Ground-water Monitoring of Shootaring Canyon Tailings Site - 2002

GROUND-WATER MONITORING
OF SHOOTARING TAILINGS SITE - 2002

FOR:
PLATEAU RESOURCES, LTD.

BY:
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1.0 SUMMARY AND INTRODUCTION

1.1 SUMMARY

This report presents the ground-water monitoring results for the Shootaring Canyon tailings site for 2002. The upper portion of the Entrada Sandstone has a lower hydraulic conductivity (permeability) than the average of the entire Entrada aquifer. These lower permeabilities decrease the rate of movement of water in the upper portion of the Entrada and have caused higher heads in the area between the Shootaring Dam and the cross valley berm. The Upper Entrada water levels are similar to the main Entrada water levels in the area of the existing tailings and the area of the final reclamation tailings cell. Ground water is moving at an average rate of 8 ft/year in the Entrada aquifer to the southwest.

Ground-water quality for the Entrada aquifer is very good for all the wells at the Shootaring site. Very little change in this ground-water quality has been seen over the last five years. The main change in water quality in 2002 was slightly higher TDS, sulfate, chloride and chromium concentrations in upgradient well RM12 which has increased the range of natural concentrations. Two upgradient wells, RM1 and RM12, define the ground-water concentrations coming into this tailings site. None of the Entrada aquifer wells show any indication of impact from the tailings. All of the Entrada wells can, therefore, be used to define the full range of natural concentrations in the Entrada aquifer. Measurable concentrations of arsenic, barium, cadmium, chromium, mercury and selenium have been observed at a few sites. These concentrations are very low and are within the expected natural range of variability in the Entrada aquifer. The Shootaring data set has been adjusted by removing the Plateau laboratory results and a few outliers. A few additional values were removed from the Shootaring data set where lower limit of detection used was above the ground-water quality standard (GWQS). This Shootaring data set was used to define the natural variability in the Entrada water quality. The ground-water protection level (GWPL) was adjusted to account for the full range of natural variability by adding the mean plus two standard

deviations as an option for the GWPL. Additional statistical analyses will be conducted when more data is obtained on the monitoring wells.

1.2 INTRODUCTION

The purpose of this report is to present the ground-water monitoring results at the Shootaring tailings site for 2002. Hydro-Engineering, LLC (1998, 1999, 2000, 2001 and 2002) present the ground-water hydrology of the Shootaring tailings site, while this report presents the 2002 monitoring results for the ground water. A final reclamation plan for the tailings was submitted in 2002 to the NRC (see Hydro-Engineering, LLC and ERG, 2002). Initially, the ground water monitoring and the GWPL are discussed. Geologic setting, tailings conditions and basic well data are presented next. Entrada ground-water flow conditions are discussed. The ground-water quality monitoring for the adjusted Shootaring data set is presented and discussed relative to exceedances of the GWPL and the GWQS. The final section of this report presents the use of the natural variation in concentrations at the Shootaring site in defining the GWPL.

Figure 1-1 presents the location of the Shootaring Canyon mill site within the State of Utah. This figure shows the location of Lake Powell, Bullfrog and Ticaboo with respect to the Shootaring Canyon site. Figure 1-2 presents the location of the Shootaring tailings site, which is 2.5 miles north of Ticaboo, Utah. The Bullfrog Marina is located 14 miles south of this site, while Hanksville, Utah is located 56 miles north of the project. Figure 1-2 shows the location of the Shootaring Dam, the cross valley berm, the location of the existing Shootaring Canyon tailings and the edge of the final reclamation tailings cell. The locations of monitoring wells at this site are also shown on this figure. Figure 1-3 presents the location of the proposed Upper Entrada monitoring wells with the planned reclamation surface configuration.

The climate is semi-arid in the vicinity of the site with variations in elevation and terrain. Winds are normally light to moderate and annual precipitation is estimated to be about 7 inches at the site.

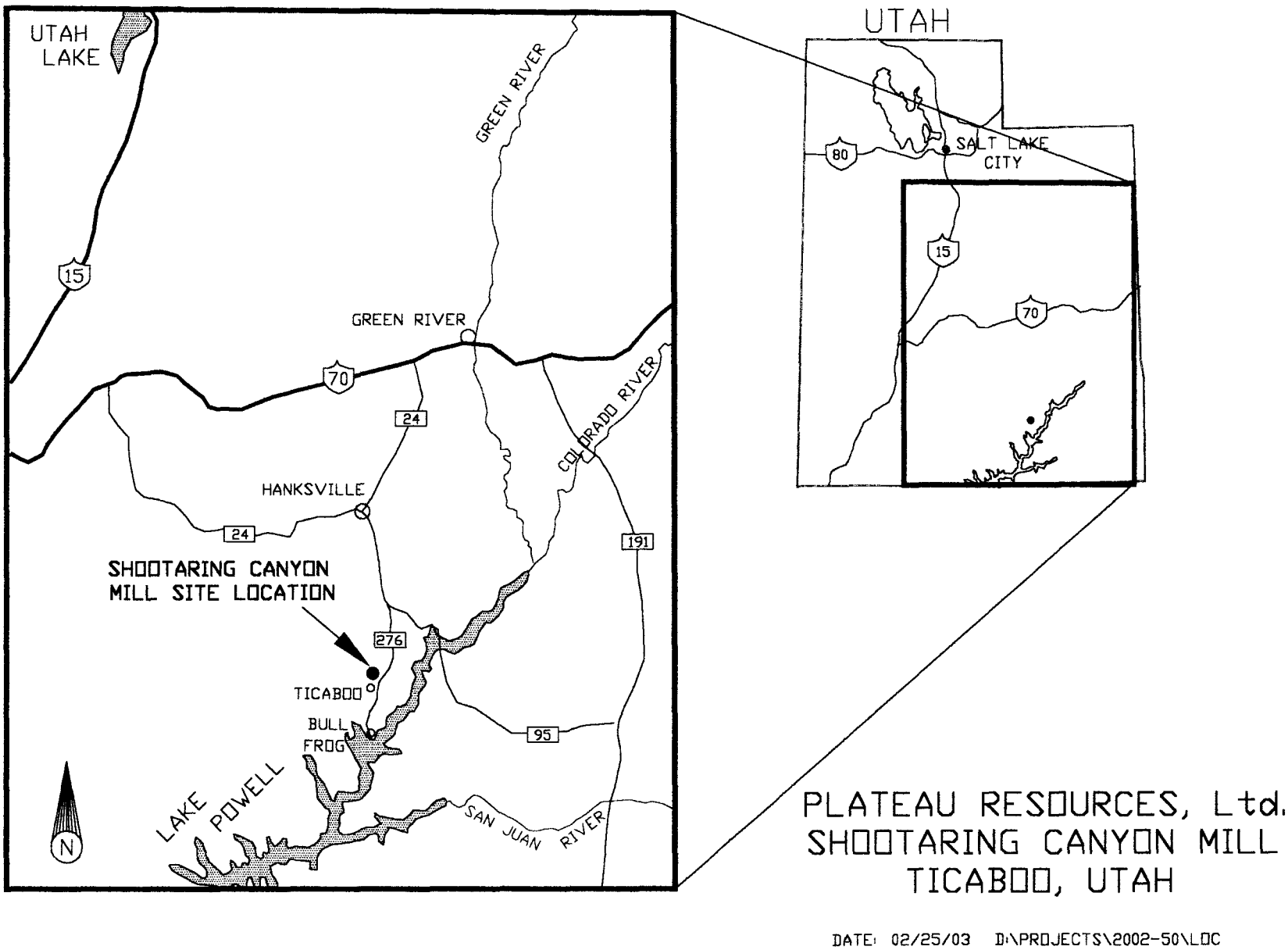

FIGURE 1-1. LOCATION OF THE SHOOTARING CANYON MILL SITE

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 1-2, "LOCATION OF WELLS AND GEOLOGIC CROSS SECTIONS"

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. FIGURE 1-2

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

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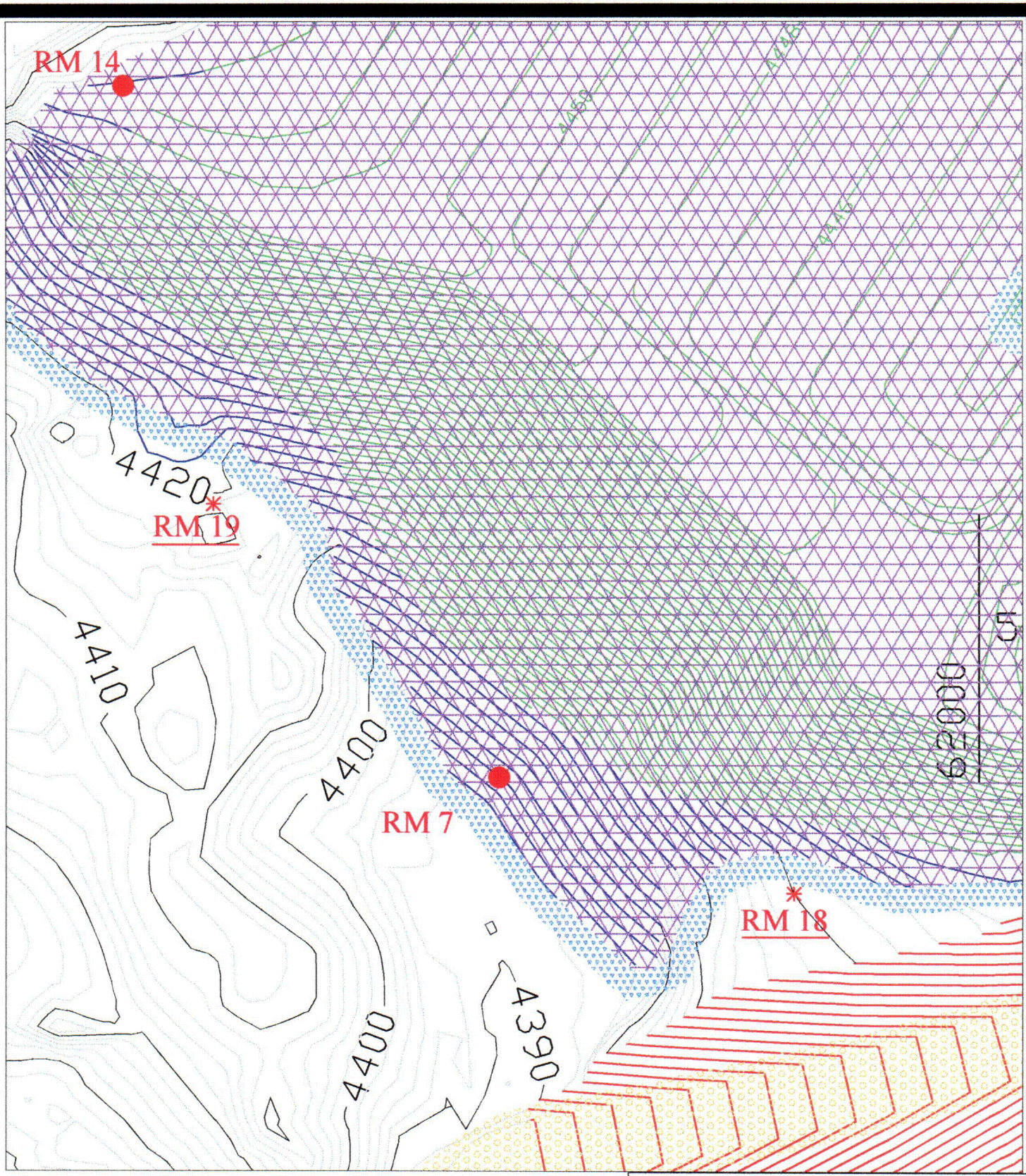

LEGEND

- RM 9 ● MONITORING WELL
- RM 18 ■ PROPOSED UPPER ENTRADA WELL
- ROCK MULCH (D50 = 2 inches)
- INTERMEDIATE RIPRAP (D50 = 6 inches)
- LARGE RIPRAP (D50 = 20 inches)
- CHANNEL TOE ROCK AND POROUS LEDGE ROCK (D50 = 24 inches)

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FIGURE 1-3. PROPOSED MONITORING WELL LOCATIONS WITH RECLAMATION PLAN ROCK COVER

DATE: 3-2003	NEWWELL.DWG	SCALE: 1"=100'

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2.0 GROUND-WATER MONITORING AND PROTECTION LEVELS

The State of Utah's Ground-Water Quality Discharge Permit UGW170003 for the Shootaring Site governs the monitoring at this site, along with the Nuclear Regulatory Commission (NRC) Source Material License. Table 2-1 lists the State wells that are included in this compliance monitoring and gives some pertinent data relative to sampling for these monitoring wells. This table also presents the type of data collected for each well, whether it is water-level measurement and water-quality sampling.

Two additional new monitoring wells are being proposed for the Shootaring site. Figure 1-2 shows the locations of the two proposed Upper Entrada wells RM18 and RM19. Figure 1-3 shows that these two new monitoring wells are being proposed at the edge of the reclamation rock cover. Additional discussion of these two new monitoring wells is presented in Section 3.2.

Adjustments in the monitoring program are recommended. Wells RM7, RM8 and RM9 and new Upper Entrada wells RM18 and RM19 are proposed to be added to the semi-annual water quality monitoring list. The following wells are therefore recommended to be monitored semi-annually: RM1, RM2R, RM3, RM7, RM8, RM9, RM10, RM11, RM12, RM13, RM14, RM15, RM16, RM17, RM18 and RM19. The shallow Upper Entrada piezometers PZ4, PZ5 and PZ6 on the downstream side of the Shootaring Dam that were installed for dam stability analysis have not ever contained any water and are not expected to ever contain water. These piezometers are not needed in this area because wells RM4R and RM10 adequately define the Upper Entrada in this area. Therefore these three piezometers are proposed to be dropped from the water level measurement data. Also, well RM2 which is near well RM2R is proposed to be dropped from the adjusted water level monitoring list of wells including the following Entrada wells: RM1, RM2R, RM3, RM4R, RM7, RM8, RM9, RM10, RM11, RM12, RM13, RM14, RM15, RM16, RM17, RM18 and RM19. Uranium is proposed to be added to the State program so the list of constituents for the NRC and the State are the same.

The parameters in the ground-water quality assurance plan for the Shootaring Site are listed in Table 2-2 with their ground-water protection level (GWPL) and the State ground-water quality standard (GWQS). The GWPL was set by the highest of the following three: 1.1 times the mean of an individual well data, mean plus two standard deviations and one-tenth of the GWQS. The largest of these three values is the GWPL. One-tenth of the GWQS for cadmium, lead and mercury is below the present minimum detection limit of these three constituents. In this circumstance, the lower limit of detection was substituted for one-tenth of the GWQS.

The calculation of the individual GWPL's for this site does not account for the natural migration of background constituents with time from one particular area to an adjacent monitoring well. The gradual natural migration of water with the higher TDS in the area of well RM12 is likely to result in a TDS in RM14 that exceeds the well GWPL of 225 mg/l. When constituent concentration is compared to an individual well GWPL under this scenario an exceedance exists. The concentration also needs to be compared to the maximum GWPL for this site. If the constituent concentration is below the maximum GWPL for this site then it is possible that the concentration is still within natural variation and reflects the minor changes in ground-water quality associated with ongoing natural ground-water movement.

The individual well data sets were calculated through the 2002 data to determine interim ground-water protection level for each well and for each parameter. Table 2-2 presents the tabulation of the individual GWPL's through the 2002 data. The data sets typically have about 10 data points, which is not enough to adequately define the full range of background concentrations at each of these wells. These GWPL's therefore should be used with caution due to the limited number of data points. Table 2-2 presents the GWPL calculations based on the assumption of a normal distribution for all of the constituents. The large number of non-detect concentrations in the trace metals makes these results even more marginal. Additional analysis will be needed for these parameters after adequate data has been collected.

Some data indicates that the class of this ground water should not be Class 1A but Class III. If additional background data reveals this to be the case, then the

calculation of the GWPL would be adjusted. All GWPL values are presently assuming Class 1A.

TABLE 2-1. SUMMARY OF STATE COMPLIANCE MONITORING WELLS AND DATA COLLECTION.

Well Name	PCV Casing ID	Open Hole ID	Data Type	Sample Method
RM1	3	-----	L,S	Bladder
RM2R	5	-----	L,S	Submersible
RM3	6	-----	L,S	Submersible
RM4R	5	-----	L,S	Submersible
RM7	3	-----	L,S	Submersible
RM10	5	-----	L,S	Bail
RM11	5	4.5	L,S	Bladder
RM12	5	-----	L,S	Bail
RM13	5	4.5	L,S	Submersible
RM14	5	4.5	L,S	Submersible
RM15	5	-----	L,S	Submersible
RM16	5	-----	L,S	Submersible
RM17	5	-----	L,S	Submersible
PZ4	1	-----	L	-----
PZ5	1	-----	L	-----
PZ6	1	-----	L	-----

NOTE: L = Water-Level Measurement
S = Water-Quality Sample

TABLE 2-2. INTERIUM* GROUND-WATER PROTECTION LEVELS AND GROUND-WATER QUALITY STANDARDS.

Parameter	GROUND-WATER PROTECTION LEVEL WELL												Ground-Water Quality Standard
	RM1	RM2R	RM3	RM4R	RM10	RM11	RM12	RM13	RM14	RM15	RM16	RM17	
TDS	348	230	361	204	364	217	328	201	225	209	237	199	500
Cl	25	25	25	25	25	25	28.5	25	25	25	25	25	250
F	0.4	0.4	0.69	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	4
NH_3	3	3	3	3	3	3	3	3	3	3	3	3	30
$NO_3 + NO_2$	7.0	1.7	6.8	2.1	3.3	1.9	1.6	2.1	2	2.7	1.8	2.1	10
SO_4	57	50	50	50	67	50	74	50	50	50	71	50	500
As	0.007	0.005	0.037	0.012	0.087	0.015	0.005	0.005	0.005	0.005	0.005	0.005	0.05
Ba	0.71	0.20	0.32	0.20	0.32	0.20	0.20	0.20	0.20	0.20	0.20	0.21	2
Cd	0.033	0.001	0.001	0.001	0.0015	0.001	0.0014	0.001	0.0101	0.001	0.001	0.0023	0.005
Cr	0.013	0.01	0.021	0.01	0.035	0.020	0.114	0.01	0.01	0.01	0.018	0.01	0.1
Cu	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1.3
Pb	0.051	0.002	0.004	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.015
Hg	0.0569	0.001	0.001	0.001	0.0034	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
Mo	0.047	0.01	0.01	0.01	0.022	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Se	0.016	0.005	0.009	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.05
Ag	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Unat	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.44
Zn	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5

NOTE: Units are in milligrams per liter (mg/l) except pH, which is in standard units.
* = Background data is still being collected.

3.0 GEOLOGIC AND TAILING CONDITIONS AND WELL COMPLETIONS

3.1 GEOLOGIC SETTING

The geologic setting at the Shootaring site was presented in Hydro-Engineering, LLC 1998. The three geophysical cross sections that were developed in the 1998 report were updated with 2002 water-level elevations and 2002 water-quality data on these cross sections. Figure 3-1 presents the geologic cross section 1-1′ while Figure 1-2 presents the locations of the three cross sections and the wells that are used on the cross sections. The cross sections were developed with the aid of neutron logs in the existing wells. The neutron logs are printed in two different scales to better define the variations below the water table. The two scales for wells RM6, RM12 and RM14 are slightly different than the remainder of the logs. Some lower permeability sandstones were interpreted from the neutron logs and are shown with a magenta cross pattern on the three cross sections. The well completion intervals were added to the cross sections with a short black horizontal line pattern in the slotted interval of the casing or open hole. Wells RM11 and RM13 on Figure 3-1 were deepened after the 1998 report. Their original depths are shown on the cross section along with their present total depth. The 2002 piezometric surface for the Entrada aquifer is shown with cyan color while the piezometric surface of the Upper low permeability Entrada is shown in green on the cross sections. Figure 3-1 shows that a small difference exists between the head and the Upper Entrada and the Entrada aquifer in the areas of wells RM11 and RM4R.

Figure 3-2 shows the geologic cross section 2-2′ which runs from the west up to the cross valley berm at well RM14 and then across the cross valley berm to well RM2. The low permeability sandstone in the upper portion of the Entrada was not detected in this cross section. Well RM14 was dry prior to being deepened in 1999. The piezometric surface of wells RM14 and RM7, which are Upper Entrada wells, fits the piezometric surface of the Entrada aquifer. Therefore, the higher water-level elevations in the upper portion of the Entrada do not exist in the tailings cell area. The infrequent ponding of water upstream of the Shootaring Dam is probably a significant factor in the higher water-level elevations to the south of the tailings cell area.

Figure 3-3 presents the geologic cross section 3-3′ (see Figure 1-2 for location of this cross section) which runs from the Shootaring Dam through the cross valley berm to the two upgradient wells. This geologic cross section shows some lower permeability sandstone in the area of the Shootaring Dam and north to well RM8 but not extending into the tailings cell area at well RM7. The neutron log was also interpreted to contain some lower permeability in the upper portion of the sandstone at well RM1. The water-level elevations in the shallow upgradient well RM12 and well RM1 are very similar. Therefore, this portion of the lower permeability sandstone is not causing a significantly higher water-level elevation in the upper portion of the Entrada aquifer. The higher water-level elevations in the area of wells RM8 and RM9 are shown with the green piezometric surface versus the cyan piezometric surface for the Entrada aquifer for 2002.

3.2 WELL COMPLETIONS

No new Entrada wells were drilled in 2002. Three tailings wells were installed in 2002. Table 3-1 presents a basic well data table for the Shootaring wells. A pump intake column is presented on the right side of the basic well data table for a well that contains a pump. The slotted casing interval and the pump intake, along with the static water level, are used in the sampling of the compliance monitoring wells.

Wells RM1, RM2, RM3, RM4, RM5, RM6, RM15 through RM17, OW1A and OW2 are completed in the Entrada aquifer. Wells RM2R, RM7 through RM14, and PZ4 through PZ6 are completed in the Upper Entrada Sandstone. Wells WW1, WW2, OW1B and OW3 are completed in the Navajo aquifer while well OW4 is completed in the Carmel aquitard. PZ1 and PZ3 are Shootaring Dam piezometers while wells T4 through T6 are completed in the tailings and both of these two groups of wells are dry.

Two new Upper Entrada wells are proposed to be added on the downgradient side of the tailings cell. Figure 1-2 shows the locations of the two new monitoring wells with respect to the existing wells at Shootaring. Figure 1-3 also shows the proposed monitoring well locations with the reclamation rock cover shown. This figure shows that the proposed locations for RM18 and RM19 are adjacent to the edge of the

covered cell. Transport modeling has not been conducted at this site due to the absence of elevated concentrations to use in the simulation. Figure 4-1 shows the uniformity of the piezometric surface in the Entrada aquifer in this area. Well RM19 was spaced approximately half way between wells RM7 and RM14 and RM18 was located a similar distance on the other side of RM7. These locations should be adequate for further defining the ground-water conditions on the downgradient side of the tailings cell.

3.3 TAILINGS CONDITIONS

The tailings conditions are presented in the tailings reclamation plan (see Hydro-Engineering, LLC and ERG, 2002). Figure 3-3, which presents the geologic cross section 3-3′, shows the design reclamation surface for the tailings cell. It also shows the northern and southern limits of the tailings cell. The present land surface of the cross valley berm and north dike are also shown on this cross section. A clay liner, which is generally 2 feet thick, was placed in the tailings cell area prior to the deposition of tailings in this area. The top of the clay liner is shown in blue on cross section 3-3′. Location and completion interval for tailings well T4 is also shown on the cross section. Figure 1-2 shows the limits of the existing tailings and the edge of the design tailings cell in the reclamation plan.

An under drain perforated pipe system bedded in a sandy material was installed on top of the clay liner which is tied to a sump on the downstream side of the cross valley berm. Figure 3-4 shows the location of the under drain pipes and sump. This figure also shows the location of the three tailings wells that were installed in 2002. Infiltration into this area enters the perforated pipes and drains to the sump. Figure 3-5 shows the location of the entire drainage area to the cross valley berm with adjustment of the berm to a post-reclamation alignment and also shows the much smaller reclaimed tailings cell area. After reclamation, no permanent ponding will occur upstream of the cross valley berm and the area contributing runoff to the covered tailings area will be limited to the higher ground to the northwest of the tailings cell.

Therefore, runoff from the majority of this drainage area will bypass the reclaimed tailings cell.

Only very small rates of water drained to the sump due to infiltration in the closed basin upstream of the cross valley berm and flow through the under drain piping system. Table 3-2 presents the under drain sump and flow rates in the Shootaring Dam from April 2002 through early 2003. The quantity in Table 3-2 is the volume of water that drains to the sump during the time period. Some surface drainage on the downstream side of the cross valley berm also flows to the sump. This data shows that the average flow rate is very low, typically less than 0.1 gpm and decreases below 0.01 gpm during drier cycles. The rates increase after rainfall events, as expected, due to capture by the under drain pipe system. These under drain rates are a function of the large drainage basin to the cross valley berm and the existence of the drainage being in a depression. The reclamation plan calls for a clay cap on top of the tailings with no depressions in the tailings cell area. With the clay cap and positive drainage, recharge to the reclaimed tailings cell should be extremely smalland infiltration rates should decrease to a small fraction of the present rates.

Water quality data from the tailings sump has also been collected in 2002. Table 3-3 presents five analyses of the water quality from the under drain system showing that the TDS, chloride and sulfates concentrations are high in this water. Uranium concentrations are also significant. Selenium and nitrate concentrations are also slightly elevated. Concentrations of the remainder of the constituents are low in the tailings sump water. The ground-water monitoring shows that this high TDS water has not affected the ground-water system at the site. Therefore, the clay liner has been effective in containing the under drain water and preventing it from entering the Entrada aquifer.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. FIGURE 3-1, REVISED 1/23/03

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D-02

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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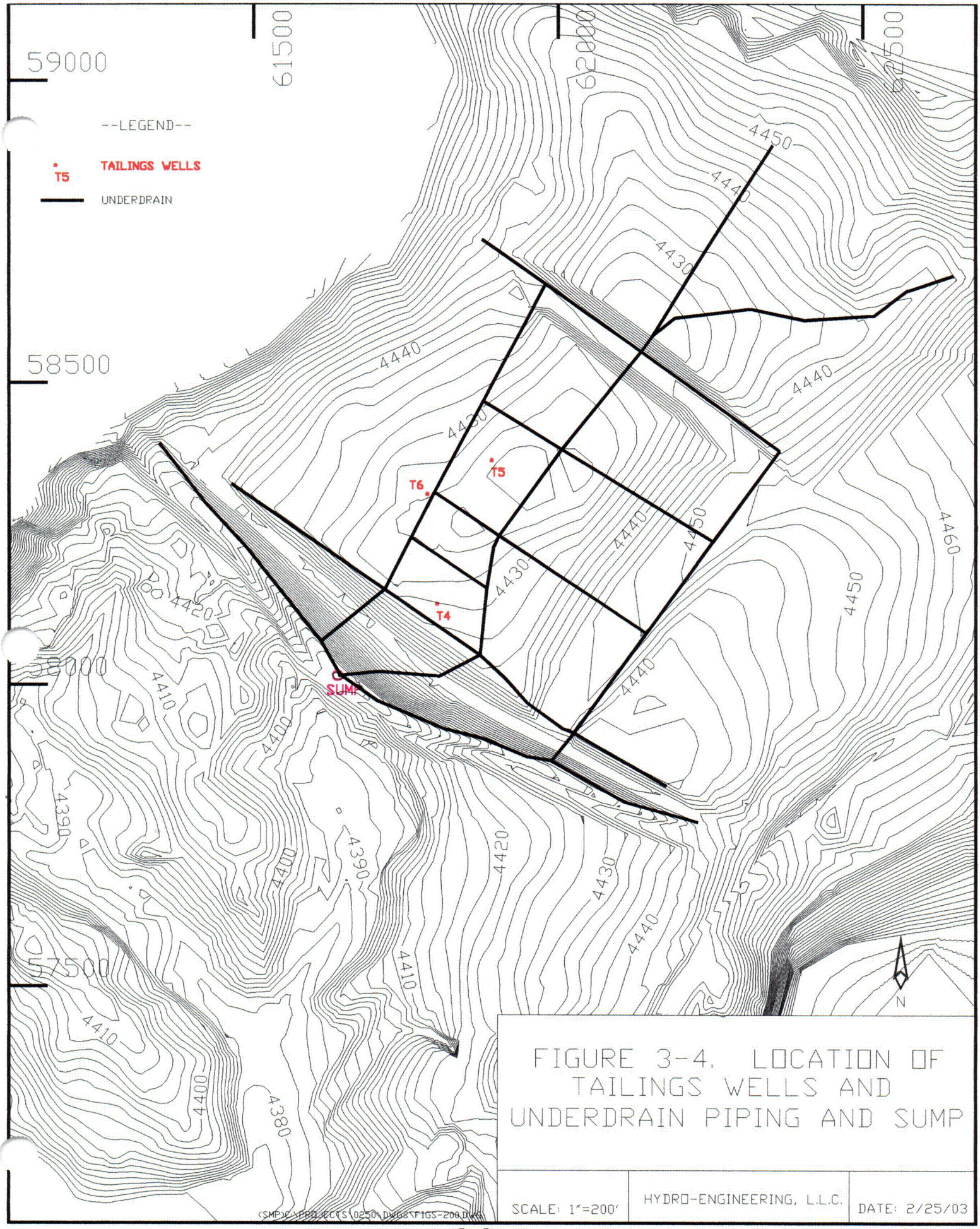

FIGURE 3-4. LOCATION OF TAILINGS WELLS AND UNDERDRAIN PIPING AND SUMP

SCALE: 1"=200'	HYDRO-ENGINEERING, L.L.C.	DATE: 2/25/03

(SMP)C:\PROJECTS\0250\DWGS\FIGS-200.DWG

C02

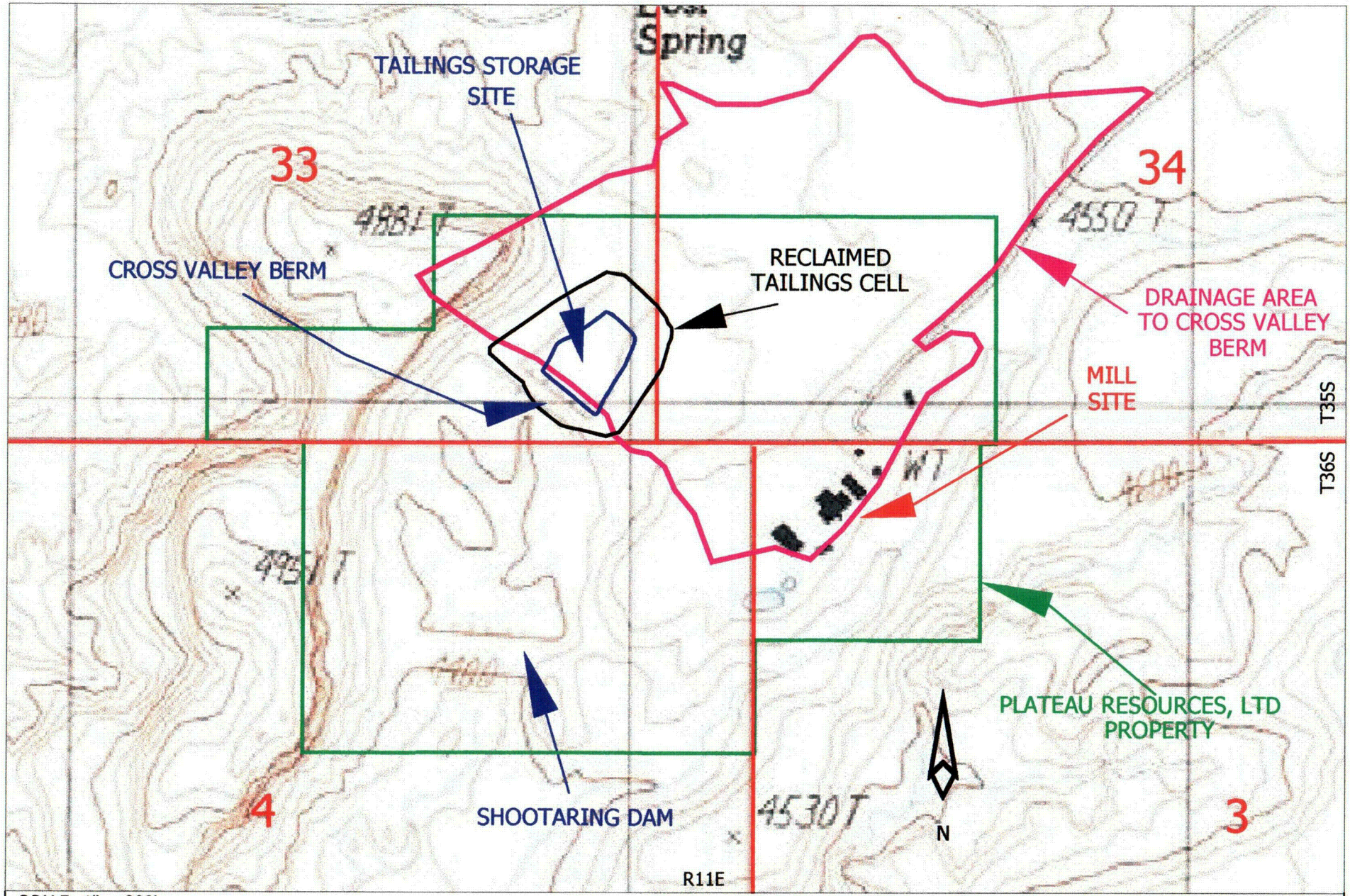

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FIGURE 3-5. LOCATION OF DRAINAGE AREA AND DESIGN TAILINGS CELL

TABLE 3-1. BASIC DATA FOR THE SHOOTARING WELLS AND PIEZOMETERS.

WELL NAME	NORTH. COORD.	EAST. COORD	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	MP ELEV. (ft-msl)	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)	PUMP INTAKE (ft-mp)
						WELLS					
OW1A	57140	63730	1.0	300.0	0.2	4472.53	229.20	4243.33	200-300	-	—
OW1B	57140	63730	1.0	798.0	1.9	4474.23	448.20	4026.03	648-798	-	—
OW2	57094	63667	1.0	300.0	0.2	4470.70	222.90	4247.80	200-300	-	—
OW3	57046	63659	1.0	798.0	2.3	4470.78	453.20	4017.58	650-798	-	—
OW4	57035	63707	1.0	570.0	2.3	4472.54	213.55	4258.99	435-570	-	—
RM1	59307	61827	3.0	487.0	2.2	4449.20	175.80	4273.40	220-480	157-487	106
RM2	57731	63040	3.0	520.0	1.6	4519.76	258.25	4261.51	260-520	250-520	—
RM2R	57924	63142	5.0	300.0	1.2	4504.86	241.00	4263.86	250-300	242-300	273
RM3	57193	60647	6.0	540.0	1.8	4461.32	214.70	4246.62	230-540	190-540	246
RM4	56472	61099	3.0	500.0	3.5	4395.50	155.10	4240.40	190-490	115-500	176
RM4R	56358	61086	5.0	160.0	1.0	4368.32	128.20	4240.12	110-160	105-160	157
RM5	56416	61286	3.0	440.0	3.6	4379.12	139.31	4239.81	150-430	130-440	172
RM6	56348	61481	3.0	460.0	2.3	4374.57	135.70	4238.87	175-455	110-460	174
RM7	57904	61645	3.0	219.5	2.0	4395.83	140.40	4255.43	187-217	177-217	200
RM8	57204	61576	3.0	79.1	1.8	4381.04	57.35	4323.69	57-77	47-77	—
RM9	56767	61363	3.0	82.8	1.2	4369.31	61.60	4307.71	62-82	52-82	—
RM10	56286	61272	5.0	99.0	2.0	4343.57	96.80	4246.77	57-97	53-97	—
RM11	56594	60769	5.0	240.0	2.0	4436.14	184.50	4251.64	140-180 180-240*	5-180 -	203
RM12	59477	61791	5.0	157.0	1.3	4415.95	142.50	4273.45	117-157	110-157	—
RM13	56648	61996	5.0	270.0	2.0	4434.81	188.10	4246.71	140-180 180-270*	5-180 -	219
RM14	58419	61368	5.0	260.0	1.5	4450.84	192.10	4258.74	120-160 160-260*	5-160 -	253
RM15	56311	61354	5.0	460.0	1.9	4343.75	105.92	4237.83	379-459	95-459	157
RM16	56615	60772	5.0	296.0	1.2	4434.95	194.30	4240.65	246-296	240-296	255
RM17	56636	61993	5.0	290.0	0.7	4433.58	187.40	4246.18	240-290	235-290	248
WW1	57144	63677	6.0	870.0	-2.8	4454.79	---	---	635-870*	-	—
WW2	56562	63086	6.0	1000.0	-3.4	4471.61	---	---	602-1000*	-	—
						TAILINGS WELLS					
T4	58456	61953	2.0	20.0	1.2	4431.20	Dry	4411.20	12.9-17.9	10-18	—
T5	58371	61891	2.0	10.0	2.5	4425.00	Dry	4415.10	2.5-7.5	0.7-8	—
T6	58133	61801	2.0	11.7	2.9	4429.00	Dry	4417.30	3.8-8.8	1-9	—
						PIEZOMETERS					
PZ1	56598	61022	1.0	87.0	2.0	4434.51	---	---	75-85	2-85	—
PZ2	56580	61327	1.0	88.0	2.0	4434.74	---	---	76-86	3-86	—
PZ3	56564	61575	1.0	88.0	2.0	4435.34	---	---	76-86	3-86	—
PZ4	56271	61383	1.0	25.0	2.0	4347.17	Dry	4320.92	13-23	2-23	—
PZ5	56301	61275	1.0	25.0	2.0	4344.79	Dry	4318.49	13-23	1-23	—
PZ6	56332	61167	1.0	25.0	2.0	4362.50	Dry	4336.90	13-23	2-23	—

TABLE 3-1. BASIC DATA FOR THE SHOOTARING WELLS AND PIEZOMETERS.

WELL NAME	NORTH. COORD.	EAST. COORD	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	MP ELEV. (ft-msl)	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)	PUMP INTAKE (ft-mp)

NOTE: Wells RM1 through RM6, RM15 through RM17, OW1A and OW2 are completed in the Entrada Aquifer
Wells RM2R, RM4R, RM7 through RM14 and PZ4 through PZ6 are completed in the Upper Entrada Sandstone
Wells WW1, WW2, OW1B and OW3 are completed in the Navajo Aquifer
Well OW4 is completed in the Carmel Aquitard
Piezometers PZ1 through PZ3 are Dam Piezometers
mp = measuring point; lsd = land surface datum; msl = mean sea level
* = open hole
Above data compiled from physical measurements, records and site surveys.

TABLE 3-2. TAILINGS UNDER DRAIN SUMP INFLOWS AT SHOOTARING CANYON.

Date	Activity	Total time (hr)	Quantity pumped (gal)	Flow rate (gpm)	Sump sample collected
04/03/2002	instantaneous flow estimate			0.037	4/3 sample liquid sample
4/16/02 to 5/16/02	pump sump	744	1505	0.034	4/29 sump liquid sample
5/16/02 to 6/26/02	pump sump	984	473	0.008	
6/26/02 to 7/14/02	pump sump	432	215	0.008	
7/14/02 to 7/31/02	rain event (7/28) clean sump on 7/31				7/29 sump sample includes rain & sediment
7/31/02 to 8/5/02	pump sump	144	86	0.009	8/5 sump liquid sample
8/5/02 to 8/23/02	rain event (8/20) clean sump on 8/23				
8/23/02 to 9/2/02	pump sump	237	280	0.020	9/2 sump liquid sample
9/2/02 to 9/7/02	pump sump	120	172	0.024	
9/7/02 to 9/12/02	rain event (9/11) clean sump on 9/12				
9-7-02 to 9-12-02	rain event clean sump on 9-12				rain on 9-7, 9-11, 9-28 and 9-29
9-12-02 to 10-5-02	pump sump	552	1849	0.056	
10-05-02 to 10-27-02	rain event and pump sump	528	2365	0.074	iincludes rain runoff from 10-27 event
10-27-02 to 11-20-02	pump sump	576	430	0.012	
11-20-02 to 12-14-02	pump sump	576	731	0.021	
12-14-02 to 01-11-03	pump sump	672	989	0.025	rain 01-10-03, 0.3 inches
01-11-03 to 01-21-03	pump sump	240	860	0.060	
01-21-03 to 02-01-03	pump sump	264	645	0.041	
02-01-03 to 02-14-03	pump sump	312	860	0.046	rain on 2-13 of 0.7 inches
02-14-03 to 02-20-03	pump sump	144	1333	0.154	0.5 inches of rain on 2-18
2-20-03 to 2-27-03	pump sump	168	1,505	0.149	1.5 in rain on 2-24 & 2-25
2-27 to 3-6-03	pump sump	168	860	0.085	drain down from previous events

Note: All sump liquid and sediment is pumped into lined pond on tailings facility.

TABLE 3-3. WATER QUALITY FROM THE TAILINGS SUMP ATTACHED TO THE UNDER DRAIN SYSTEM

Well Name	Date	pH (units)	TDS (mg/l)	Cl (mg/l)	SO4 (mg/l)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	F (mg/l)	NO3+NO2 (mg/l)
TAILS SUMP	04/03/2002	7.13	32400	980	19800	9.31	0.117	0.033	6.4	48.7
	04/29/2002	8.12	50400	1570	30700	12.20	0.147	0.053	8.3	12.0
	07/29/2002	7.94	28500	785	15900	4.95	0.056	0.256	2.0	67.3
	08/05/2002	7.80	38500	1090	23500	11.20	0.199	0.058	7.8	17.9
	09/02/2002	7.96	44700	1410	28300	13.40	0.151	0.055	9.2	9.9

Well Name	Date	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Pb (mg/l)	Hg (mg/l)	Ag (mg/l)	Zn (mg/l)
TAILS SUMP	04/03/2002	0.005	0.12	< 0.001	0.004	0.056	< 0.001	< 0.001	< 0.001	0.12
	04/29/2002	0.006	< 0.10	< 0.001	< 0.010	0.070	< 0.002	< 0.001	< 0.005	0.13
	07/29/2002	0.017	0.20	< 0.001	< 0.010	0.050	0.009	< 0.001	< 0.005	0.37
	08/05/2002	0.011	< 0.10	< 0.001	< 0.010	0.040	0.005	< 0.001	< 0.005	0.23
	09/02/2002	0.011	<0.10	<0.001	<0.010	0.070	<0.002	<0.001	<0.005	0.14

4.0 GROUND-WATER FLOW

The 2002 water-level elevations for the Entrada aquifer and the Upper Entrada are presented on Figure 4-1. The Entrada aquifer water-level elevations are presented in blue with blue contours corresponding to these water levels. The Upper Entrada data is presented in red. Upper Entrada water-level elevation contours were drawn on the 2002 water-level elevation map to show the area where the lower permeability upper portion of the sandstone causes higher water levels than the main Entrada aquifer. Figure 4-1 shows that the ground-water flow in the Shootaring Canyon tailings area is from the upper reaches of the tailings basin to downstream of the Shootaring dam to the southwest. The average gradient of the 2002 piezometric surface is 0.011 ft/ft, which is the same as that which existed in the last five years. This gradient indicates a ground-water velocity of 0.022 ft/day, based on the average horizontal hydraulic conductivity of 0.2 ft/day, and an effective porosity of 0.1. This shows that the ground water in the Entrada aquifer is moving at only 8 feet per year.

The head in the Upper Entrada is very similar to the main Entrada aquifer at combination wells RM1/RM12, RM2/RM2R, RM4/RM4R and RM13/RM17. Based on the Entrada water-level elevation contours, the head is also very similar at Upper Entrada wells RM7 and RM14. Therefore, the head in the Upper Entrada and the Entrada aquifer are very similar in the northeast half of the Shootaring tailings site. The head at well RM11 is 11 feet higher than the head in RM16, while the head is higher upstream of the Shootaring Dam. A slightly higher head exists in the Upper Entrada at wells RM4R and RM10. The higher head in the Upper Entrada is due to smaller permeabilities in this portion of the Entrada sandstone, which mounds water due to slower movement rates.

Water-level elevations for 1998 through 2002 for the Entrada aquifer wells are presented in Table 4-1. Figure 4-2 presents the water levels with time for the Entrada wells northeast of the Shootaring Dam including all wells upgradient of the tailings cell and wells RM3 and RM7 downgradient. This figure shows that the water-level elevations in each of these Entrada wells have been very steady over the last five

years except for a decline in water levels in well RM12 prior to the rise in early 2003. Local recharge may have influenced the level in Upper Entrada well RM12.

Water-level elevations for the Entrada wells just upstream of the Shootaring Dam and on each end of the Shootaring Dam are presented in Figure 4-3. This plot shows that the water levels have been steady for the two Upper Entrada wells upstream of the Shootaring Dam in 2002. A gradual decline in water level has been observed in Upper Entrada well RM11 while the three remaining wells on the Shootaring Dam have been fairly steady in 2002.

The water levels for the Entrada wells on the downstream side of the Shootaring Dam are presented in Figure 4-4. This figure shows that water levels have been fairly steady in the majority of these Entrada wells with a decline in well RM10 in 2002. This water level change is likely a function of recharge. Water levels in wells RM4 and RM6 in 2002 gradually rose while the remaining water levels on this plot were fairly steady.

The head difference between the Entrada aquifer and the Carmel aquitard measured in wells OW2 and OW4 indicated a small vertical gradient upward from the Carmel to the Entrada sandstone. A small vertical downward gradient existed in 1998. This change is likely due to stresses in one of the units but is expected to be a downward gradient over the long term. The head in the Navajo aquifer, which is below the Carmel, is approximately 230 feet lower than the head in the Entrada aquifer showing the overall gradient from the Entrada to the Navajo has to be downward as expected. Larger vertical gradients typically occur at the interface of hydraulically dissimilar materials, so it is likely that much of the head differential between the Entrada aquifer and Navajo sandstone occurs at the interfaces with the Carmel aquitard or possibly at some internal permeability discontinuity within the Carmel aquitard. Therefore, typical gradients within the Carmel may be much lower than indicated by the head differential.

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FIGURE 4-1, "WATER-LEVEL ELEVATION IN THE UPPER ENTRADA AND ENTRADA AQUIFER, 2002, FT-MSL"

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. FIGURE 4-1

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

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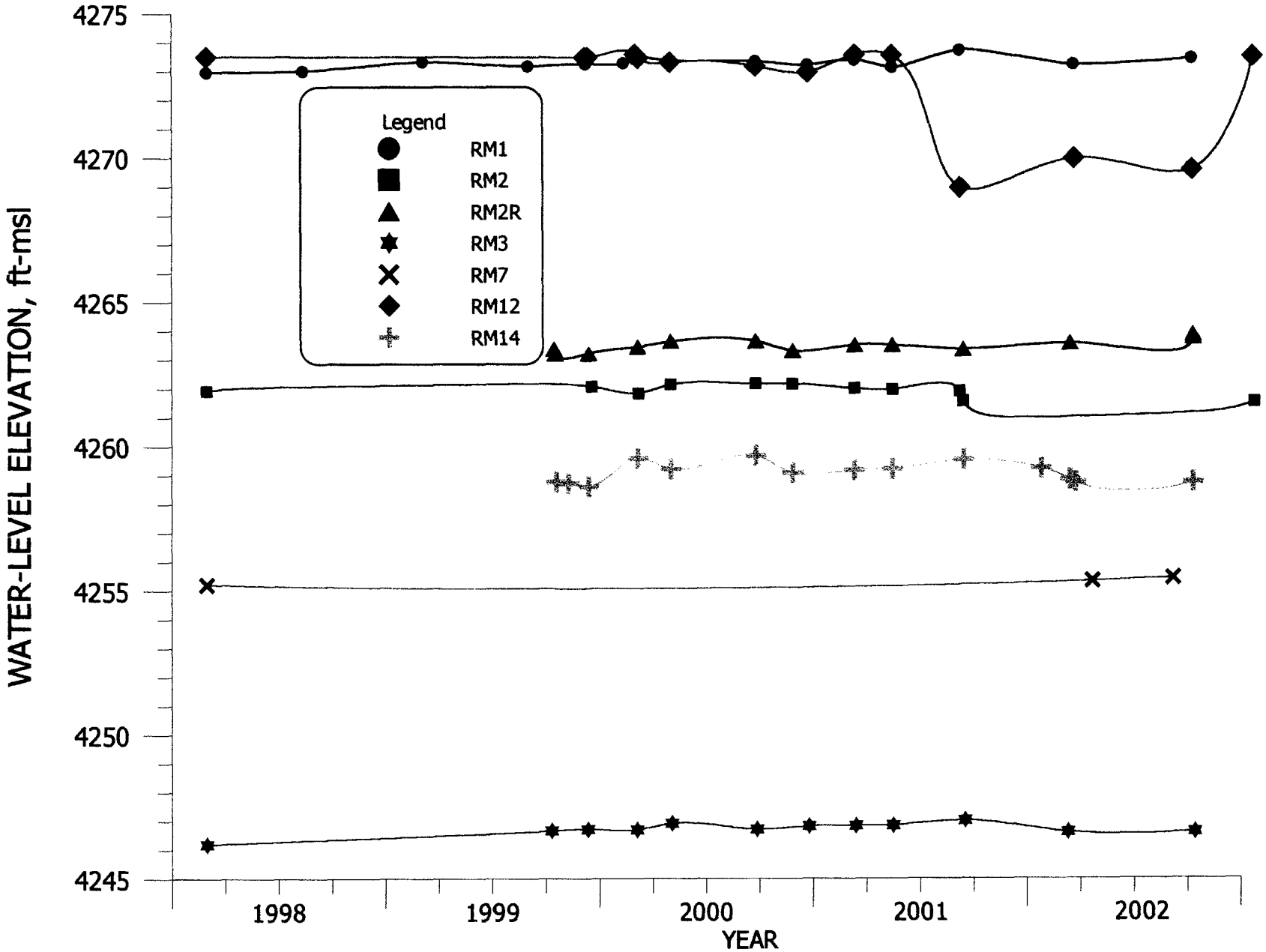

FIGURE 4-2. WATER-LEVEL ELEVATION FOR ENTRADA WELLS RM1, RM2, RM2R, RM3, RM7, RM12 AND RM14.

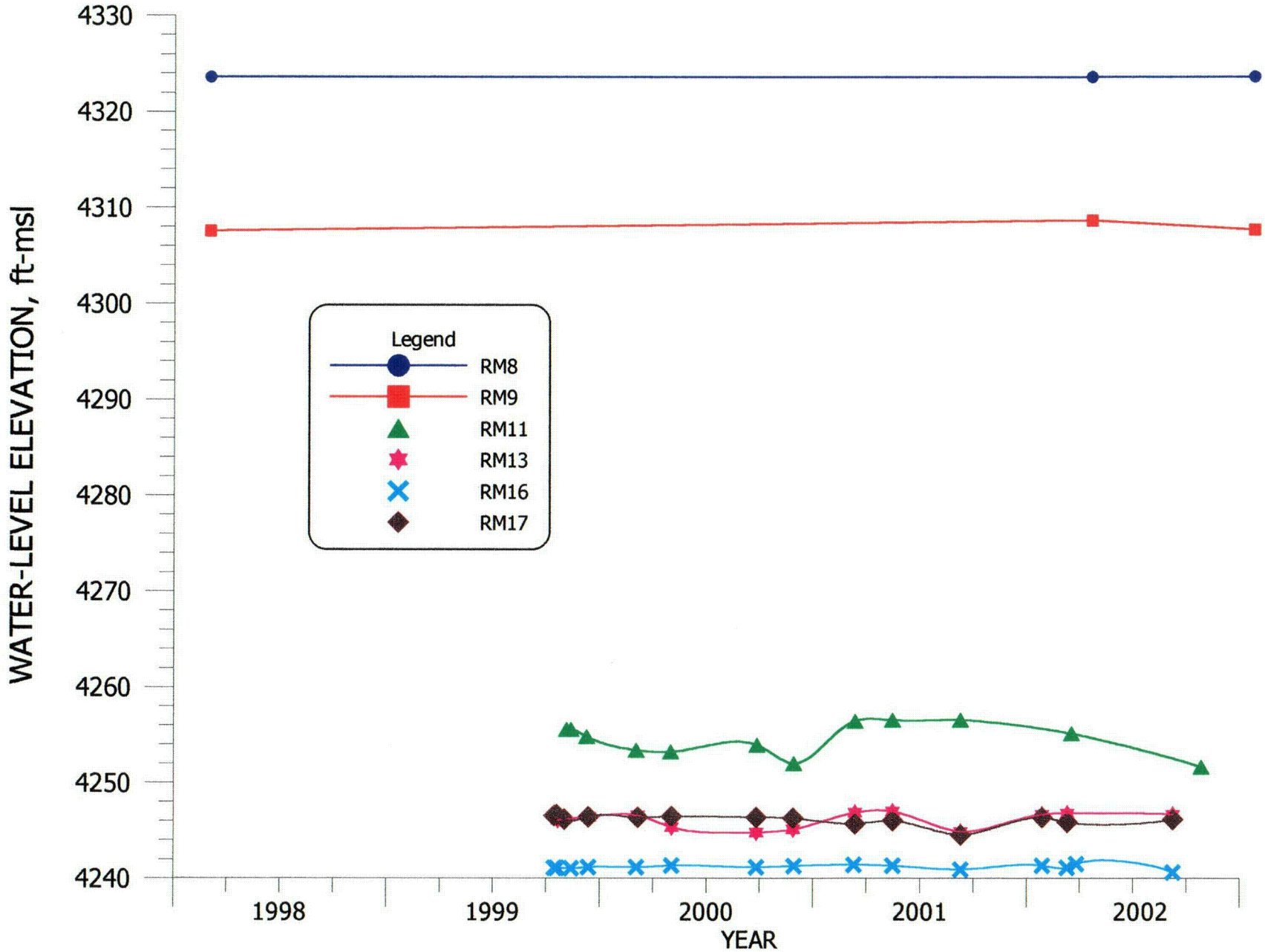

FIGURE 4-3. WATER-LEVEL ELEVATION FOR ENTRADA WELLS RM8, RM9, RM11, RM13, RM16 AND RM17.

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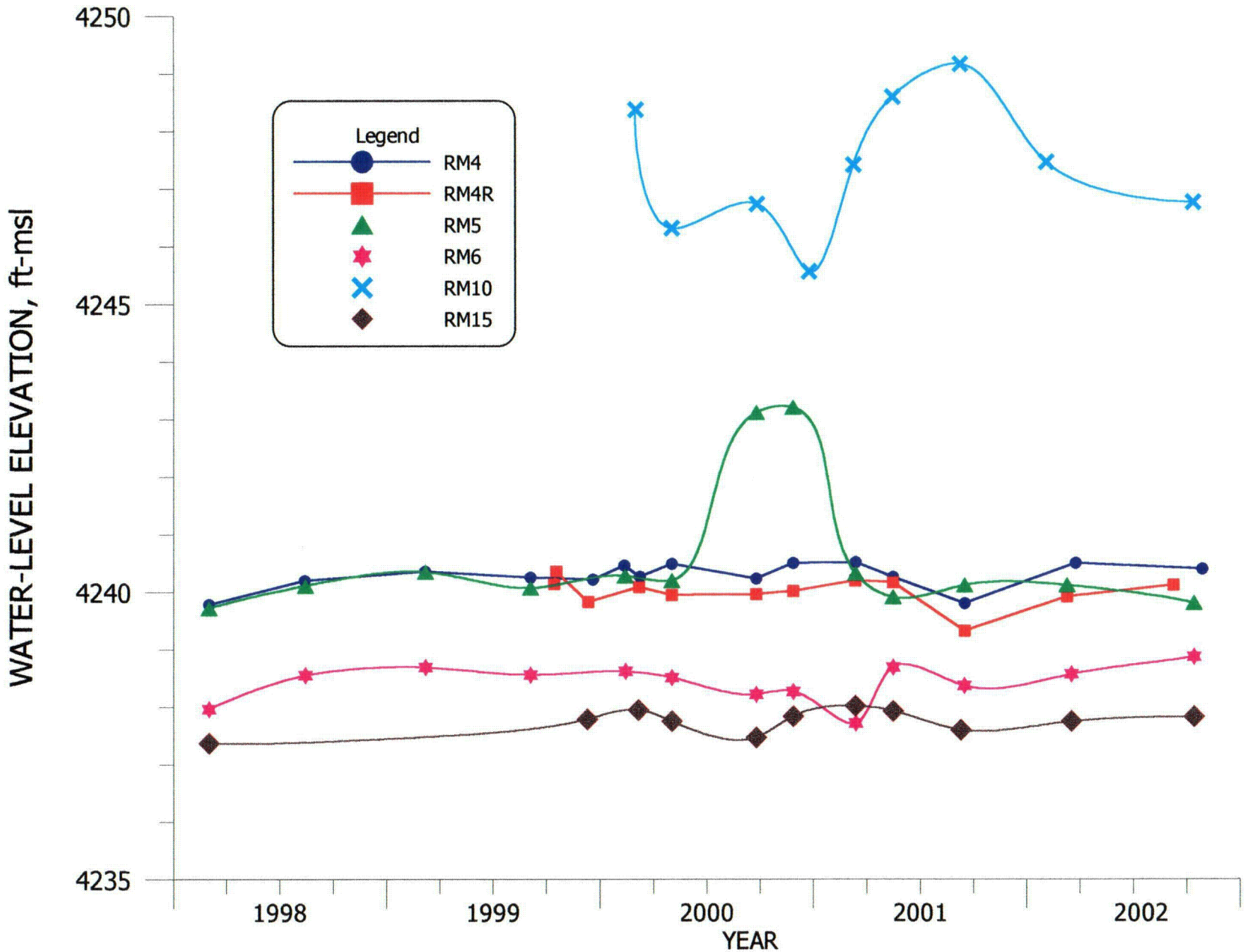

FIGURE 4-4. WATER-LEVEL ELEVATION FOR ENTRADA WELLS RM4, RM4R, RM5, RM6, RM10 AND RM15.

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TABLE 4-1. GROUND-WATER LEVELS FOR SHOOTARING WELLS.

WATER LEVEL ELEVATION (FT-MSL)

Date	Water Level (ft-MP)	Water Level Elevation (ft-MSL)
OW1A		
3/3/1998	218.18	4254.35
1/25/2003	229.20	4243.33
OW2		
1/25/2003	222.90	4247.80
OW3		
2/2/2003	453.20	4017.58
OW4		
1/25/2003	213.55	4258.99
PZ4		
12/9/1999	> 25.00	< 4322.17
3/3/2000	> 25.00	< 4322.17
5/3/2000	> 25.00	< 4322.17
11/28/2000	> 25.00	< 4322.17
3/14/2001	> 25.00	< 4322.17
5/17/2001	> 25.00	< 4322.17
9/16/2001	> 25.00	< 4322.17
1/27/2003	> 26.25	< 4320.92
PZ5		
12/9/1999	> 25.00	< 4319.79
3/3/2000	> 25.00	< 4319.79
5/3/2000	> 25.00	< 4319.79
11/28/2000	> 25.00	< 4319.79
3/14/2001	> 25.00	< 4319.79
5/17/2001	> 25.00	< 4319.79
9/16/2001	> 25.00	< 4319.79
1/27/2003	> 26.30	< 4318.49
PZ6		
12/9/1999	> 25.00	< 4337.50
3/3/2000	> 25.00	< 4337.50
5/3/2000	> 25.00	< 4337.50
11/28/2000	> 25.00	< 4337.50
3/14/2001	> 25.00	< 4337.50
5/17/2001	> 25.00	< 4337.50
9/16/2001	> 25.00	< 4337.50
1/27/2003	> 25.60	< 4336.90
RM1		
3/2/1998	176.23	4272.97
8/14/1998	176.19	4273.01
3/8/1999	175.88	4273.32
9/4/1999	176.03	4273.17
12/11/1999	175.96	4273.24
2/14/2000	175.93	4273.27
3/5/2000	175.79	4273.41
5/2/2000	175.83	4273.37
9/28/2000	175.87	4273.33
12/26/2000	176.00	4273.20
3/16/2001	175.83	4273.37
5/19/2001	176.08	4273.12
9/11/2001	175.50	4273.70
3/25/2002	176.00	4273.20
10/13/2002	175.80	4273.40
RM2		
3/2/1998	257.82	4261.94
12/20/1999	257.68	4262.08
3/9/2000	257.92	4261.84
5/4/2000	257.62	4262.14
9/27/2000	257.59	4262.17
11/29/2000	257.60	4262.16
3/15/2001	257.76	4262.00
5/18/2001	257.80	4261.96
9/10/2001	257.85	4261.91
9/16/2001	258.20	4261.56
1/27/2003	258.25	4261.51
RM2R		
10/17/1999	241.48	4263.38
10/19/1999	241.64	4263.22
12/15/1999	241.64	4263.22
3/8/2000	241.41	4263.45
5/4/2000	241.22	4263.64
9/27/2000	241.21	4263.65
11/29/2000	241.55	4263.31
3/15/2001	241.35	4263.51
5/18/2001	241.36	4263.50
9/16/2001	241.50	4263.36
3/18/2002	241.30	4263.56
10/14/2002	241.10	4263.76
RM3		
3/2/1998	215.12	4246.20
10/12/1999	214.65	4246.67
12/12/1999	214.60	4246.72
3/5/2000	214.62	4246.70
5/4/2000	214.40	4246.92
9/27/2000	214.60	4246.72
12/25/2000	214.50	4246.82
3/15/2001	214.48	4246.84
5/17/2001	214.46	4246.86
9/17/2001	214.30	4247.02
3/11/2002	214.70	4246.62
10/14/2002	214.70	4246.62
RM4		
3/3/1998	155.72	4239.78
8/14/1998	155.30	4240.20
3/8/1999	155.14	4240.36
9/5/1999	155.25	4240.25
12/20/1999	155.28	4240.22
2/12/2000	155.04	4240.46
3/9/2000	155.23	4240.27
5/3/2000	155.01	4240.49
9/25/2000	155.27	4240.23
11/28/2000	155.00	4240.50
3/15/2001	154.98	4240.52
5/17/2001	155.24	4240.26
9/17/2001	155.70	4239.80
3/26/2002	155.00	4240.50
10/28/2002	155.10	4240.40
RM4R		
10/16/1999	128.18	4240.14
10/19/1999	127.96	4240.36
12/12/1999	128.49	4239.83
3/8/2000	128.23	4240.09
5/3/2000	128.37	4239.95
9/25/2000	128.36	4239.96
11/28/2000	128.30	4240.02
3/14/2001	128.12	4240.20
5/17/2001	128.15	4240.17
9/17/2001	129.00	4239.32
3/11/2002	128.40	4239.92
9/9/2002	128.20	4240.12

TABLE 4-1. GROUND-WATER LEVELS FOR SHOOTARING WELLS. (cont'd.)

WATER LEVEL ELEVATION (FT-MSL)

Date	Water Level (ft-MP)	Water Level Elevation (ft-MSL)
RM5		
3/3/1998	139.40	4239.72
8/15/1998	139.01	4240.11
3/9/1999	138.77	4240.35
9/5/1999	139.05	4240.07
2/13/2000	138.84	4240.28
5/3/2000	138.92	4240.20
9/26/2000	136.00	4243.12
11/28/2000	135.91	4243.21
3/15/2001	138.80	4240.32
5/17/2001	139.21	4239.91
9/17/2001	139.00	4240.12
3/11/2002	139.00	4240.12
10/14/2002	139.31	4239.81
RM6		
3/3/1998	136.61	4237.96
8/15/1998	136.02	4238.55
3/9/1999	135.88	4238.69
9/5/1999	136.01	4238.56
2/14/2000	135.95	4238.62
5/3/2000	136.06	4238.51
9/25/2000	136.35	4238.22
11/28/2000	136.30	4238.27
3/15/2001	136.85	4237.72
5/17/2001	135.88	4238.69
9/16/2001	136.20	4238.37
3/18/2002	136.00	4238.57
10/14/2002	135.70	4238.87
RM7		
3/2/1998	140.61	4255.22
4/24/2002	140.51	4255.32
9/8/2002	140.40	4255.43
RM8		
3/4/1998	57.43	4323.61
4/24/2002	57.40	4323.64
1/28/2003	57.35	4323.69
RM9		
3/4/1998	61.73	4307.58
4/24/2002	60.61	4308.70
1/27/2003	61.60	4307.71
RM10		
12/9/1999	92.00	4251.57
12/16/1999	92.00	4251.57
3/3/2000	95.19	4248.38
5/4/2000	97.25	4246.32
9/27/2000	96.83	4246.74
12/26/2000	98.00	4245.57
3/12/2001	96.15	4247.42
5/17/2001	94.97	4248.60
9/10/2001	94.40	4249.17
2/5/2002	96.10	4247.47
10/13/2002	96.80	4246.77
RM11		
11/6/1999	180.57	4255.57
11/13/1999	180.59	4255.55
12/10/1999	181.32	4254.82
3/4/2000	182.75	4253.39
5/2/2000	182.93	4253.21
9/27/2000	182.19	4253.95
11/29/2000	184.12	4252.02
3/15/2001	179.69	4256.45
5/17/2001	179.60	4256.54
9/10/2001	179.60	4256.54
3/19/2002	181.00	4255.14
10/27/2002	184.50	4251.64
RM12		
3/2/1998	142.44	4273.51
12/9/1999	142.49	4273.46
12/14/1999	142.49	4273.46
3/10/2000	142.50	4273.45
5/4/2000	142.65	4273.30
9/28/2000	142.79	4273.16
12/26/2000	143.00	4272.95
3/16/2001	142.40	4273.55
5/19/2001	142.42	4273.53
9/11/2001	147.00	4268.95
3/26/2002	146.00	4269.95
10/13/2002	146.40	4269.55
1/27/2003	142.50	4273.45
RM13		
10/22/1999	188.71	4246.10
12/14/1999	188.38	4246.43
3/7/2000	188.23	4246.58
5/3/2000	189.45	4245.36
9/26/2000	190.00	4244.81
11/28/2000	189.68	4245.13
3/14/2001	187.93	4246.88
5/17/2001	187.80	4247.01
9/10/2001	189.90	4244.91
1/28/2002	188.10	4246.71
3/12/2002	188.00	4246.81
9/8/2002	188.10	4246.71
RM14		
10/21/1999	192.07	4258.77
11/11/1999	192.12	4258.72
12/15/1999	192.23	4258.61
3/8/2000	191.26	4259.58
5/4/2000	191.62	4259.22
9/27/2000	191.16	4259.68
11/29/2000	191.77	4259.07
3/14/2001	191.67	4259.17
5/18/2001	191.63	4259.21
9/17/2001	191.31	4259.53
1/28/2002	191.60	4259.24
3/18/2002	192.00	4258.84
3/27/2002	192.10	4258.74
10/13/2002	192.10	4258.74
RM15		
3/3/1998	106.38	4237.37
12/11/1999	105.96	4237.79
3/7/2000	105.80	4237.95
5/3/2000	106.00	4237.75
9/25/2000	106.28	4237.47
11/28/2000	105.91	4237.84
3/14/2001	105.73	4238.02
5/17/2001	105.82	4237.93
9/10/2001	106.15	4237.60
3/18/2002	106.00	4237.75
10/14/2002	105.92	4237.83

RM5 - RM15

TABLE 4-1. GROUND-WATER LEVELS FOR SHOOTARING WELLS. (cont'd.)

WATER LEVEL ELEVATION (FT-MSL)

Date	Water Level (ft-MP)	Water Level Elevation (ft-MSL)	Date	Water Level (ft-MP)	Water Level Elevation (ft-MSL)	Date	Water Level (ft-MP)	Water Level Elevation (ft-MSL)	Date	Water Level (ft-MP)	Water Level Elevation (ft-MSL)
RM16											
10/16/1999	193.84	4241.11									
10/20/1999	193.84	4241.11									
11/13/1999	193.89	4241.06									
12/13/1999	193.77	4241.18									
3/4/2000	193.78	4241.17									
5/3/2000	193.60	4241.35									
9/26/2000	193.77	4241.18									
11/29/2000	193.64	4241.31									
3/12/2001	193.51	4241.44									
5/17/2001	193.62	4241.33									
9/10/2001	194.00	4240.95									
1/28/2002	193.60	4241.35									
3/11/2002	193.80	4241.15									
3/27/2002	193.44	4241.51									
9/8/2002	194.30	4240.65									
RM17											
10/16/1999	187.02	4246.56									
10/20/1999	186.92	4246.66									
11/2/1999	187.38	4246.20									
12/13/1999	187.13	4246.45									
3/7/2000	187.20	4246.38									
5/3/2000	187.11	4246.47									
9/26/2000	187.19	4246.39									
11/28/2000	187.28	4246.30									
3/14/2001	187.85	4245.73									
5/17/2001	187.54	4246.04									
9/10/2001	189.00	4244.58									
1/28/2002	187.20	4246.38									
3/12/2002	187.70	4245.88									
9/8/2002	187.40	4246.18									

5.0 GROUND-WATER QUALITY

Ground-water quality at the Shootaring tailings site is very good. Table 5-1 presents the water-quality data compliance permit parameters for the Shootaring site. This table also includes uranium concentrations, which is an important parameter monitored for the NRC. Uranium concentrations have remained small in 2002. Table 5-1 presents the adjusted Shootaring data set. All Plateau laboratory analyses and any with detection limits above the GWQS were removed from the adjusted data set. Table 5-2 presents the water quality analyses from the Shootaring data that were removed from the adjusted data set. A few TDS values smaller than the major constituents were removed because they were too low in comparison to the major constituent concentrations. The high September 10, 2001, TDS from well RM10 was not supported by the field conductivity or the TDS of the re-sample of this well and was removed. All zero values were removed from the database.

The TDS at the Shootaring site is less than 500 mg/l with sulfate concentrations generally less than 50 mg/l. The TDS, sulfate and chloride concentrations in 2002 in upgradient well RM12 contained higher values than normal. These larger values have increased the upper natural range for chloride and were near the upper observed values for sulfate and TDS. The concentrations above the individual well ground-water protection levels are shaded light blue on Table 5-1. Concentrations that exceed the State ground-water quality standard are shaded yellow. The yellow shade is used if both the GWPL and GWQS are exceeded. Table 2-2 should be referred to for the individual well ground-water protection levels (GWPL) and the State ground-water quality standards (GWQS) for this site. The historical water-quality data for the Shootaring wells is tabulated in Table 5-1.

The areal variations of eight key parameters are presented on two figures to aid in evaluating present concentrations over the area. Figure 5-1 presents the latest TDS, sulfate, chloride and field pH values for the Shootaring Canyon monitoring wells for 2002. The Upper Entrada wells are shown with their names labeled in red, while the Entrada wells are labeled in blue. Figure 5-2 presents the key trace metals arsenic, barium, chromium and selenium for the Entrada aquifer for 2002.

The chloride concentrations, which are presented below the TDS concentrations in light blue, vary from a low of 4 to a high of 33 mg/l. This high is

present in upgradient Upper Entrada at well RM12. This shows that all chloride concentrations are within the natural expected range and less than the GWPL of 25 mg/l except for the value of 33 mg/l from well RM12. Time plots have been developed for this key parameter to determine whether a trend exists in chloride concentrations. Figure 5-3 presents the chloride concentrations for the northeastern Entrada wells at the Shootaring Tailings site. The range in individual well GWPL from Table 2-2 for the wells on a figure are shown by two solid black lines. The GWPL's for wells RM1, RM2R, RM3 and RM14 is 25 mg/l for chloride while the GWPL for well RM12 is 28.5 mg/l. The chloride concentrations in each of these wells are very low and steady except for the increase observed in well RM12. This higher chloride value, even though above the GWPL, has to be a natural variation because RM12 is upgradient of the site. These GWPLs account for the estimated upper limit for the adjusted data through 2002 and is presented on each figure in the GWPL range. Upgradient well RM12 contains a chloride concentration above its GWPL and shows that additional data is likely needed to define the full natural range of chloride at this site. The ground-water quality standard for chloride of 250 mg/l is also noted. Figure 5-4 presents the chloride concentration for the Entrada wells located on top of the tailings dam and RM4, which is located approximately half way off the downstream side of the tailings dam. These five wells all contain chloride concentrations in 2002 that are near 8 mg/l. No trends are indicated in any of these five Entrada wells for chloride concentration. Figure 5-5 presents the chloride concentrations versus time for the wells downstream of the tailings dam. This plot shows similar concentrations with all recent levels below the 25 mg/l GWPL for each of these wells. No trend in chloride concentrations is observed in any of the Entrada wells.

The TDS in these monitoring wells varies from a low of 119 mg/l at well RM11 to a high of 354 mg/l at upgradient well RM12 (see Figure 5-1). The TDS from the 2002 sample from well RM12 is near the GWPL for TDS for well RM12 at 361 mg/l. This higher TDS from RM12 is considered to be representative of the Entrada because the field conductivity and major constituent concentrations support this value. None of the 2002 TDS values from the Entrada exceeds the GWPL. The TDS concentrations versus time for the Entrada wells are presented on Figures 5-6 through 5-8. The TDS concentrations in the Entrada wells are all fairly close to 200 mg/l, except for a lower

value in well RM11 and a higher value in well RM12. The higher concentrations in 1998 and 1999 for wells RM10 and RM11 could be natural variations with time. Longer monitoring periods may confirm these variations. The latest value for well RM12 indicates that these values are likely natural. Figure 5-6 presents the TDS concentrations with time for the Entrada wells in the northern portion of the Shootaring tailings site. This figure shows that most of the concentrations for TDS are less than the lower range of GWPL of 225 mg/l except most of the values from well RM12. No consistent trends have been shown in these wells in the last few years. Additional data is needed to determine if the last value is a start of a trend for well RM12. Figure 5-7 shows the TDS concentrations versus time for the wells on the tailings dam and RM4. Concentrations in wells RM11, RM13, RM16 and RM17 are less than their respective GWPL. The GWPL was not calculated for the RM4 data and the range of GWPL's on Figure 5-7 do not account for the GWPL for well RM4. The RM4 data indicates that a larger range in the GWPL may be needed to account for all natural TDS values. Figure 5-8 shows the TDS concentrations for the Entrada wells below the tailings dam. TDS concentrations in RM10 are all below its GWPL except for the first value. Concentrations in all five of these wells are very similar in 2002. GWPL's were not calculated for wells RM5 and RM6 and therefore are not included in the range presented on this figure. Historical data for RM5 and RM6 indicate that the range in GWPL presented in Table 2-2 for the Entrada wells may need to be larger.

Sulfate concentrations, which are shown in green on Figure 5-1, also vary over a small range. The sulfate concentrations in 2002 vary from a low of 19 to a high of 75 mg/l. Only the sulfate concentration in 2002 from the upgradient Entrada well RM12 which is presented in Figure 5-1 slightly exceeds its GWPL of 74 mg/l. The sulfate concentrations in the northeast Entrada wells are presented in Figure 5-9 and generally show a band from slightly less than 20 mg/l to 50 mg/l except the latest value from well RM12. Figure 5-10 presents the sulfate concentrations versus time for the Entrada wells on the dam. The initial sulfate concentration in well RM16 was likely influenced by cement contamination. Additional monitoring is needed to show that these concentrations do not naturally vary over a larger range as indicated by the latest sulfate in well RM12. These concentrations vary over a similar range to those presented in Figure 5-9. The sulfate concentrations in RM11 have become steady after

a gradual increase with time but are still within the natural concentrations expected for the Entrada aquifer in this area. Figure 5-11 presents the sulfate concentrations for the Entrada wells on the downgradient side of the tailings dam. The sulfate concentrations for these five Entrada wells vary over a similar range to those upgradient of the area. The September 2001 sulfate concentration in RM10 appears to be an outlier but is similar to the October 2002 value for RM12. This value was not removed from the database because it does fit within the full natural range of concentrations expected for this aquifer (only slightly above the upper limit).

Table 5-1 presents the nitrate + nitrite concentrations for the Entrada wells. The nitrate + nitrite concentrations for well RM14 are above the lower range GWPL of 1.6 mg/l but less than its GWPL of 2 mg/l. The nitrate + nitrite data in general is close to their GWPL value which increases the likelihood of future values exceeding the GWPL. Time concentration plots were developed for nitrate + nitrite concentrations for the Entrada wells and are presented in Figures 5-12 through 5-14. Nitrate values were used on these plots where nitrate + nitrite values were not measured. The nitrate + nitrite concentrations are essentially nitrate concentrations since nitrite concentration is very low in the ground water. The historical nitrate concentrations were added to the nitrate plus nitrite data if no nitrite plus nitrate was measured because they have to be at least this value. These higher historical concentrations are indicative of some natural variability with time. Figure 5-12 shows that these concentrations are fairly steady. Figure 5-13 presents the similar nitrate plus nitrite concentrations with time. This figure also indicates fairly steady concentrations in 2002. The nitrate plus nitrite concentrations for the Entrada wells downstream of the Shootaring tailings dam are presented in Figure 5-14. The nitrate plus nitrite are within their respective GWPL's in 2002. The RM5 and RM6 data would yield larger GWPL's which would likely increase the band of the nitrate plus nitrite GWPL's in the Entrada aquifer. Nitrate plus nitrite concentrations are significantly below the ground-water quality standard. These plots show that observed concentrations are very near the GWPL for some wells and a small natural increase will exceed the GWPL.

The arsenic concentrations, which are shown in red on Figure 5-2, are highest in wells RM3, RM4R, RM10 and RM11. Based on the similar concentrations for conservative parameters, these arsenic concentrations are considered to be natural.

The arsenic concentrations at the Shootaring site are low with concentrations varying from very low to 0.07 mg/l in the Entrada wells in 2002. The GWPL set for the Shootaring site for arsenic ranges from a very low value of 0.005 mg/l to 0.087 mg/l. Arsenic concentrations from well RM3 are higher than the other values on Figure 5-15 with 2002 concentrations of 0.010 to 0.016 mg/l. Figure 5-16 shows the arsenic concentrations for Entrada wells RM4, RM11, RM13, RM16 and RM17. This plot shows very low arsenic concentrations with a slight increasing trend to near the ground-water protection level for well RM11. The steady low values in chloride concentrations in well RM11 indicate that these arsenic concentrations are natural. Figure 5-17 shows the arsenic concentrations for the five wells downstream of the Shootaring tailings dam. The concentrations in RM5, RM6 and RM15 are very low. A slightly higher concentration exists in monitoring well RM4R with concentrations near its GWPL of 0.012 mg/l. Higher arsenic concentrations exist in RM10. Concentrations in well RM10 were above the GWQS of 0.05 mg/l in 2002 but below its GWPL of 0.087 mg/l. Based on the conservative chloride concentrations, these arsenic concentrations are natural.

Uranium concentrations are presented in Table 5-1 because this is an additional key parameter for the NRC. The highest uranium concentration is less than 0.02 mg/l. All of the fluoride concentrations are below their respective GWPL. Figures 5-18 through 5-20 present the fluoride concentration for the Shootaring tailings wells. These three plots show that the fluoride concentrations do not exhibit a consistent trend with time.

All of the ammonia levels are significantly less than the GWPL of 3 mg/l. Figures 5-21 through 5-23 presents the ammonia concentrations for the Entrada wells. The ammonia concentration increased in wells RM10 and RM12 in 2002. Additional data is needed to determine if a significant trend for ammonia concentration has started in these two wells.

The barium GWPL is above all concentrations in the Entrada wells in 2002. Figures 5-24 through 5-26 present the barium concentrations with time. The barium concentrations in these three plots are fairly steady with time and do not indicate any significant trend. Cadmium concentration slightly exceeded the GWPL in well RM12 in 2002 but was less than the GWQS. This higher value has to be natural because well RM12 is upgradient of the site (see Figures 5-27 through 5-29).

Figures 5-30 through 5-32 present the chromium concentrations for the Entrada wells. These figures show low chromium concentrations with time except a higher value in 2002 for wells RM12 and RM10 which slightly exceed their respective GWPL. Additional data is needed to determine if a trend is beginning to develop.

None of the copper or lead concentrations exceed the GWPL (see Figures 5-33 through 5-38). None of these figures for copper or lead concentrations indicate a trend with time. None of the mercury levels in 2002 exceeded the GWPL. Figures 5-39 through 5-41 present the mercury concentrations for the Entrada wells with time. Figures 5-42 through 5-44 presents the molybdenum concentrations versus time for the Entrada wells. No significant trend is observed in the 2002 data for molybdenum. None of the 2002 selenium, silver or zinc concentrations exceed the GWPL (see Figures 5-45 through 5-53). The zinc level in 2002 in well RM12 was higher but has to be natural for this upgradient well.

The pH of all of the ground water is on the slightly alkaline side with the exception of the pH value at RM11. Wells RM11 and RM16 were thought to contain some effects from cement contamination. Additional pumping of well RM16 has resulted in a reasonable drop in pH in this well to levels similar to those in well RM4. The very low TDS in well RM11 may be allowing a higher natural pH in this water. Figures 5-54 through 5-56 present the pH(field) for Entrada wells at the Shootaring site. These plots show the lower ground-water quality standard of 6.5. The lower limit of the pH standards is the more important standard for comparison for pH because seepage from tailings has a potential to decrease the pH of the ground water. In general, these plots show a gradual decrease in pH with time in the last couple of years. This small change in pH is likely to be a short-term natural fluctuation in this parameter.

This analysis shows that a few of the ground-water protection levels are naturally exceeded at the Shootaring tailings site. Adjustments in the procedure to define individual GWPLs have decreased the frequency of indicated exceedances. The ground-water quality standards were only exceeded for two arsenic values in 2002 plus one pH exceedance. The TDS, sulfate and chloride GWPL for well RM12 were exceeded in 2002. The GWPL was slightly exceeded for arsenic for well RM11 and for cadmium for well RM12 during 2002. The chloride concentrations indicate that the water in these

two wells is representative of non-affected Entrada. Therefore, it is likely that the arsenic and cadmium concentrations in these wells are natural.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 5-1, "CONCENTRATION OF TDS, SULFATE, CHLORIDE AND FIELD pH IN ENTRADA AQUIFER AND UPPER ENTRADA, 2002"

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. FIGURE 5-1

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-06

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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FIGURE 5-2, "CONCENTRATIONS OF TRACE METALS ARSENIC, BARIUM CHROMIUM AND SELENIUM IN ENTRADA AND UPPER ENTRADA, 2002"

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. FIGURE 5-2

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

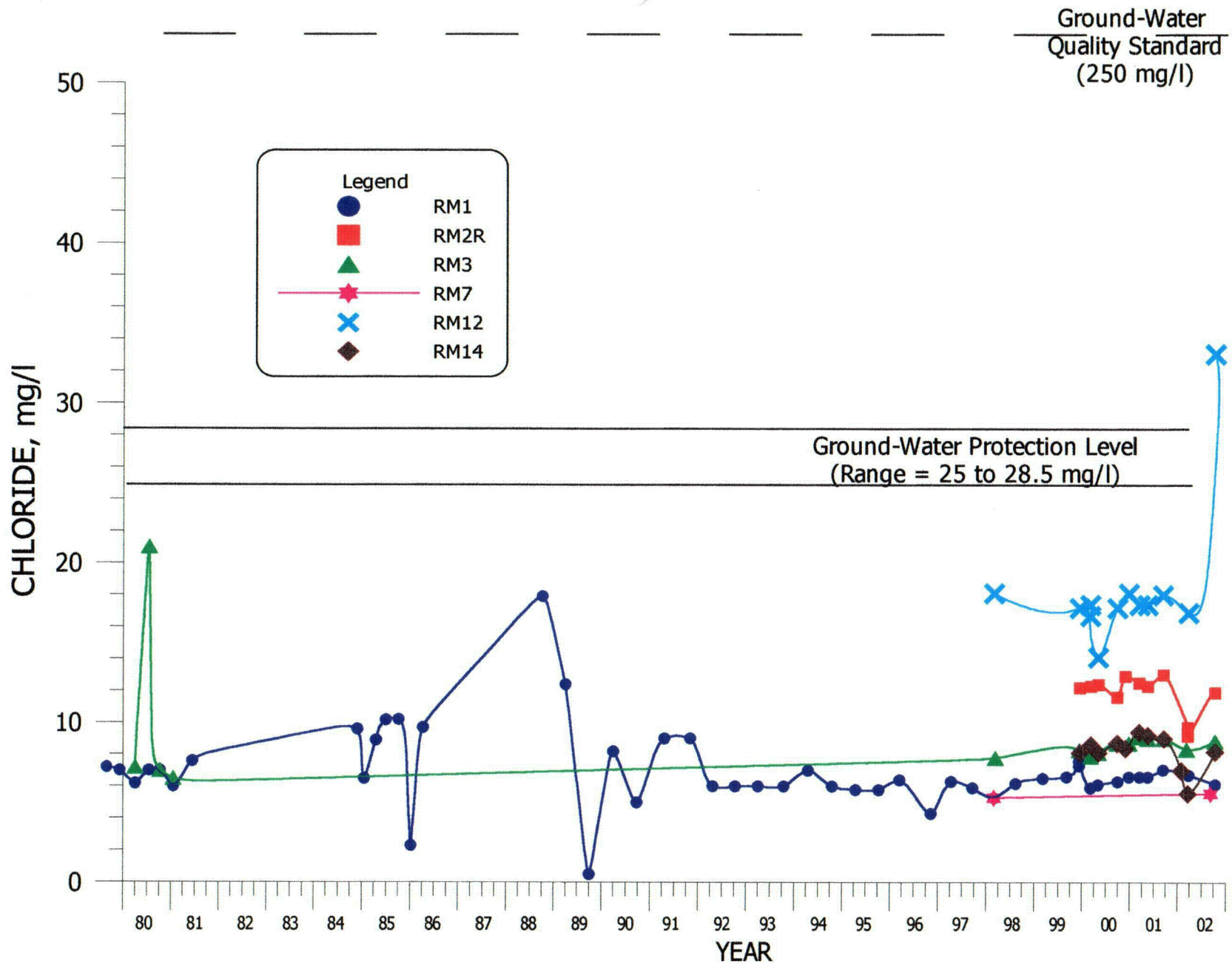

FIGURE 5-3. CHLORIDE CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12, AND RM14.

C06

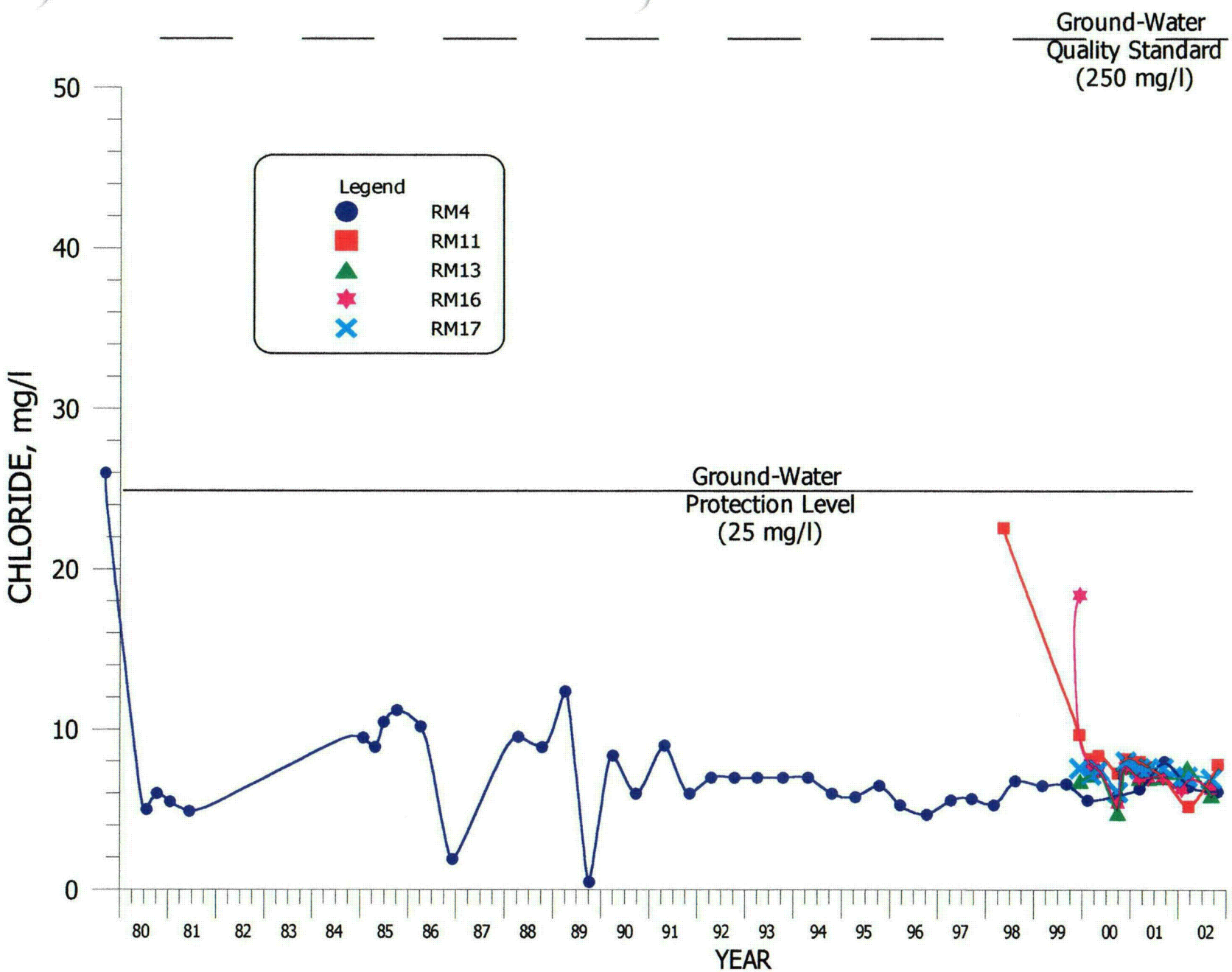

FIGURE 5-4. CHLORIDE CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

C07

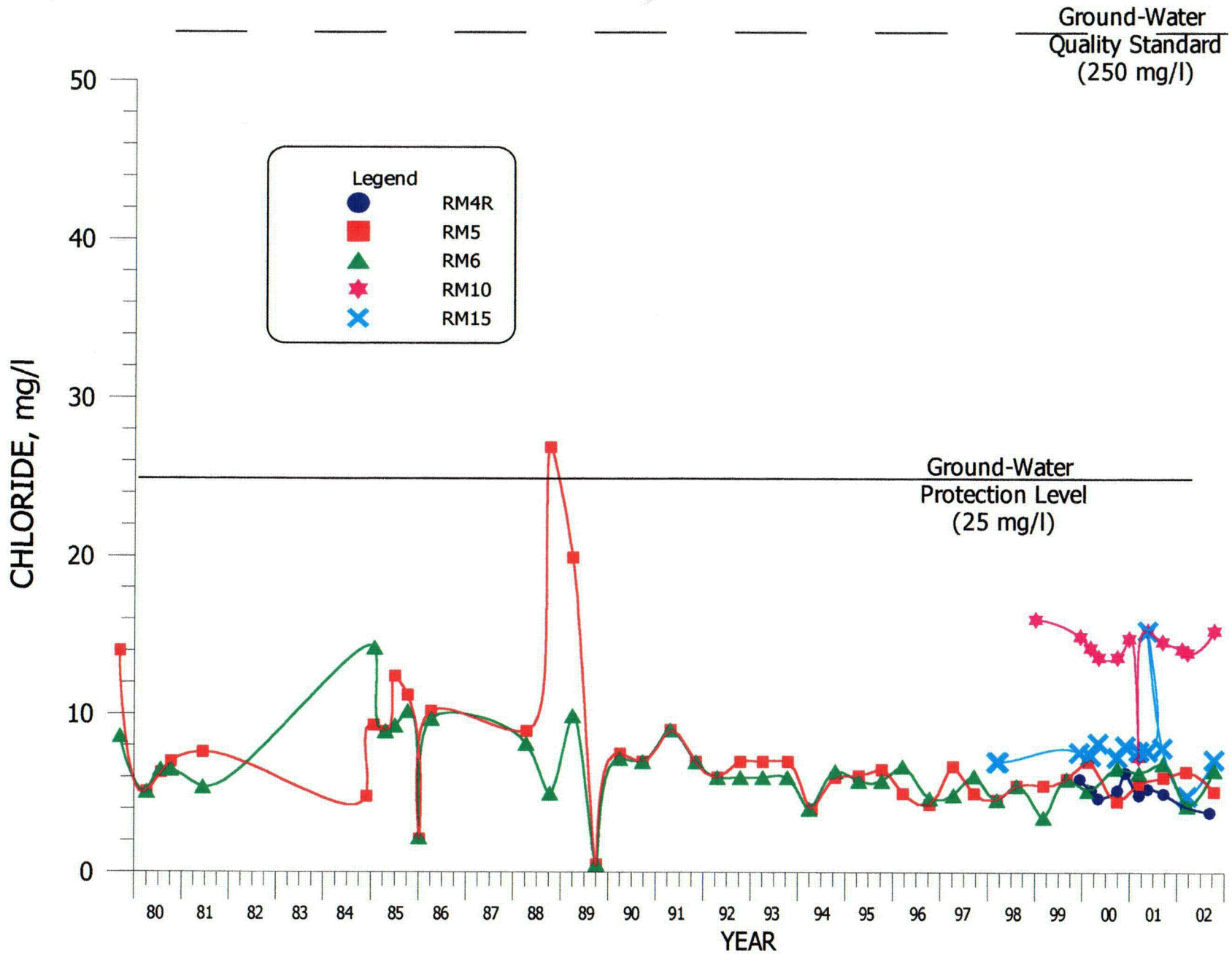

FIGURE 5-5. CHLORIDE CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

C08

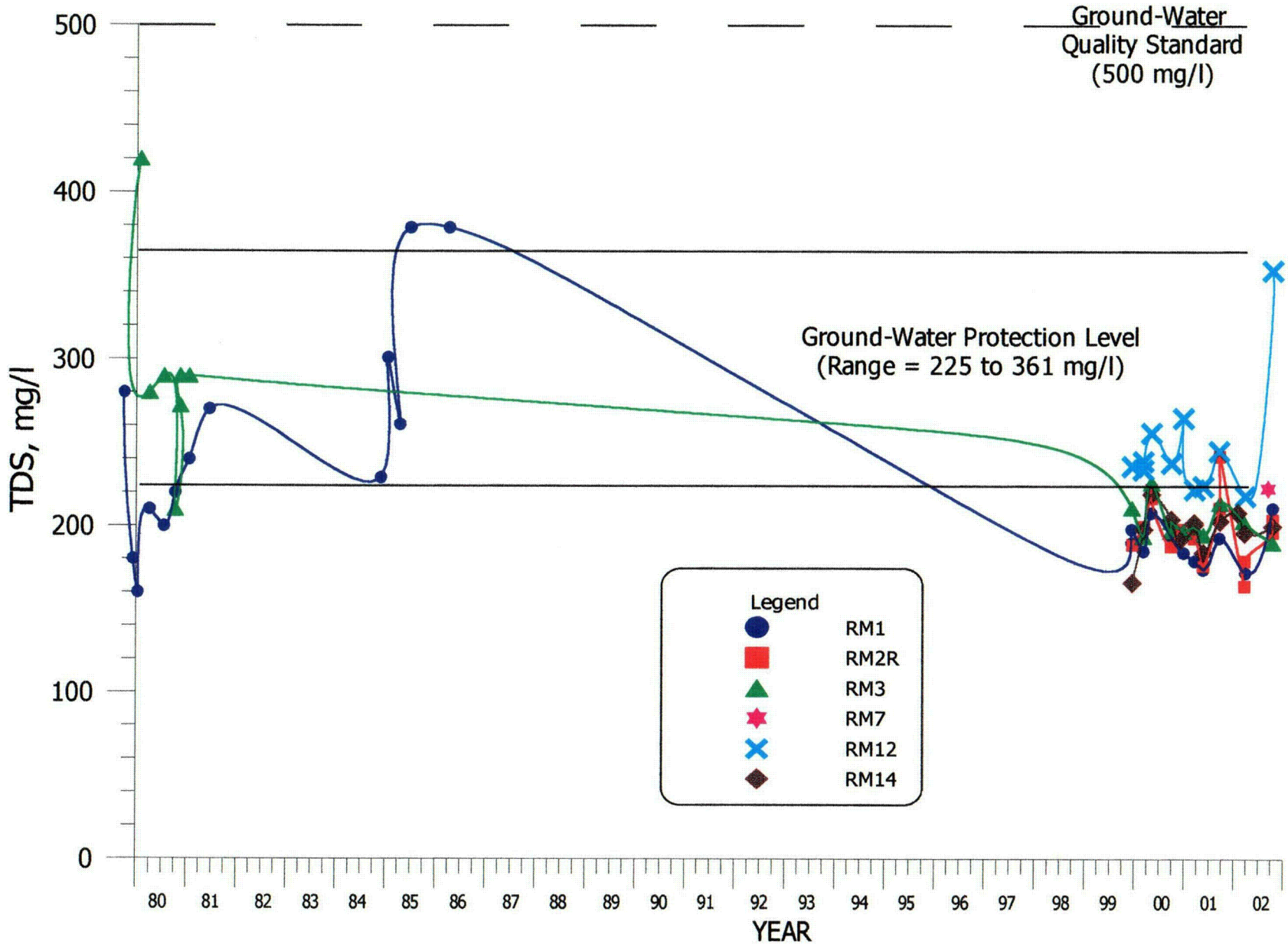

FIGURE 5-6. TDS CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12, AND RM14.

C09

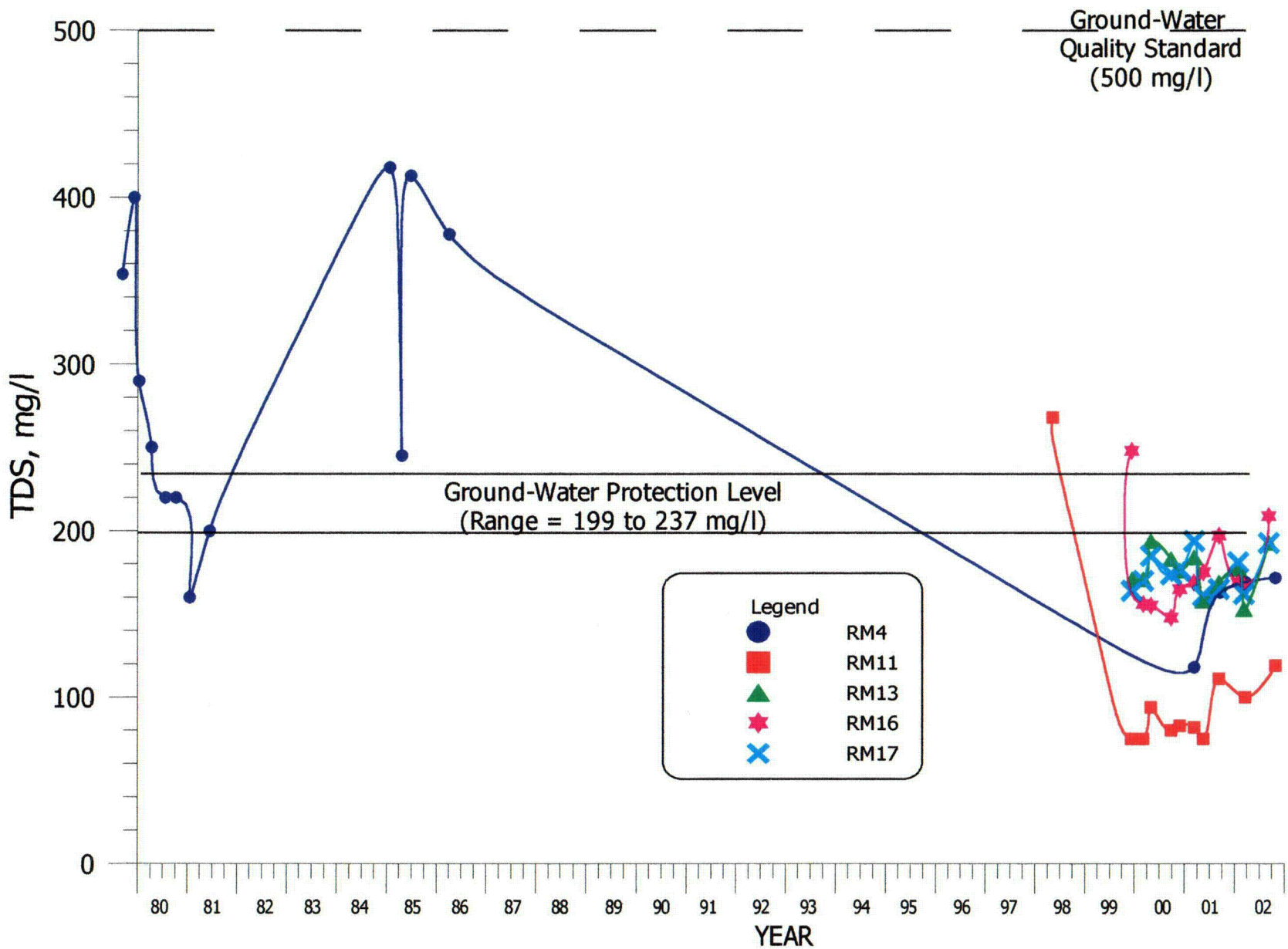

FIGURE 5-7. TDS CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

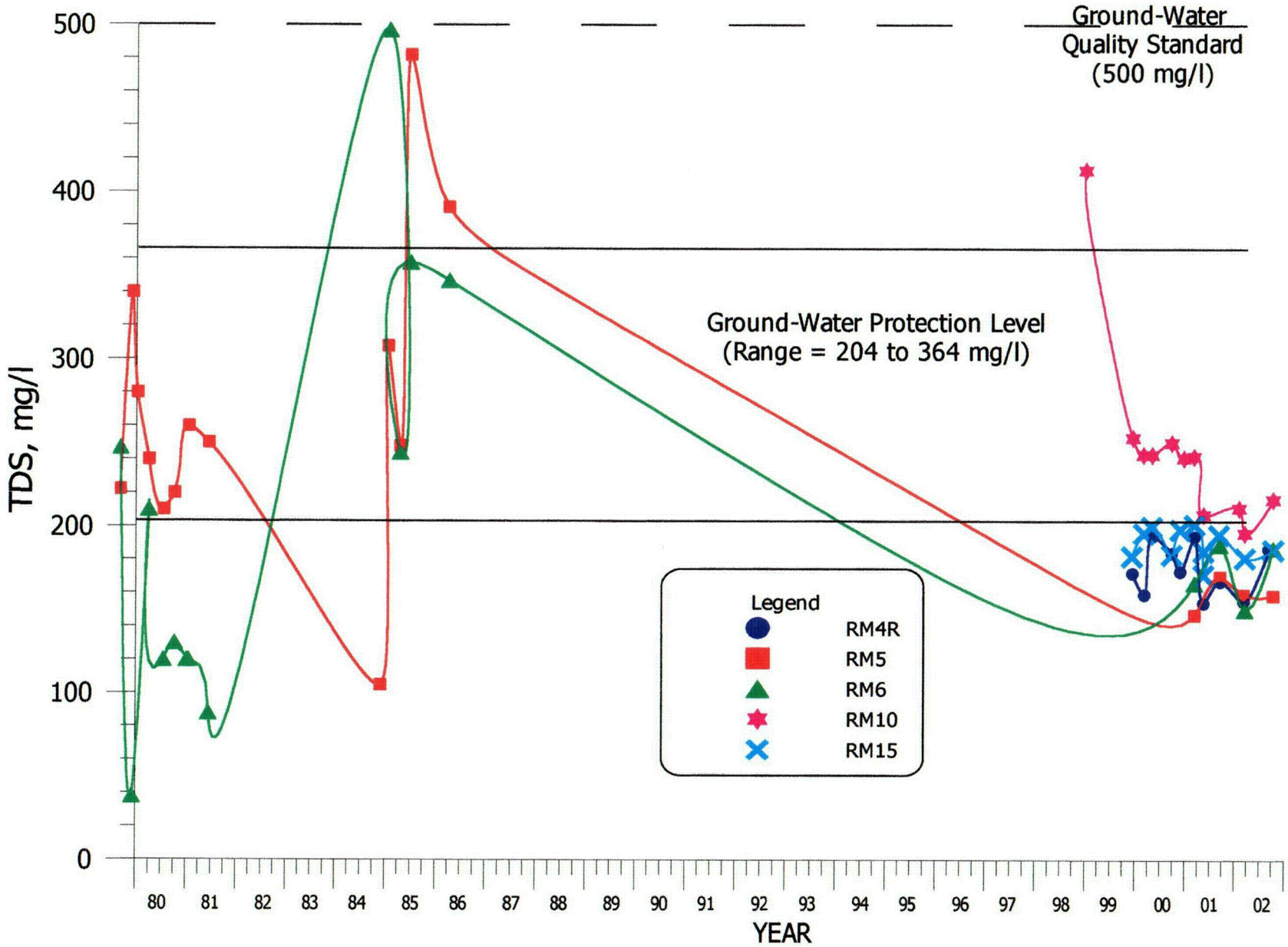

FIGURE 5-8. TDS CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

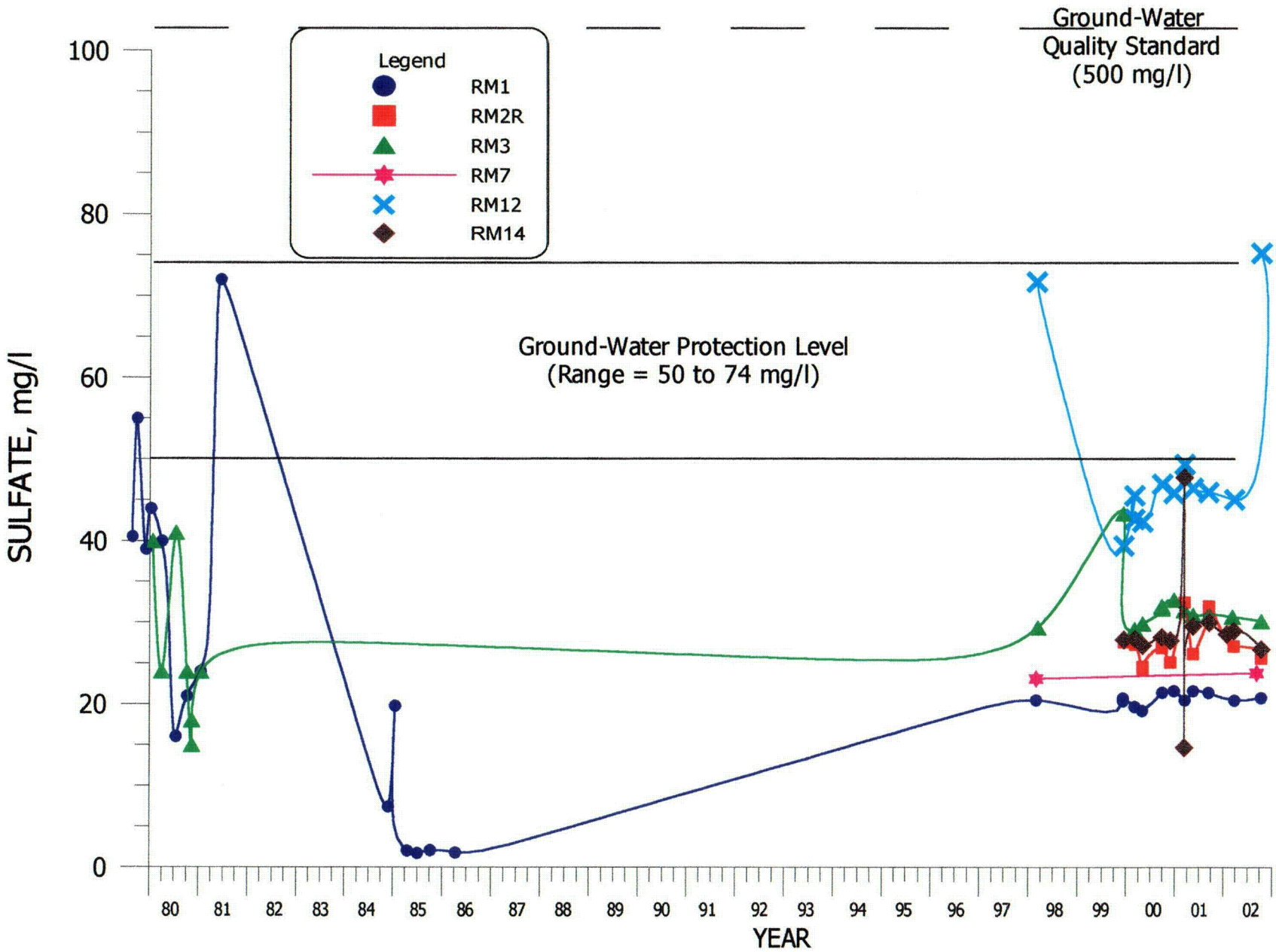

FIGURE 5-9. SULFATE CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12 AND RM14.

C12

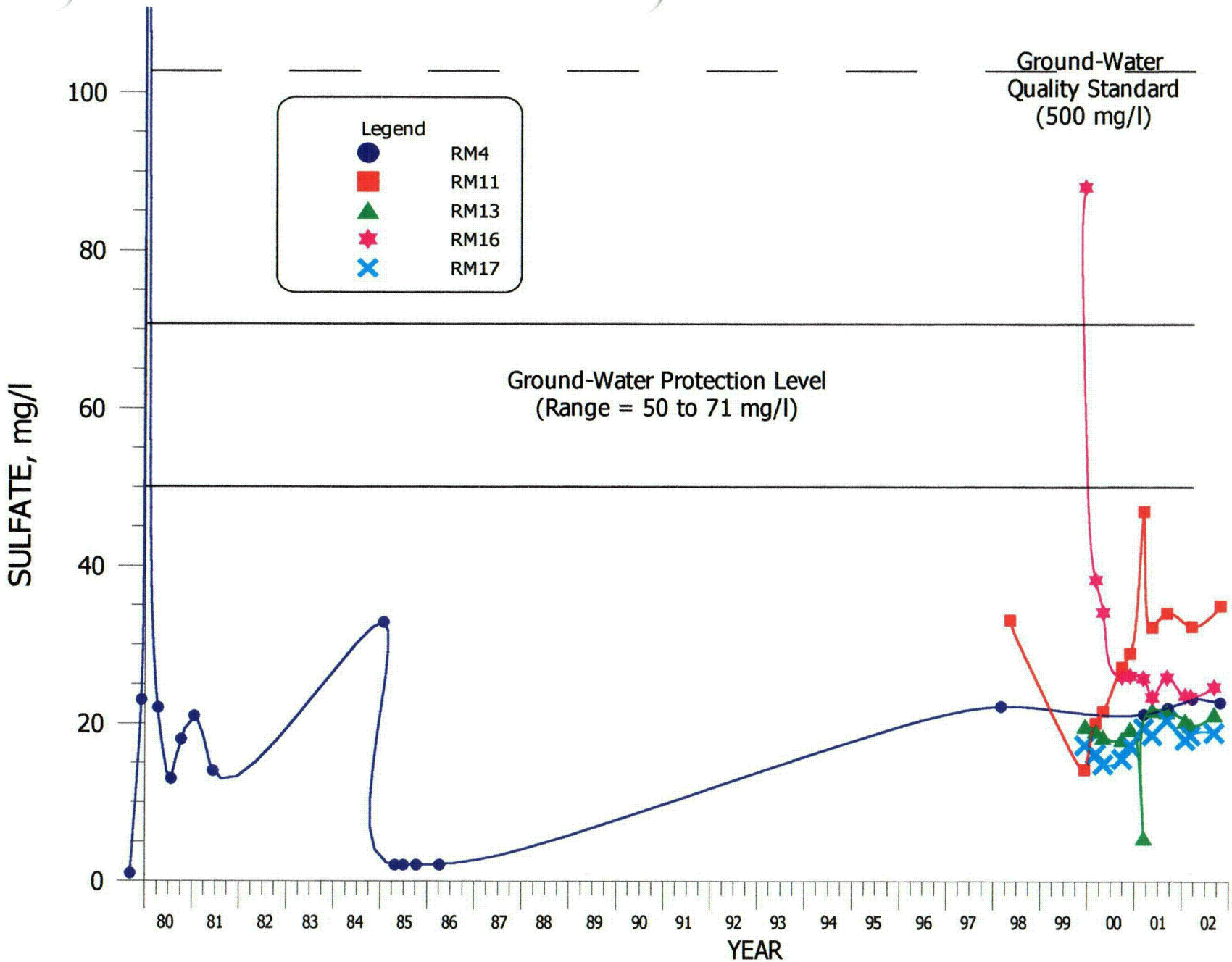

FIGURE 5-10. SULFATE CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

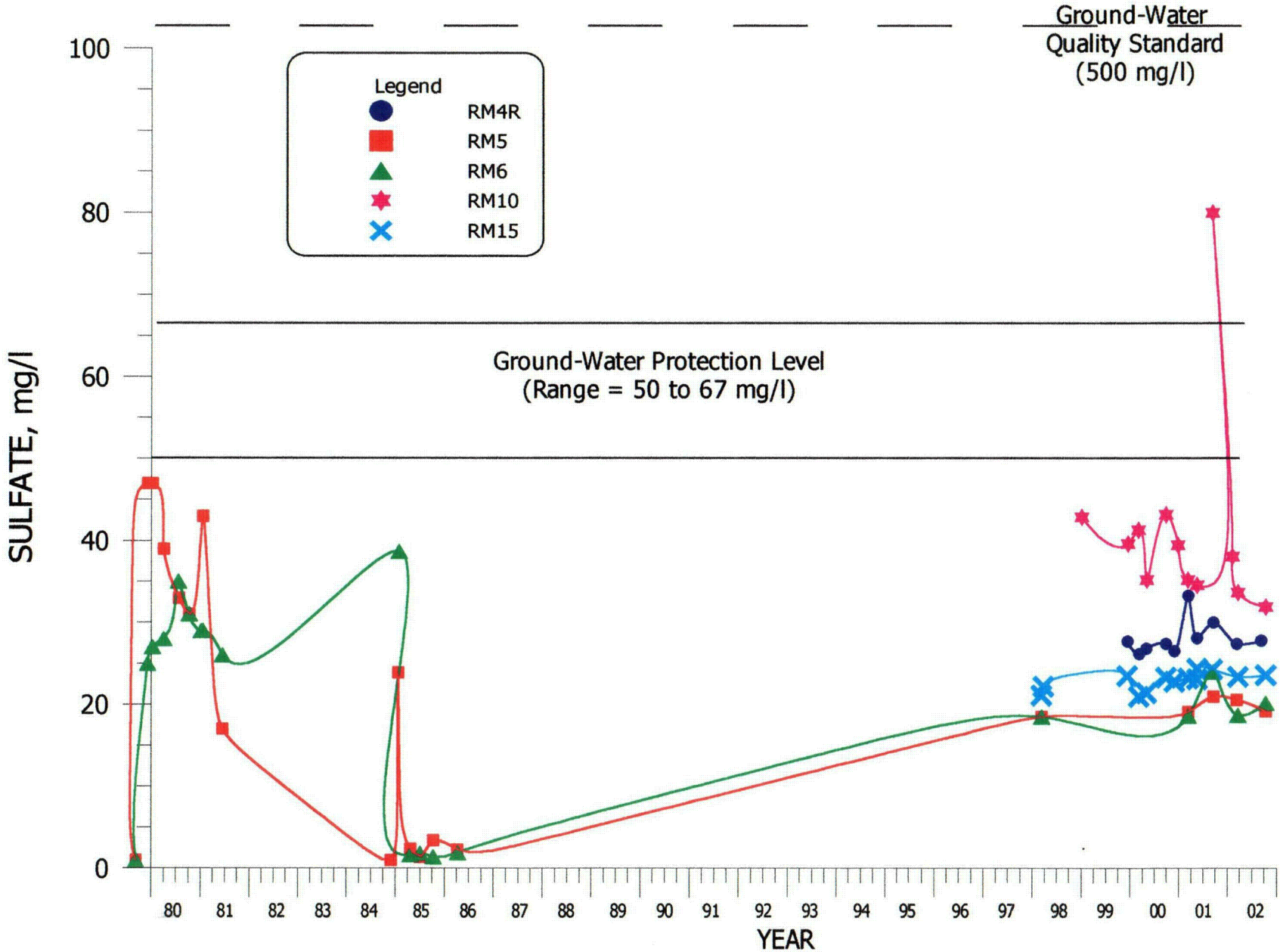

FIGURE 5-11. SULFATE CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

C14

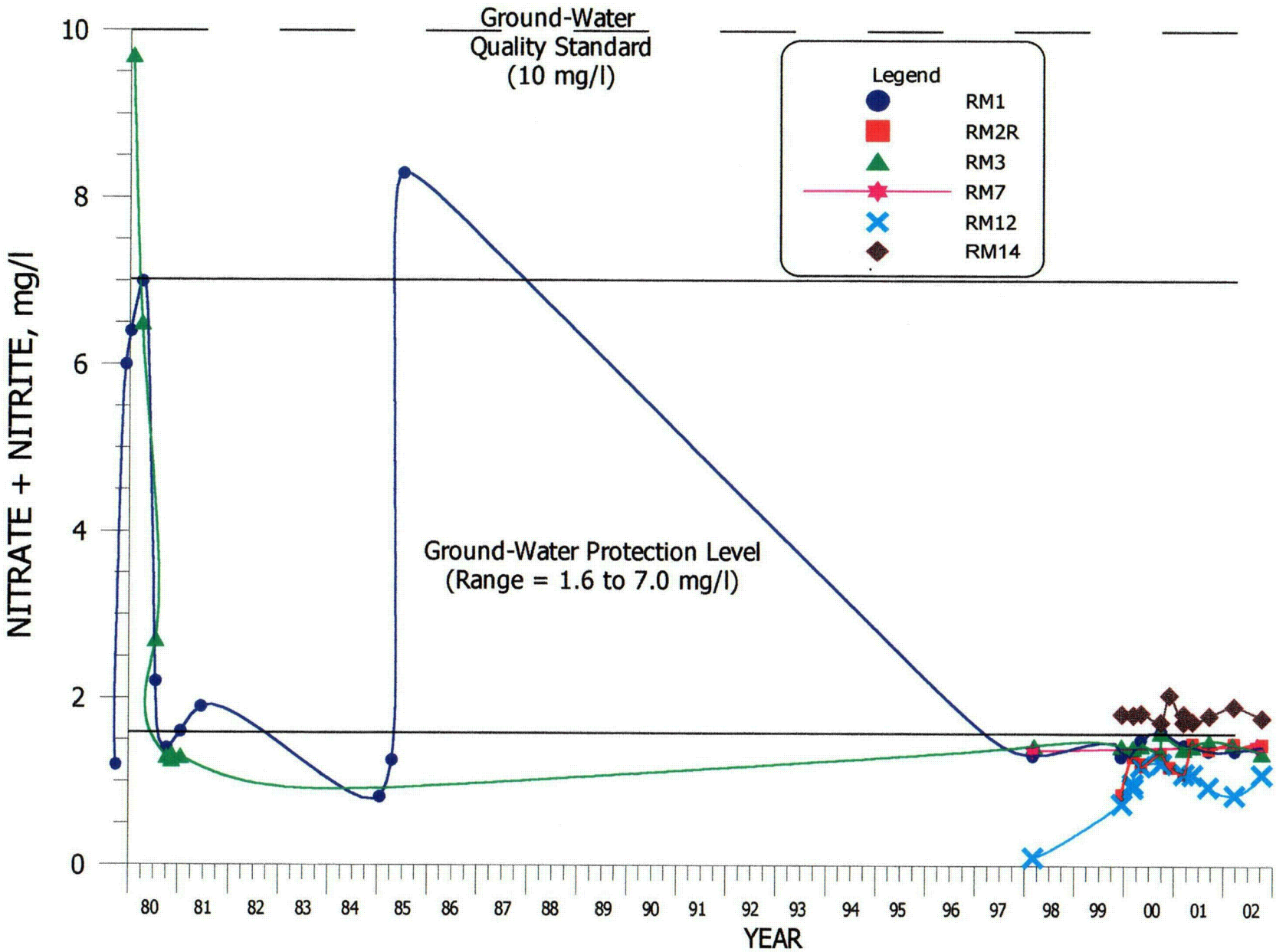

FIGURE 5-12. NITRATE + NITRITE CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12 AND RM14.

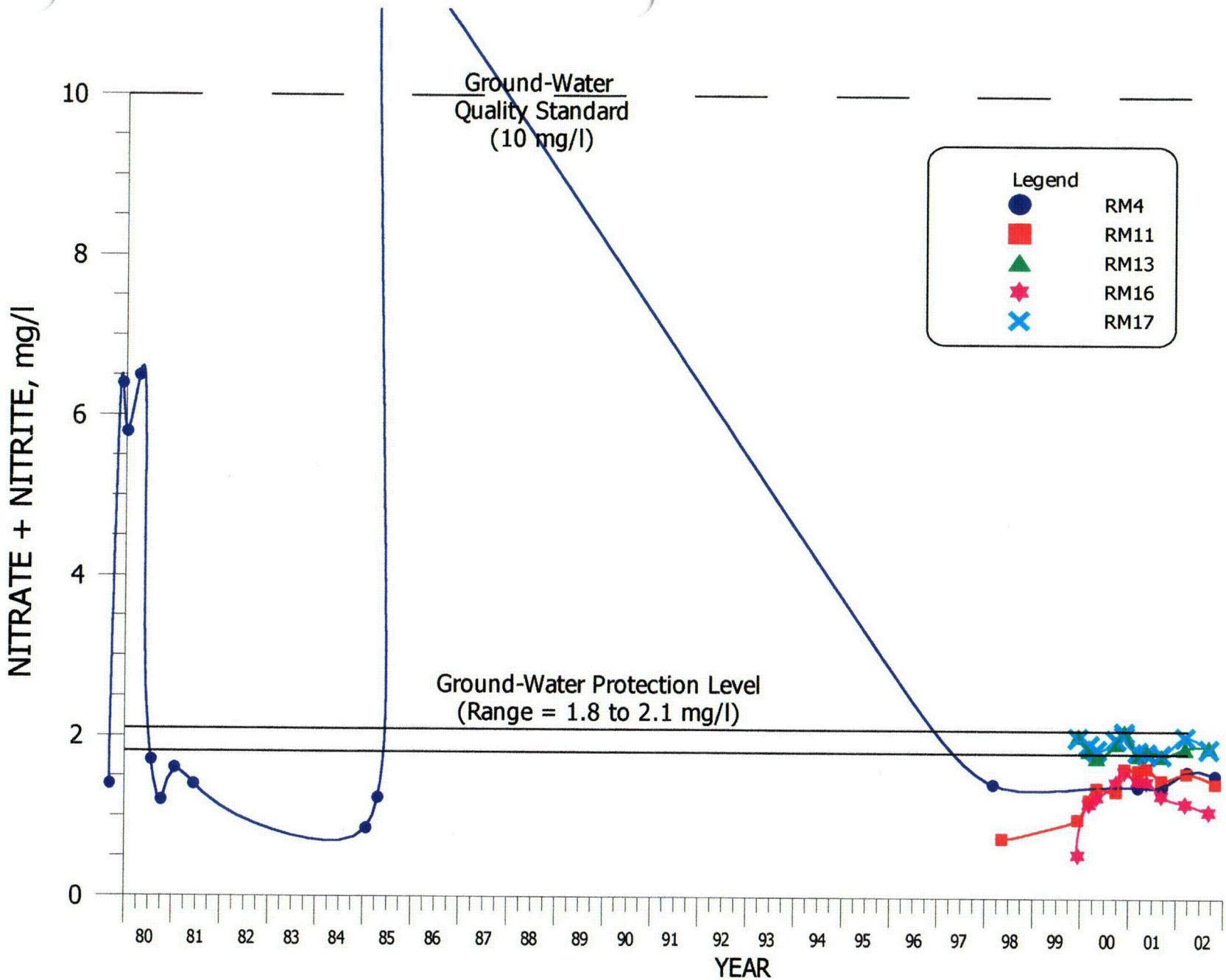

FIGURE 5-13. NITRATE + NITRITE CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

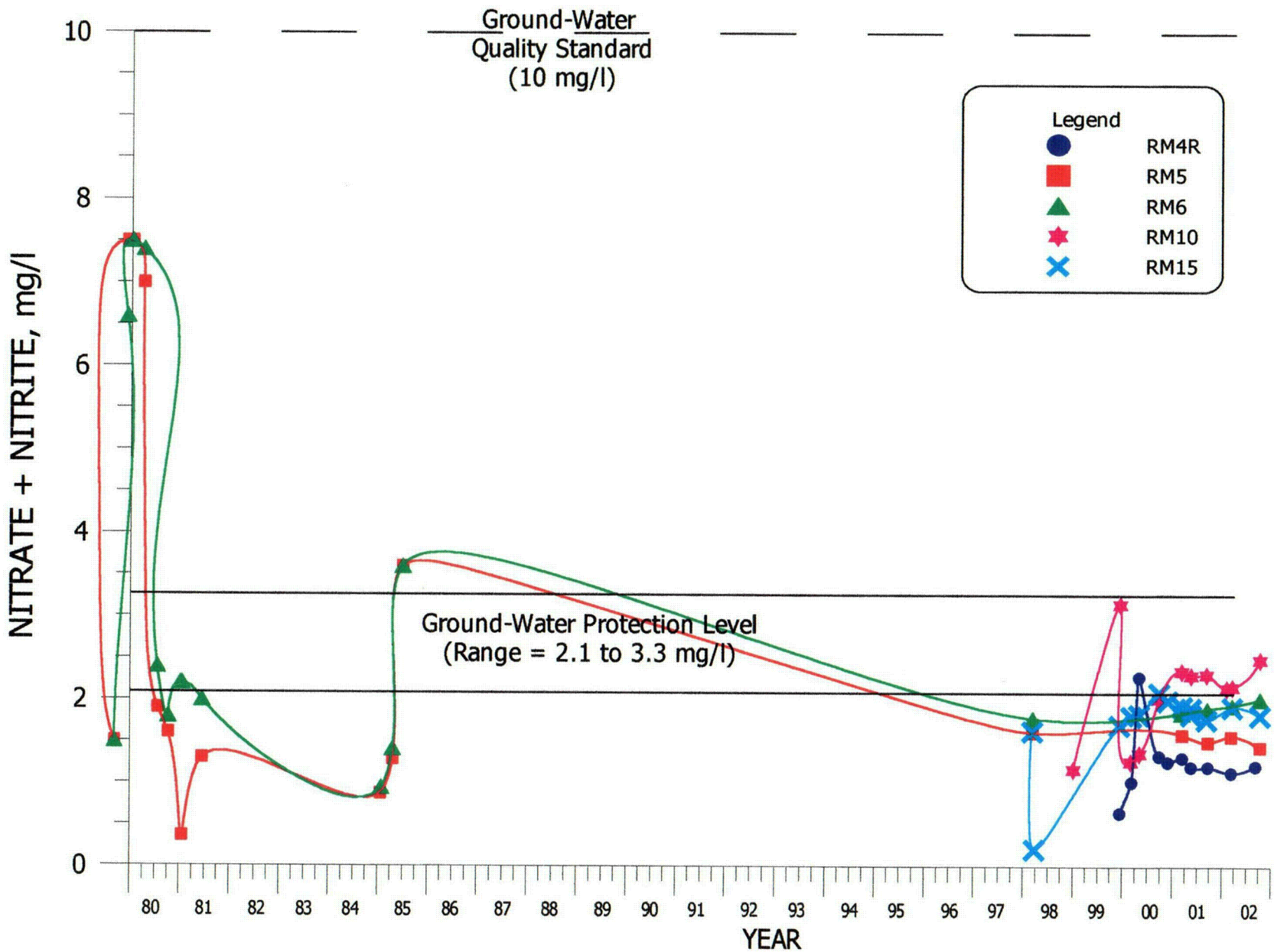

FIGURE 5-14. NITRATE + NITRITE CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

C17

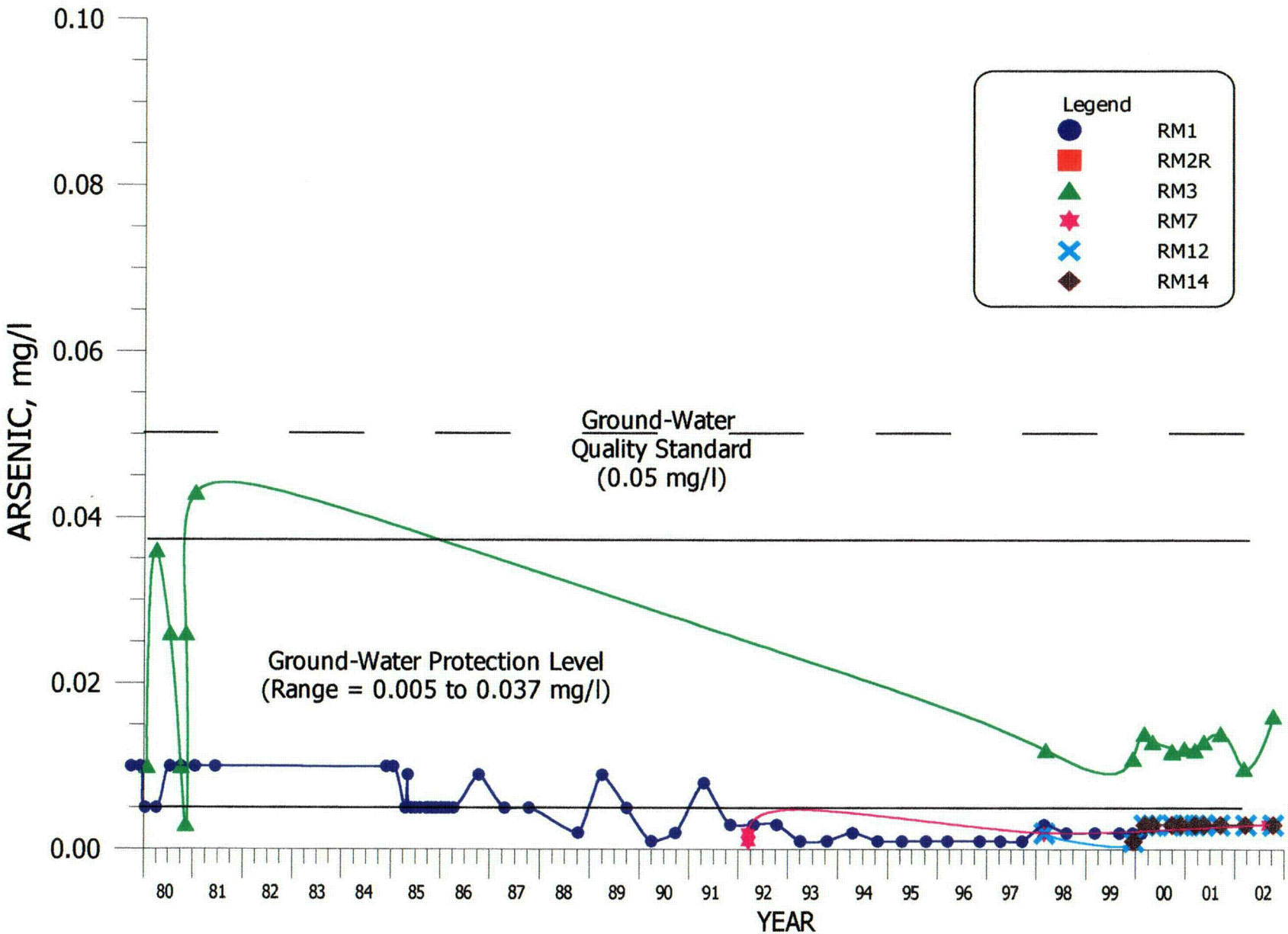

FIGURE 5-15. ARSENIC CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12 AND RM14.

C18

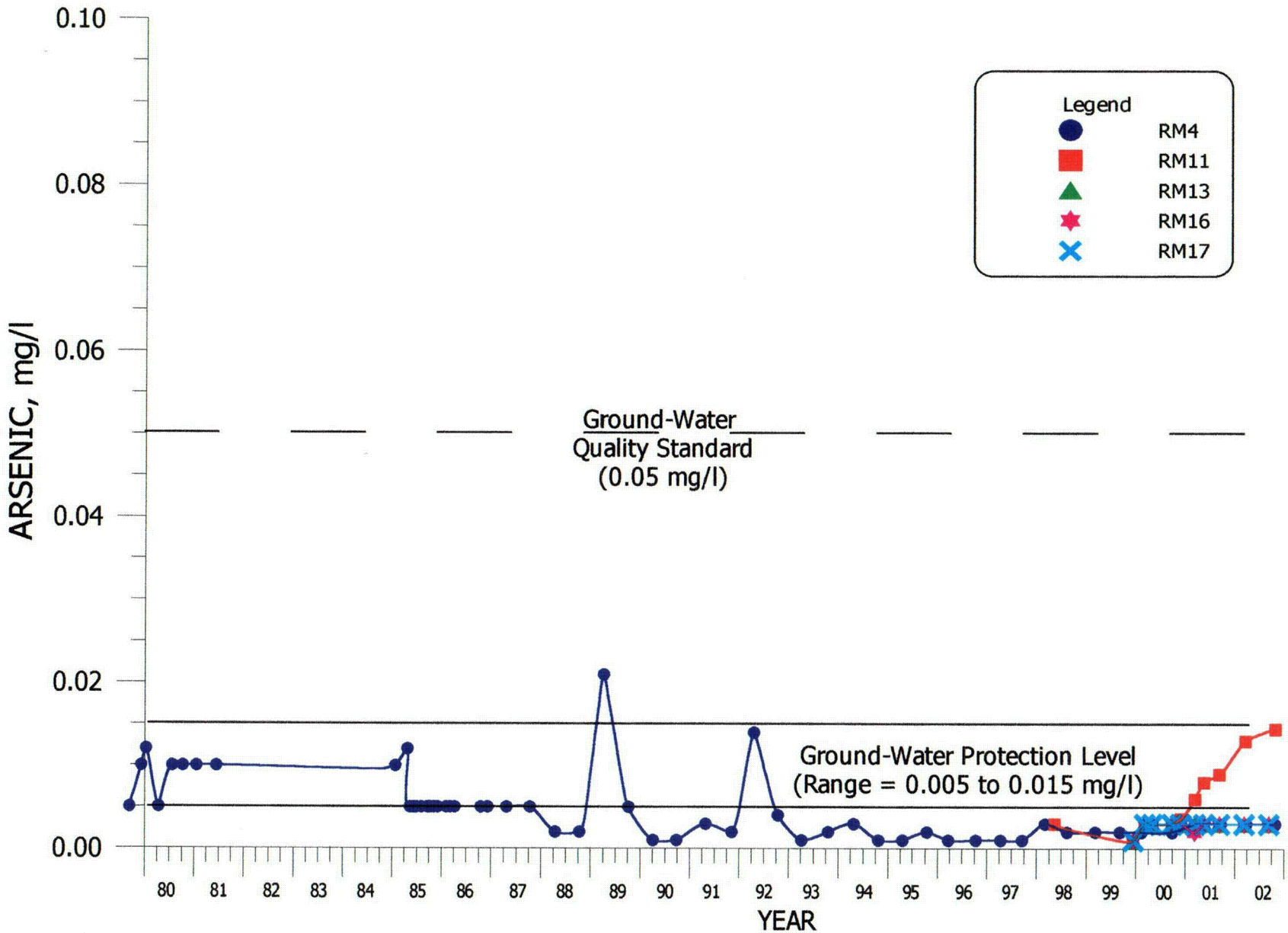

FIGURE 5-16. ARSENIC CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

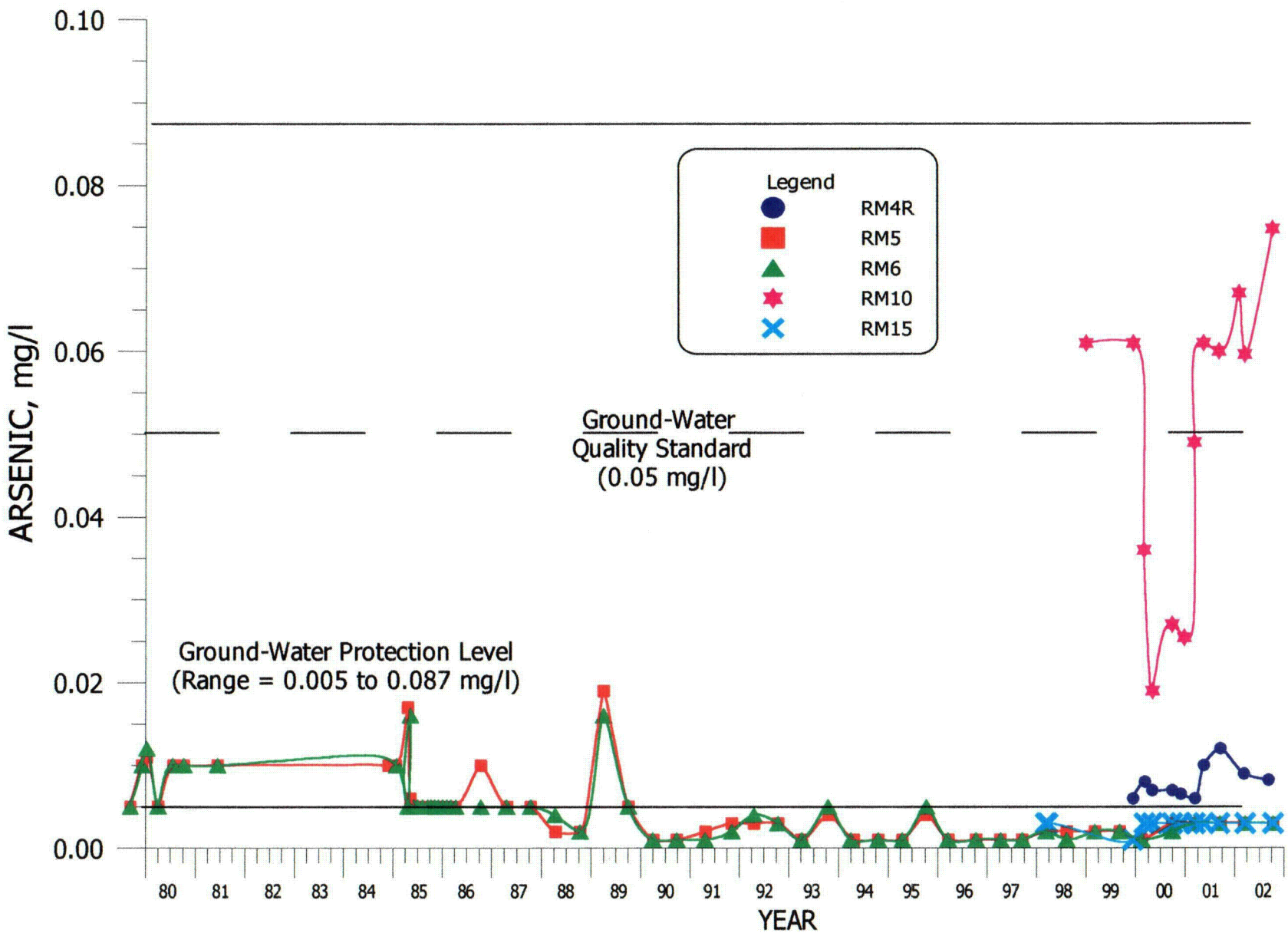

FIGURE 5-17. ARSENIC CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

C20

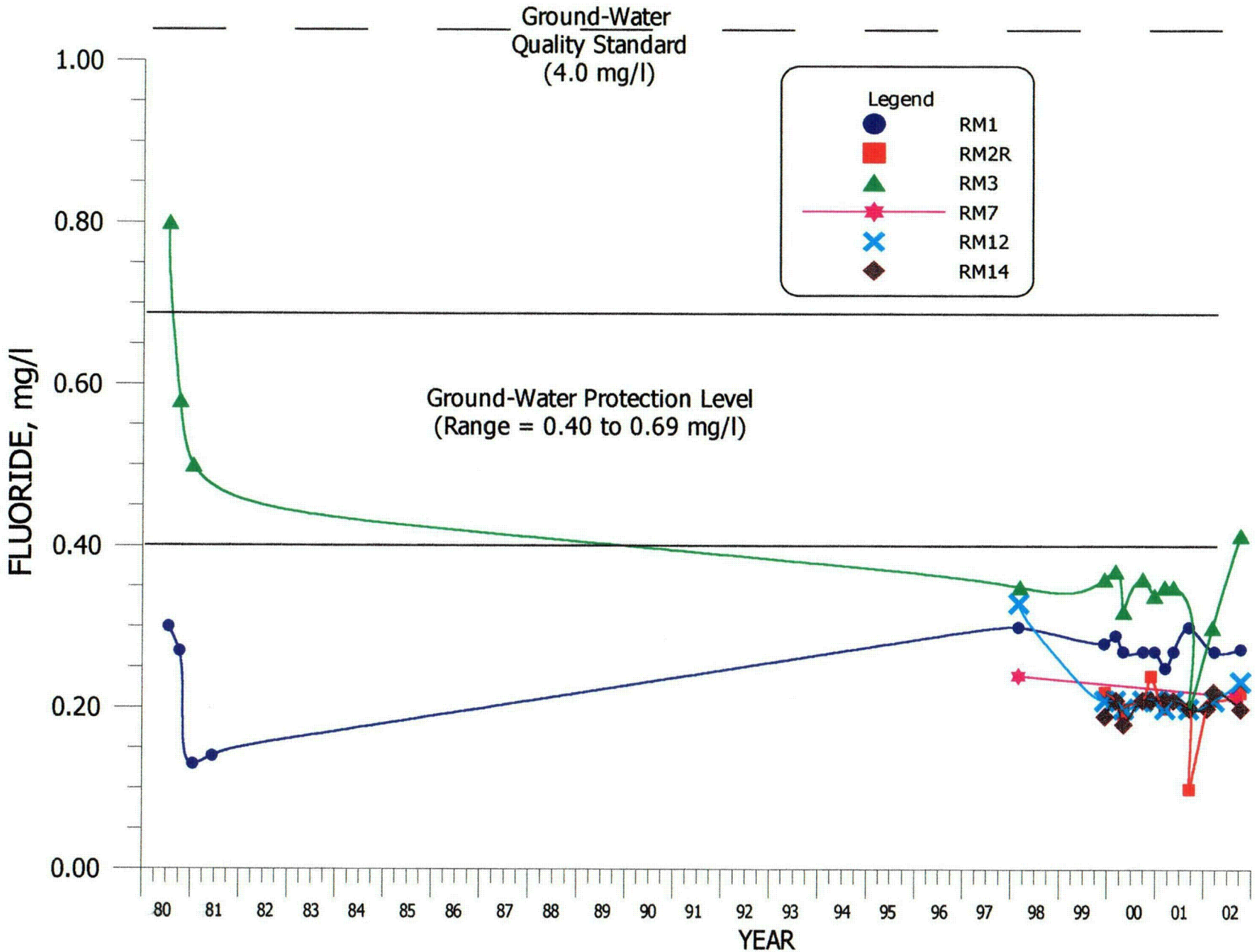

FIGURE 5-18. FLUORIDE CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12 AND RM14.

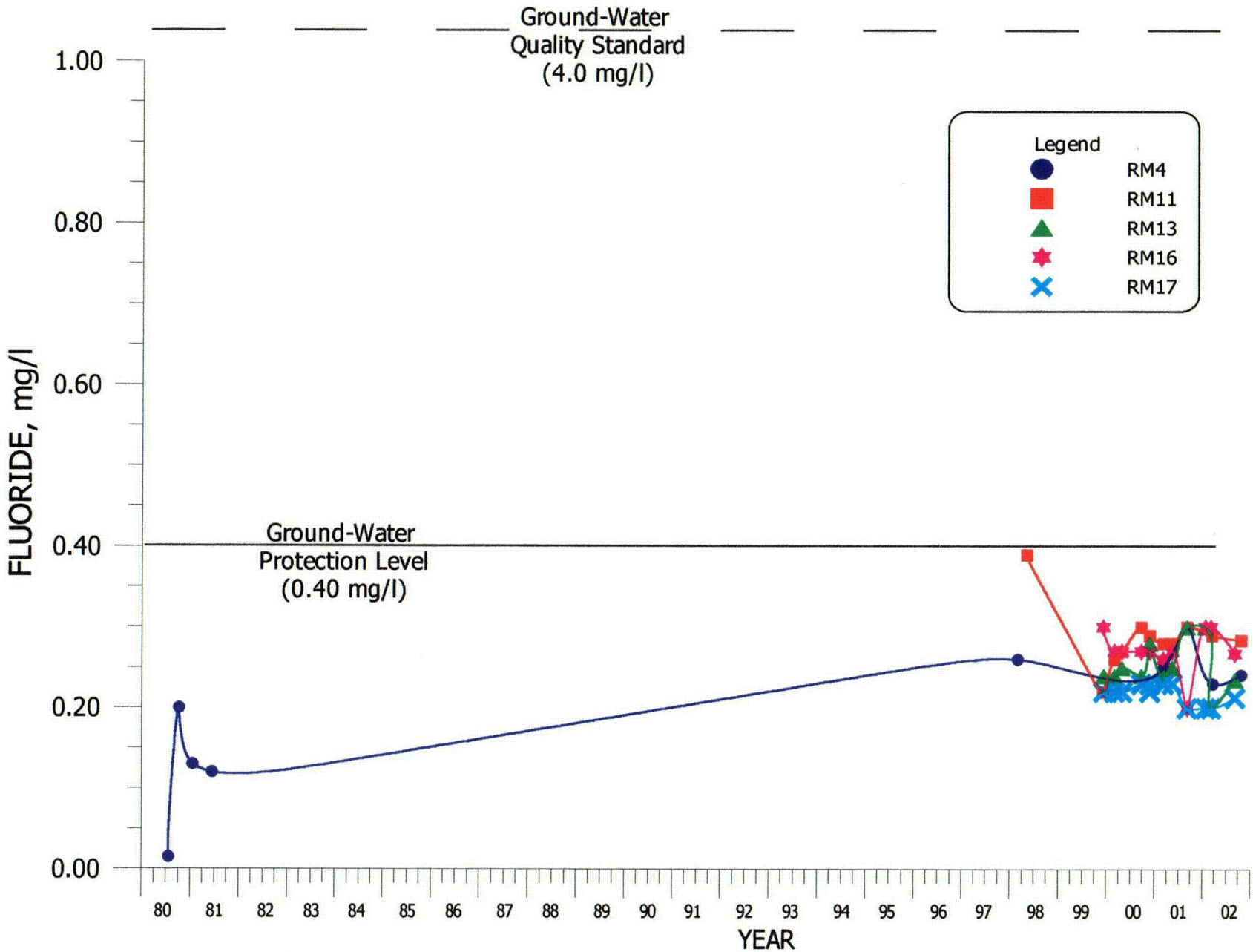

FIGURE 5-19. FLUORIDE CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

C22

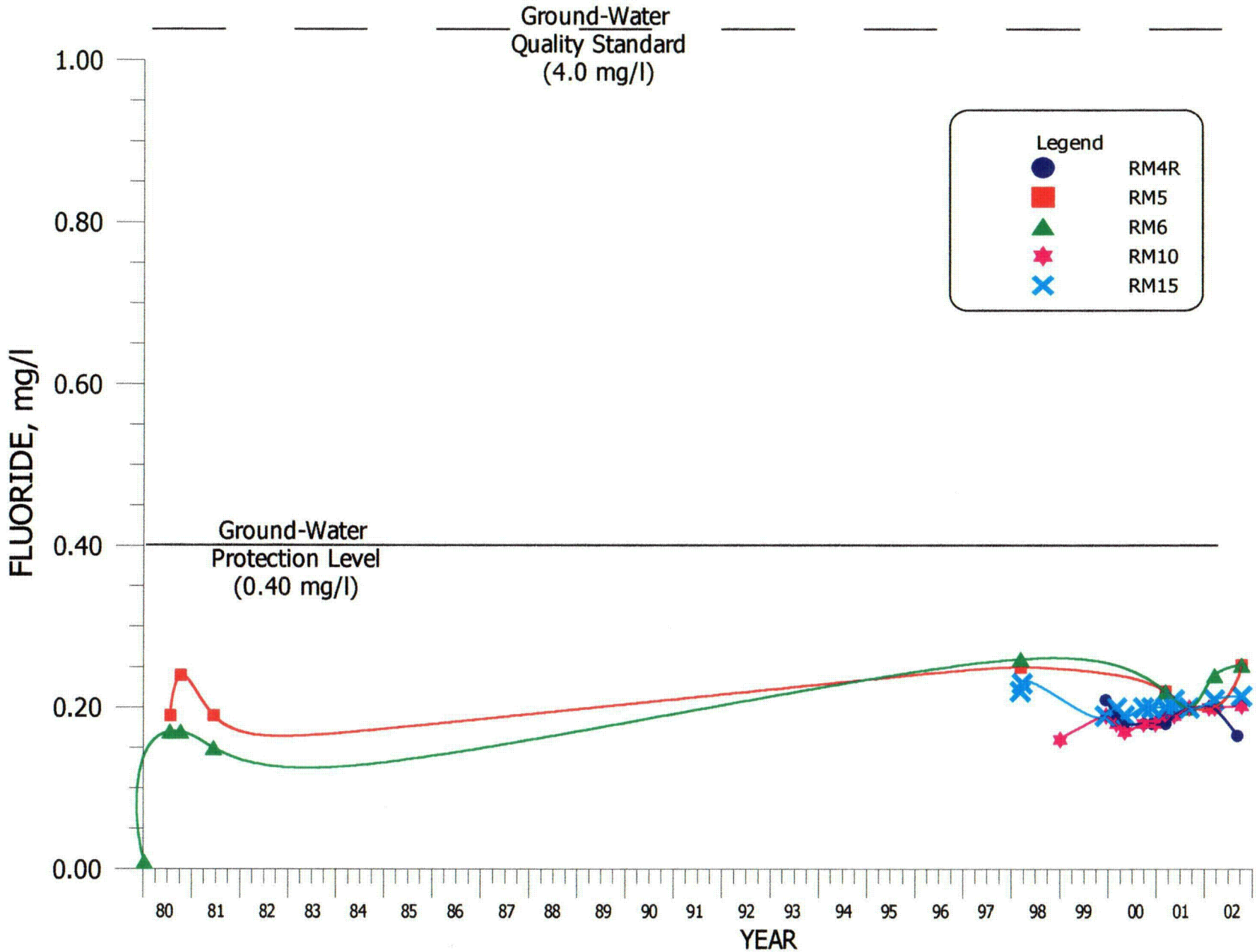

FIGURE 5-20. FLUORIDE CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

C23

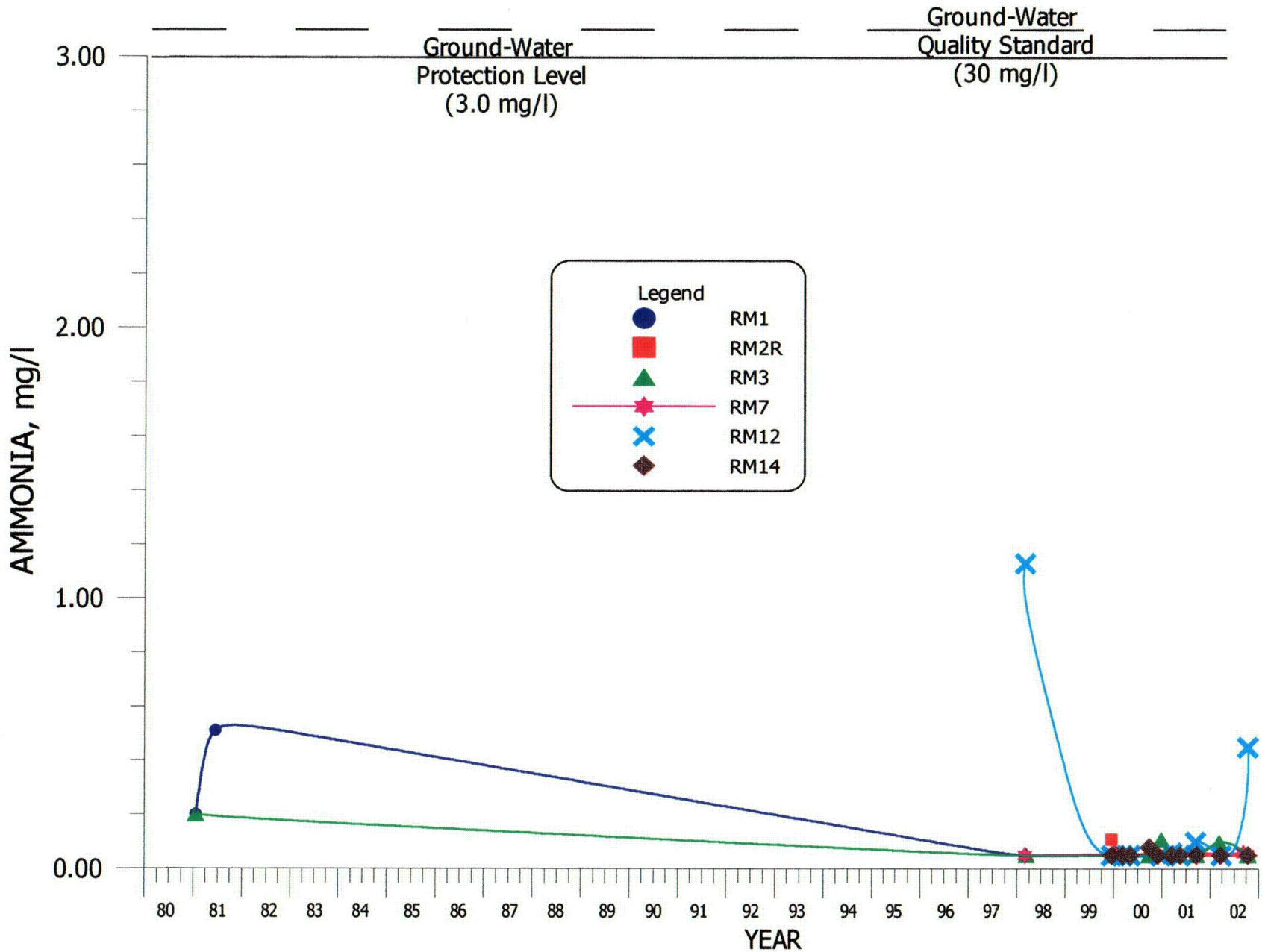

FIGURE 5-21. AMMONIA CONCENTRATIONS FOR ENTRADA WELLS RM1, RM2R, RM3, RM7, RM12 AND RM14.

C24

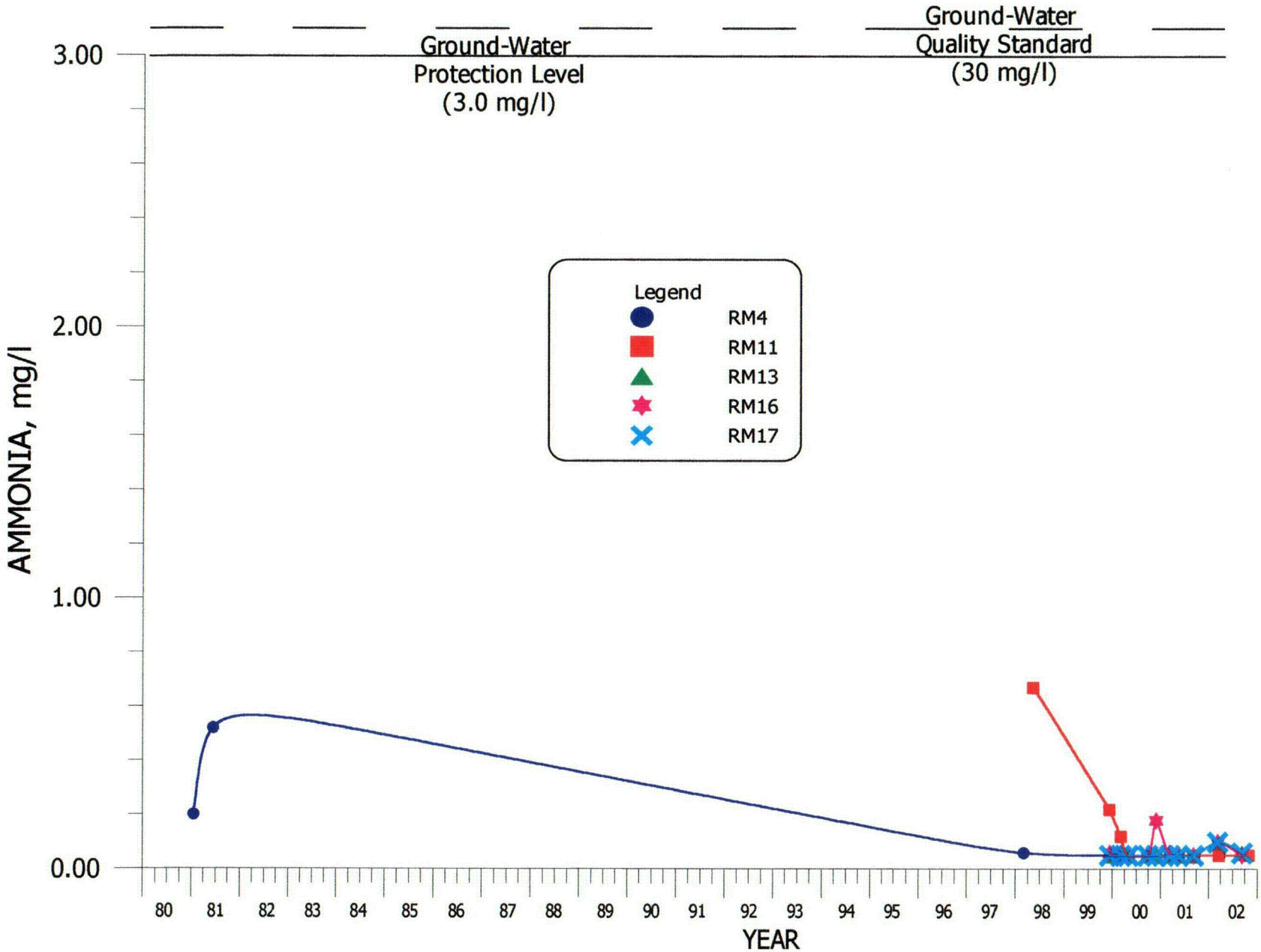

FIGURE 5-22. AMMONIA CONCENTRATIONS FOR ENTRADA WELLS RM4, RM11, RM13, RM16 AND RM17.

C25

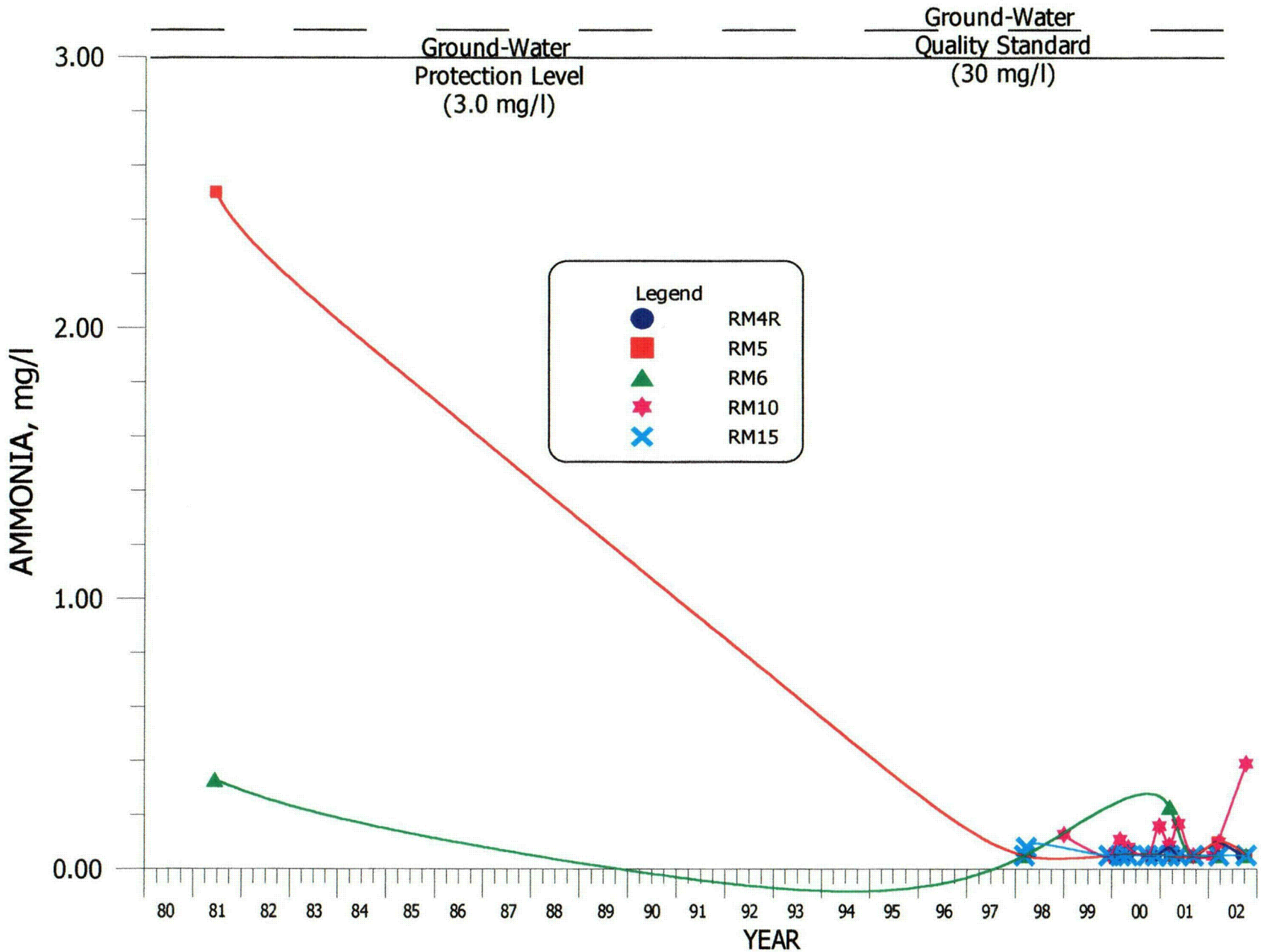

FIGURE 5-23. AMMONIA CONCENTRATIONS FOR ENTRADA WELLS RM4R, RM5, RM6, RM10 AND RM15.

C26