen sizes down to a specified screen opening size were subtracted from 100 percent. This indicated the percentage of subsample material finer than the screen

Table 1. Physical characteristics and concentrations of chemical and radiological species in water, Goose Egg Spring near Casper, Wyoming, through July 1992

[NGVD, National Geodetic Vertical Datum of 1929; m^3/s, cubic meters per second; ft^3/s, cubic feet per second; lab, laboratory; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; NTU, nephelometric turbidity units; mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no data; <, less than; ±, plus or minus]

Date	Elevation of land surface datum (meters above NGVD)	Discharge, instantaneous (m^3/s)	Discharge, instantaneous (ft^3/s)	Specific conductance, field (µS/cm)	Specific conductance, lab (µS/cm)	pH, water, whole, field (standard units)	pH, water, whole, lab (standard units)	Temperature, air (°C)	Temperature, water (°C)	Turbidity (NTU)	Barometric pressure (mm of Hg)	Oxygen, dissolved (mg/L)
10-11-89	1,600	0.45	16	655	578	7.3	7.8	18.0	15.5	0.60	--	--
8-31-90	1,600	0.51	18	--	620	--	7.8	16.0	15.5	1.2	--	--
10-24-91	1,600	0.51	18	610	636	--	7.7	7.0	15.5	.30	--	--
5-27-92	1,600	0.48	17	--	644	7.7	7.8	13.5	14.5	--	628	5.9
7-17-92	1,600	0.51	18	670	654	7.6	7.8	24.5	15.5	--	636	6.7

Date	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Potassium, dissolved (mg/L as K)	Bicarbonate, water, dissolved iterative titration, field (mg/L as HCO_3)	Carbonate, water, dissolved iterative titration, field (mg/L as CO_3)	Alkalinity, water dissolved iterative titration, field	Alkalinity, lab (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)
10-11-89	280	77	22	27	0.7	1.8	--	--	--	180	73
8-31-90	280	77	22	23	.6	2.5	--	--	--	170	84
10-24-91	280	79	21	24	.6	2.4	--	--	--	190	75
5-27-92	280	77	21	24	.6	2.4	242	0	198	194	78
7-17-92	280	78	21	23	.6	2.5	236	0	193	197	81

Table 1.--Physical characteristics and concentrations of chemical and radiological species in water, Goose Egg Spring near Casper, Wyoming, through July 1992--Continued

Date	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, total (mg/L as P)	Aluminum, dissolved (µg/L as Al)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)
10-11-89	41	0.3	13	365	0.4	<0.03	--	3	67	--	40
8-31-90	46	.3	12	370	.20	<.03	<10	3	<100	--	40
10-24-91	42	.2	12	372	.40	<.03	<10	3	68	<0.5	50
5-27-92	47	.3	13	385	.49	.03	20	3	63	<.5	50
7-17-92	48	.2	12	384	.45	.01	<10	3	62	<.5	50

Date	Cadmium, dissolved (µg/L as Cd)	Chromium; dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)
10-11-89	<1	1	--	2	5	<1	--	<1	0.2	<1	1
8-31-90	<1	<1	--	2	10	<1	--	<10	<.1	<1	<1
10-24-91	<1	<1	<3	<1	23	<1	38	<1	<.1	1	<1
5-27-92	<1	4	<3	2	8	<1	36	<1	.2	<1	<1
7-17-92	<1	<1	<3	5	<3	1	33	<1	.5	1	<1

Date	Strontium, dissolved (µg/L as Sr)	Zinc, dissolved (µg/L as Zn)	Gross alpha, dissolved (µg/L as U-nat)	Gross alpha, suspended total (µg/L as U-nat)	Gross beta, dissolved (pCi/L as CS-137)	Gross beta, suspended total (pCi/L as CS-137)	Gross beta, dissolved (pCi/L as Sr/Yt-90)	Gross beta, suspended total (pCi/L as Sr/Yt-90)	Radium-226, dissolved, radon method (pCi/L)	Uranium, natural dissolved (µg/L as U)	Tritium, total (pCi/L)
10-11-89	--	<3	--	--	--	--	--	--	--	--	--
8-31-90	--	10	13 ± 4.3	<0.6	4.0 ± 1.2	0.8	3.1 ± 0.9	0.6	1.2 ± 0.17	6.6 ± 1.0	--
10-24-91	780	9	14 ± 4.7	<0.6	6.4 ± 1.6	1.2	4.8 ± 1.2	1.1	1.1 + 0.18	5.8 ± 0.90	--
5-27-92	800	3	--	--	--	--	--	--	--	--	--
7-17-92	800	14	--	--	--	--	--	--	--	--	35

Table 2. Particle-size distribution analyses of soil samples and sediment-core layers, in percent less than indicated size, Goose Egg Spring near Casper, Wyoming, May 1992

[Numbering system: SS-2, soil sample 2; C1-1, core 1, layer 1]

Sample	Screen opening size (millimeters)									
	32	16	8	4	2	1	0.5	0.25	0.125	0.062
SS-2	100.0	100.0	96.7	94.8	91.4	83.6	77.4	67.4	53.3	26.8
SS-6	100.0	100.0	80.3	68.4	58.2	49.7	41.4	31.7	24.0	15.9
SS-9	100.0	100.0	100.0	92.8	81.2	57.1	36.5	23.3	12.7	5.2
C1-1	100.0	100.0	98.7	90.7	77.0	51.1	29.7	19.8	14.3	9.9
C1-2	100.0	92.9	85.7	72.6	60.5	45.5	32.3	23.0	16.7	11.3
C1-3	100.0	100.0	96.9	85.6	61.4	30.4	5.5	2.1	1.5	.7
C2-1	100.0	100.0	85.3	81.2	73.9	66.2	58.3	49.0	38.8	22.6
C2-2	100.0	100.0	88.0	82.5	75.3	67.1	56.4	44.7	32.7	18.6
C4-1	100.0	100.0	100.0	99.4	96.0	86.2	58.0	29.3	11.2	3.9
C4-2	100.0	100.0	100.0	100.0	97.9	90.1	59.7	28.5	16.9	10.2
C4-3	100.0	100.0	100.0	99.5	96.6	88.0	74.3	54.4	35.9	19.6
C4-4	100.0	91.0	88.0	83.1	75.2	57.9	28.1	9.9	5.2	2.6

opening size. Table 2 indicates the percentage of subsample material that passed through specified screen opening sizes.

Sediment-core samples from the upper pool of Goose Egg Spring were transported to the USGS District office in Cheyenne, where each core was split lengthwise. Cores were photographed while still moist, and visual descriptions of the stratigraphy were recorded (see Sediment-Core Descriptions section of report). Both halves of each core were then air dried for approximately one week. Because of study limitations, only core samples C1, C2, and C4 were selected for additional analysis. These cores characterized bed material found in the middle of the upper pool (C1), the delta of the small spring inflow from the west (C2), and the delta of the larger spring inflow from the southwest (C4). From each core, the half with the most well-defined stratigraphy was separated into stratigraphic layers, and the layers were analyzed for their particle-size distribution in the same manner as the soil subsamples (table 2).

Visual Mineralogical Assessment

For the visual mineralogical assessment, the 0.5- to 1.0-millimeter fraction was examined from the particle-size distribution analysis of the composited soil samples SS-2, SS-6, and SS-9 and the individual stratigraphic layers in cores C1, C2, and C4. The following procedure for visually determining the mineralogical species present in each sample was used.

1. The sample was uniformly mixed in a sample bag by shaking until visually homogeneous.
2. A portion of the sample was poured into a sample tray and the tray was shaken to distribute the sample in a layer of single grains.
3. The sample tray was placed under a paleontological binocular microscope on the lowest magnification (1.05X), and all the grains in the field of view were separated for counting.
4. The grains were identified by mineral type and grouped on the tray on the basis of appearance. Criteria used for identification were color, cleavage, hardness, fracture, and twinning. The number of grains in each group was counted and recorded.
5. Each subset then was treated with dilute hydrochloric acid to differentiate carbonate and non-carbonate minerals. Grain counts were corrected for any misidentification. Differentiation between quartz and feldspar was not possible with this technique.
6. Prior to the treatment with hydrochloric acid, the "red composite grains" were poured onto a sheet of white paper and covered with a second sheet of white paper. The grains were rolled manually between the sheets of paper to crush the softer grains. The remaining powder and grains then were observed under the microscope.
7. The remaining "red composite grains" were treated with dilute hyrochloric acid.

The visual assessment of the "red composite grains" indicated that these grains were iron concretions, occasionally nucleated on quartz or limestone fragments. The most competent grains strongly effervesced and quickly disintegrated during the treatment with hydrochloric acid. Some small grains of quartz, muscovite, mafic minerals, and shell fragments were observed in the powder after the composite grains were crushed. The results of this visual mineralogical assessment are listed in table 3.

X-Ray Diffraction

X-ray diffraction analysis was used to qualitatively identify clays and crystalline minerals present in soil samples SS-2, SS-6, and SS-9 as well as in some stratigraphic layers of cores C1, C2, and C4. Nine samples from the soil samples and sediment cores were analyzed by the Department of Geology and Geophysics at the University of Wyoming, using a Scintag X-ray diffractometer. These samples consisted of the material from the particle-size distribution analysis of the respective soil samples and core layers with grain diameters less than 0.062 millimeters. The samples were prepared further for X-ray diffraction by wet grinding; the slurry was applied to a glass slide and then air dried at room temperature. Each sample then was X-rayed from 2 to 40 degrees, 2Θ (which represents the angle between the incident and reflected X-ray beam), at 2 degrees per minute on a solid-state detector with $CuK\alpha$ radiation. This X-radiation is produced by electron transition from an outer (L) to an inner (K) electronic shell from a copper (Cu) source. Characteristic wavelength for $CuK\alpha$ radiation is 15.418 nanometers (nm) (Klein and Hurlbut, 1985, p.222). The minerals identified in the respective samples are listed in table 4.

Table 3. Mineral distribution, by percent, from visual mineralogical analysis of soil samples and sediment-core layers, Goose Egg Spring near Casper, Wyoming, May 1992

[All values rounded to nearest percent; numbering system: SS-2, soil sample 2; C1-1, core 1, layer 1; --, not present]

Sample	Quartz	Feldspar	Limestone	Calcite (amorphous)	Composite grains	Comments
SS-2	3	--	--	13	84	Quartz subangular and frosted, shell fragments
SS-6	58	13	20	9	--	A few muscovite and mafic grains, organic material
SS-9	5	2	3	--	90	None
C1-1	9	4	11	23	53	Approximately 50 percent of the quartz is angular and frosted; other 50 percent is rounded and frosted
C1-2	10	3	10	18	59	Same as C1-1. Small muscovite fleck in powder from crushed composite grains
C1-3	49	48	--	2	1	Individual grains of mafic minerals and rock fragments observed in bulk sample
C2-1	50	24	1	10	15	Small muscovite fleck in powder from crushed composite grains
C2-2	56	13	--	6	25	Small muscovite flecks in powder from crushed composite grains, some organic material
C4-1	54	28	3	2	13	Some rounded and frosted quartz grains, most angular and polished, one grain of igneous rock (basalt)
C4-2	43	18	1	6	32	None
C4-3	44	24	2	15	15	Limestone shows laminae, snail shell, 10 pieces calcified organic material
C4-4	67	31	--	--	2	Quartz grains subrounded and polished

Table 4. Minerals identified by X-ray diffraction in soil samples and sediment-core layers, Goose Egg Spring near Casper, Wyoming, May 1992

[SS2, soil sample 2; C1-1, core 1, layer 1; X, mineral detected; --, mineral not detected]

Sample	Quartz	Potassium feldspar	Plagioclase feldspar	Illite	Muscovite	Gypsum	Calcite	Dolomite	Chlorite	Hematite
SS2	X	X	X	X	X	X	X	X	--	--
SS6	X	X	X	X	X	--	X	X	X	X
SS9	X	X	X	X	X	--	X	X	X	--
C1-1	X	X	X	X	X	--	X	X	X	X
C1-2	X	X	X	X	X	--	X	X	X	X
C2-1	X	X	X	X	X	--	X	X	X	X
C4-1	X	X	X	X	X	--	X	X	X	--
C4-2	X	X	X	X	X	--	X	X	X	X
C4-3	X	X	X	X	X	--	X	X	X	X

SEDIMENT-CORE DESCRIPTIONS

Eight sediment cores were collected at various locations in the upper pool of Goose Egg Spring (fig. 2). The core numbers match those shown in figure 2. The interval numbers were assigned during the core-description process to correspond to changes in stratigraphy. Descriptions and numbering of the individual stratigraphic layers in the sediment-core samples begin at the surface and proceed downward (table 5). Color designations are from Munsell soil color charts (Kollmorgen Instruments Corp., 1975) and are specified in parentheses. Unless specifically stated, the following scale of particle sizes and descriptions was used to characterize the stratigraphy of the core material:

silt and clay: less than 0.062 millimeter (mm)

very fine sand: 0.062 - 0.125 mm

fine sand: 0.125 - 0.250 mm

medium sand: 0.250 - 0.50 mm

coarse sand: 0.50 - 1.00 mm

very coarse sand: 1.00 - 2.00 mm

granules: 2.00 - 4.00 mm

pebbles: 4.00 - 64 mm

REFERENCES

Crist, M.A. and Lowry, M.E., 1972, Ground-water resources of Natrona County, Wyoming: U.S. Geological Survey Water-Supply Paper 1897, 92 p.

Druse, S.A., Glass, W.R., Ritz, G.F., and Smalley, M.L., 1993, Water resources data, Wyoming, water year 1992: U.S. Geological Survey Water-Data Report WY-92-1, 556 p.

Klein, C. and Hurlburt, C.S., Jr., 1985, Manual of mineralogy. Twentieth edition, John Wiley and Sons, 596 p.

Kollmorgen Instruments Corp., 1975, Munsell soil color charts: Newburgh, New York, Macbeth Division, 10 p. and color charts.

Table 5. Stratigraphic description of sediment-core layers, Goose Egg Spring near Casper, Wyoming, May 1992

[mm, millimeter; cm, centimeter; C1-1, core 1, layer 1; Color designations are from Munsell soil color charts (Kollmorgan Instruments Corp., 1975) and are specified in parentheses]

Layer	Depth interval (cm)	Description
		CORE 1
C1-1	Ground surface to 6.5	One large (about 1.5-cm square), limestone or shale chip on surface, interval poorly sorted. Limestone chips, rounded quartz grains, and rock fragments ranging in size from very fine sand to pebble. Red (2.5YR 4/6) mud matrix.
C1-2	6.5 to 12.5	Reddish mud matrix supporting limestone chips up to 0.5 cm, few medium sand grains and very little quartz sand.
C1-3	12.5 to 15.5	Similar to interval C1-1 in composition and color. One large (2 x 4 cm) limestone/shale pebble; pebble destroyed interval stratigraphy during splitting of core.
C1-4	15.5 to 17.5	Similar to interval C1-2 in composition and color.
C1-5	17.5 to 34.0	Coarse quartz sand, well-sorted in composition and size, grains generally well-rounded and polished. Some chert and occasional rock fragments and feldspars; grain sizes range from 0.2 to 5.0 mm.
		CORE 2
C2-1	Ground surface to 2.0	Very dark gray (5YR 3/1) mud matrix with thin, dark, possibly organic layers. Increased number of very coarse sand grains and pebbles at base of interval composed of quartz, rock fragments, and limestone chips.
C2-2	2.0 to 6.5	Reddish-brown (5YR 4/3) mud matrix with very fine sand, few medium sand grains, one large (1.0 x 1.5 cm) pebble of quartzite, and one red (2.5YR 4/6) mud clump.
C2-3	6.5 to 10.5	Similar to interval C2-1. Very dark gray mud matrix, medium sand grains more prevalent. Few small very red mud clumps.
		CORE 3
C3-1	Ground surface to 0.8	Vegetative mat.
C3-2	0.8 to 4.5	Reddish-brown (2.5YR 4/4) mud matrix. About 50 percent of sand grains are coarse size (1 mm). Sand predominantly composed of quartz and chert; some grains are polished.
C3-3	4.5 to 7.5	Dark reddish-brown (5YR 3/3) mud matrix with several organic layers. Wooden twig, 0.5 cm in diameter, near top of interval. Several seed casings noted. Rock fragments and limestone chips increase toward bottom of interval.
C3-4	7.5 to 8.5	Reddish mud layer with very few quartz sand grains.
C3-5	8.5 to 11.5	Similar to C3-2 interval. Bottom of core contains medium quartz sand and rock fragments.
		CORE 4
C4-1	Ground surface to 2.5	Steeply inclined basal contact. Dark reddish-brown (5YR 3/4) mud matrix. Fine to very fine sand prevalent.
C4-2	2.5 to 6.5	Slightly angled basal contact, high in relative percentage of sand. Sand grains coarse to very coarse (0.5-2.0 mm), mostly quartz. Most grains well-rounded, some are highly polished. Horizontal layer of very coarse sand grains at 3-cm level along which the core tends to separate. Some chert, rock fragments, and dark minerals. Few small clumps of red mud.
C4-3	6.5 to 11.5	Steeply angled basal contact. Dark red (2.5YR 3/6) mud matrix with small amount of dispersed very fine sand. Few medium (0.25-0.5 mm) quartz grains.

Table 5. Stratigraphic description of sediment-core layers, Goose Egg Spring near Casper, Wyoming, May 1992--Continued

Layer	Depth interval (cm)	Description
C4-4	11.5 to 13.5	Red mud with very little fine sand present. Several dark (organic) layers, angled, but parallel with each other. Sharp horizontal contact of clean sand at base of interval.
C4-5	13.5 to 19.5	Relatively well-sorted sand. Few granules and pebbles (2-5 mm) and one large, basal pebble (10 mm), possibly gypsum. The 13.5- to 14.5- and 16.5- to 19.5-cm intervals are slightly darker in color and appear to contain more mud. The 14.5- to 16.5-cm interval is well sorted, clean, white sand with mostly well-rounded quartz grains.
		CORE 5
C5-1	Ground surface to 2.5	Reddish-brown mud layer (2.5YR 4/4) containing very fine sand. Indistinct layer of slightly larger sand grains across center of interval.
C5-2	2.5 to 5.0	Sand, fine- to medium-grained (0.125-0.5 mm), reduced mud matrix. Grains mostly quartz, rounded, some highly polished.
C5-3	5.0 to 9.5	Muddy interval with some very fine (0.125 mm) dispersed sand. Zone from 7.5 to 8.5 cm is slightly more red in color and contains somewhat larger sand grains. Dark organic layers noted in muddy layer near bottom of interval. Sharp basal contact with lower interval.
C5-4	9.5 to 13.5	Fairly clean, white quartz sand, well-rounded grains. Few small pebbles.
		CORE 6
C6-1	Ground surface to 4.0	Muddy layer with very fine dispersed sand, several round pebbles. Desiccation crack at surface. Indistinct lower boundary.
C6-2	4.0 to 8.5	Interval appears to grade top-to-bottom from pebbles to fine, clean sand. Lower 1 cm of interval is clean, whitish quartz sand. Rounded quartz grains, some polished, few rock fragments.
C6-3	8.5 to 9.5	Reddish mud matrix with dispersed fine sand.
C6-4	9.5 to 13.5	Interval very poorly sorted in size and composition. Fine sand, pebbles, quartz pieces, rock fragments, and large clump of white clay. Sand in lower 1 cm of interval is brownish-yellow (10YR 6/8).
C6-5	13.5 to 16.5 cm	Reddish-brown mud, no sand. Upper 1.5 cm of interval exhibits black, organic color.
		CORE 7
C7-1	Ground surface to 1.0	Vegetative mat.
C7-2	1.0 to 2.0	Mud, very fine sand, plant roots.
C7-3	2.0 to 17.0	Coarse sand and pebbles. Quartz, quartzite, and rock fragments. Zone of larger pebbles from 6.0 to 9.0 cm.
		CORE 8
C8-1	Ground surface to 5.0	Reddish mud matrix. Medium quartz sand prevalent. One large (3 cm) pebble in center of interval.
C8-2	5.0 to 30.0	Grayish-brown mud containing numerous twigs and roots. One large (3 cm) pebble at top of interval. Indistinct lower boundary.
C8-3	30.0 to 36.0	Rust-red mud matrix. Several rounded, polished pebbles. Very fine, dispersed sand.
C8-4	36.0 to 40.0	Gray mud matrix. Medium quartz sand, rounded grains. Several larger quartz pebbles.

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