DELINEATION OF DRINKING WATER SOURCE PROTECTION ZONES FOR THE MOUNTAIN GREEN PUBLIC-WATER-SUPPLY WELL, MORGAN COUNTY, UTAH

by

Charles E. Bishop

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UTAH GEOLOGICAL SURVEY
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Cover Photo: The Weber River in western Morgan Valley near Mountain Green, Utah.

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DELINEATION OF DRINKING WATER SOURCE PROTECTION ZONES FOR THE MOUNTAIN GREEN PUBLIC-WATER- SUPPLY WELL, MORGAN COUNTY, UTAH

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ABSTRACT

The Mountain Green Water Association operates a single well to supply potable water for consumptive use by the Mountain Green subdivision, Mountain Green, Morgan County, Utah. The well is in western Morgan Valley, near the head of Weber Canyon. To protect the well from contamination and to comply with Utah's Drinking Water Source Protection Program, the water system managers are developing a drinking water source protection plan. I describe in this report the delineation of the drinking water source protection zones for the well, to be used in the plan.

The valley fill in Morgan Valley consists of Tertiary and younger sediments, primarily semiconsolidated to unconsolidated coarse gravel and cobbles, sand, silt, and clay. Some of these were deposited in Lake Bonneville during its highest level. Surficial sediments around the well are predominantly Holocene alluvial and Pleistocene lacustrine and alluvial-fan deposits. Tertiary and Precambrian rocks crop out in the mountains above the well. Multiple episodes of deformation, including Sevier orogenic compression and subsequent Basin and Range extension, have affected this area.

The well was drilled to a total depth of 163 feet (50 m) and has a 30-foot-long (9 m) perforated interval, from 130 to 160 feet (40-49 m) in depth. The well derives water from coarse-grained intervals below 130 feet (40 m). A well test, performed when the public-water-supply well was completed in July of 1962, indicates that the local aquifer has relatively high transmissivity. Recharge mechanisms to the valley-fill aquifer include infiltration of direct precipitation, significant seepage of surface water from streams and irrigation canals along the valley margins, and underflow from the surrounding mountains. Water levels in Morgan Valley indicate that ground water moves from the valley margins towards the valley center, and then westward.

I used a "Preferred Delineation Procedure" to delineate protection zones around the Mountain Green Water Association well. I combined field observations and aquifer data with a semianalytical, steady-state, two-dimensional ground-water-flow model to delineate the protection zones. The particle-tracking algorithm used in the model requires estimates of porosity, flow direction, hydraulic gradient, and transmissivity to predict ground-water flow pathlines and travel times to the well. Protection zones were generated for 250-day (zone 2), 3-year (zone 3), and 15-year (zone 4) ground-water travel times. Results from the simulation and subsequent particle tracking indicate that the protection zones for the well are large fan-shaped zones that extend upgradient from the well. The maximum extent of the zones, under maximum pumping conditions, is approximately 4700 feet (1400 m) upgradient, 400 feet (120 m) downgradient, and 7000 feet (2100 m) wide.

INTRODUCTION

This report describes the delineation of drinking water source protection (DWSP) zones for an existing public-water-supply well (Utah Division of Drinking Water system number 15015, source number 01) in the NW¼NW¼SE¼ section 26, T. 5 N., R. 1 E., Salt Lake Base Line and Meridian, in western Morgan Valley, Morgan County, Utah (figure 1). The well is in western Mountain Green near Interstate 84, at the head of Weber Canyon. The Mountain Green Water Association, which requested and assisted in this delineation of DWSP zones, owns the well. The well provides drinking water to the Mountain Green subdivision. The scope of work included a literature search, review of water-well logs, field reconnaissance, interpretation of test data, delineation of the DWSP zones, and preparation of this report.

Utah's Drinking Water Source Protection Rule (R309-600, Utah Administrative Code; administered by the Utah Division of Drinking Water) requires public-water suppliers in Utah to develop a DWSP plan for each well or spring used as a public drinking-water source. The delineation of DWSP zones around public-water supplies is a major component of the DWSP plan. The delineation of DWSP zones is part of a preventive strategy to minimize potential degradation of water quality by defining areas in which contamination or withdrawals would significantly affect the water supply. This strategy creates a limited area to concentrate resources for inventory, control, and monitoring with an overall goal of assuring the quality of public-water supplies. Local governments can then implement land-use regulations to reduce the risk of future ground-water contamination and costly remediation efforts in these areas. Utah's DWSP Rule (R309-600-9 [3]) defines four DWSP zones:

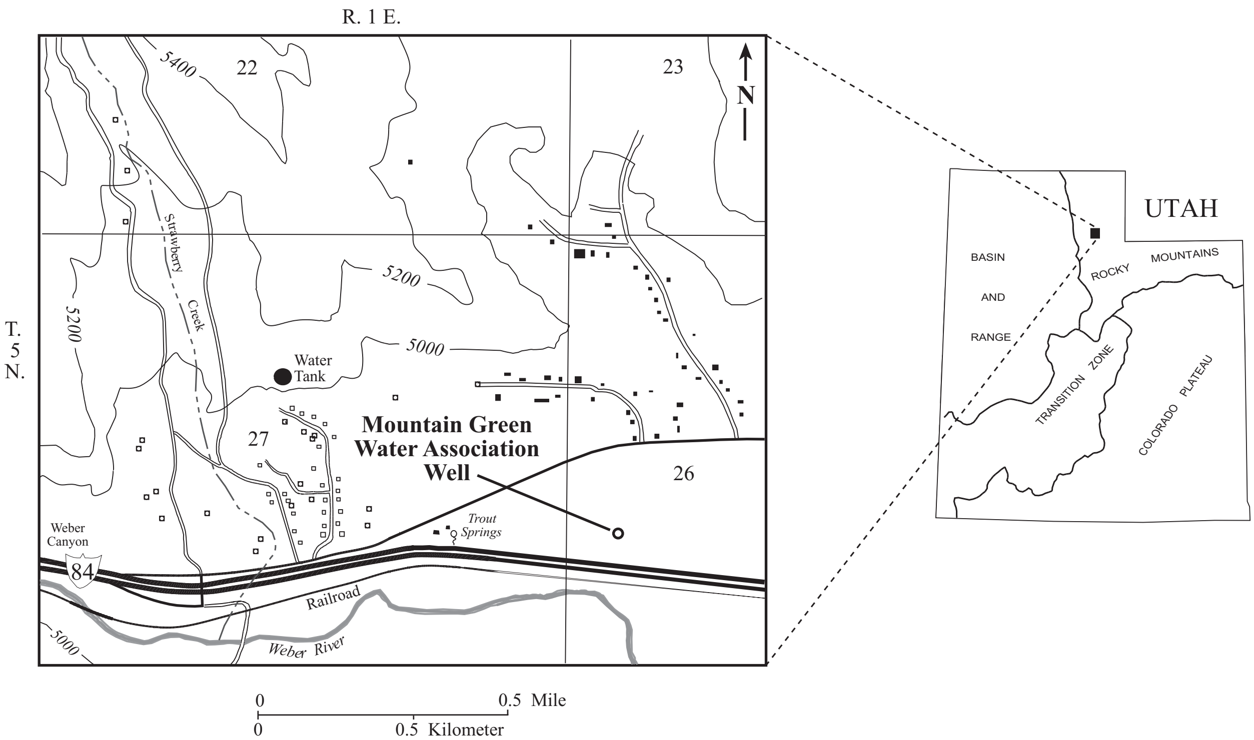

Figure 1. *Location of the Mountain Green Water Association well.*

Zone 1 - the area within a 100-foot (30 m) radius from the wellhead;

Zone 2 - the area within a 250-day ground-water time-of-travel to the wellhead, the boundary of the aquifer(s) which supplies water to the well, or the ground-water divide, whichever is closer to the well;

Zone 3 (waiver zone) - the area within a 3-year ground-water time-of-travel to the wellhead, the boundary of the aquifer(s) which supplies water to the well, or the ground-water divide, whichever is closer to the well; and

Zone 4 - the area within a 15-year ground-water time-of-travel to the wellhead, the boundary of the aquifer(s) which supplies water to the well, or the ground-water divide, whichever is closer to the well.

The DWSP Rules require the delineation of zones 1, 2, and 4. A waiver zone, zone 3, is included to help the water supplier with future monitoring waivers (see R309-600-9-[3][iii]).

To delineate DWSP zones, one of two procedures may be used: (1) a "Preferred Delineation Procedure," based on ground-water times of travel and local geology and hydrogeology, or (2) an "Optional Two-Mile Radius Delineation Procedure," based on identifying all upgradient areas supplying water to a well or spring within a 2-mile (3.2 km) radius of the drinking-water source. I delineated the DWSP zones for the Mountain Green well using the "Preferred Delineation Procedure" because this approach incorporates information about the hydrogeologic system and I believe it is more accurate than the other procedure.

In this study, I delineated DWSP zones 2, 3, and 4. Zone 1, a 100-foot (30 m) fixed radius around the well, is not shown on the map or discussed further in this report.

GEOLOGY

The Mountain Green Water Association's well is in northwestern Morgan Valley, on the east side of the Wasatch Range. Morgan Valley is part of the Wasatch Hinterland section of the Middle Rocky Mountains physiographic province (Stokes, 1977), and is also referred to as a back valley of the Wasatch Range. The Wasatch Range trends north and has a minimum structural relief, between basement rocks under Morgan Valley and the crest of the mountains, of about 10,800 feet (3300 m) (Naeser and others, 1983). Morgan Valley is part of the Weber River drainage and is a northwest-southeast trending valley that abruptly bends westward at its northern end, following the Weber River. The Weber River leaves Morgan Valley through Weber Canyon, west of the well. The Weber River's elevation is about 4770 feet (1450 m) near the well. The topography of the area includes gentle slopes and low hills in the valley and steep slopes in the mountains.

Stratigraphic and radiometric data suggest that multiple tectonic episodes have affected the area (Hedge and others, 1983), including Sevier orogenic compression and subsequent Basin and Range extension. These tectonic episodes formed a series of small grabens in the study area bounded by a complex system of faults (Naeser and others, 1983).

Extensive erosion in the area subsequently filled the grabens with Tertiary and younger sediments (Naeser and others, 1983). The variation in thickness of Tertiary sediments reflects syndepositional fault activity.

Structural features in the area include northwest-trending and relatively steeply (>70°) dipping, irregularly spaced, planar high-angle normal faults with minor branches. The geologic map (figure 2) shows only the more continuous faults. The faults clearly cut the exposed Precambrian rocks; however, it is less clear how they affect the Tertiary rocks because these rocks are poorly exposed. Erosion by the Weber River, and the underlying structural elements helped form the present-day topography of Morgan Valley.

Tertiary and Precambrian rocks underlie and crop out near the well (figure 2) (Bryant, 1984; Gates and others, 1984). The mid- to late-Eocene Norwood Tuff unconformably overlies the Paleocene to early Eocene Wasatch Formation and underlies the unconsolidated deposits in some areas. The Norwood Tuff is composed of white or light gray to pale green tuff, altered tuff, tuffaceous sandstone, and conglomerate containing some gray to reddish-brown shale (Bryant, 1984). The Wasatch Formation consists of grayish-red to red quartz-pebble conglomerate, sandstone, siltstone, clay, and minor limestone; it unconformably overlies the Precambrian Farmington Canyon Complex and underlies the unconsolidated deposits around the well (Bryant, 1984). The

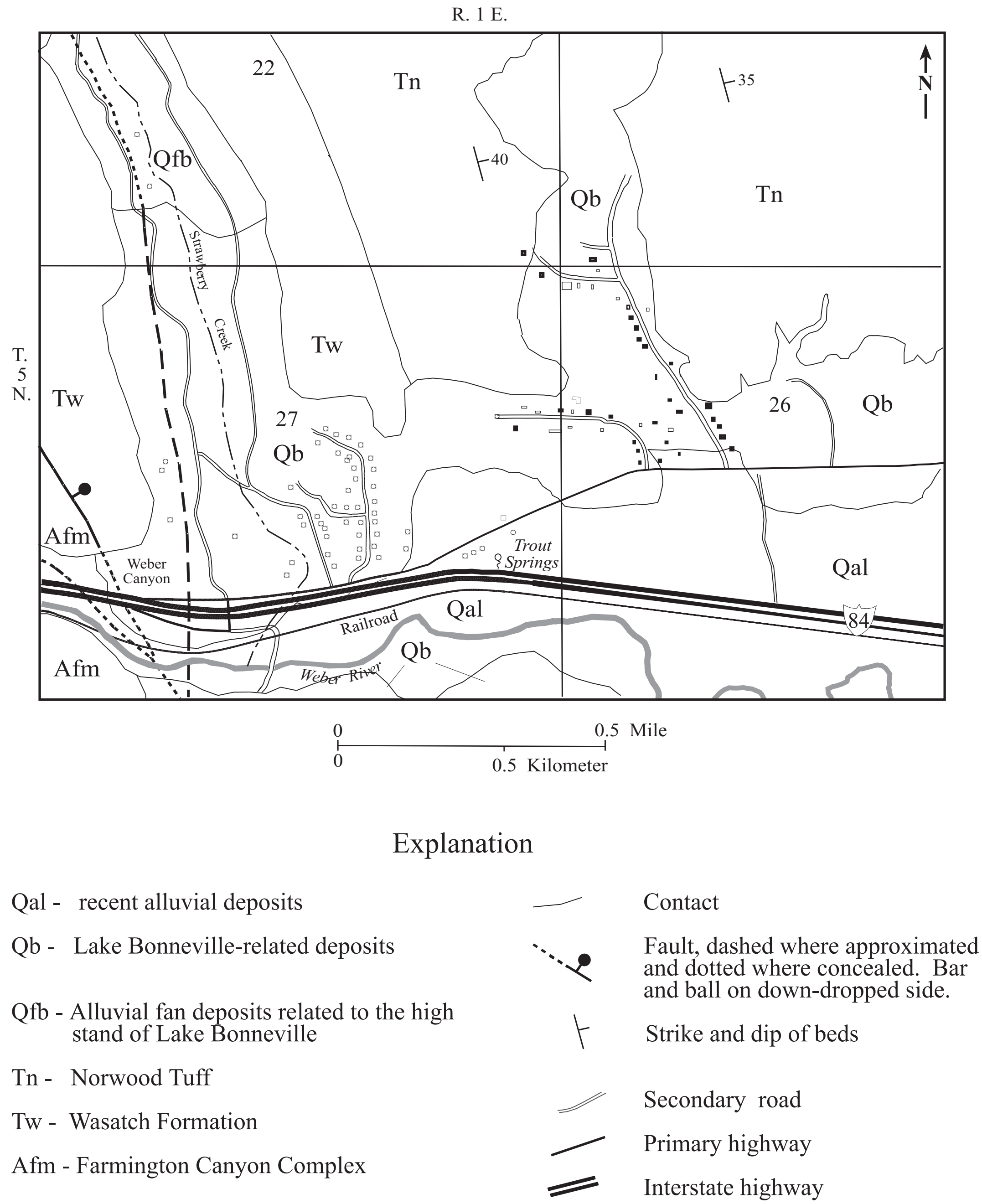

Figure 2. *Geologic map of the western Morgan Valley area, northern Utah (modified from Bryant, 1984).*

Farmington Canyon Complex, exposed within the Wasatch Range to the west, consists of a migmatitic gneiss that probably represents highly deformed and metamorphosed sedimentary rocks (Bryant, 1984). The absence of surface exposures of Paleozoic and Mesozoic rocks suggests erosion has removed these rocks, although some may be buried beneath younger rocks.

Surficial sediments near the well consist of predominantly Holocene alluvial deposits of silt, sand, and gravel, and late Pleistocene lacustrine and alluvial-fan deposits of clay, silt, sand, and gravel. Alluvial deposits along the Weber River and its tributary streams are generally fine-grained sediments near the river and coarser grained sediments away from the river. The alluvium probably has a maximum thickness in the Mountain Green area of about 200 feet (60 m) (Saxon, 1972). Lake Bonneville formed an estuary in Morgan Valley during its highest level, and rivers entering the estuary deposited clast-supported coarse gravel and cobbles in a matrix of sand, silt, clay, and marl that is exposed above the present river flood plain.

The driller's log for the well indicates that alluvium, consisting of clay, sand, and gravel, is at least 163 feet (50 m) thick (appendix A). The well log indicates that fine-grained material ("clay") forms less than 1 percent of the total thickness of the fill at the well site. Other wells in the area indicate that up to 33 percent of the fill is composed of fine-grained materials.

WELL CONSTRUCTION AND PUMP DATA

The well was cable-tool drilled at a surface elevation of 4825 feet (1471 m) in July 1962. The well is 163 feet (50 m) deep, and is cased with 8-inch (20 cm) diameter casing from the surface to 163 feet (50 m). The casing is 0.330 gauge steel and welded at all joints, and is perforated by Mill's knife from 130 to 160 feet (40-50 m), with 180, 3/8 by 1-½ inch (1 by 4 cm) perforations. The Mountain Green Water Association houses the well, pump controls, valves, and in-line flow meter in a concrete structure that is part underground.

The pump in the Mountain Green well is a 460 volt, 7.5-horsepower, three-phase submersible Grundfos pump, rated at a maximum pumping rate of 70 gallons per minute (0.3 m^3/min). Pump depth is unknown.

HYDROGEOLOGY

Ground water occurs in unconsolidated alluvium and in older semiconsolidated and consolidated rocks in Morgan Valley (Gates and others, 1984). Ground water in the alluvium is commonly unconfined. Wells in the Morgan Valley alluvium have average yields of about 149 gallons per minute (0.5 m^3/min), and maximum reported yields as high as 2500 gallons per minute (9.5 m^3/min) (Gates and others, 1984). Lower permeability consolidated sedimentary and volcanic rocks underlie and bound the valley-fill aquifer laterally.

Regional ground-water and surface-water flow is from the topographic divides in the Wasatch Range and surrounding hills, toward the mountain front, and ultimately to and along the Weber River. Locally the associated south-southeast-facing drainages affect the movement of ground water. In and near the lower valley, recharge is from direct precipitation, seepage from tributary perennial and ephemeral streams, seepage from irrigation canals located along the valley margins, and underflow from the surrounding rocks along the valley margins (Gates and others, 1984). Recharge area boundaries coincide with the topographic slope breaks in the mountains. Ground water moves from areas of recharge to discharge in response to hydraulic gradients. Discharge is by seepage to the Weber River; transpiration by phreatophytes, crops, and pastures; discharge from wells and springs; and underflow out of the area in the alluvium of the Weber River valley (Gates and others, 1984).

Water levels in western Morgan Valley indicate that ground water moves generally perpendicular to the mountain front and inward from the valley margins, and westward in the center of the valley toward and along the Weber River (figure 3). Steep water table gradients along the valley margins may indicate lower permeability materials in these areas. Near Cottonwood Creek, a major drainage east of the well (figure 3), ground water moves down the valley toward the Weber River. Hydraulic gradients range from about 0.002 in the center of the valley to 0.02 near the mountain front, and the orientation of the hydraulic gradient varies. The hydraulic gradient of the aquifer in the area of the well is approximately 0.003 to the west.

AQUIFER DATA

The principal aquifer in Morgan Valley, which the Mountain Green Water Association's well taps, is unconfined, and consists of unconsolidated sediments (Gates and others, 1984). The municipal well partially penetrates this unconfined valley-fill aquifer. Water was encountered during the drilling of the well below 116 feet (35 m). The driller's report for the well indicates no significant clay layers above the well perforations, and an examination of other drillers' reports, for surrounding wells, indicates no extensive clay layers in the area. The driller's report for the well indicates the water-yielding interval was composed of gravel. I consider the aquifer unprotected.

The effective aquifer thickness (section of aquifer supplying water to the well) influences the aquifer characteristics determined from a well test. Based on the driller's log, about 18 percent (30 feet [9 m]) of the well is perforated. Well perforations are typically positioned at permeable intervals in the well, where the well encounters water. Sediments adjacent to perforated intervals provide water, and ground-water flow converges to the perforated intervals. This part of the aquifer supplies the bulk of the water to the well; I used the perforated intervals of 30 feet (9 m) as the aquifer thickness. I estimate the porosity of the sediments described in the well driller's log to range between 25 to 35 percent with an average of about 30 percent. The effective porosity of the sediments is approximately 25 percent.

Because a large pumping rate is required to effectively stress the aquifer, and an aquifer test at such a rate is cost-prohibitive for this water system, an aquifer test was not conducted for this study. In addition, the proximity of the well to Interstate Highway 84 could allow water to flow onto the

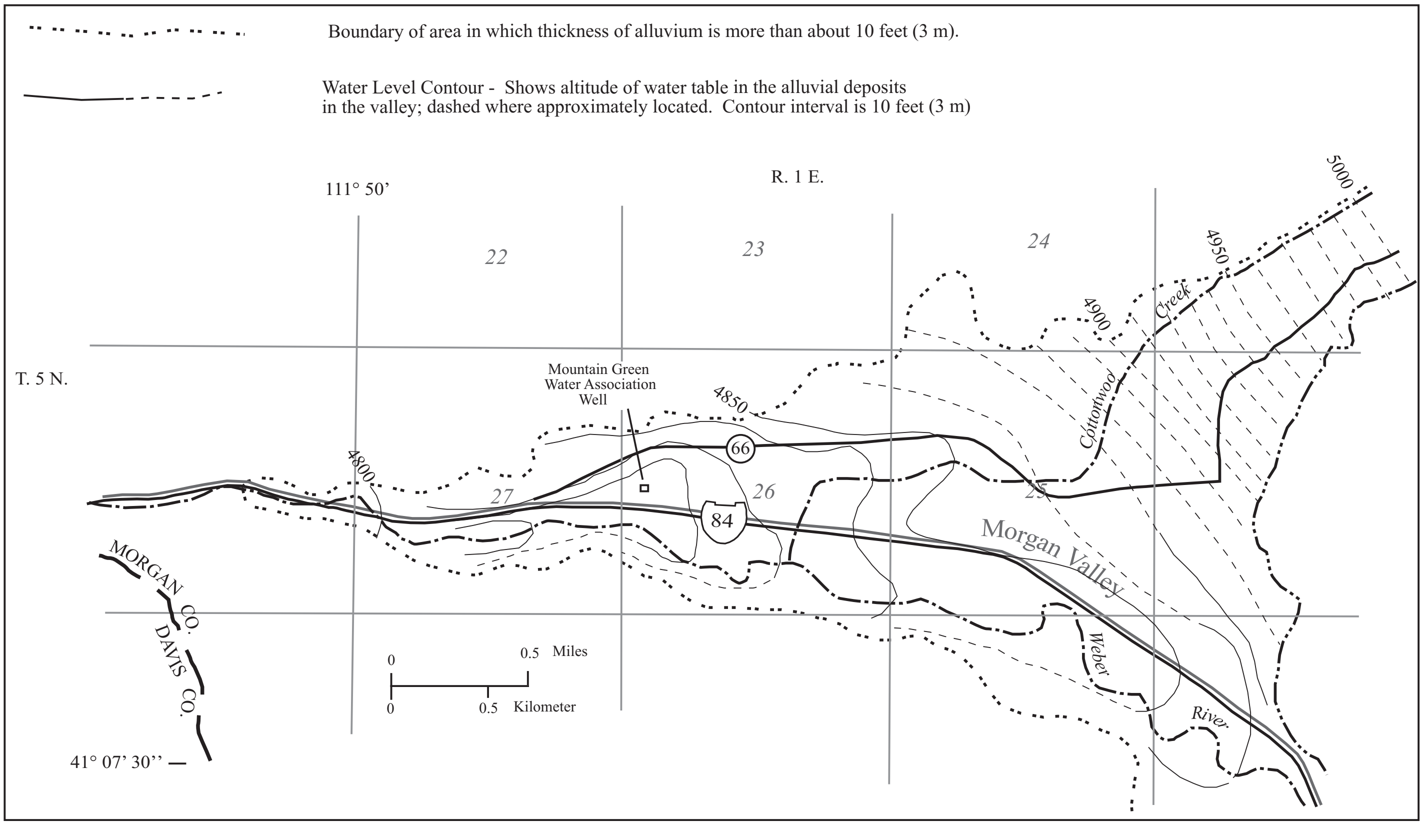

Figure 3. *Water-level contours in the unconsolidated valley fill of western Morgan Valley (from Gates and others, 1984).*

highway during any aquifer test for the well. Instead, I used well-test data reported on the driller's report (appendix A) to estimate aquifer transmissivity. That test, performed after the well's completion in 1962, involved bailing the well at 150 gallons per minute (0.6 m^3/min) for 0.5 hours and measuring 15 feet (5 m) of drawdown. The specific capacity of the well based on the well test was 10 gallons per minute per foot (0.12 m^3/min/m). This specific capacity of the well is representative of the aquifer system intercepted by the well, and will provide a reasonable aquifer transmissivity (Theis, 1963; Walton, 1991).

I estimate the transmissivity of the aquifer penetrated by the well using a theoretical relationship from Theis (1963) for specific capacity, Theis' aquifer test solutions, and an assumption of 100 percent efficiency. Using these factors, I estimate the transmissivity of the aquifer to be about 1700 square feet per day (160 m^2/day).

DRINKING WATER SOURCE PROTECTION ZONES

I delineated DWSP zones 2, 3, and 4 for the well using hydrogeologic data and application of the RESSQC module of WHPA, version 2.1. WHPA is a two-dimensional semi-analytical ground-water-flow model published by the U.S. Environmental Protection Agency. The RESSQC module delineates two-dimensional time-related capture zones for pumping, injection, or a combination of pumping and injection wells in a homogenous aquifer of infinite aerial extent and steady-state ground-water flow (Blandford and Huyakorn, 1991). Time-related capture zones are based on the volume of aquifer supplying water and a specified pumping rate of a well for a given time. Particle tracking in the RESSQC module is based on Darcy's law for water flowing through a porous medium. The semianalytical model requires that the direction and magnitude of a regional hydraulic gradient, transmissivity, porosity, and thickness of the aquifer be specified.

I assumed the maximum pumping rate of the well, 70 gallons per minute (0.3 m^3/min), equivalent to 13,500 cubic feet per day (380 m^3/day), to simulate time-related capture zones for the well. In accordance with the determined value of transmissivity from this report, I used a transmissivity of 1700 square feet per day (160 m^2/day) representing a hydraulic conductivity of 57 feet per day (17 m/day) (table 1). I assumed that the aquifer was isotropic and homogeneous and has an effective porosity of 25 percent, based on the driller's log of the well. I used a flow field having a roughly uniform hydraulic gradient of 0.003, determined from measured water levels in the area, that varied from N. 45° E. to S. 45° E. Using this hydraulic gradient and conservative hydraulic parameters provides a conservative (protective) protection zone and compensates for the uncertainty of the variables used in the delineation.

DWSP zones 2, 3, and 4 for the well are shown on figure 4 and given in table 2. The relatively moderate pumping rate, high hydraulic conductivity, and the variable direction of the hydraulic gradient at the well site lead to large, fan-shaped time-related capture zones that extend eastward (upgradient) from the well. The zone 4 boundary extends out

Table 1. *Input parameters to WHPA model for the Mountain Green Water Association well.*

Parameters	Value	Source
Number of pumping wells	1	This report
Transmissivity	1700 ft^2/day	This report
Aquifer thickness	30 ft.	Perforated interval on driller's log, this report
Aquifer effective porosity	0.25 (dimensionless)	Driller's log, this report
Average hydraulic gradient	0.003 (dimensionless)	Based on land surface topography, this report
Direction of gradient	N. 45° E. to S. 45° E	Based on land surface topography, this report
Discharge rate	13,500 ft^3/day	This report
Well radius	0.33 ft.	Driller's report, this report

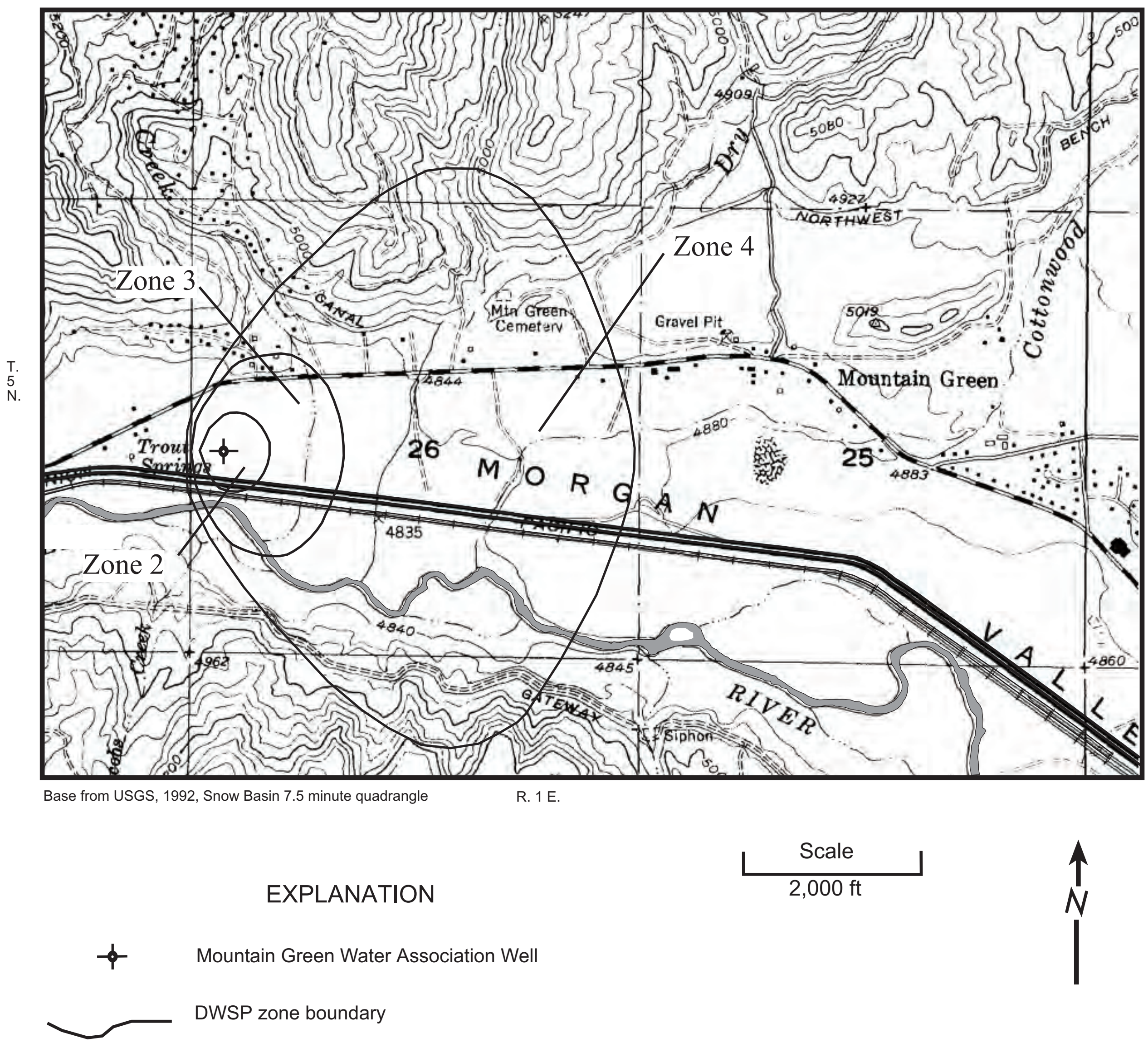

Figure 4. *Boundaries of drinking water source protection (DWSP) zones 2, 3, and 4.*

Table 2. *Drinking water source protection zones 2, 3, and 4 for the Mountain Green Water Association well.*

	Zone 2	**Zone 3**	**Zone 4**
Maximum upgradient distance	500 ft (150 m)	1300 ft (400 m)	4700 ft (1400 m)
Orientation (from well) of maximum upgradient distance	East	East	East
Maximum downgradient distance	240 ft (70 m)	340 ft (100 m)	400 ft (120 m)
Maximum width	900 ft (270 m)	2360 ft (720 m)	7000 ft (2100 m)

of the valley fill and into the bedrock on its north and south sides (figure 4); however, the valley fill is considered the more permeable aquifer (Gates and others, 1984). Using the boundary for zone 4, determined for the valley fill, should provide a conservative boundary in the bedrock areas and account for under flow from the rocks into the protection zone for the well. I used conservative hydraulic parameters, which resulted in large, conservative (protective) protection-zones. The actual well is not pumped at the frequencies used in the simulation, and the area of the overall effect on local ground-water levels in the valley-fill aquifer is probably smaller than the determined zones.

SUMMARY AND RECOMMENDATIONS

Accurate delineation of areas contributing ground water to a well is an important requisite to protecting ground-water quality. I determined aquifer properties by evaluating geology, hydrogeology, and well data for the area surrounding the Mountain Green well. Transmissivity for the aquifer was estimated using a theoretical relationship for specific-capacity data. I determined the specific capacity of the Mountain Green well from data in the driller's report of the well. I applied a semianalytical model that used aquifer data from the well and the hydrogeologic investigation of the area to delineate the 250-day and 3- and 15-year time-related capture zones. The model results in large fan-shaped protection zones with boundaries extending a maximum upgradient distances and orientation from the well as follows: (1) zone 2, 500 feet, east; (2) zone 3, 1300 feet, east; and (3) zone 4, 4700 feet, east.

I based the DWSP zones on: (1) determined aquifer properties or conservative estimates of unknown aquifer parameters, (2) a single, heterogeneous, anisotropic aquifer composed of sand and gravel in the perforated interval of the well, (3) published ground-water-flow data, and (4) the application of ground-water flow travel-time calculations. Using these criteria, I produced conservative protection zones for the well. Factors influencing the area recharging the well are: (1) the hydrogeologic framework of the aquifer system, (2) aquifer transmitting and storing properties, and (3) water withdrawals (pumping). This is considered an initial DWSP-zone delineation, because it is based a single-well test performed 42 years ago. The DWSP zones should be redelineated if additional wells are drilled to permit water-level measurements and performance of a multiple-well aquifer test. If significant changes occur in the regional ground-water-flow system, then the DWSP zones should be redelineated based on that additional information.

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APPENDIX A

DRILLER'S LOG OF WELL

Form 113—5M—12-60

Examined Aug-1-1962 R.C.T.
Recorded: B. C. Aug-1-1962 T. B. R.C.T.
Inspection Sheet
Copied

REPORT OF WELL DRILLER
STATE OF UTAH

Exchange Application No. 105
Claim No.
Coordinate No. (A-5-1)26cbb

GENERAL STATEMENT: Report of well driller is hereby made and filed with the State Engineer, in accordance with the laws of Utah. This report shall be filed with the State Engineer within 30 days after the completion or abandonment of the well. Failure to file such eports constitutes a misdemeanor.)

(1) WELL OWNER:
Name Verl J. [illegible]oll & [illegible]eorge [illegible]ate
Address Mountain Green, Utah

(2) LOCATION OF WELL:
County Morgan Ground Water Basin (leave blank)
~~North~~ South 720 feet, East ~~West~~ 351.2' feet from W 1/4 Corner
of Section 26, T. 5N, R. 1 E SLBM ~~W USM~~ (strike out words not needed)

(3) NATURE OF WORK (check): New Well ☒
Replacement Well ☐ Deepening ☐ Repair ☐ Abandon ☐
If abandonment, describe material and procedure:

(4) NATURE OF USE (check):
Domestic ☒ Industrial ☐ Municipal ☐ Stockwater ☐
Irrigation ☐ Mining ☐ Other ☐ Test Well ☐

(5) TYPE OF CONSTRUCTION (check):
Rotary ☐ Dug ☐ Jetted ☐
Cable ☒ Driven ☐ Bored ☐

(6) CASING SCHEDULE: Threaded ☐ Welded ☒
8" Diam. from 0 feet to 163 feet Gage 330
" Diam. from feet to feet Gage
" Diam. from feet to feet Gage
New ☒ Reject ☐ Used ☐

(7) PERFORATIONS: Perforated? Yes ☒ No ☐
Type of perforator used Millas Blade type
Size of perforations 3/8 inches by 1½ inches
180 perforations from 130 feet to 160 feet
perforations from feet to feet
perforations from feet to feet
perforations from feet to feet
perforations from feet to feet

(8) SCREENS: Well screen installed? Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to
Diam. Slot size Set from ft. to

(9) CONSTRUCTION:
Was well gravel packed? Yes ☐ No ☒ Size of gravel:
Gravel placed from feet to feet
Was a surface seal provided? Yes ☒ No ☐
To what depth? 5 feet
Material used in seal: Bentinite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water: Depth of strata
Method of sealing strata off:

Was surface casing used? Yes ☐ No ☒
Was it cemented in place? Yes ☐ No ☒

(10) WATER LEVELS:
Static level 5 feet below land surface Date 7-30-62
Artesian pressure feet above land surface Date

LOG RECEIVED:

(11) FLOWING WELL:
Controlled by (check) Valve ☐
Cap ☐ Plug ☐ No Control ☐
Does well leak around casing? Yes ☐ No ☐

(12) WELL TESTS: Drawdown is the distance in feet the water level is lowered below static level.
Was a pump test made? Yes ☐ No ☒ If so, by whom?
Yield: gal./min. with feet drawdown after hours
Bailer test 150 gal./min. with 15 feet drawdown after 1/2 hours
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? No ☐X Yes ☐

(13) WELL LOG: Diameter of well 8 inches
Depth drilled 163 feet. Depth of completed well 163 feet.

NOTE: Place an "X" in the space or combination of spaces needed to designate the material or combination of materials encountered in each depth interval. Under REMARKS make any desirable notes as to occurrence of water and the color, size, nature, etc., of material encountered in each depth interval. Use additional sheet if needed.

DEPTH		MATERIAL										REMARKS
From	To	Clay	Silt	Sand	Gravel	Cobbles	Boulders	Hardpan	Conglomerate	Bedrock	Other	
0	12				x							Dirt
12	14	x			x							Sandy
14	30			x	x							
30	116			x								Brown Heaving
116	163				x							Water

SCANNED 01-02-96

Work started July 20, 1962 Completed July 30, 1962

(14) PUMP:
Manufacturer's Name
Type: H. P.
Depth to pump or bowles feet

Well Driller's Statement:
This well was drilled under my supervision, and this report is true to the best of my knowledge and belief.
Name J. E. Lee & Sons (Person, firm, or corporation) (Type or print)
Address 4091 South State Street
(Signed) Kenneth L. Lee (Well Driller)
K. E. Lee by Kenneth L. Lee
License No. 11 Date July 30, 1962

USE OTHER SIDE FOR ADDITIONAL REMARKS

APPENDIX B

Problem Summaries and WHPA Printouts Using RESSQC Module

RESSQC PROBLEM SUMMARY

Simulation Option:	capture zones
Number of Pumping Wells:	1
Number of Recharge Wells:	0
Transmissivity:	1700 ft**2/d
Hydraulic Gradient:	0.003000 ft/ft
Angle of Ambient Flow:	135.00 degrees
Aquifer Porosity:	0.25 dimensionless
Aquifer Thickness:	30 ft
Simulation Time:	5480 days
No. of Capture Zone Times:	3

PUMPING WELL #1 PARAMETERS

X Coordinate:	1416375. ft
Y Coordinate:	14942937. ft
Well Discharge Rate:	13500. ft**3/d
Number of Pathlines:	10
Pathline Plotting Interval:	1

RESSQC.OUT FOR MOUNTAIN GREEN WATER ASSOCIATION

FT AND DA SYSTEM OF UNITS IS USED

REGIONAL FLOW, PORE VELOCITY	=	0.69 FT/DAY
ORIENTATION OF REGIONAL FLOW	=	135.00 DEGREES
THICKNESS OF THE AQUIFER	=	30.00 FEET
POROSITY	=	25.00 PERCENT
PERIOD STUDIED	=	5480.00 DAYS
INITIAL AQUIFER CONCENTRATION	=	0.000E-01
DEFAULT INJECTION CONCENTRATION	=	0.000E-01
STREAMLINE STEP LENGTH	=	10.00 FEET
ADSORPTION CAPACITY OF ROCK	=	00.00 PERCENT

3 FRONTS ARE PLOTTED AT 2.50E+02 DAYS 1.09E+03 DAYS 5.47E+03 DAYS

NUMBER OF INJECTION WELLS = 0
NUMBER OF PUMPING WELLS = 1

1 PRODUCTION WELLS

WELL NAME	X FEET	Y FEET	FLOW-RATE FT3/DAY	RADIUS FEET	INDICATOR
	1416375.00	**********	13500.00	3.30E-01	0

STREAMLINES DEPARTING FROM INJECTION WELL

NUMBER OF STREAMLINE	WELL REACHED	TIME OF ARRIVAL	ANGLE BETA IN DEGREES
1	+++NONE+++	5486.2 DAYS	0.0
2	+++NONE+++	5487.1 DAYS	36.0
3	+++NONE+++	5484.4 DAYS	72.0
4	+++NONE+++	5492.7 DAYS	108.0
5	+++NONE+++	5486.3 DAYS	144.0
6	+++NONE+++	5483.4 DAYS	180.0
7	+++NONE+++	5486.6 DAYS	216.0
8	+++NONE+++	5489.1 DAYS	252.0
9	+++NONE+++	5489.7 DAYS	288.0
10	+++NONE+++	5480.2 DAYS	324.0

RESSQC PROBLEM SUMMARY

Simulation Option:	capture zones
Number of Pumping Wells:	1
Transmissivity:	1700. ft**2/d
Hydraulic Gradient:	0.003000 ft/ft
Angle of Ambient Flow:	180.00 degrees
Aquifer Porosity:	0.25 dimensionless
Aquifer Thickness:	30 ft
Simulation Time:	5480 days
No. of Capture Zone Times:	3

PUMPING WELL #1 PARAMETERS

X Coordinate:	1416375 ft
Y Coordinate:	14942937 ft
Well Discharge Rate:	13500 ft**3/d
Number of Pathlines:	10
Pathline Plotting Interval:	1

RESSQC.OUT FOR MOUNTAIN GREEN WATER ASSOCIATION

FT AND DA SYSTEM OF UNITS IS USED

REGIONAL FLOW, PORE VELOCITY	=	0.69 FT/DAY
ORIENTATION OF REGIONAL FLOW	=	180.00 DEGREES
THICKNESS OF THE AQUIFER	=	30.00 FEET
POROSITY	=	25.00 PERCENT
PERIOD STUDIED	=	5480.00 DAYS
INITIAL AQUIFER CONCENTRATION	=	0.000E-01
DEFAULT INJECTION CONCENTRATION	=	0.000E-01
STREAMLINE STEP LENGTH	=	10.00 FEET
ADSORPTION CAPACITY OF ROC	=	00.00 PERCENT

3 FRONTS ARE PLOTTED AT 2.50E+02 DAYS 1.09E+03 DAYS 5.47E+03 DAYS

NUMBER OF INJECTION WELLS = 0
NUMBER OF PUMPING WELLS = 1

1 PRODUCTION WELLS

WELL NAME	X FEET	Y FEET	FLOW-RATE FT^3/DAY	RADIUS FEET	INDICATOR
	1416375.00	**********	13500.00	3.30E-01	0

STREAMLINES DEPARTING FROM INJECTION WELL

NUMBER OF STREAMLINE	WELL REACHED	TIME OF ARRIVAL	ANGLE BETA IN DEGREES
1	+++NONE+++	5493.4 DAYS	0.0
2	+++NONE+++	5483.8 DAYS	36.0
3	+++NONE+++	5492.3 DAYS	72.0
4	+++NONE+++	5485.9 DAYS	108.0
5	+++NONE+++	5483.3 DAYS	144.0
6	+++NONE+++	5741.6 DAYS	180.0
7	+++NONE+++	5483.3 DAYS	216.0
8	+++NONE+++	5485.9 DAYS	252.0
9	+++NONE+++	5492.3 DAYS	288.0
10	+++NONE+++	5483.8 DAYS	324.0

RESSQC PROBLEM SUMMARY

Simulation Option:	capture zones
Number of Pumping Wells:	1
Number of Recharge Wells:	0
Transmissivity:	1700 ft**2/d
Hydraulic Gradient:	0.003000 ft/ft
Angle of Ambient Flow:	225.00 degrees
Aquifer Porosity:	0.25 dimensionless
Aquifer Thickness:	30 ft
Simulation Time:	5480 days
No. of Capture Zone Times:	3

PUMPING WELL #1 PARAMETERS

X Coordinate:	1416375 ft
Y Coordinate:	14942937 ft
Well Discharge Rate:	13500 ft**3/d
Number of Pathlines:	10
Pathline Plotting Interval:	1

RESSQC.OUT FOR MOUNTAIN GREEN WATER ASSOCIATION

FT AND DA SYSTEM OF UNITS IS USED

REGIONAL FLOW, PORE VELOCITY	=	0.69 FT/DAY
ORIENTATION OF REGIONAL FLOW	=	225.00 DEGREES
THICKNESS OF THE AQUIFER	=	30.00 FEET
POROSITY	=	25.00 PERCENT
PERIOD STUDIED	=	5480.00 DAYS
INITIAL AQUIFER CONCENTRATION	=	0.000E-01

DEFAULT INJECTION CONCENTRATION	=	0.000E-01
STREAMLINE STEP LENGTH	=	10.00 FEET
ADSORPTION CAPACITY OF ROCK	=	00.00 PERCENT

3 FRONTS ARE PLOTTED AT 2.50E+02 DAYS 1.09E+03 DAYS 5.47E+03 DAYS

NUMBER OF INJECTION WELLS = 0
NUMBER OF PUMPING WELLS = 1

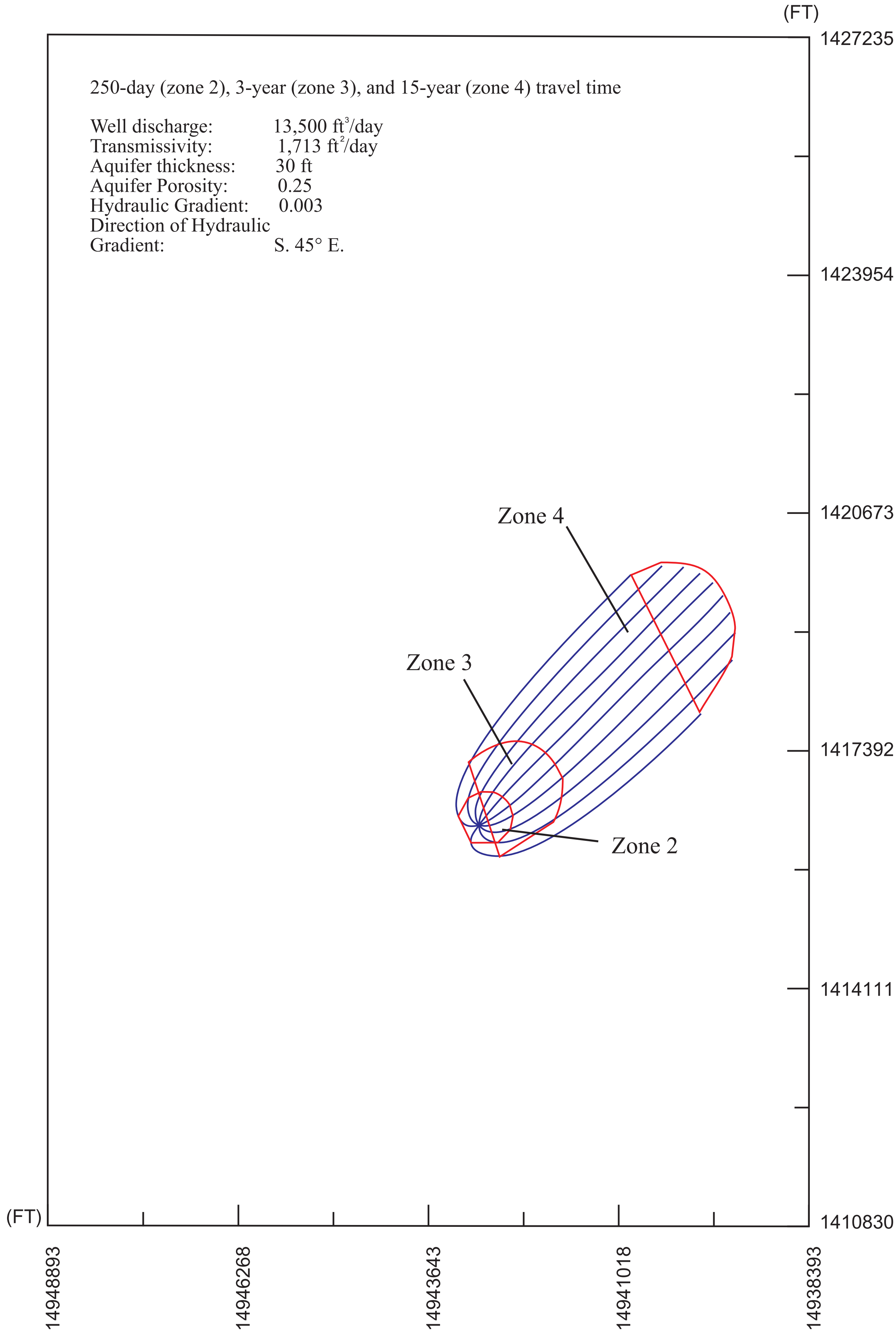
1 PRODUCTION WELLS

WELL NAME	X FEET	Y FEET	FLOW-RATE FT^3/DAY	RADIUS FEET	INDICATOR
	1416375.00	**********	13500.00	3.30E-01	0

STREAMLINES DEPARTING FROM INJECTION WELL

NUMBER OF STREAMLINE	WELL REACHED	TIME OF ARRIVAL	ANGLE BETA IN DEGREES
1	+++NONE+++	5486.2 DAYS	0.0
2	+++NONE+++	5480.2 DAYS	36.0
3	+++NONE+++	5489.7 DAYS	72.0
4	+++NONE+++	5489.1 DAYS	108.0
5	+++NONE+++	5486.6 DAYS	144.0
6	+++NONE+++	5483.4 DAYS	180.0
7	+++NONE+++	5486.3 DAYS	216.0
8	+++NONE+++	5492.7 DAYS	252.0
9	+++NONE+++	5484.4 DAYS	288.0
10	+++NONE+++	5487.1 DAYS	324.0

Combined capture zones for three hydraulic gradient direction end members (pages 13,14,15). These are combined to represent the maximum range of the direction of ground-water flow to the Mountain Green well (page 16).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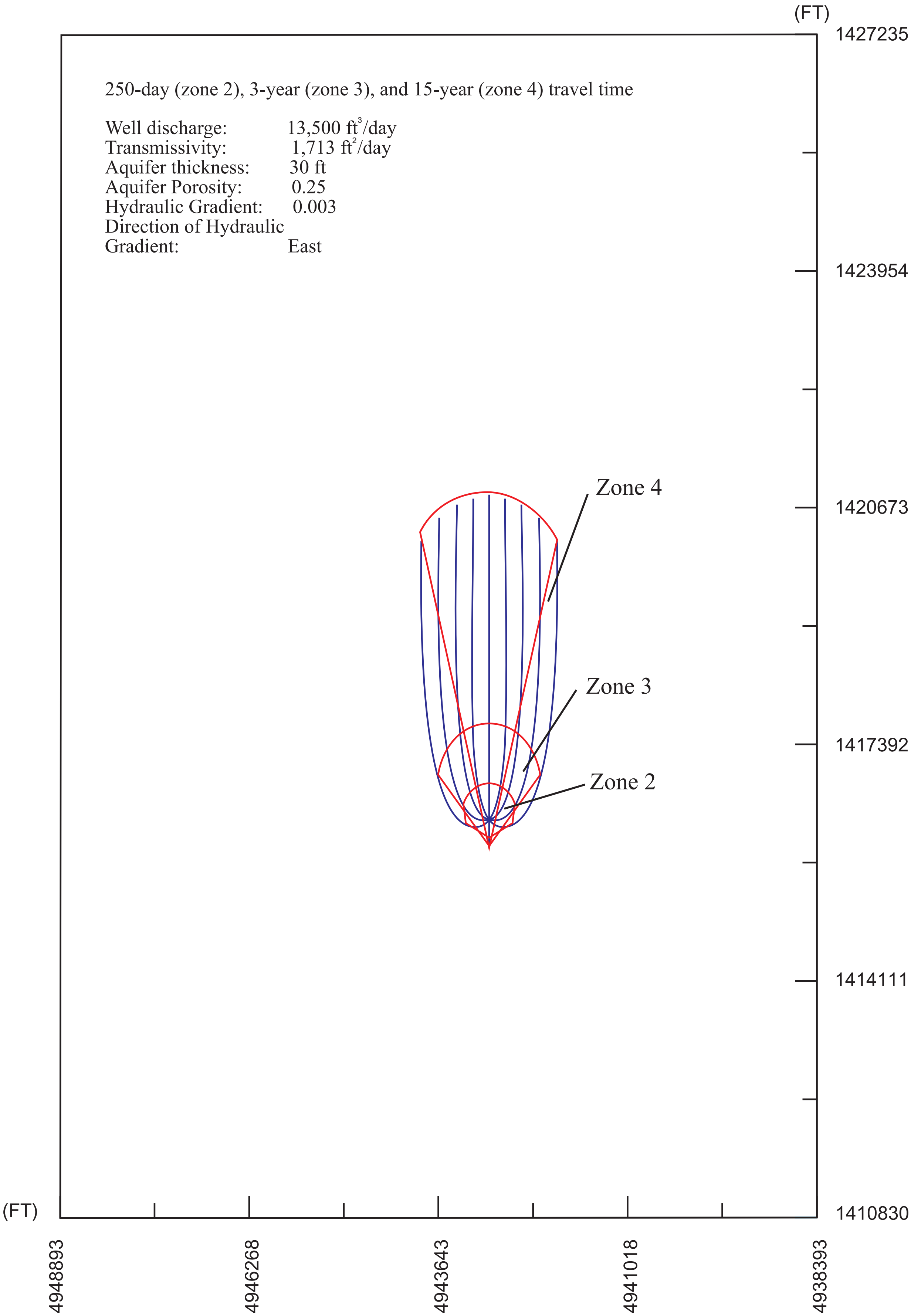
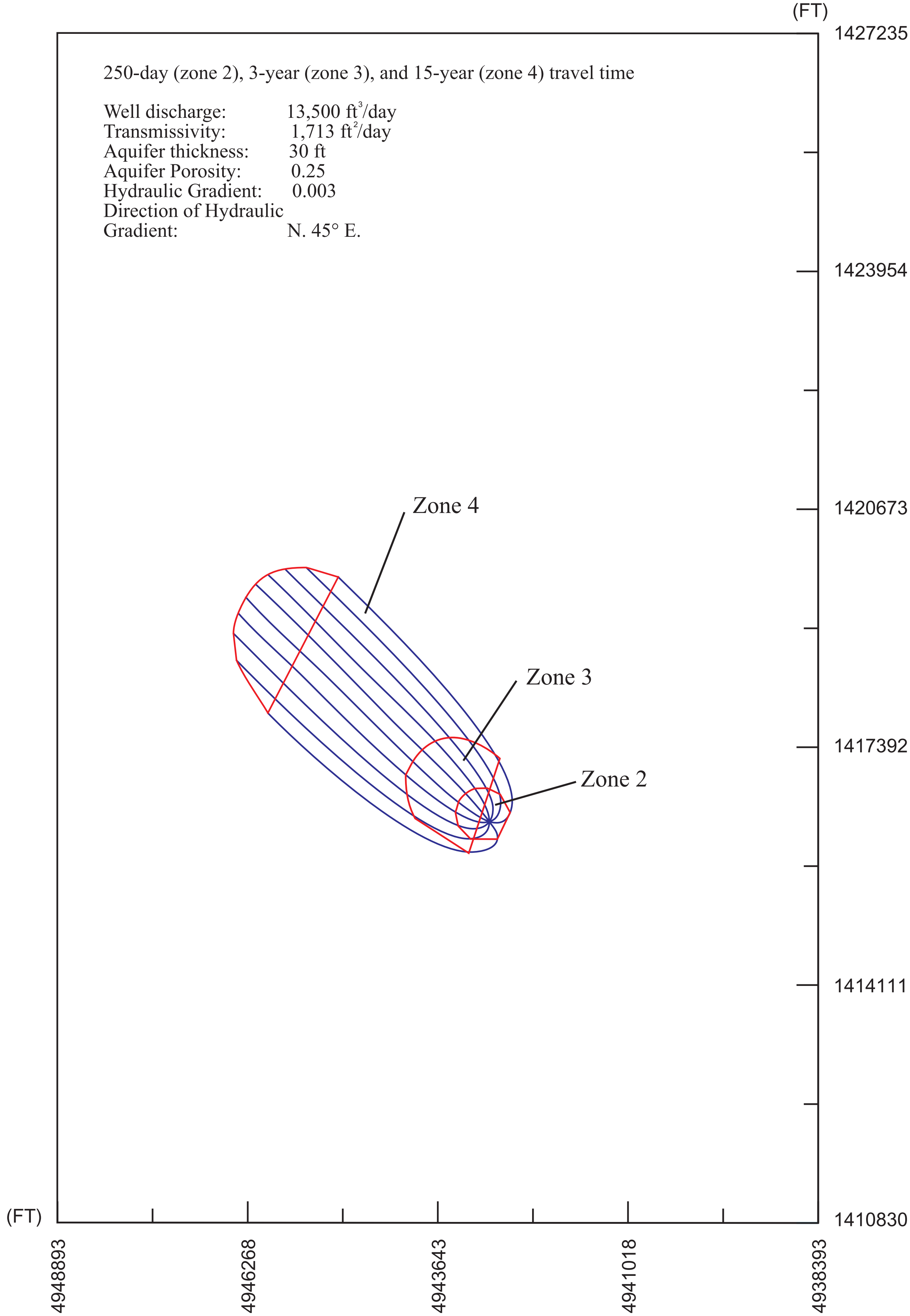
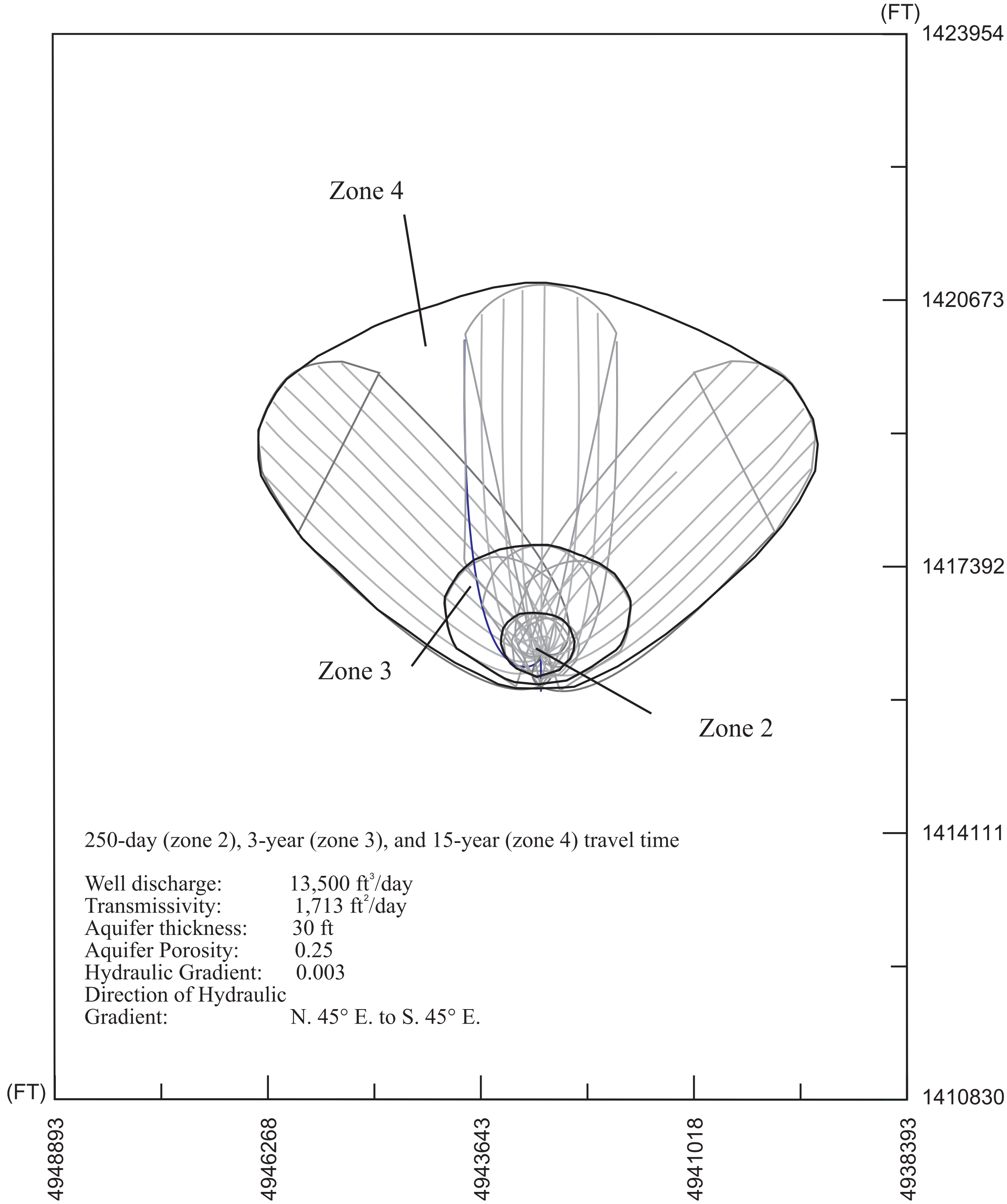
1420673
1417392
1414111
1410830
(FT)
14948893
14946268
14943643
14941018
14938393
250-day (zone 2), 3-year (zone 3), and 15-year (zone 4) travel time
Well discharge: 13,500 ft³/day
Transmissivity: 1,713 ft²/day
Aquifer thickness: 30 ft
Aquifer Porosity: 0.25
Hydraulic Gradient: 0.003
Direction of Hydraulic Gradient: S. 45° E.
Zone 4
Zone 3
Zone 2


250-day (zone 2), 3-year (zone 3), and 15-year (zone 4) travel time
Well discharge: 13,500 ft³/day
Transmissivity: 1,713 ft²/day
Aquifer thickness: 30 ft
Aquifer Porosity: 0.25
Hydraulic Gradient: 0.003
Direction of Hydraulic Gradient: East
Zone 4
Zone 3
Zone 2
(FT)
1427235
1423954
1420673
1417392
1414111
1410830
(FT)
14948893
14946268
14943643
14941018
14938393


(FT)
1427235
1423954
1420673
1417392
1414111
1410830
(FT)
14948893
14946268
14943643
14941018
14938393
250-day (zone 2), 3-year (zone 3), and 15-year (zone 4) travel time
Well discharge: 13,500 ft³/day
Transmissivity: 1,713 ft²/day
Aquifer thickness: 30 ft
Aquifer Porosity: 0.25
Hydraulic Gradient: 0.003
Direction of Hydraulic Gradient: N. 45° E.
Zone 4
Zone 3
Zone 2


(FT)
1423954
1420673
1417392
1414111
1410830
Zone 4
Zone 3
Zone 2
250-day (zone 2), 3-year (zone 3), and 15-year (zone 4) travel time
Well discharge: 13,500 ft^3/day
Transmissivity: 1,713 ft^2/day
Aquifer thickness: 30 ft
Aquifer Porosity: 0.25
Hydraulic Gradient: 0.003
Direction of Hydraulic Gradient: N. 45° E. to S. 45° E.
(FT)
14948893
14946268
14943643
14941018
14938393