APPENDIX 3.A. MEASURABLE OBJECTIVES AND MINIMUM THRESHOLDS FOR GROUNDWATER LEVELS

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

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Revision 1 July 2022
Revision 2 May 2023

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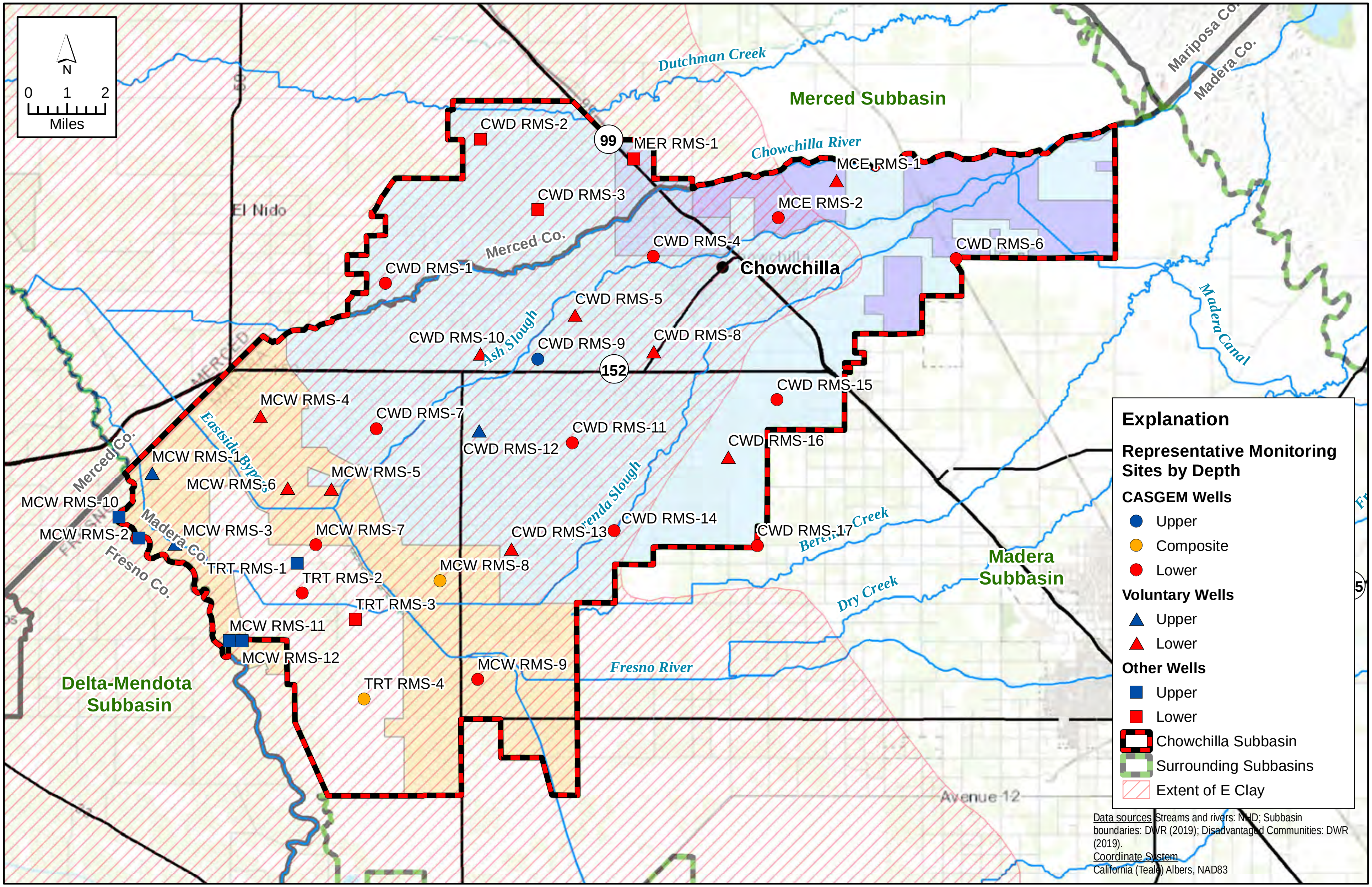

\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 3.A-1 Chowchilla Subbasin Proposed Sustainability Indicator Wells.mxd

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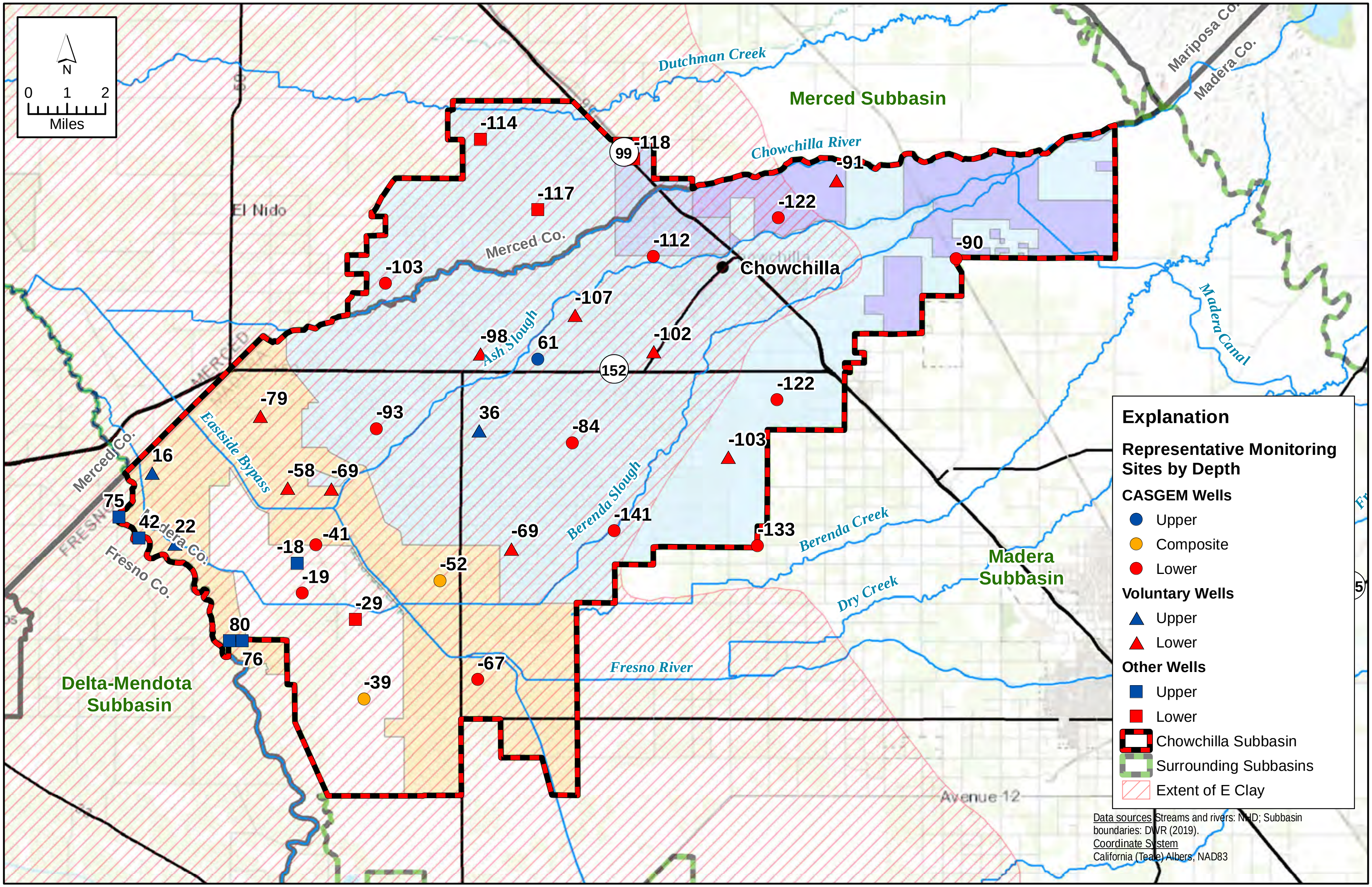
FIGURE 3.A-1
Proposed Groundwater Level Sustainability Indicator Representative Monitoring Sites

Chowchilla Subbasin
Groundwater Sustainability Plan



\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 3.A-2 Chowchilla Subbasin Elevation of Minimum Thresholds.mxd

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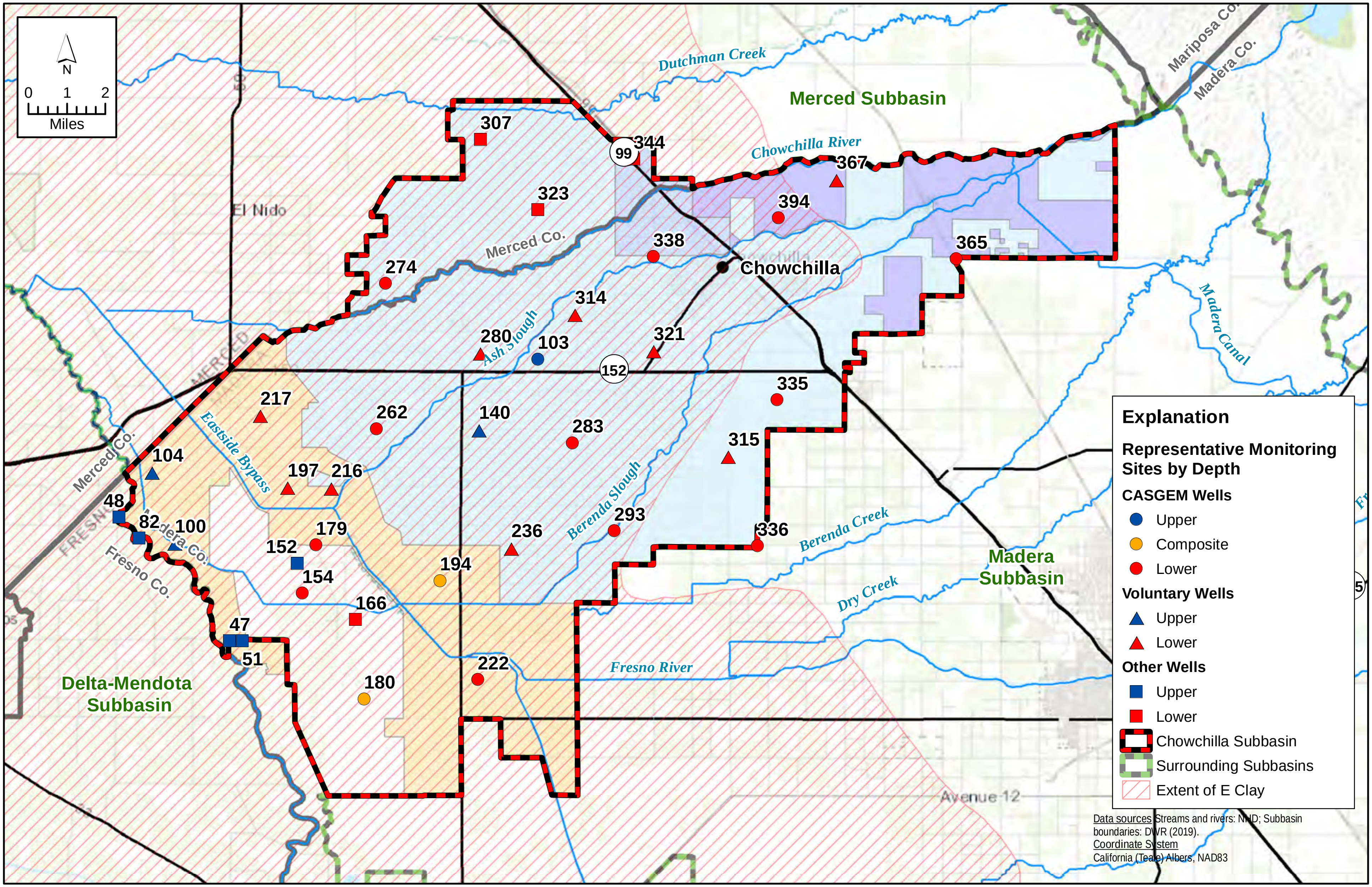
FIGURE 3.A-2

Elevation of Groundwater Level Minimum Thresholds

Chowchilla Subbasin
Groundwater Sustainability Plan



\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 3.A-3 Chowchilla Subbasin Depth to Minimum Thresholds.mxd

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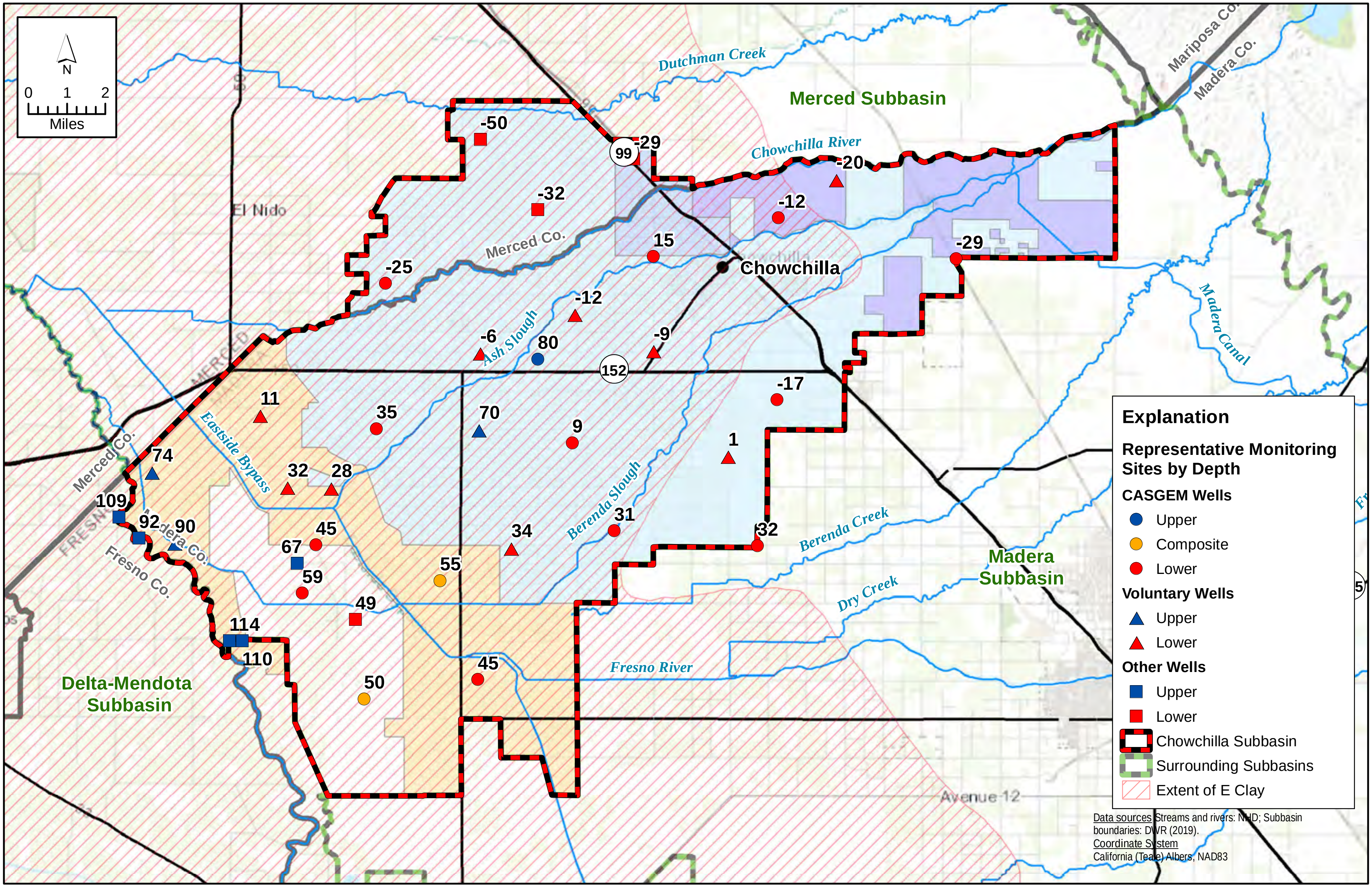
FIGURE 3.A-3

Depth to Groundwater Level Minimum Thresholds

Chowchilla Subbasin
Groundwater Sustainability Plan



\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 3.A-4 Chowchilla Subbasin Elevation of Measurable Objectives.mxd

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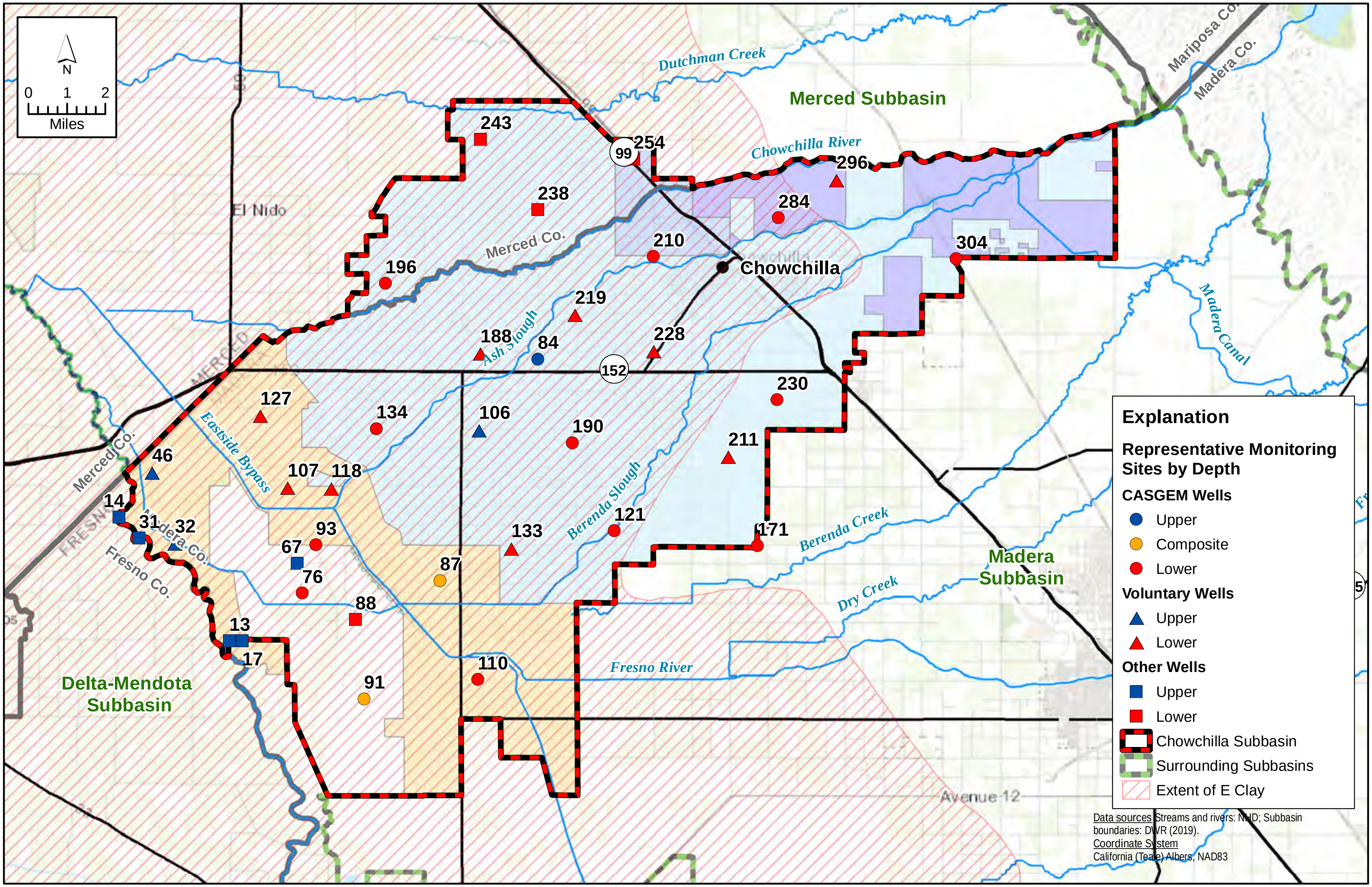
FIGURE 3.A-4

Elevation of Groundwater Level Measurable Objectives

Chowchilla Subbasin
Groundwater Sustainability Plan



\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 3.A-5 Chowchilla Subbasin Depth to Measurable Objectives.mxd

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FIGURE 3.A-5

Depth to Groundwater Level Measurable Objectives

Chowchilla Subbasin
Groundwater Sustainability Plan

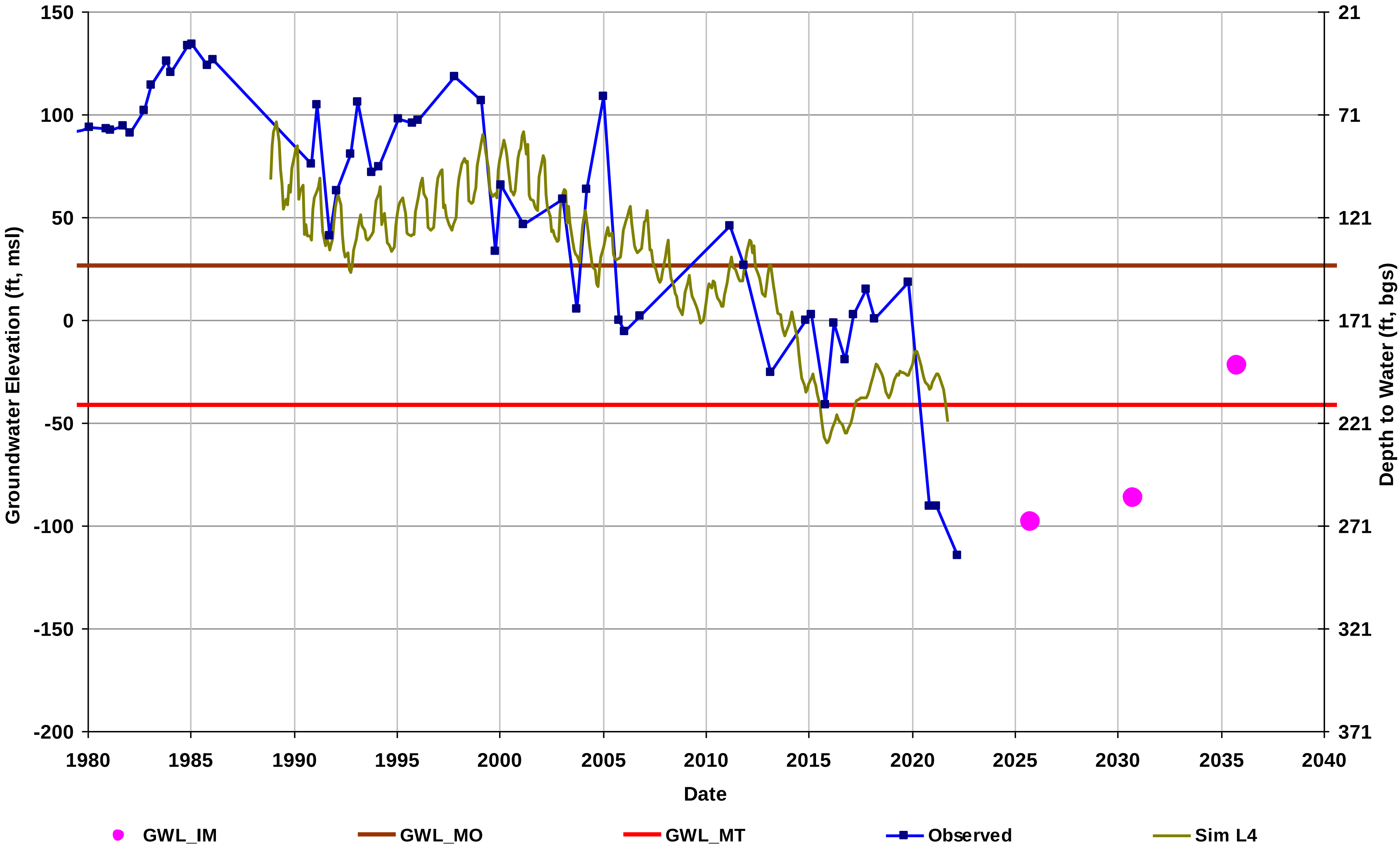
Well Name: CWD RMS-1
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 171

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 7
Total Depth Average: 415
Total Depth Minimum: 118
Total Depth Maximum: 960

Top Perf. Count: 5
Top Perf. Average: 340
Top Perf. Minimum: 98
Top Perf. Maximum: 604

Total Depth (ft bgs): 275
Perf. Top (ft bgs): 160
Perf. Bottom (ft bgs): 275
Top Model Layer: 4
Bottom Model Layer: 4



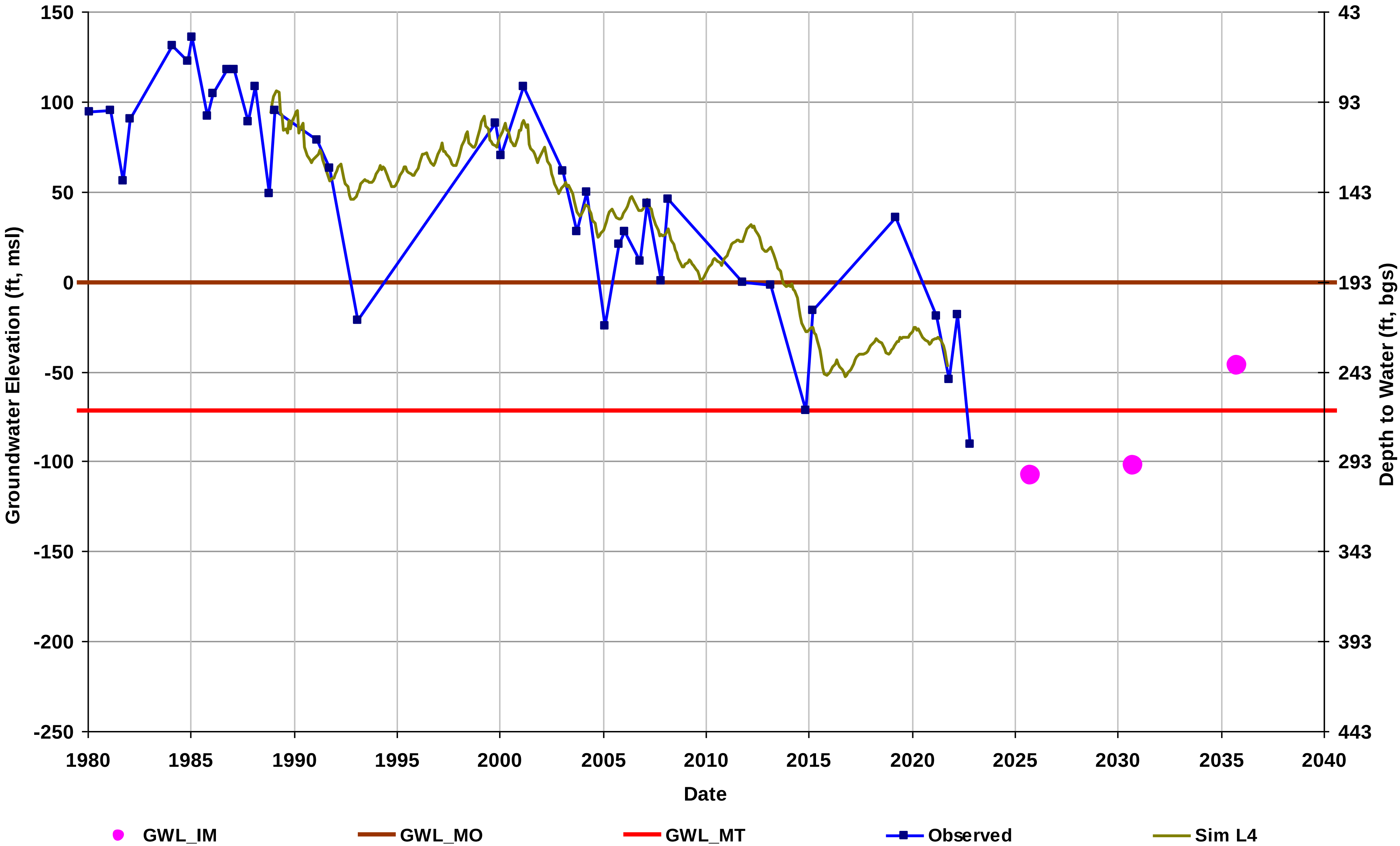
Well Name: CWD RMS-2
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 193

Domestic Well Data: *Total Sections Included: 8*

Total Depth Count: 4
Total Depth Average: 640
Total Depth Minimum: 208
Total Depth Maximum: 800

Top Perf. Count: 2
Top Perf. Average: 360
Top Perf. Minimum: 320
Top Perf. Maximum: 400

Total Depth (ft bgs): 780
Perf. Top (ft bgs): 230
Perf. Bottom (ft bgs): 775
Top Model Layer: 4
Bottom Model Layer: 4



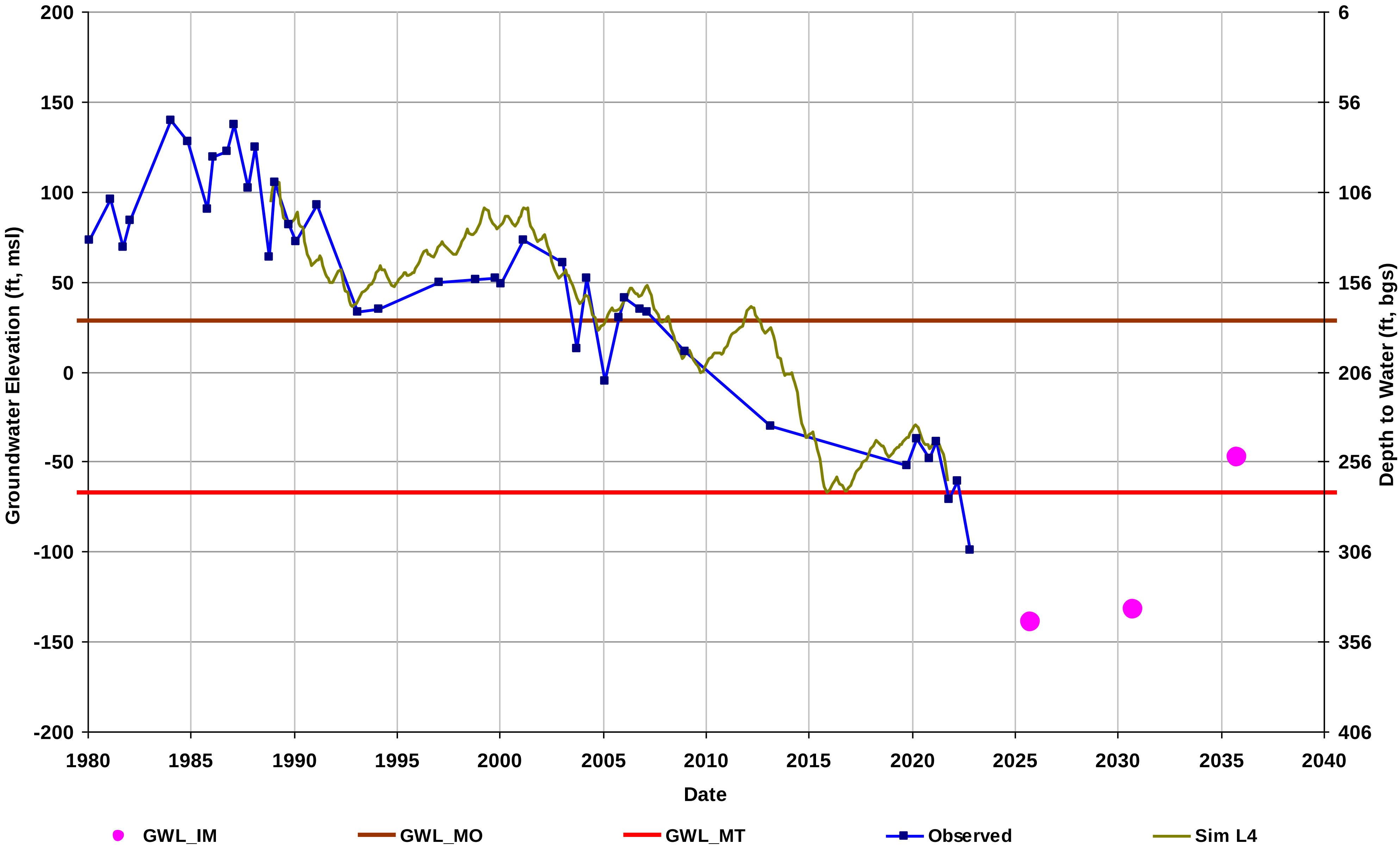
Well Name: CWD RMS-3
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 206

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 3
Total Depth Average: 352
Total Depth Minimum: 280
Total Depth Maximum: 467

Top Perf. Count: 1
Top Perf. Average: 279
Top Perf. Minimum: 279
Top Perf. Maximum: 279

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



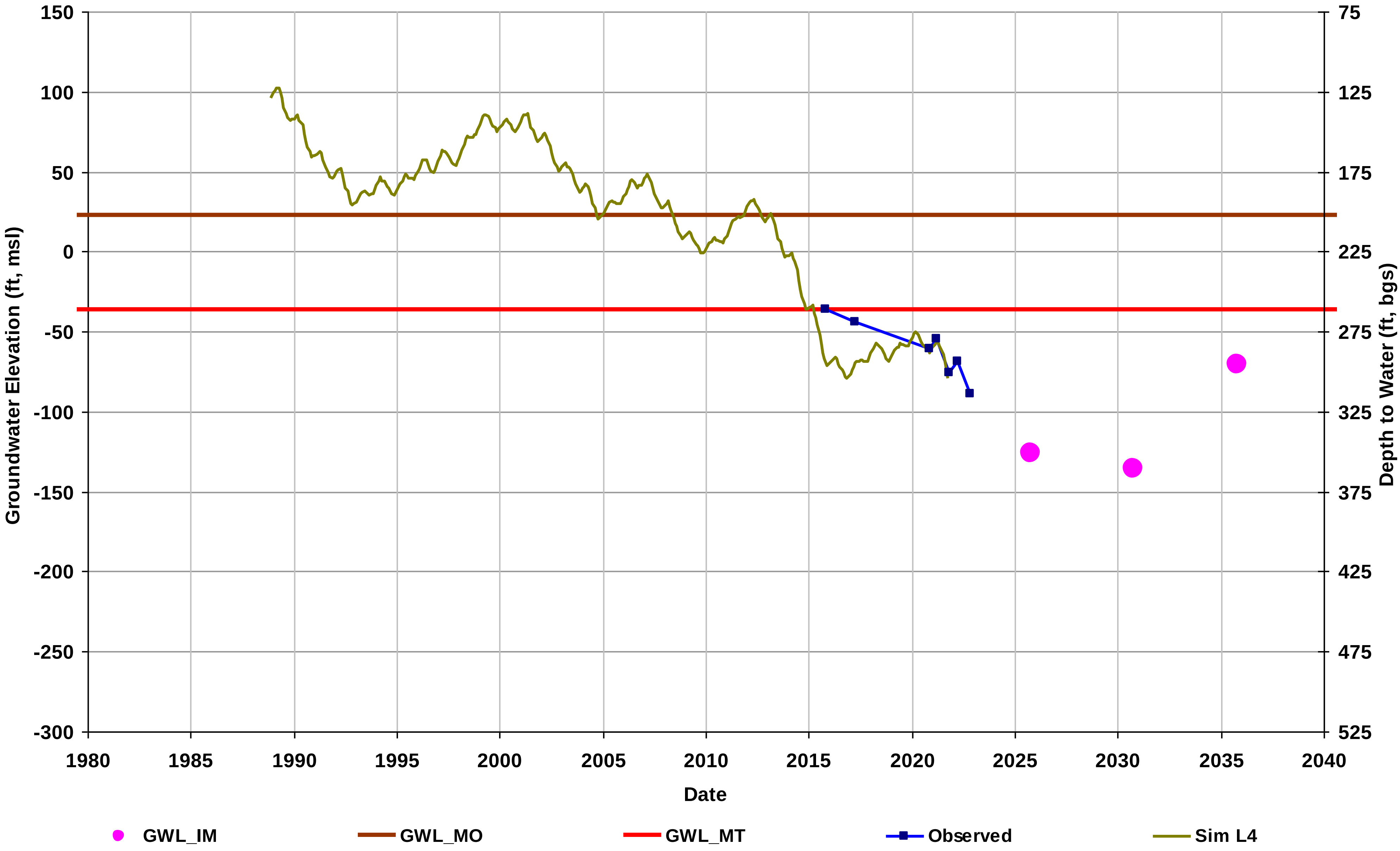
Well Name: CWD RMS-4
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 225

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 41
Total Depth Average: 369
Total Depth Minimum: 144
Total Depth Maximum: 600

Top Perf. Count: 24
Top Perf. Average: 244
Top Perf. Minimum: 145
Top Perf. Maximum: 420

Total Depth (ft bgs): 800
Perf. Top (ft bgs): 320
Perf. Bottom (ft bgs): 800
Top Model Layer: 4
Bottom Model Layer: 4

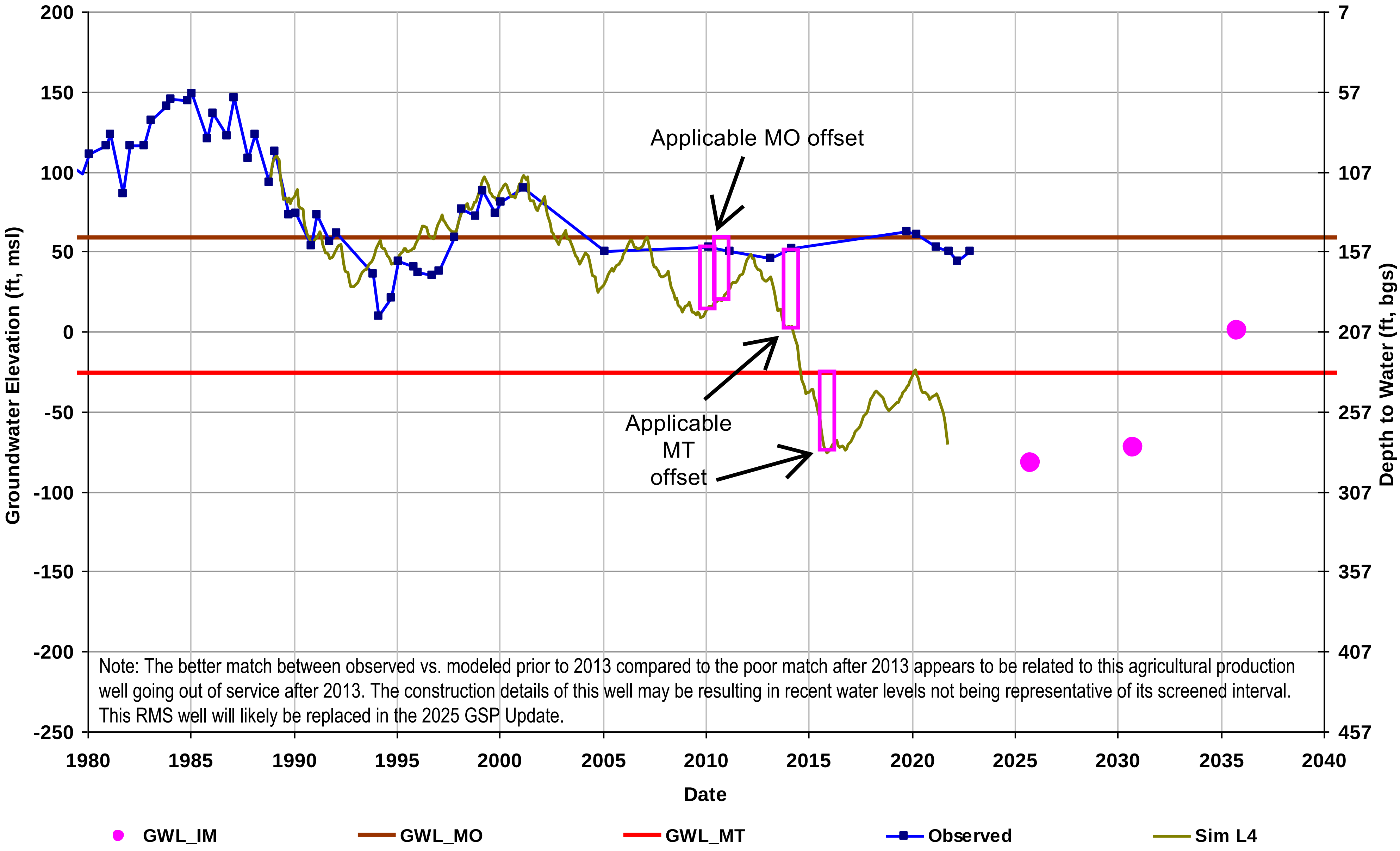


Well Name: CWD RMS-5
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 207

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	20	Top Perf. Count:	13
Total Depth Average:	310	Top Perf. Average:	225
Total Depth Minimum:	103	Top Perf. Minimum:	145
Total Depth Maximum:	600	Top Perf. Maximum:	308

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



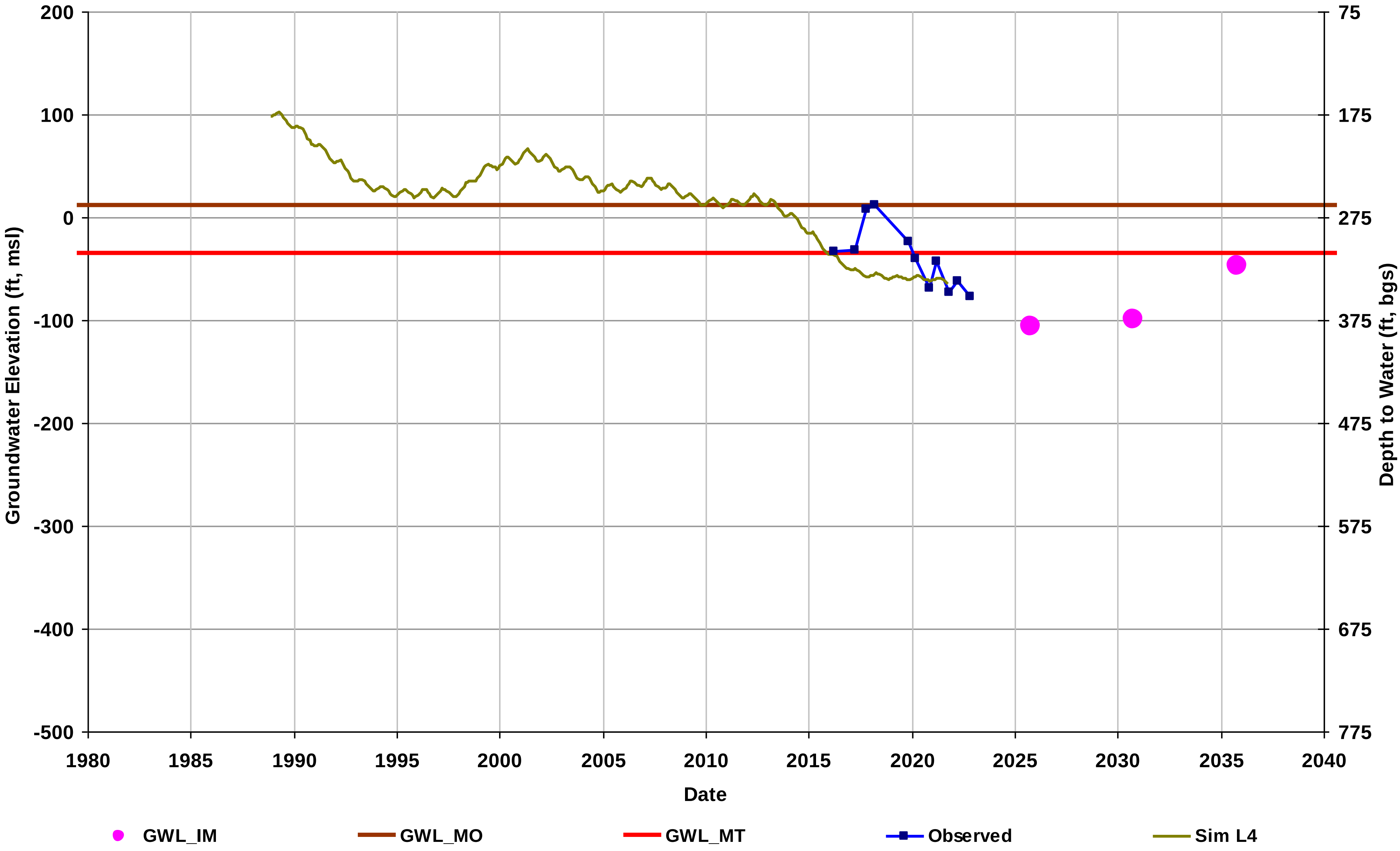
Well Name: CWD RMS-6
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 275

Domestic Well Data: *Total Sections Included:*

Total Depth Count:
Total Depth Average:
Total Depth Minimum:
Total Depth Maximum:

Top Perf. Count:
Top Perf. Average:
Top Perf. Minimum:
Top Perf. Maximum:

Total Depth (ft bgs): 820
Perf. Top (ft bgs): 257
Perf. Bottom (ft bgs): 726
Top Model Layer: 4
Bottom Model Layer: 4



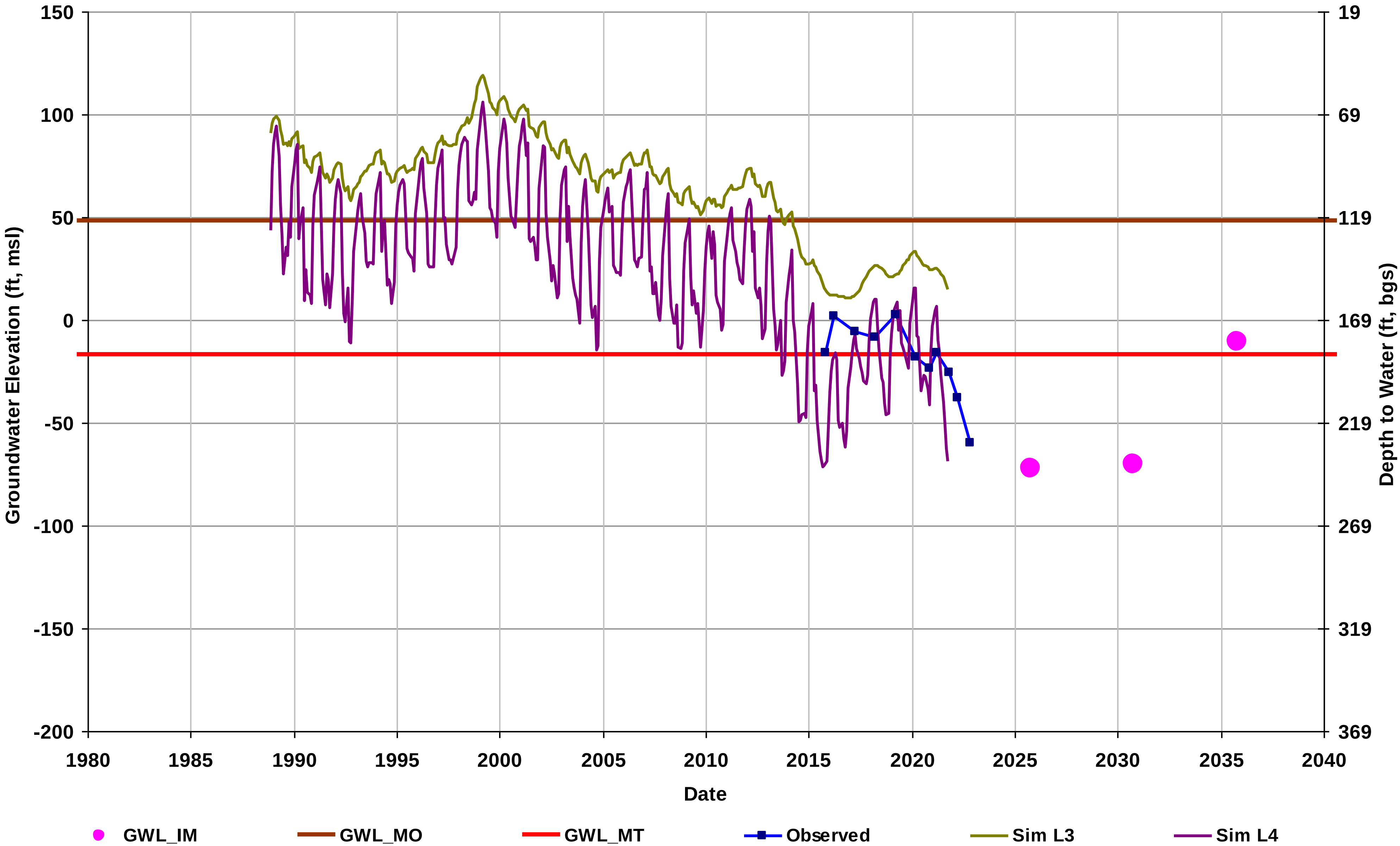
Well Name: CWD RMS-7
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 169

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 14
Total Depth Average: 381
Total Depth Minimum: 146
Total Depth Maximum: 600

Top Perf. Count: 5
Top Perf. Average: 262
Top Perf. Minimum: 220
Top Perf. Maximum: 360

Total Depth (ft bgs): 330
Perf. Top (ft bgs): 135
Perf. Bottom (ft bgs): 288
Top Model Layer: 3
Bottom Model Layer: 4



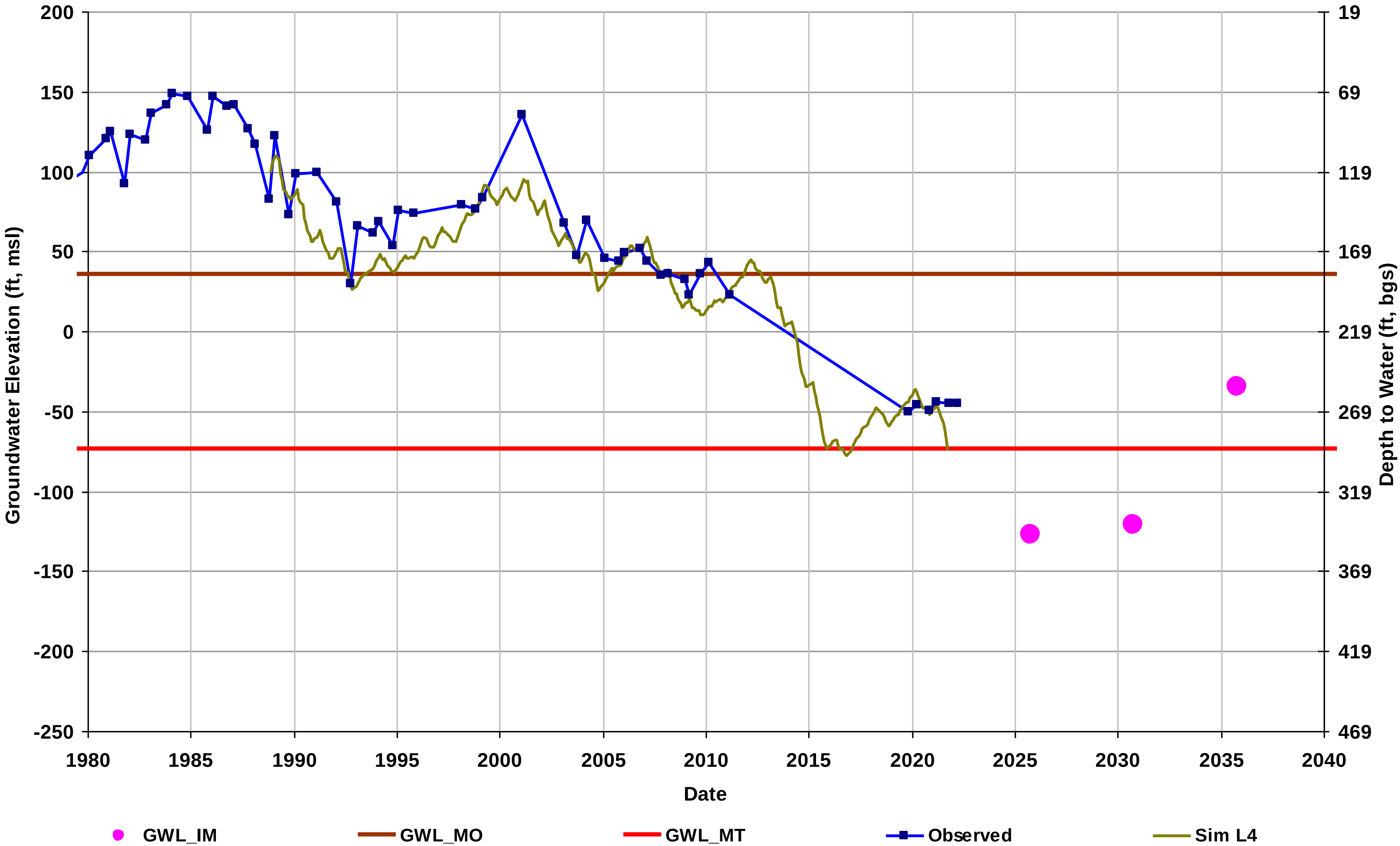
Well Name: CWD RMS-8
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 219

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 110
Total Depth Average: 373
Total Depth Minimum: 130
Total Depth Maximum: 700

Top Perf. Count: 77
Top Perf. Average: 241
Top Perf. Minimum: 112
Top Perf. Maximum: 365

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



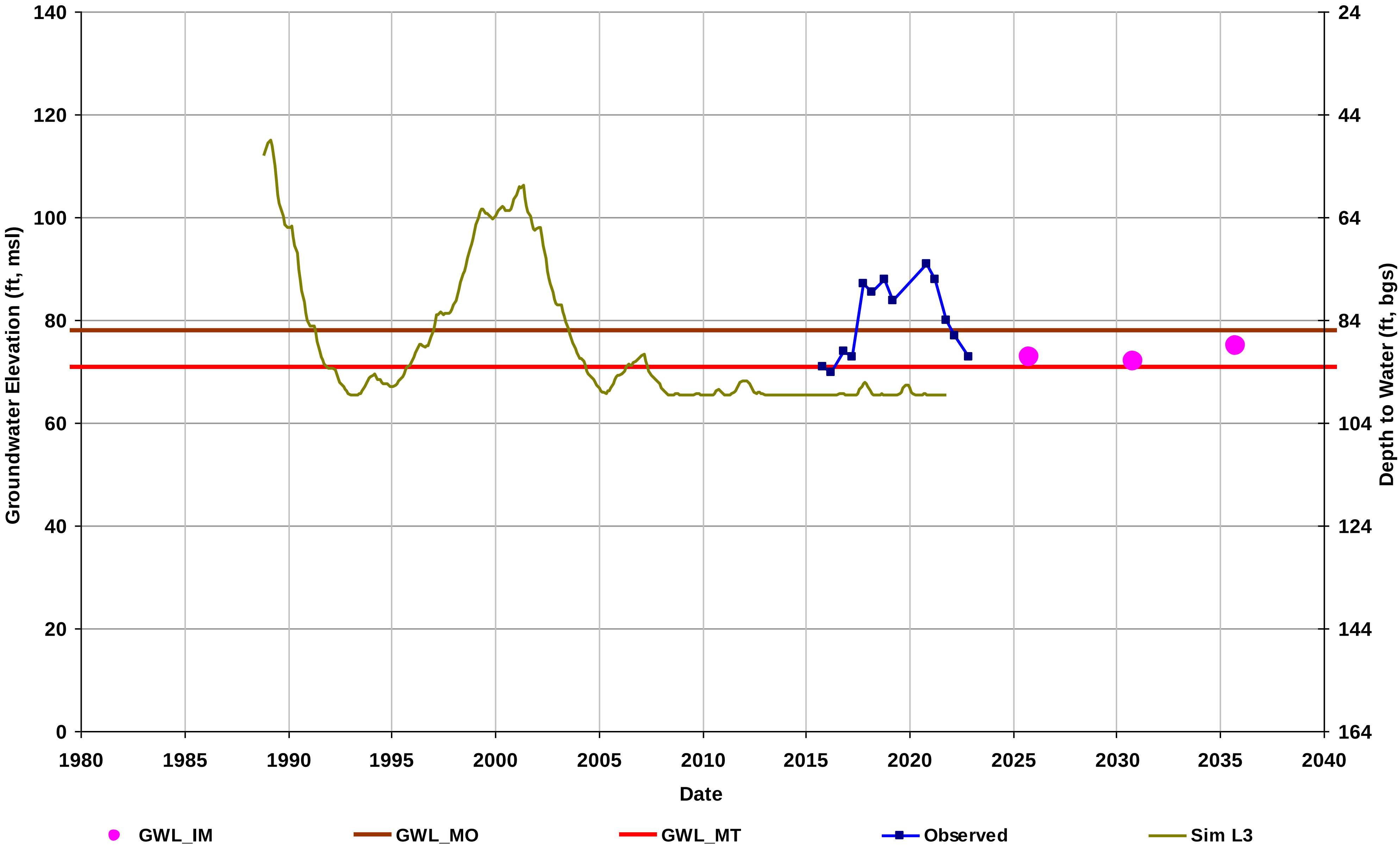
Well Name: CWD RMS-9
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 164

Domestic Well Data: *Total Sections Included:*

Total Depth Count:
Total Depth Average:
Total Depth Minimum:
Total Depth Maximum:

Top Perf. Count:
Top Perf. Average:
Top Perf. Minimum:
Top Perf. Maximum:

Total Depth (ft bgs): 97
Perf. Top (ft bgs): 82
Perf. Bottom (ft bgs): 97
Top Model Layer: 3
Bottom Model Layer: 3



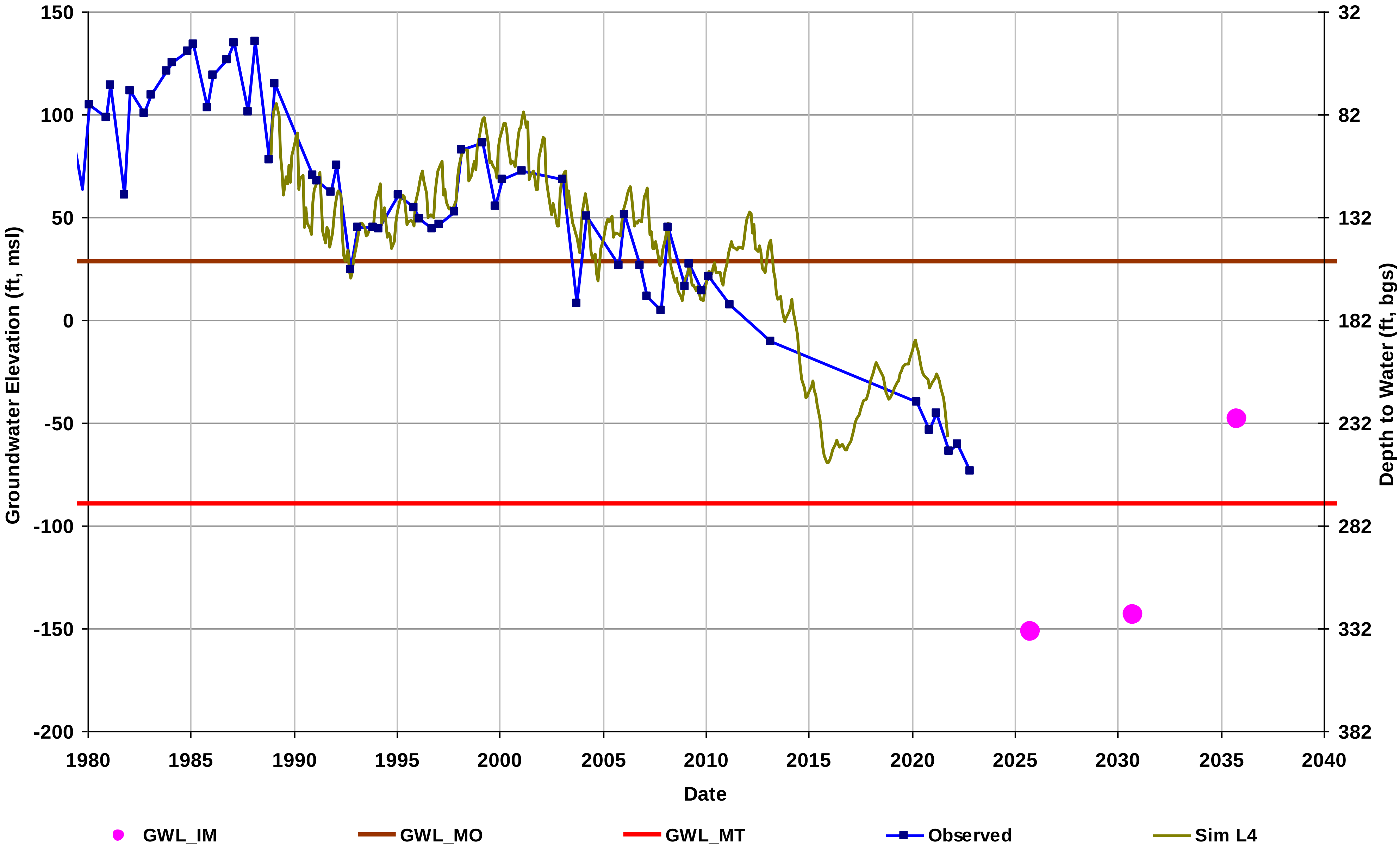
Well Name: CWD RMS-10
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 182

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 13
Total Depth Average: 335
Total Depth Minimum: 103
Total Depth Maximum: 800

Top Perf. Count: 7
Top Perf. Average: 226
Top Perf. Minimum: 145
Top Perf. Maximum: 320

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



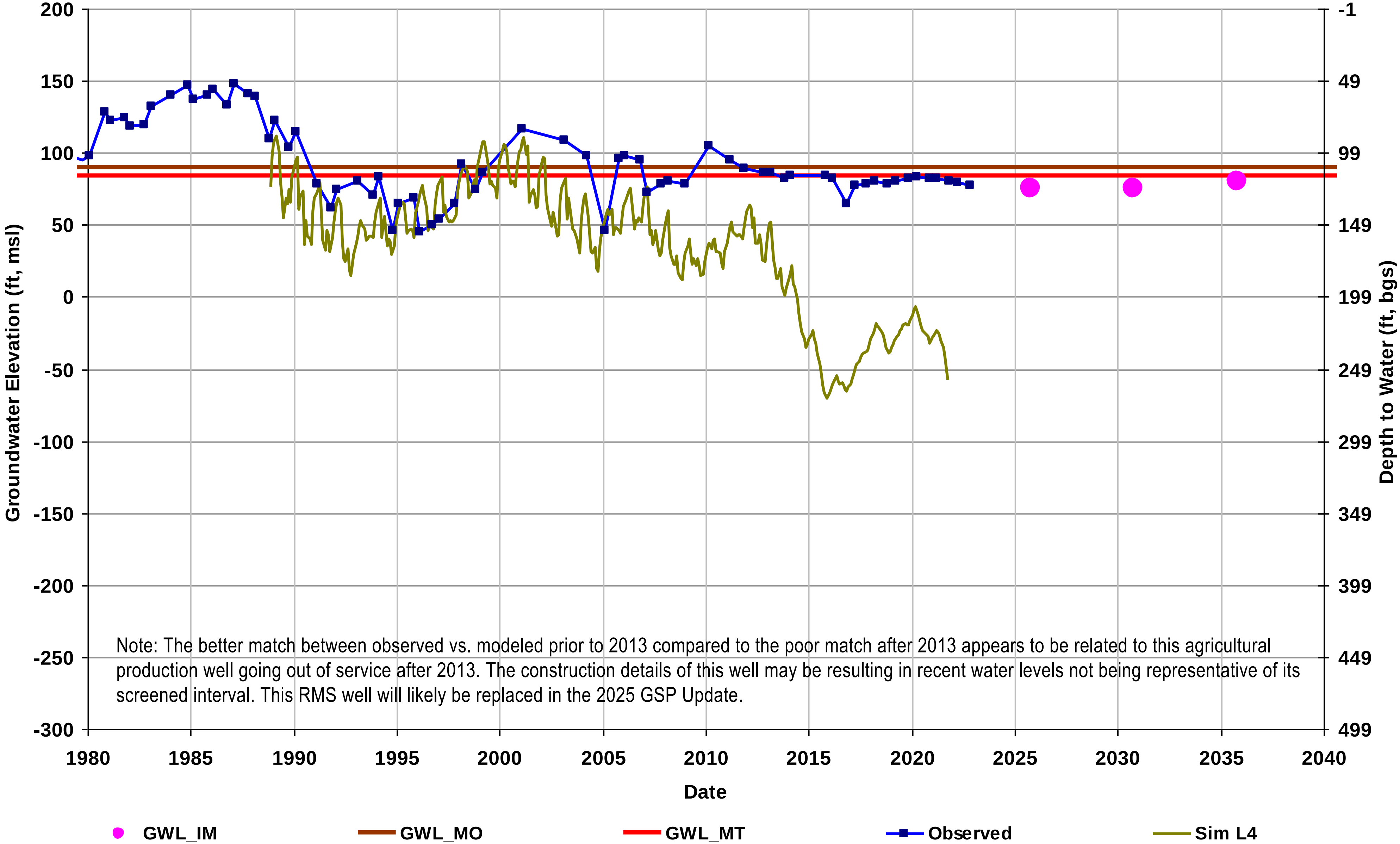
Well Name: CWD RMS-11
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 199

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 27
Total Depth Average: 351
Total Depth Minimum: 112
Total Depth Maximum: 660

Top Perf. Count: 14
Top Perf. Average: 246
Top Perf. Minimum: 72
Top Perf. Maximum: 337

Total Depth (ft bgs): 529
Perf. Top (ft bgs): 187
Perf. Bottom (ft bgs): 529
Top Model Layer: 4
Bottom Model Layer: 4



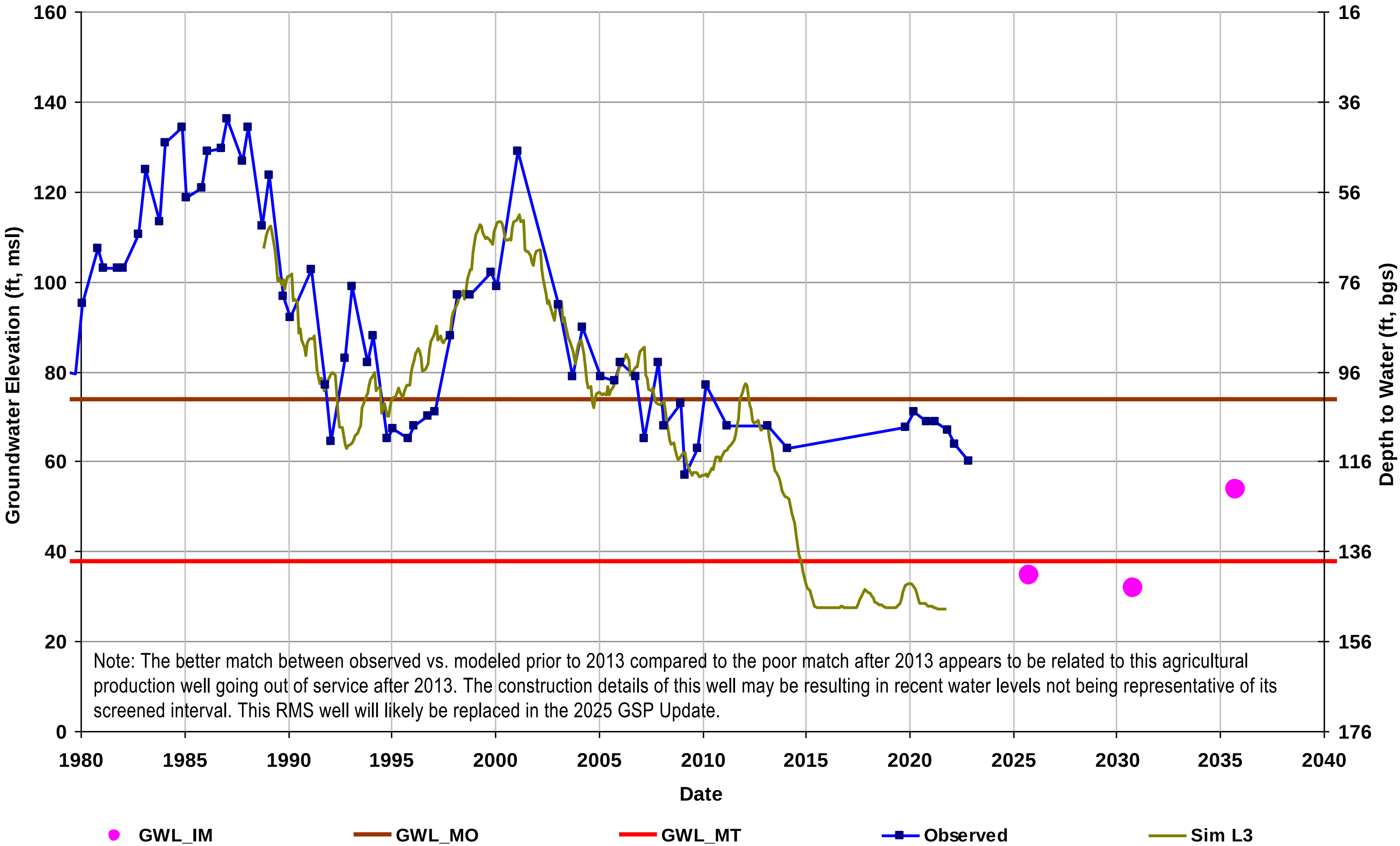
Well Name: CWD RMS-12
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 176

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 12
Total Depth Average: 364
Total Depth Minimum: 150
Total Depth Maximum: 660

Top Perf. Count: 8
Top Perf. Average: 246
Top Perf. Minimum: 201
Top Perf. Maximum: 336

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 3
Bottom Model Layer: 3



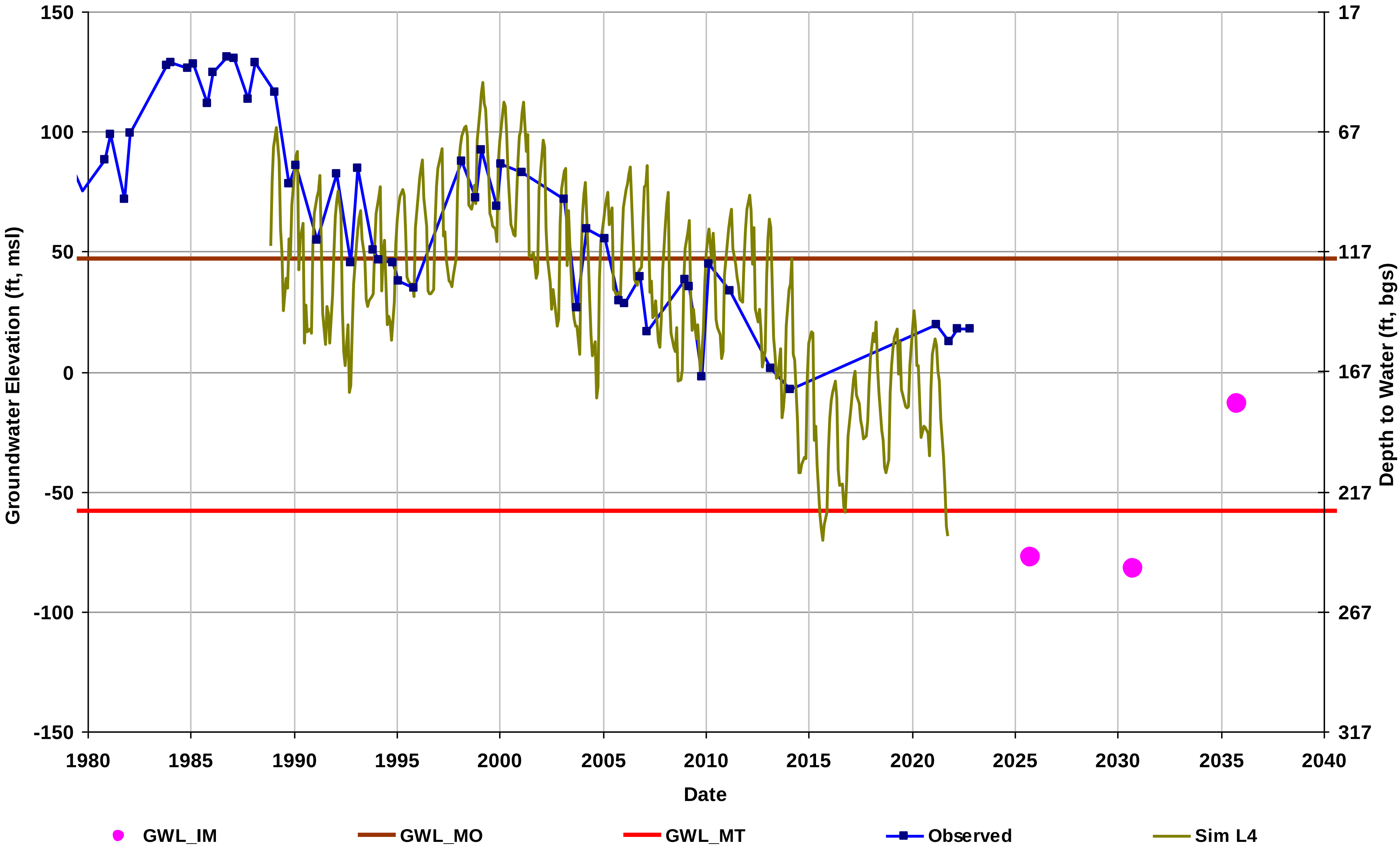
Well Name: CWD RMS-13
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 167

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 24
Total Depth Average: 313
Total Depth Minimum: 126
Total Depth Maximum: 600

Top Perf. Count: 15
Top Perf. Average: 224
Top Perf. Minimum: 145
Top Perf. Maximum: 389

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4

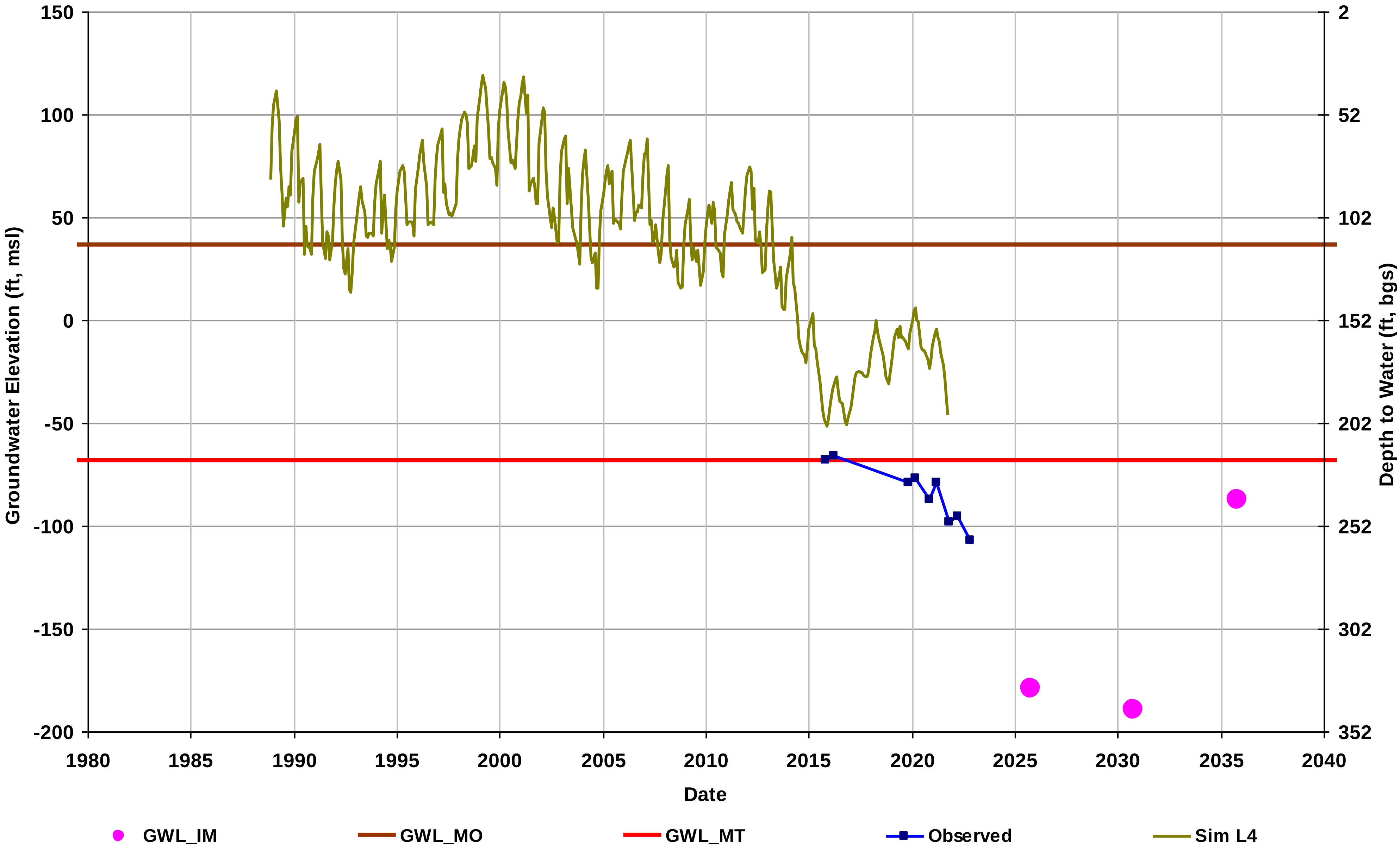


Well Name: CWD RMS-14
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 152

Domestic Well Data: *Total Sections Included:*

Total Depth Count:	Top Perf. Count:
Total Depth Average:	Top Perf. Average:
Total Depth Minimum:	Top Perf. Minimum:
Total Depth Maximum:	Top Perf. Maximum:

Total Depth (ft bgs): 455
Perf. Top (ft bgs): 185
Perf. Bottom (ft bgs): 365
Top Model Layer: 4
Bottom Model Layer: 4



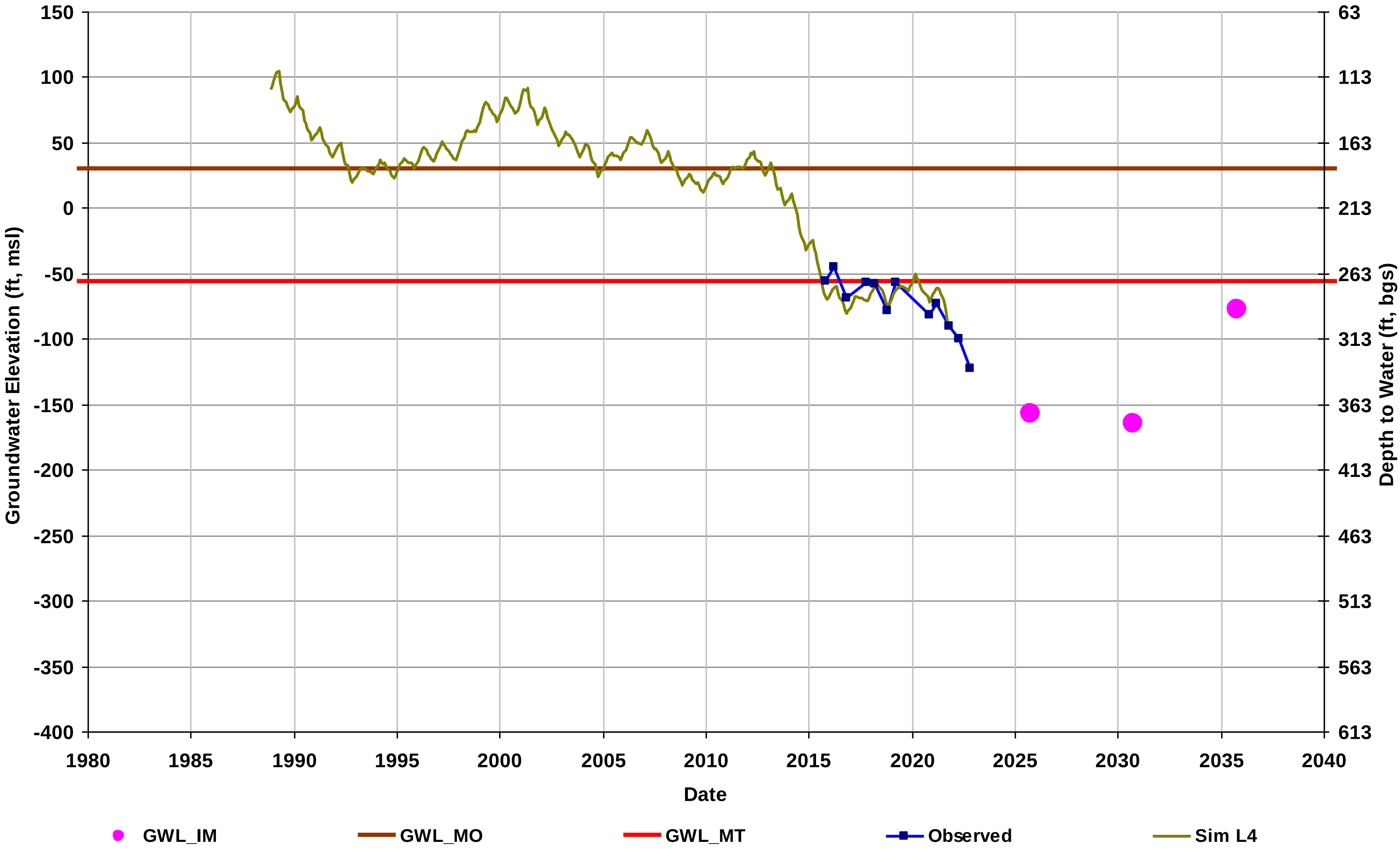
Well Name: CWD RMS-15
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 213

Domestic Well Data: *Total Sections Included:*

Total Depth Count:
Total Depth Average:
Total Depth Minimum:
Total Depth Maximum:

Top Perf. Count:
Top Perf. Average:
Top Perf. Minimum:
Top Perf. Maximum:

Total Depth (ft bgs): 955
Perf. Top (ft bgs): 290
Perf. Bottom (ft bgs): 935
Top Model Layer: 4
Bottom Model Layer: 4



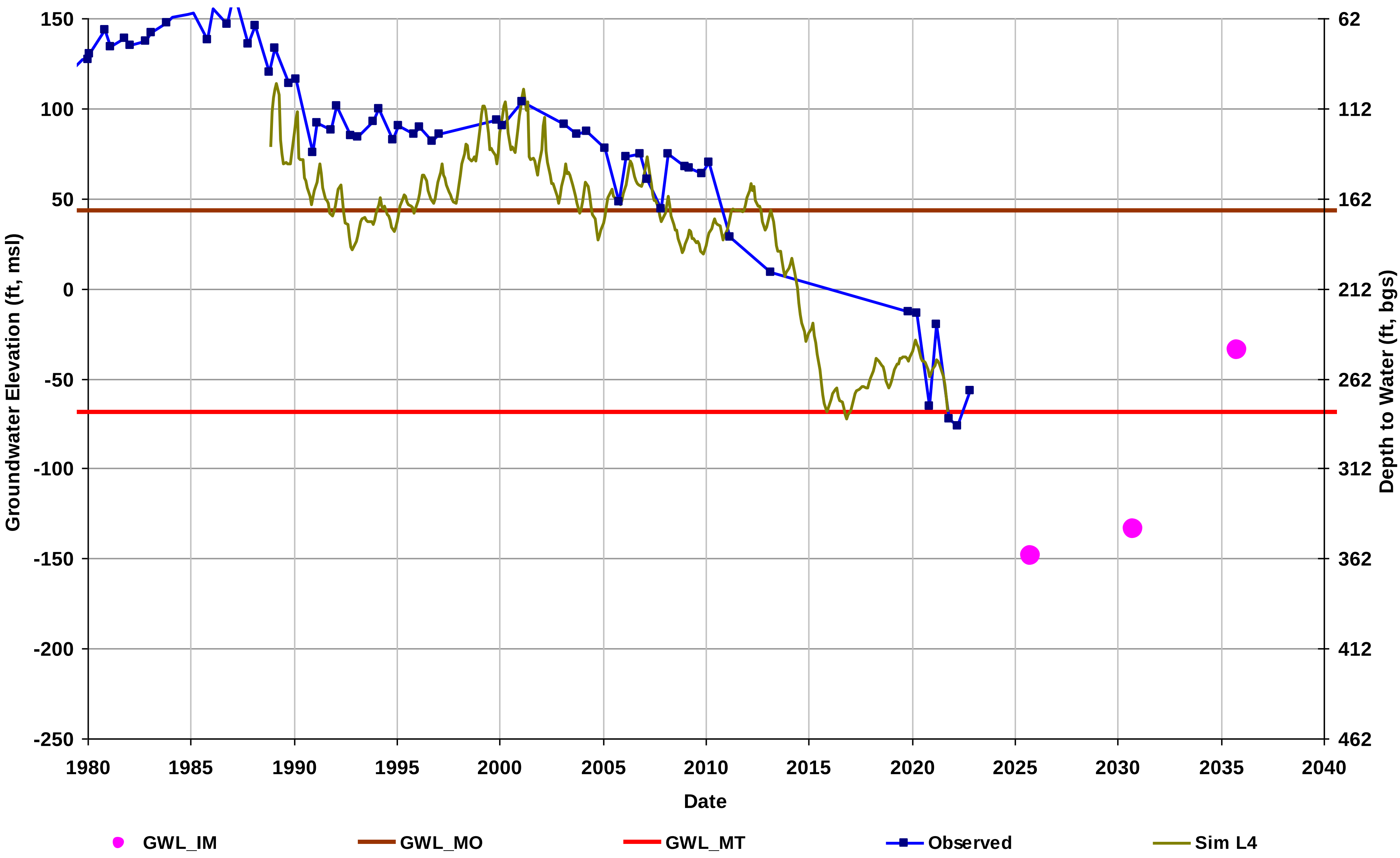
Well Name: CWD RMS-16
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 212

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 22
Total Depth Average: 339
Total Depth Minimum: 168
Total Depth Maximum: 600

Top Perf. Count: 13
Top Perf. Average: 222
Top Perf. Minimum: 160
Top Perf. Maximum: 340

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



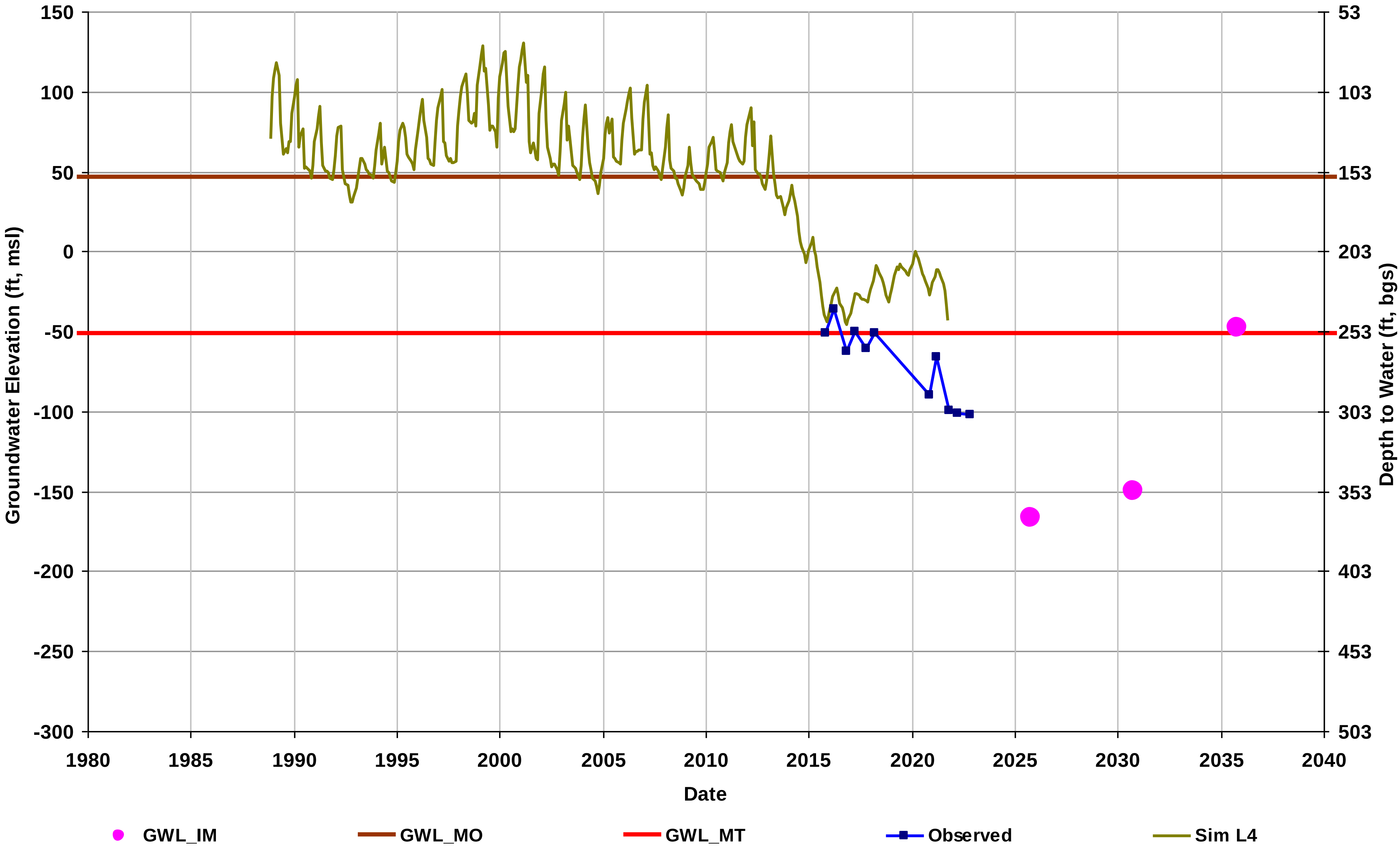
Well Name: CWD RMS-17
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 203

Domestic Well Data: *Total Sections Included:*

Total Depth Count:
Total Depth Average:
Total Depth Minimum:
Total Depth Maximum:

Top Perf. Count:
Top Perf. Average:
Top Perf. Minimum:
Top Perf. Maximum:

Total Depth (ft bgs): 624
Perf. Top (ft bgs): 278
Perf. Bottom (ft bgs): 588
Top Model Layer: 4
Bottom Model Layer: 4



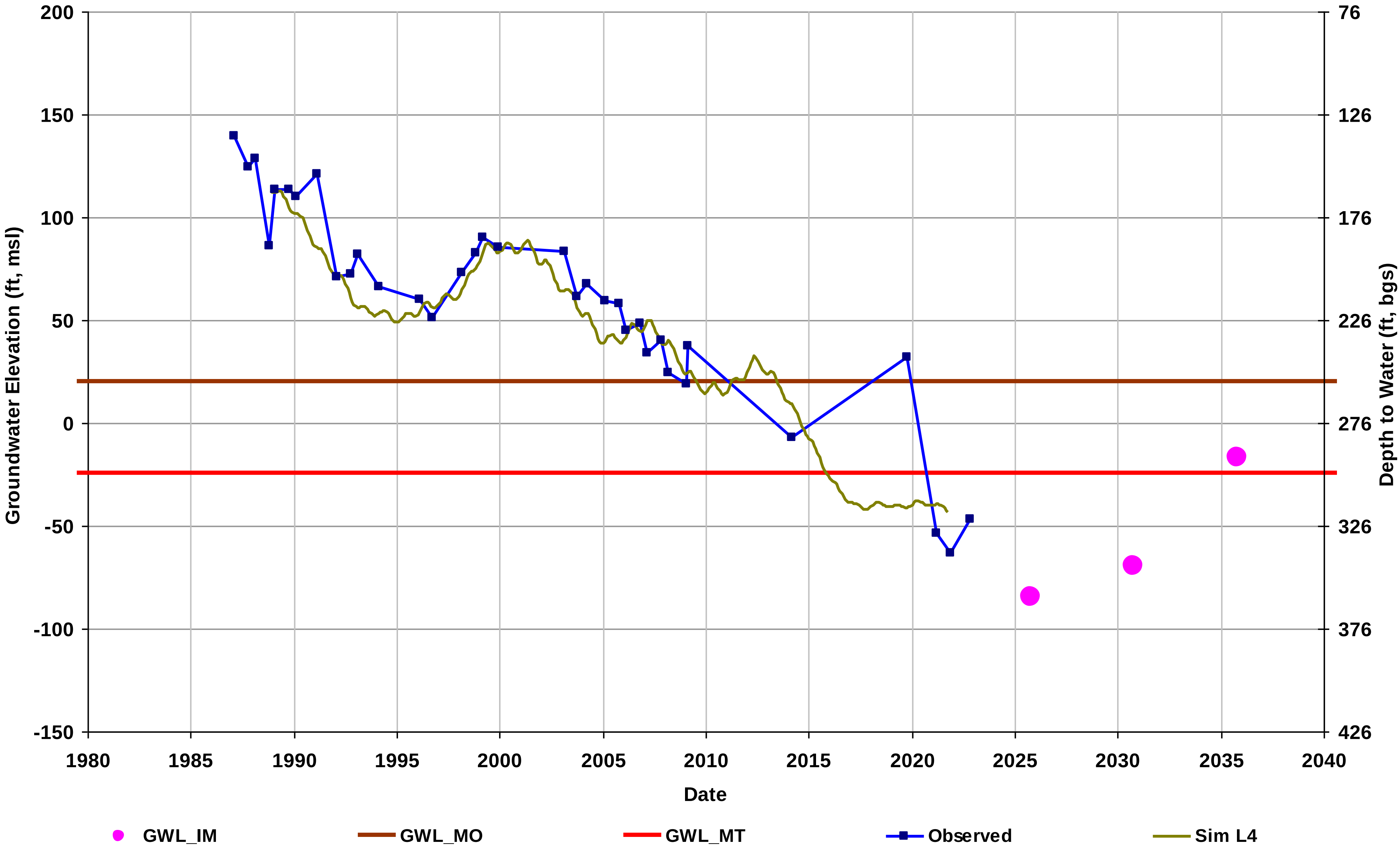
Well Name: MCE RMS-1
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 276

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 7
Total Depth Average: 336
Total Depth Minimum: 205
Total Depth Maximum: 440

Top Perf. Count: 5
Top Perf. Average: 229
Top Perf. Minimum: 164
Top Perf. Maximum: 300

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



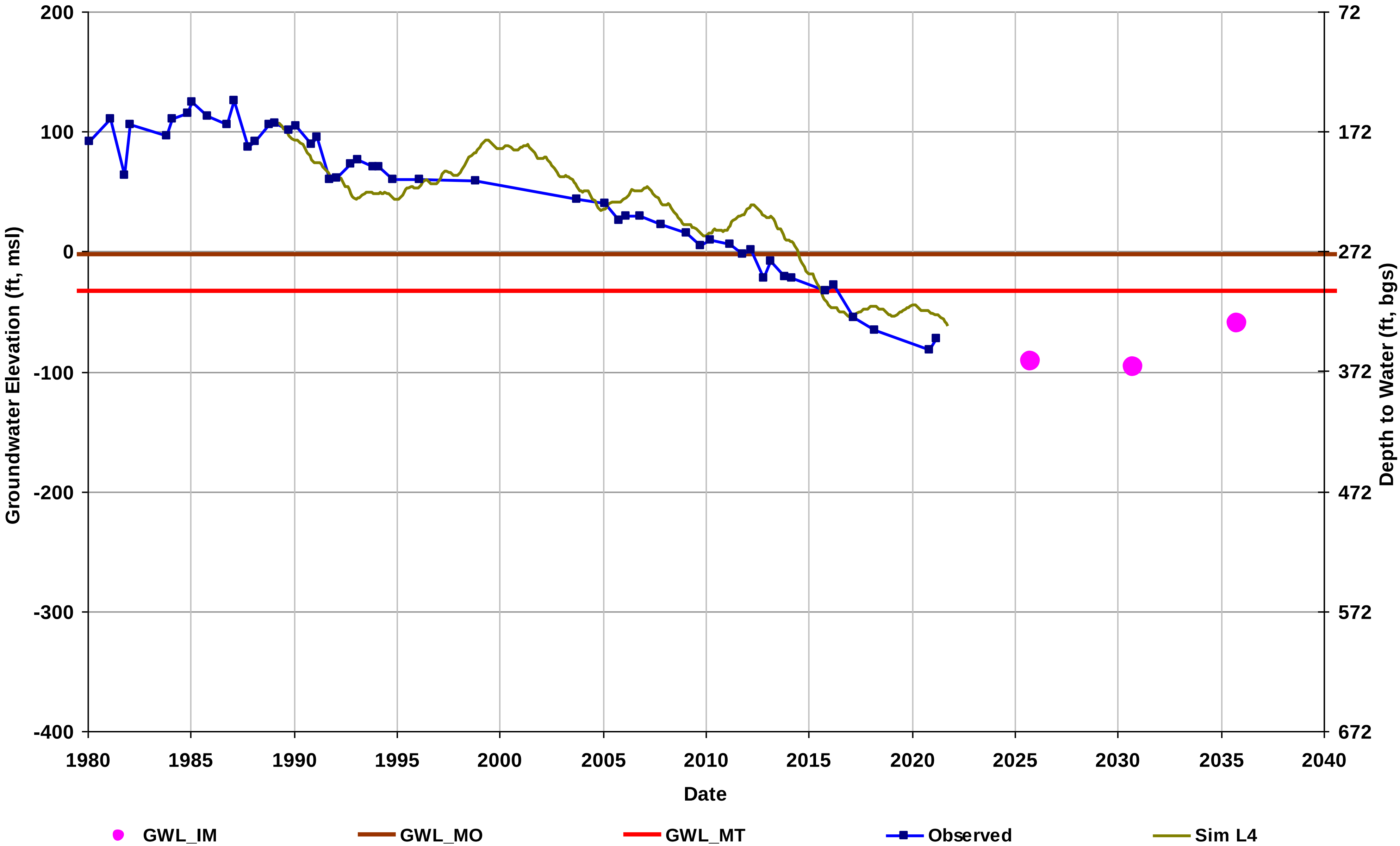
Well Name: MCE RMS-2
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 272

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 14
Total Depth Average: 378
Total Depth Minimum: 204
Total Depth Maximum: 600

Top Perf. Count: 11
Top Perf. Average: 245
Top Perf. Minimum: 155
Top Perf. Maximum: 338

Total Depth (ft bgs): 466
Perf. Top (ft bgs): 218
Perf. Bottom (ft bgs): 464
Top Model Layer: 4
Bottom Model Layer: 4

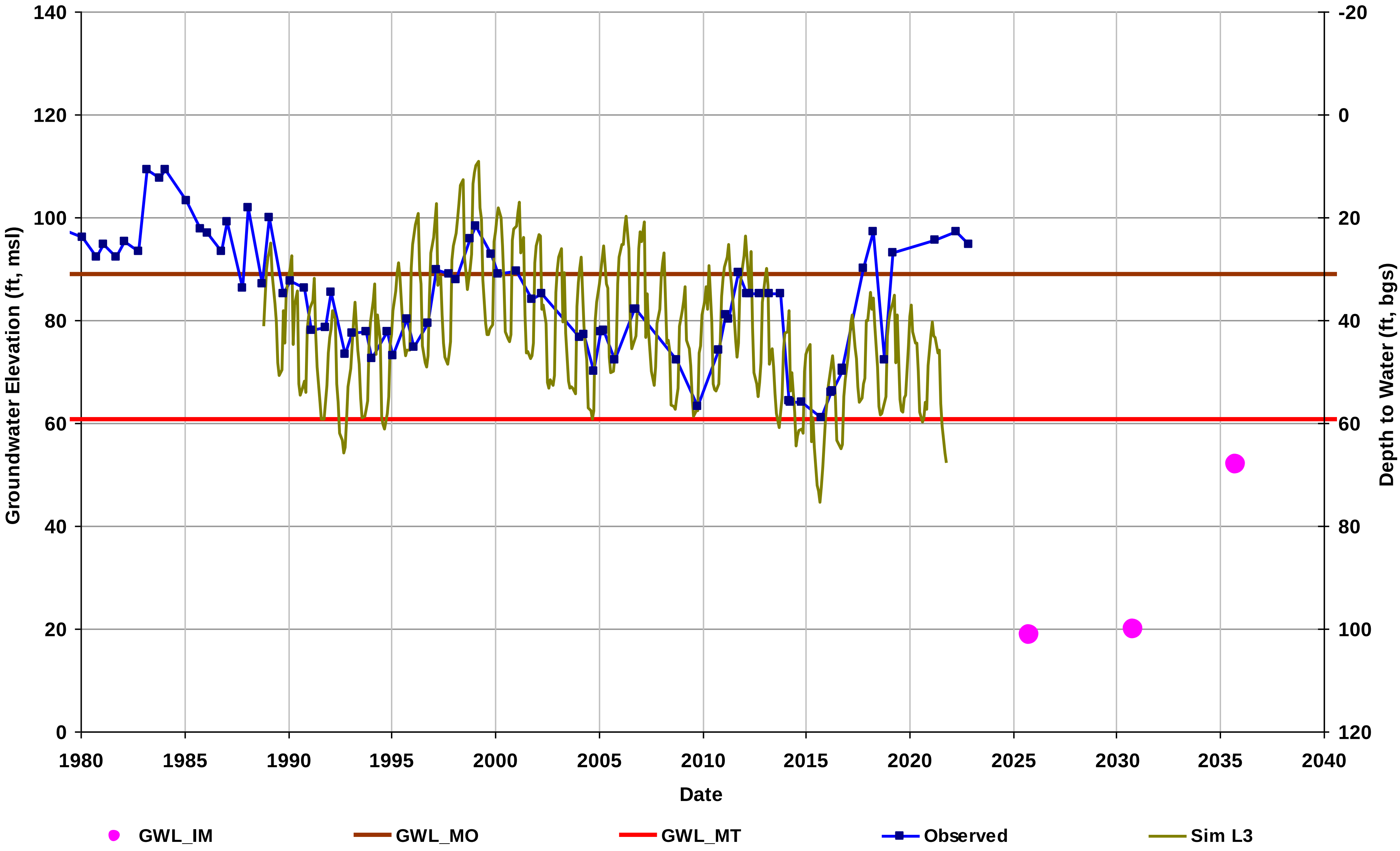


Well Name: MCW RMS-1
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 120

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	9	Top Perf. Count:	6
Total Depth Average:	344	Top Perf. Average:	208
Total Depth Minimum:	152	Top Perf. Minimum:	130
Total Depth Maximum:	650	Top Perf. Maximum:	340

Total Depth (ft bgs): 186
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 3
Bottom Model Layer: 3



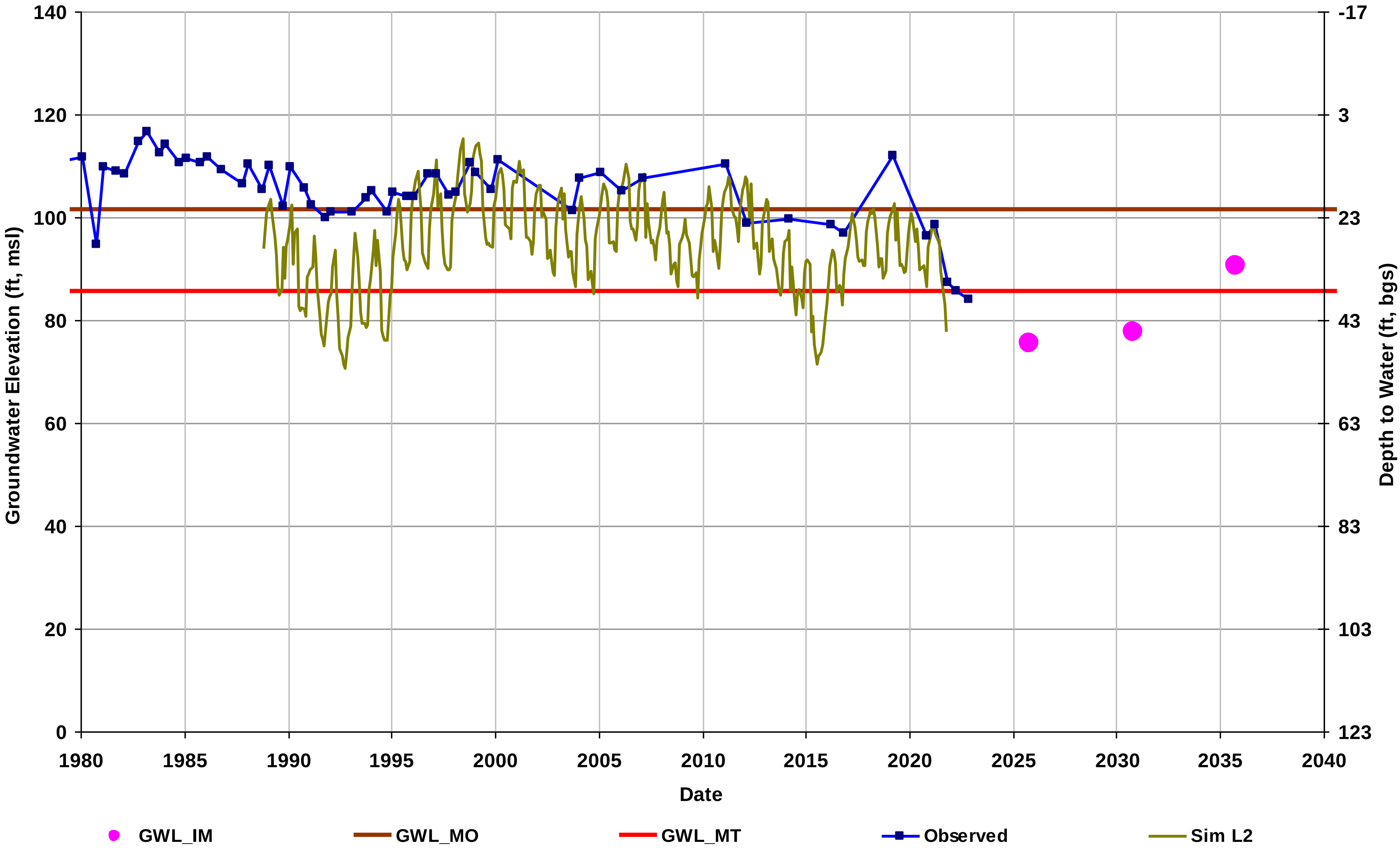
Well Name: MCW RMS-2
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 123

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 6
Total Depth Average: 183
Total Depth Minimum: 152
Total Depth Maximum: 220

Top Perf. Count: 6
Top Perf. Average: 159
Top Perf. Minimum: 130
Top Perf. Maximum: 210

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 2
Bottom Model Layer: 2



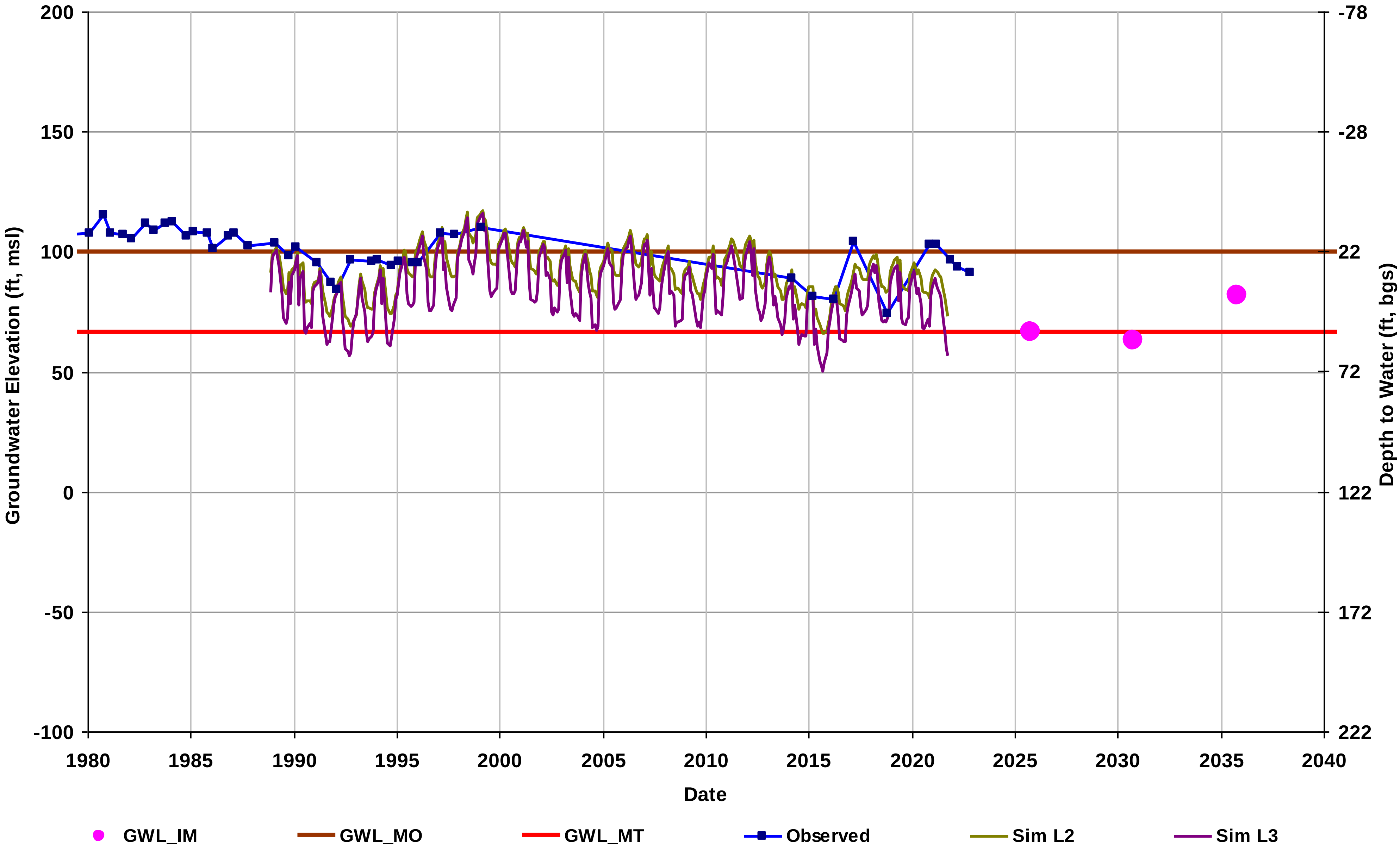
Well Name: MCW RMS-3
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 122

Domestic Well Data: *Total Sections Included: 8*

Total Depth Count: 2
Total Depth Average: 195
Total Depth Minimum: 170
Total Depth Maximum: 220

Top Perf. Count: 2
Top Perf. Average: 165
Top Perf. Minimum: 130
Top Perf. Maximum: 200

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 2
Bottom Model Layer: 3



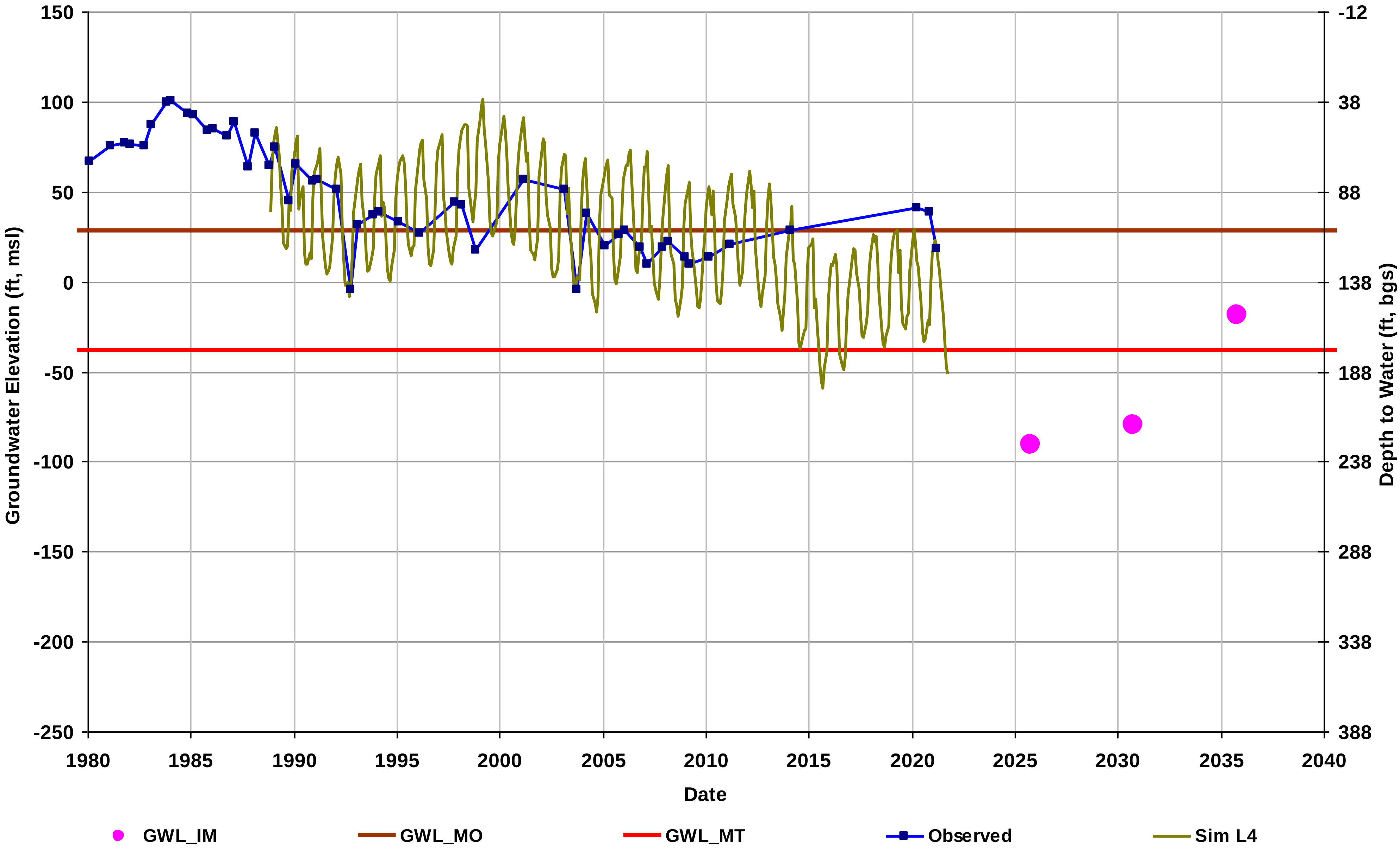
Well Name: MCW RMS-4
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 138

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 9
Total Depth Average: 283
Total Depth Minimum: 160
Total Depth Maximum: 450

Top Perf. Count: 6
Top Perf. Average: 231
Top Perf. Minimum: 154
Top Perf. Maximum: 400

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4



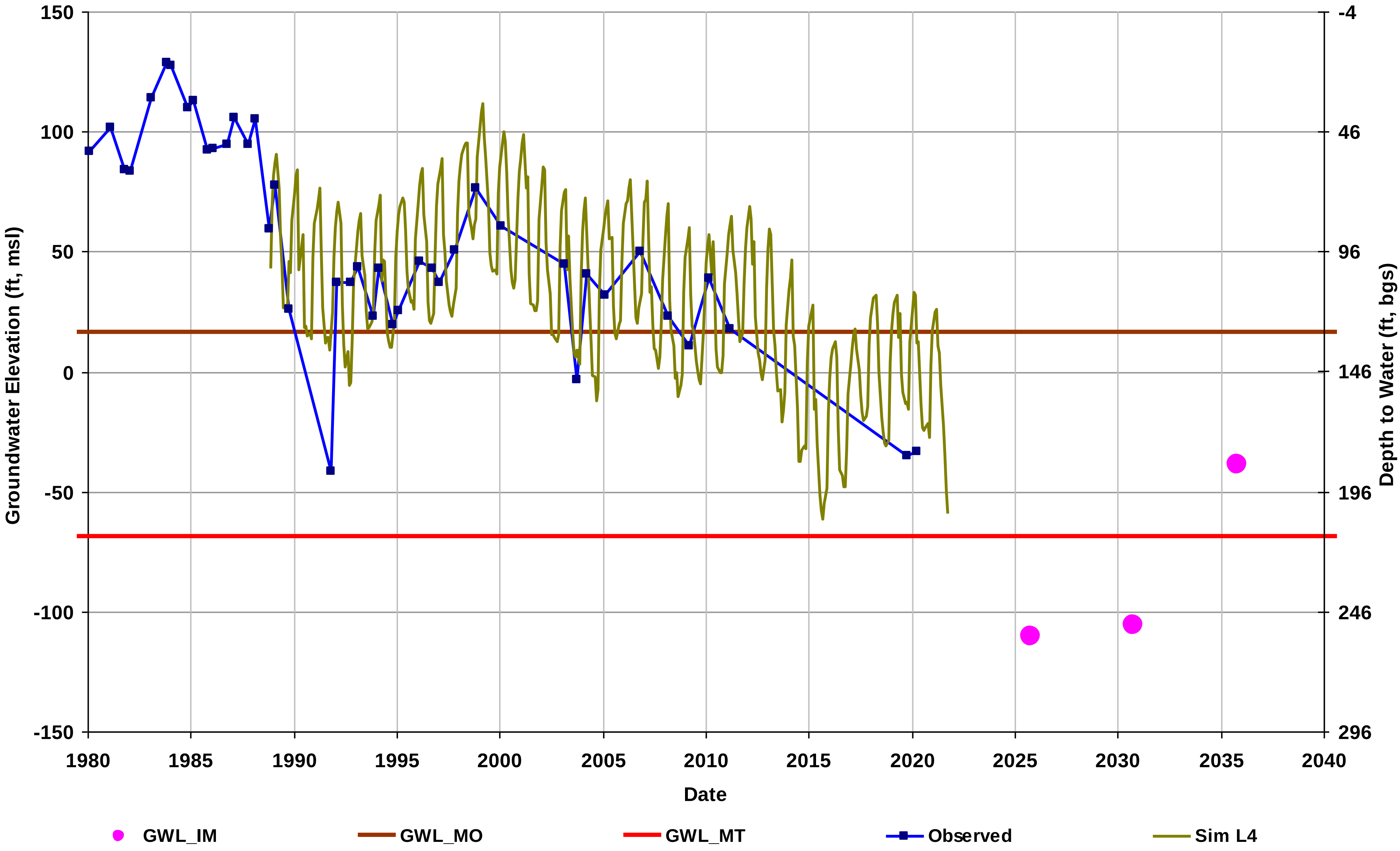
Well Name: MCW RMS-5
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 146

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 6
Total Depth Average: 268
Total Depth Minimum: 165
Total Depth Maximum: 400

Top Perf. Count: 4
Top Perf. Average: 207
Top Perf. Minimum: 100
Top Perf. Maximum: 300

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4

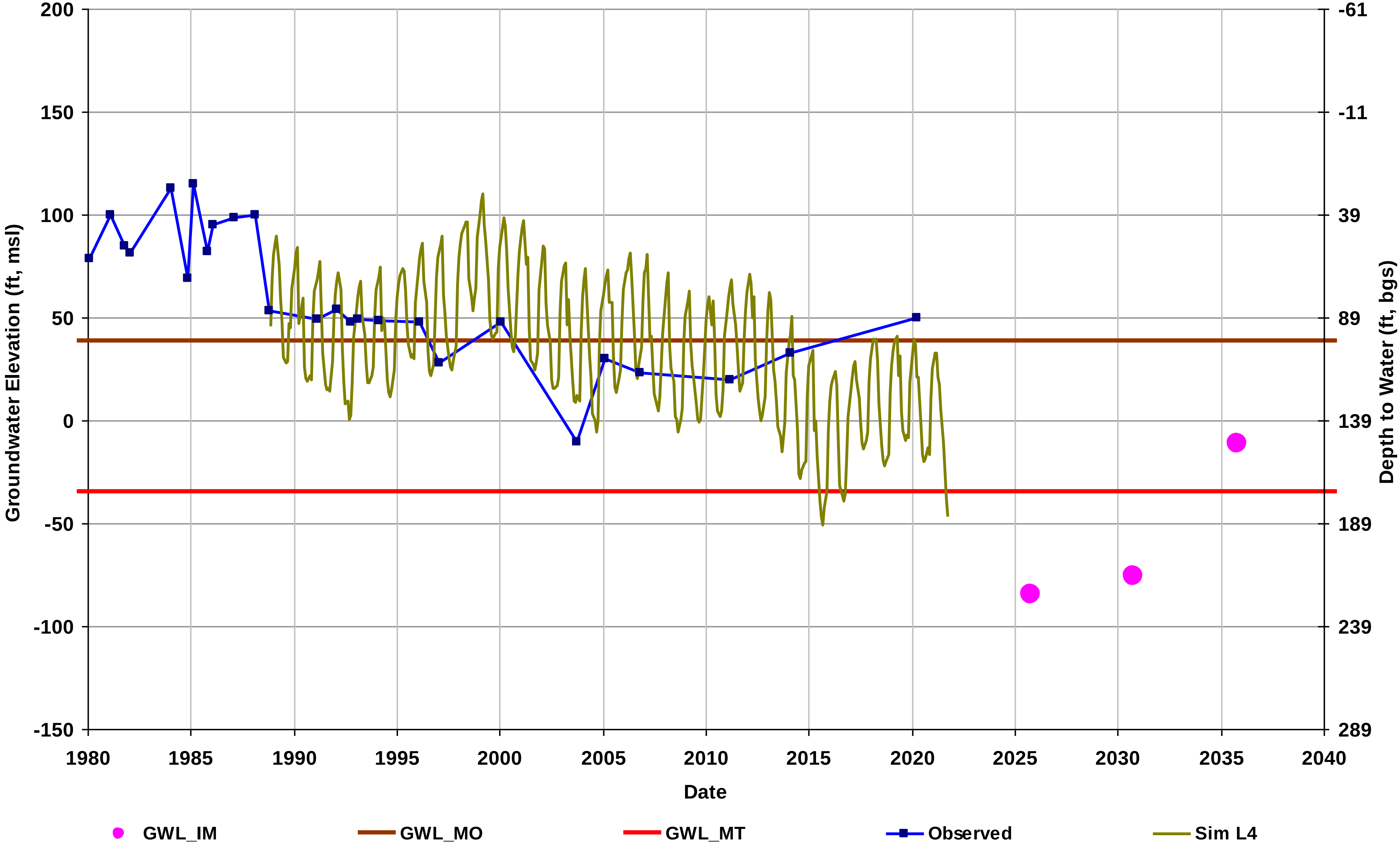


Well Name: MCW RMS-6
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 139

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	6	Top Perf. Count:	5
Total Depth Average:	292	Top Perf. Average:	218
Total Depth Minimum:	165	Top Perf. Minimum:	100
Total Depth Maximum:	400	Top Perf. Maximum:	310

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4

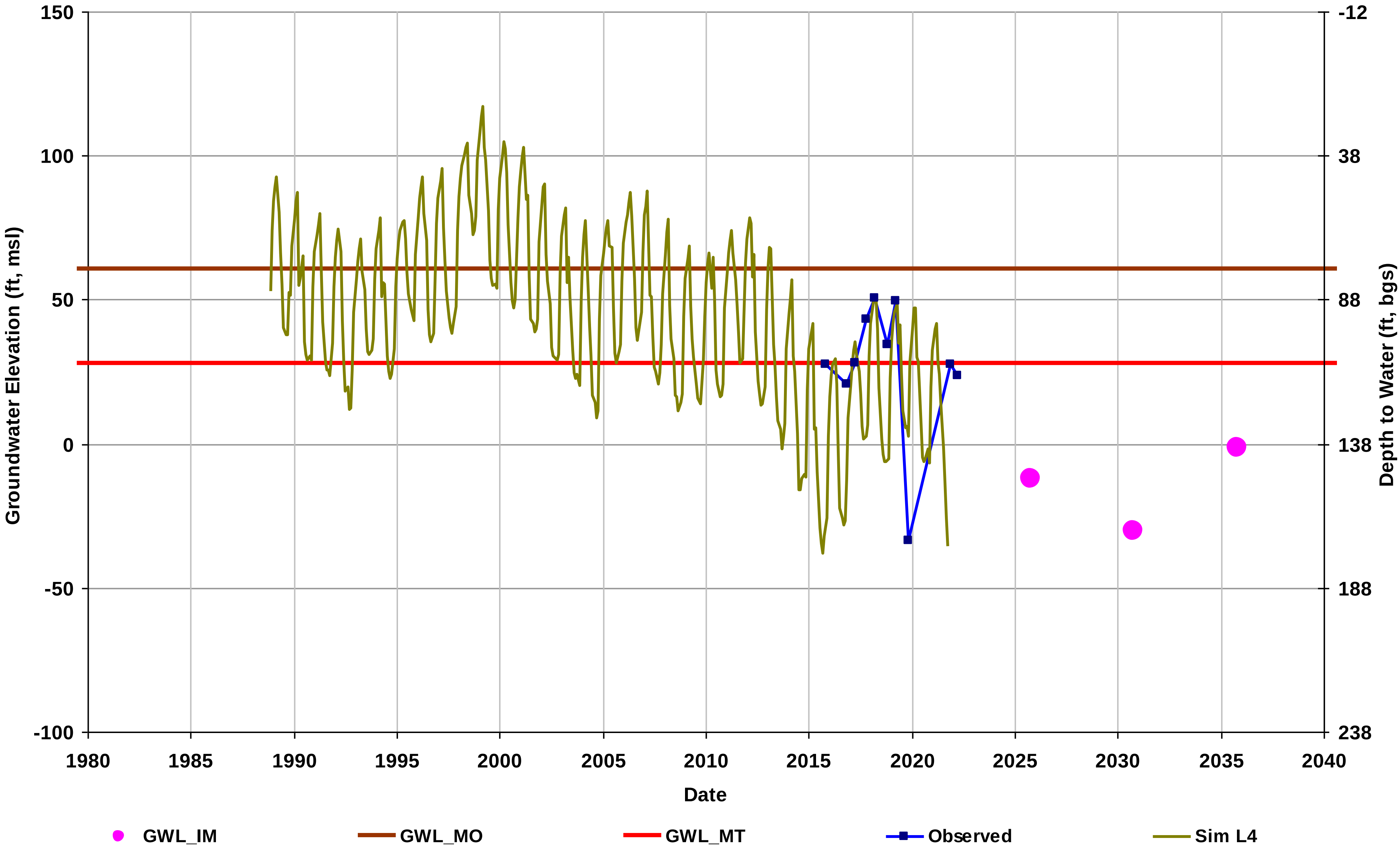


Well Name: MCW RMS-7
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 138

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	4	Top Perf. Count:	3
Total Depth Average:	248	Top Perf. Average:	203
Total Depth Minimum:	165	Top Perf. Minimum:	100
Total Depth Maximum:	400	Top Perf. Maximum:	300

Total Depth (ft bgs): 800
Perf. Top (ft bgs): 290
Perf. Bottom (ft bgs): 400
Top Model Layer: 4
Bottom Model Layer: 4



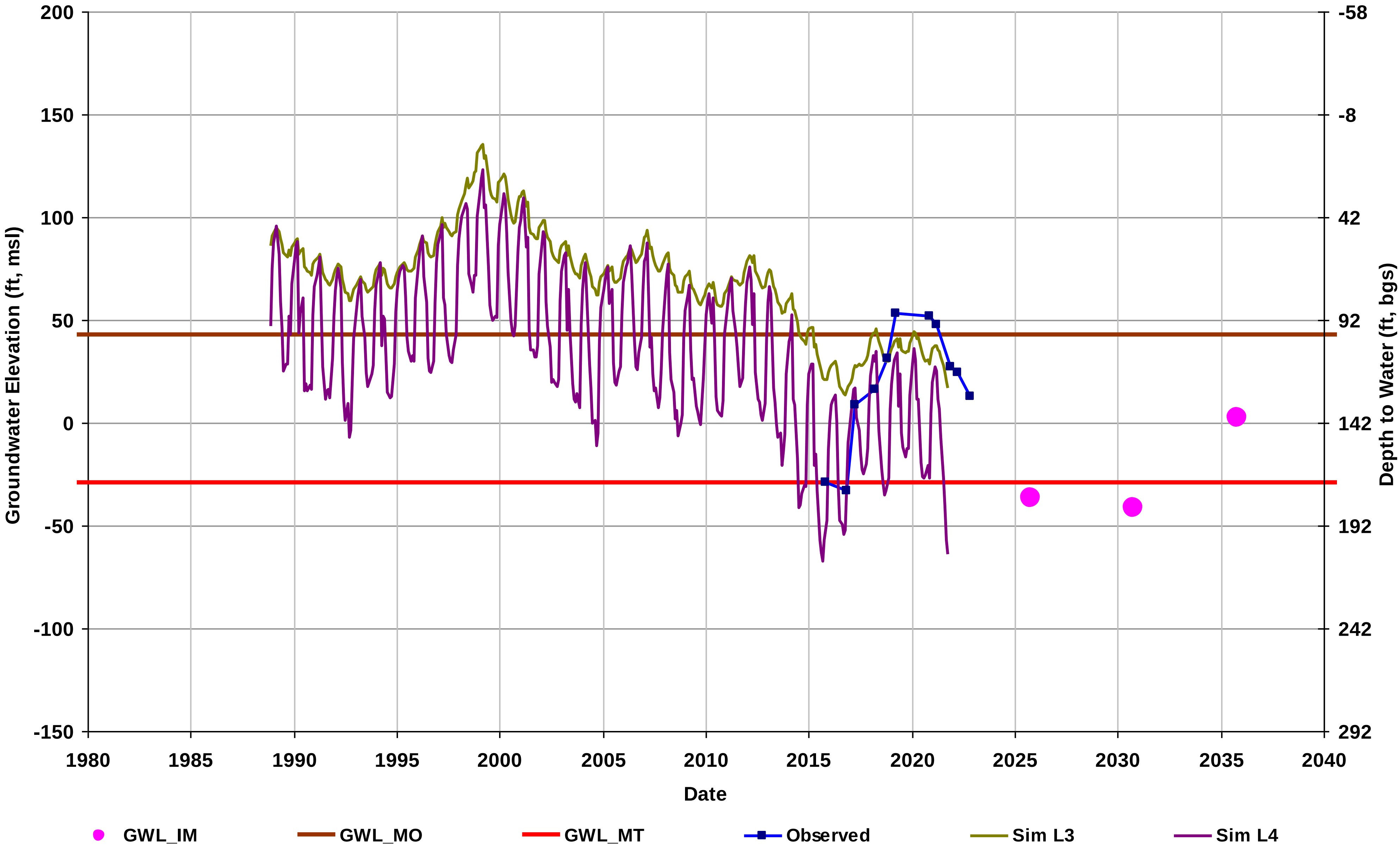
Well Name: MCW RMS-8
Depth Zone: Composite
Subbasin: Chowchilla
GSE (ft, msl): 142

Domestic Well Data: *Total Sections Included:*

Total Depth Count:
Total Depth Average:
Total Depth Minimum:
Total Depth Maximum:

Top Perf. Count:
Top Perf. Average:
Top Perf. Minimum:
Top Perf. Maximum:

Total Depth (ft bgs): 480
Perf. Top (ft bgs): 160
Perf. Bottom (ft bgs): 475
Top Model Layer: 3
Bottom Model Layer: 4

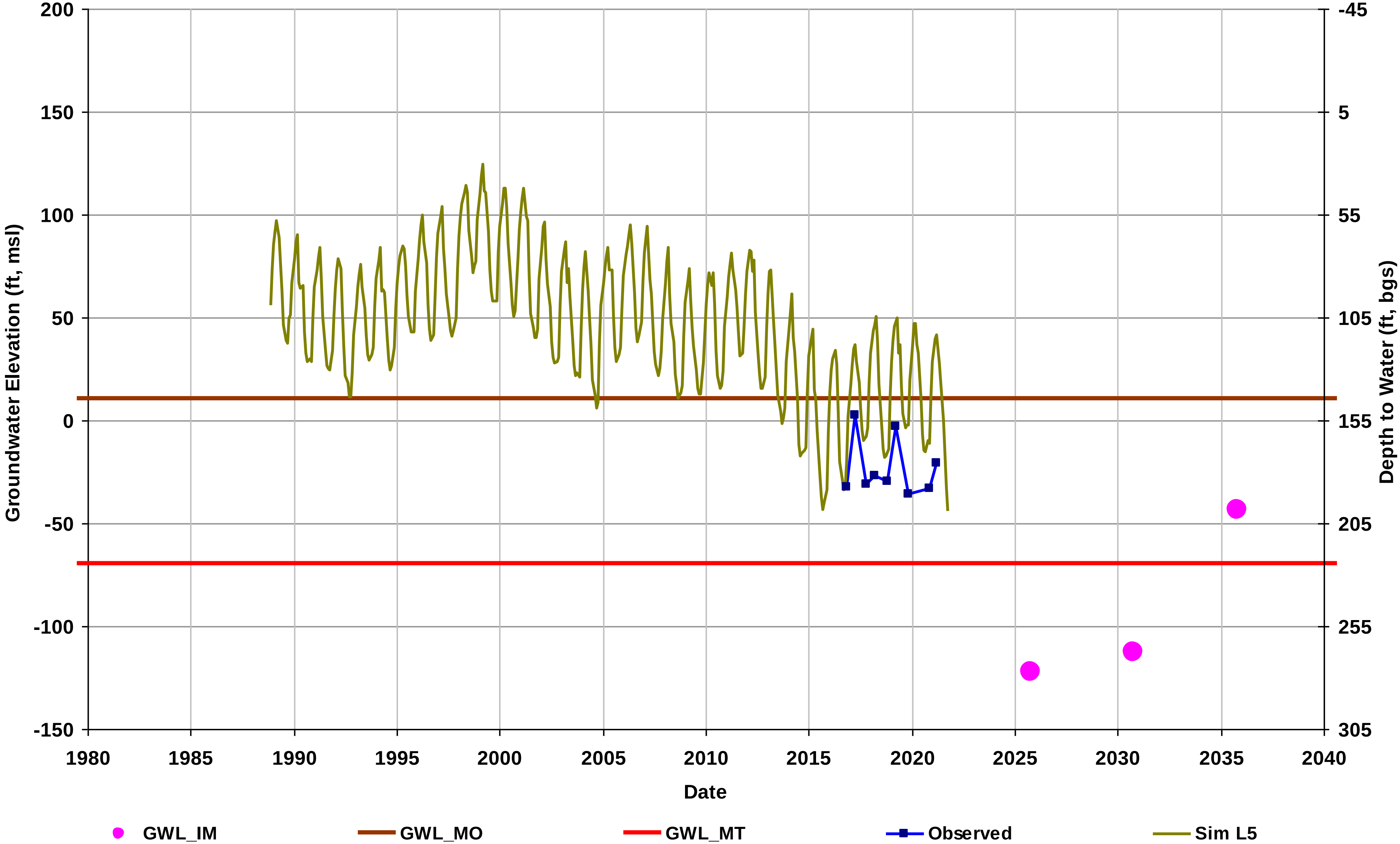


Well Name: MCW RMS-9
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 155

Domestic Well Data: *Total Sections Included: 10*

Total Depth Count:	9	Top Perf. Count:	3
Total Depth Average:	246	Top Perf. Average:	256
Total Depth Minimum:	110	Top Perf. Minimum:	160
Total Depth Maximum:	400	Top Perf. Maximum:	308

Total Depth (ft bgs): 700
Perf. Top (ft bgs): 265
Perf. Bottom (ft bgs): 696
Top Model Layer: 5
Bottom Model Layer: 5

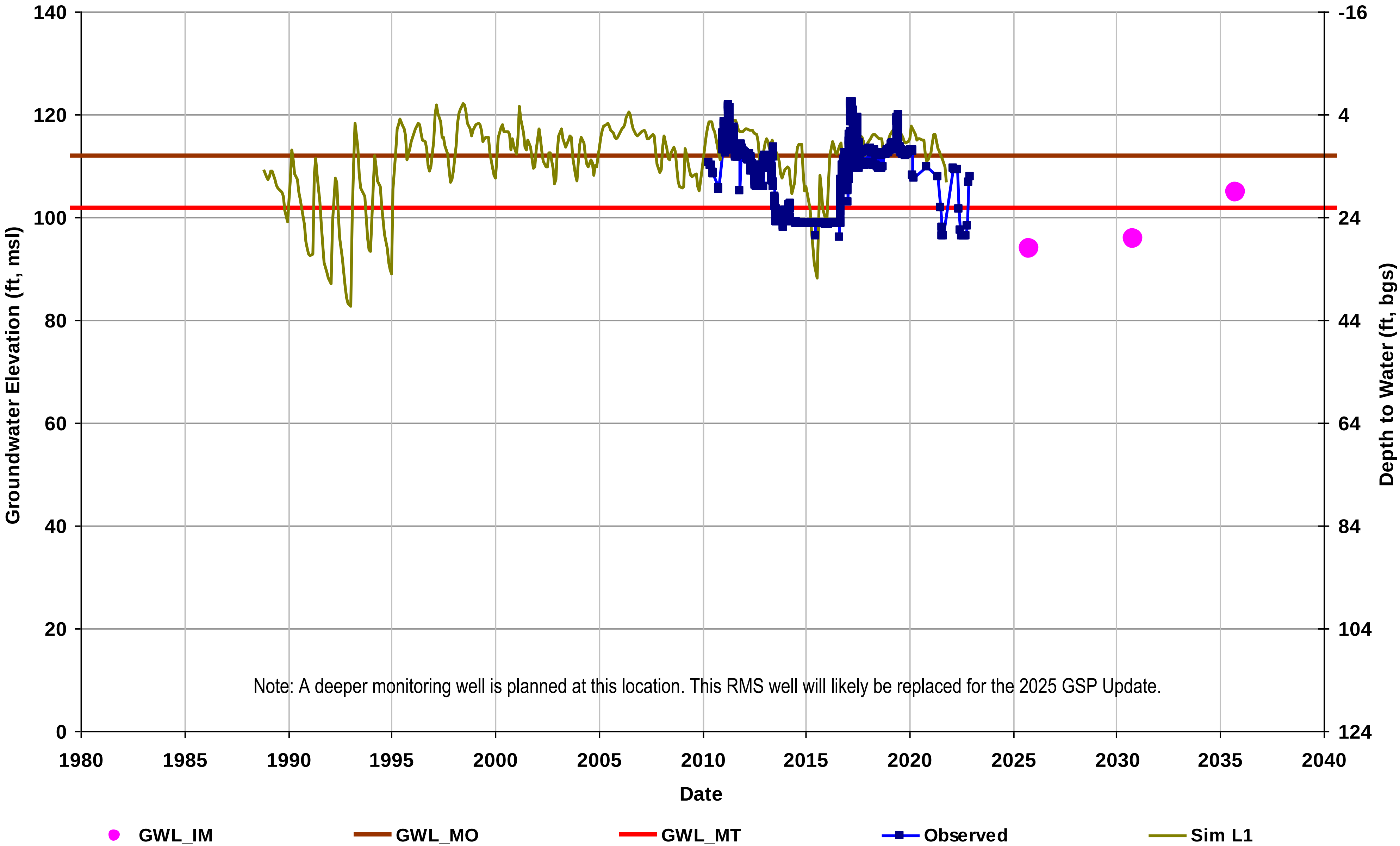


Well Name: MCW RMS-10
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 123

Domestic Well Data: *Total Sections Included: 8*

Total Depth Count:	9	Top Perf. Count:	7
Total Depth Average:	245	Top Perf. Average:	158
Total Depth Minimum:	152	Top Perf. Minimum:	130
Total Depth Maximum:	500	Top Perf. Maximum:	210

Total Depth (ft bgs): 26
Perf. Top (ft bgs): 10
Perf. Bottom (ft bgs): 25
Top Model Layer: 1
Bottom Model Layer: 1



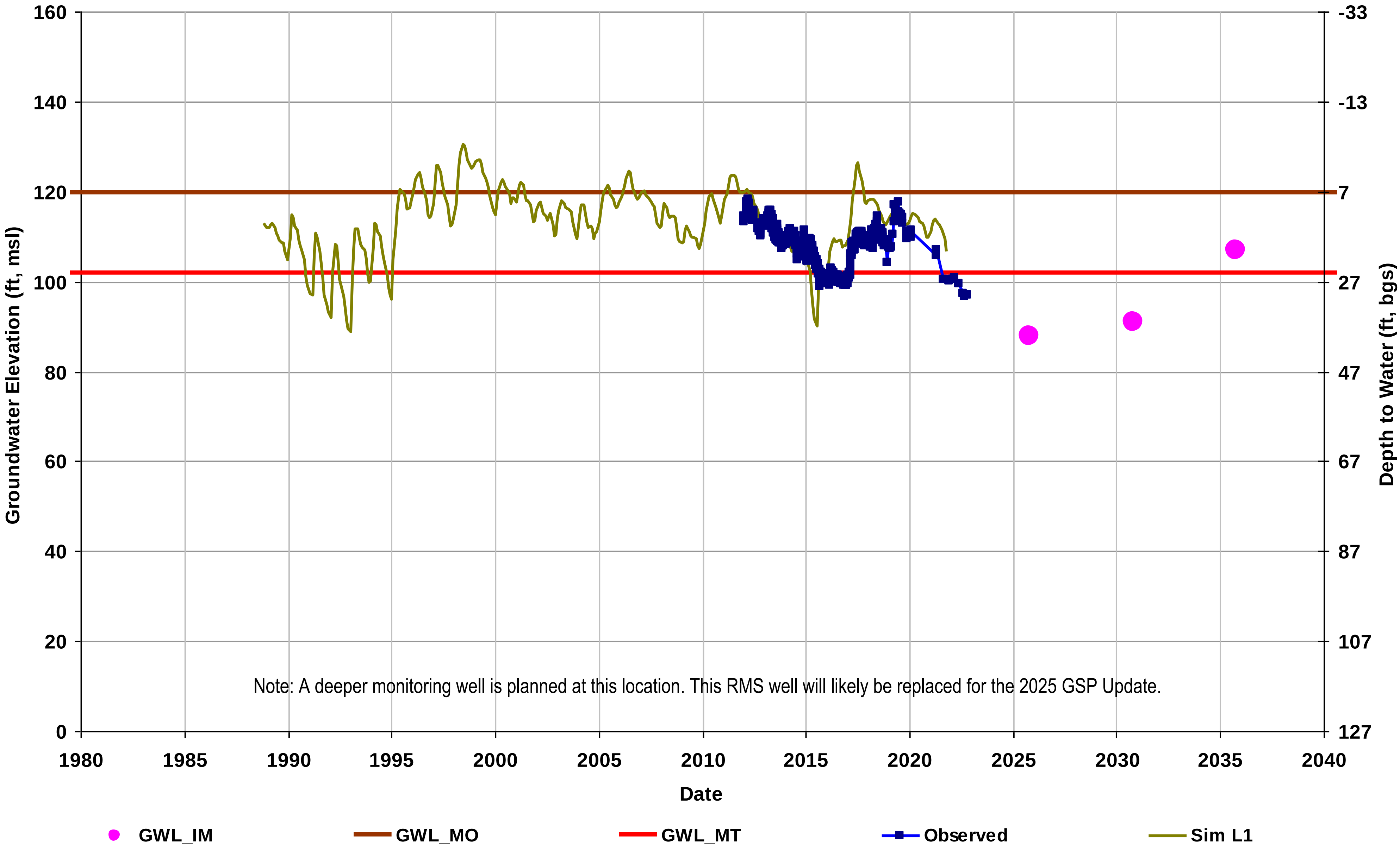
Well Name: MCW RMS-11
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 127

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 9
Total Depth Average: 216
Total Depth Minimum: 110
Total Depth Maximum: 470

Top Perf. Count: 8
Top Perf. Average: 154
Top Perf. Minimum: 90
Top Perf. Maximum: 400

Total Depth (ft bgs): 30
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 1
Bottom Model Layer: 1



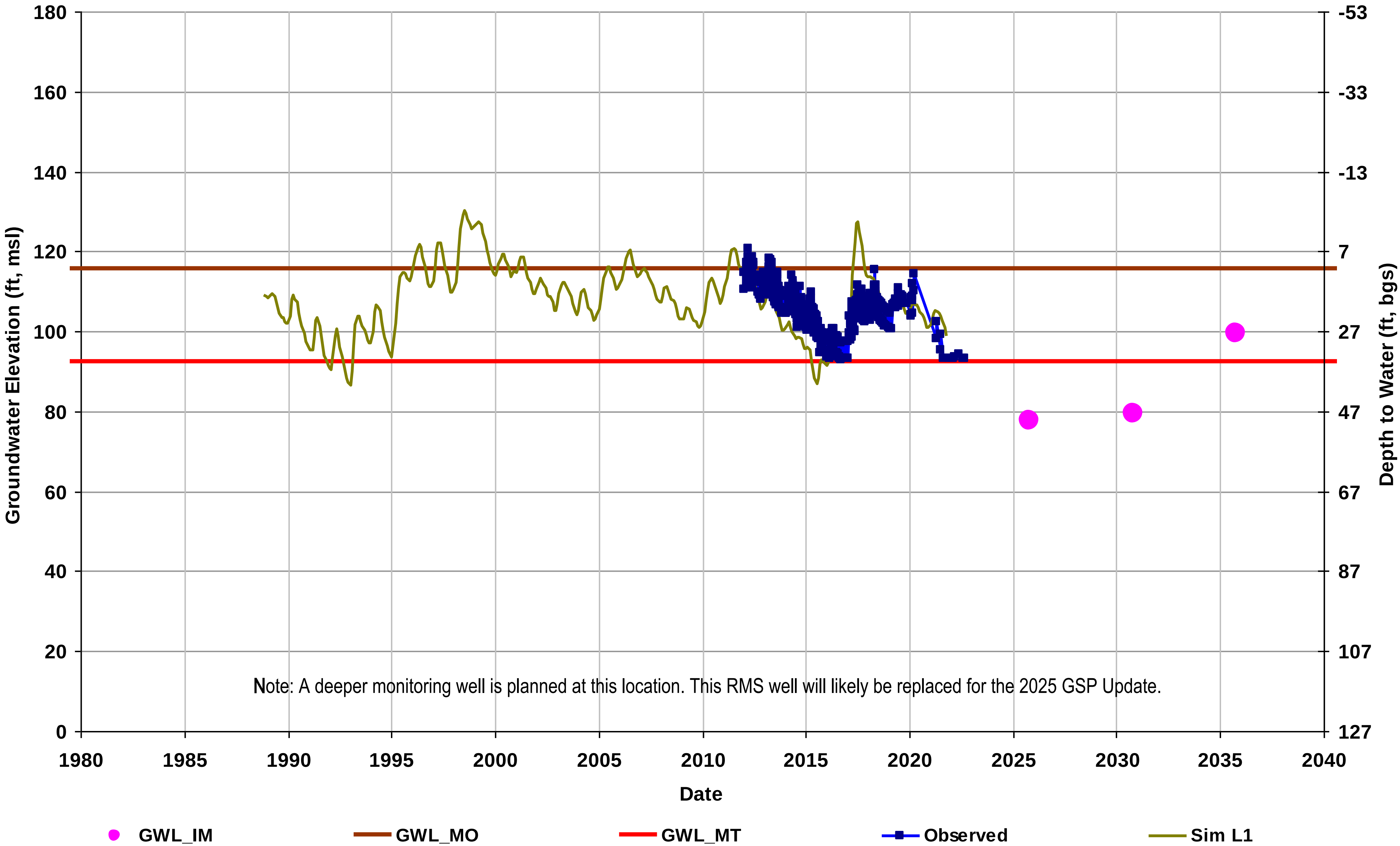
Well Name: MCW RMS-12
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 127

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 4
Total Depth Average: 309
Total Depth Minimum: 140
Total Depth Maximum: 470

Top Perf. Count: 3
Top Perf. Average: 227
Top Perf. Minimum: 120
Top Perf. Maximum: 400

Total Depth (ft bgs): 29
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 1
Bottom Model Layer: 1

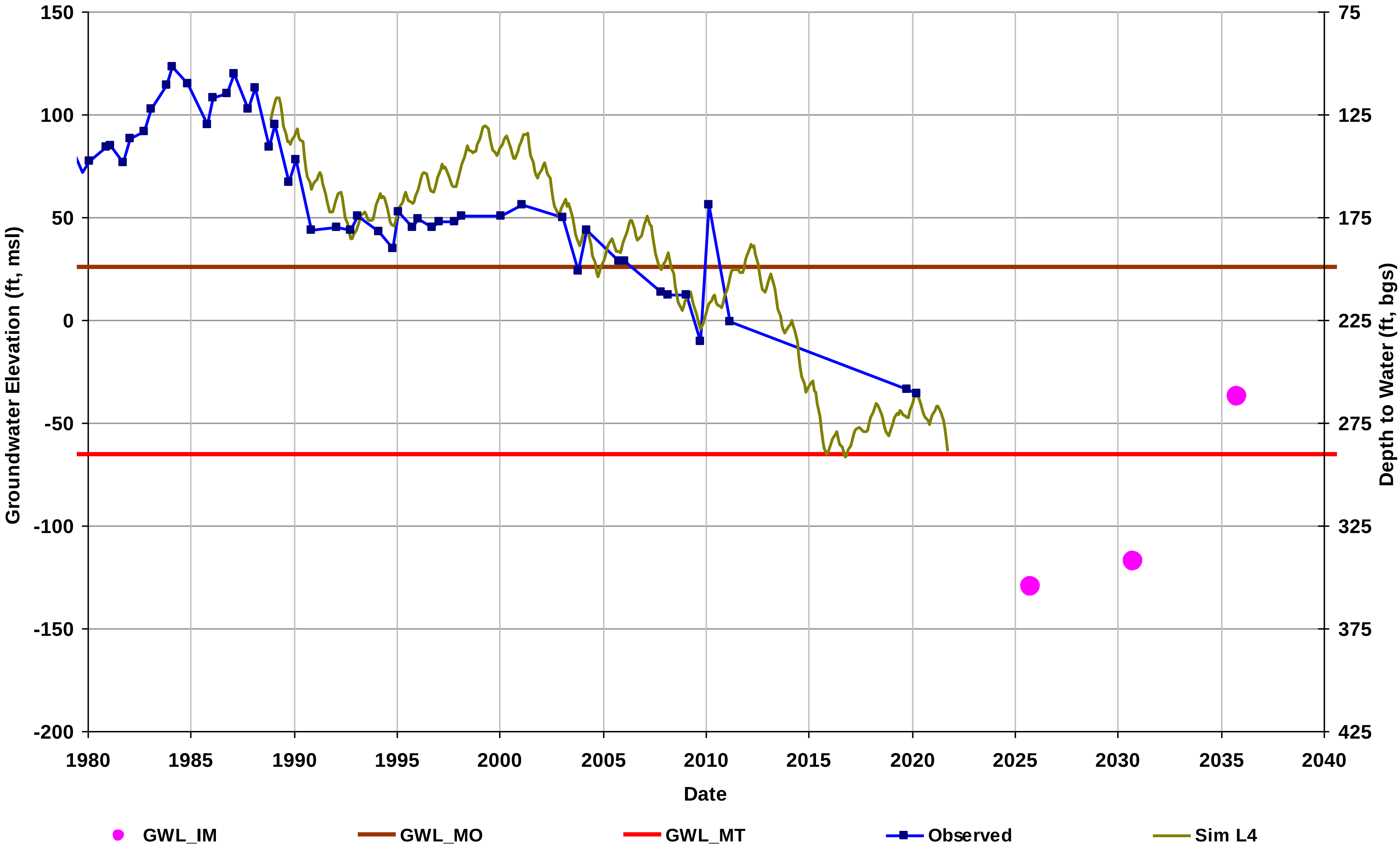


Well Name: MER RMS-1
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 225

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	13	Top Perf. Count:	9
Total Depth Average:	403	Top Perf. Average:	338
Total Depth Minimum:	215	Top Perf. Minimum:	160
Total Depth Maximum:	810	Top Perf. Maximum:	545

Total Depth (ft bgs):
Perf. Top (ft bgs):
Perf. Bottom (ft bgs):
Top Model Layer: 4
Bottom Model Layer: 4

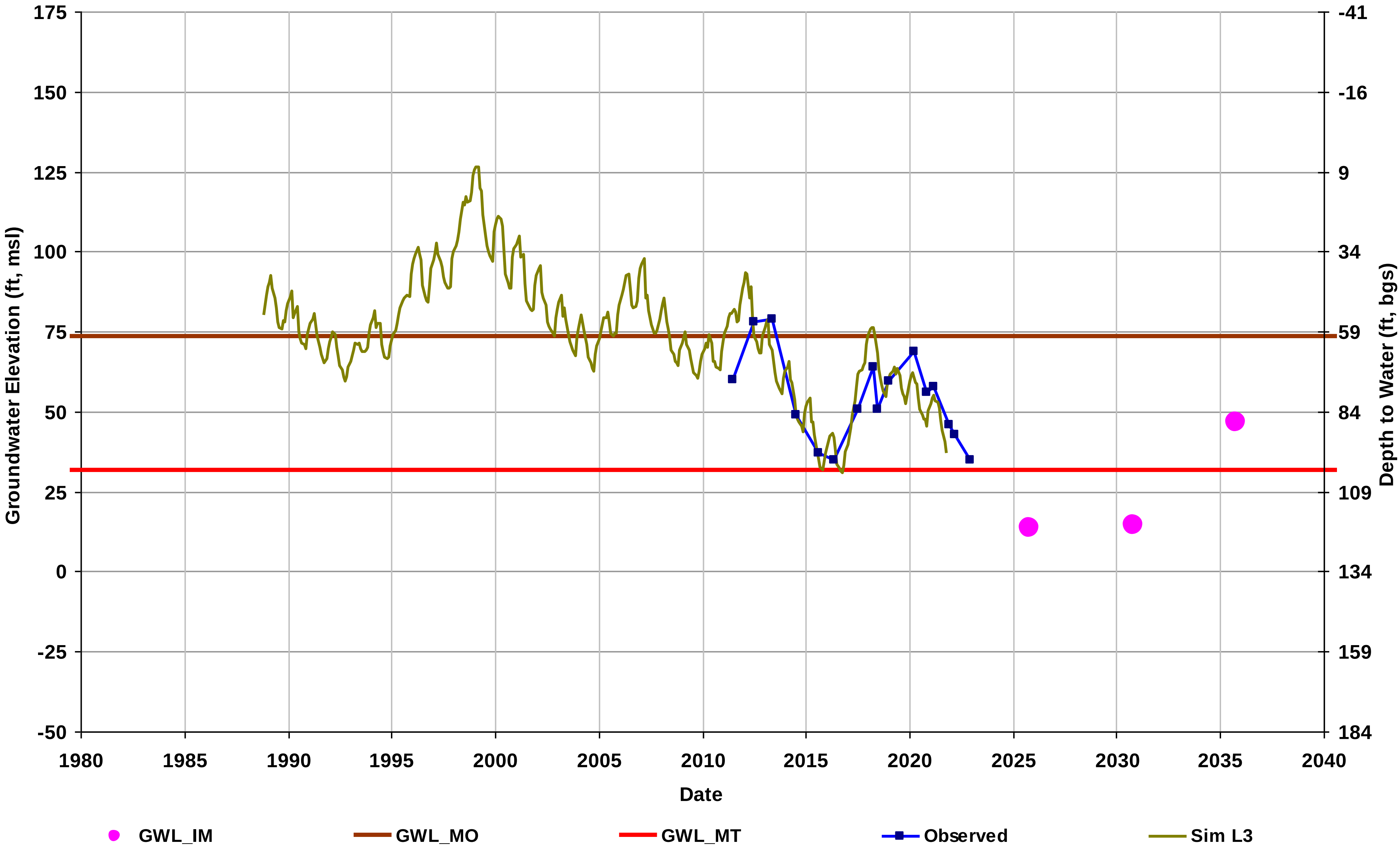


Well Name: TRT RMS-1
Depth Zone: Upper
Subbasin: Chowchilla
GSE (ft, msl): 134

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	3	Top Perf. Count:	2
Total Depth Average:	257	Top Perf. Average:	200
Total Depth Minimum:	165	Top Perf. Minimum:	100
Total Depth Maximum:	400	Top Perf. Maximum:	300

Total Depth (ft bgs): 196
Perf. Top (ft bgs): 158
Perf. Bottom (ft bgs): 192
Top Model Layer: 3
Bottom Model Layer: 3

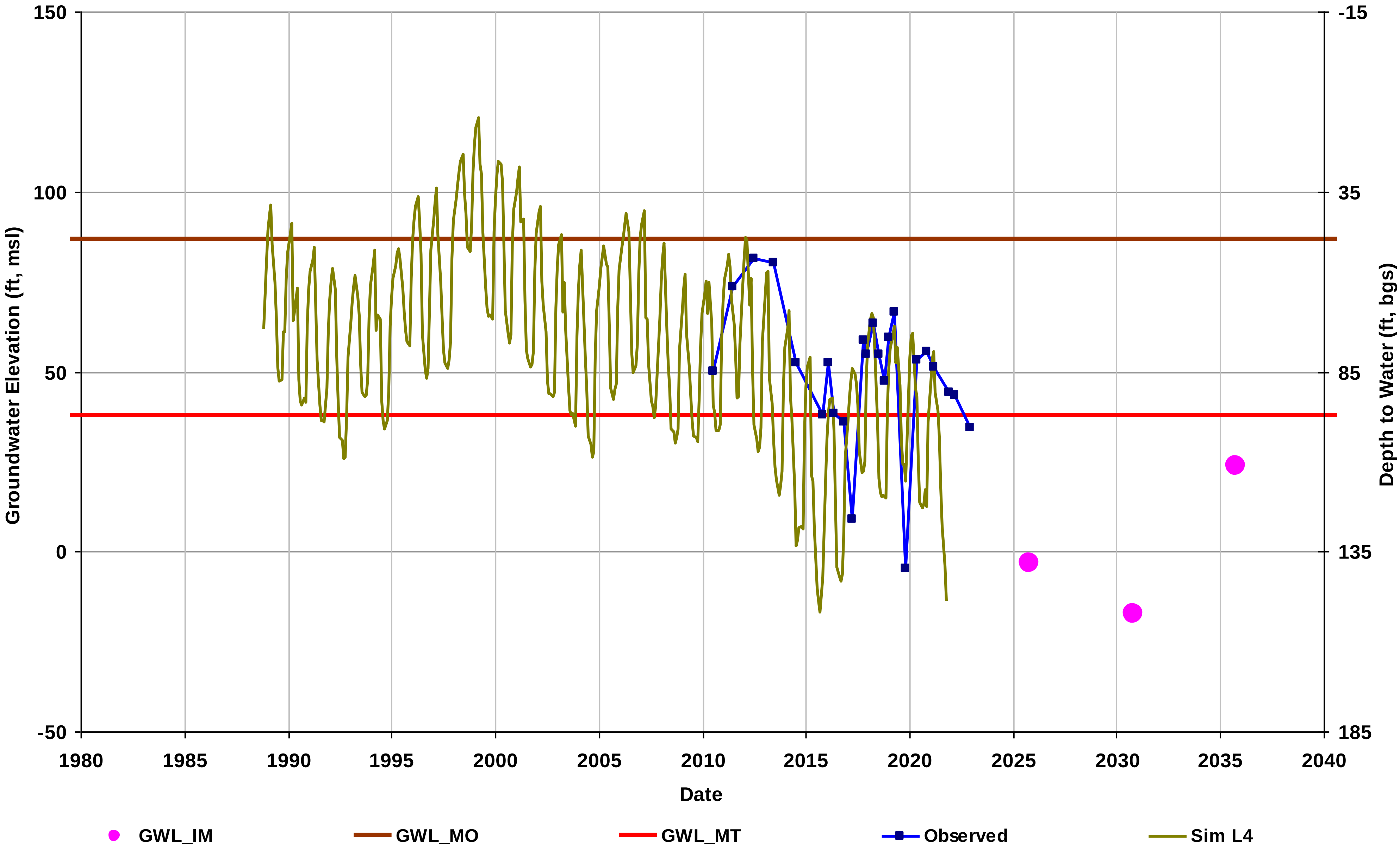


Well Name: TRT RMS-2
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 135

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	7	Top Perf. Count:	4
Total Depth Average:	314	Top Perf. Average:	202
Total Depth Minimum:	150	Top Perf. Minimum:	100
Total Depth Maximum:	500	Top Perf. Maximum:	300

Total Depth (ft bgs): 500
Perf. Top (ft bgs): 300
Perf. Bottom (ft bgs): 500
Top Model Layer: 4
Bottom Model Layer: 4

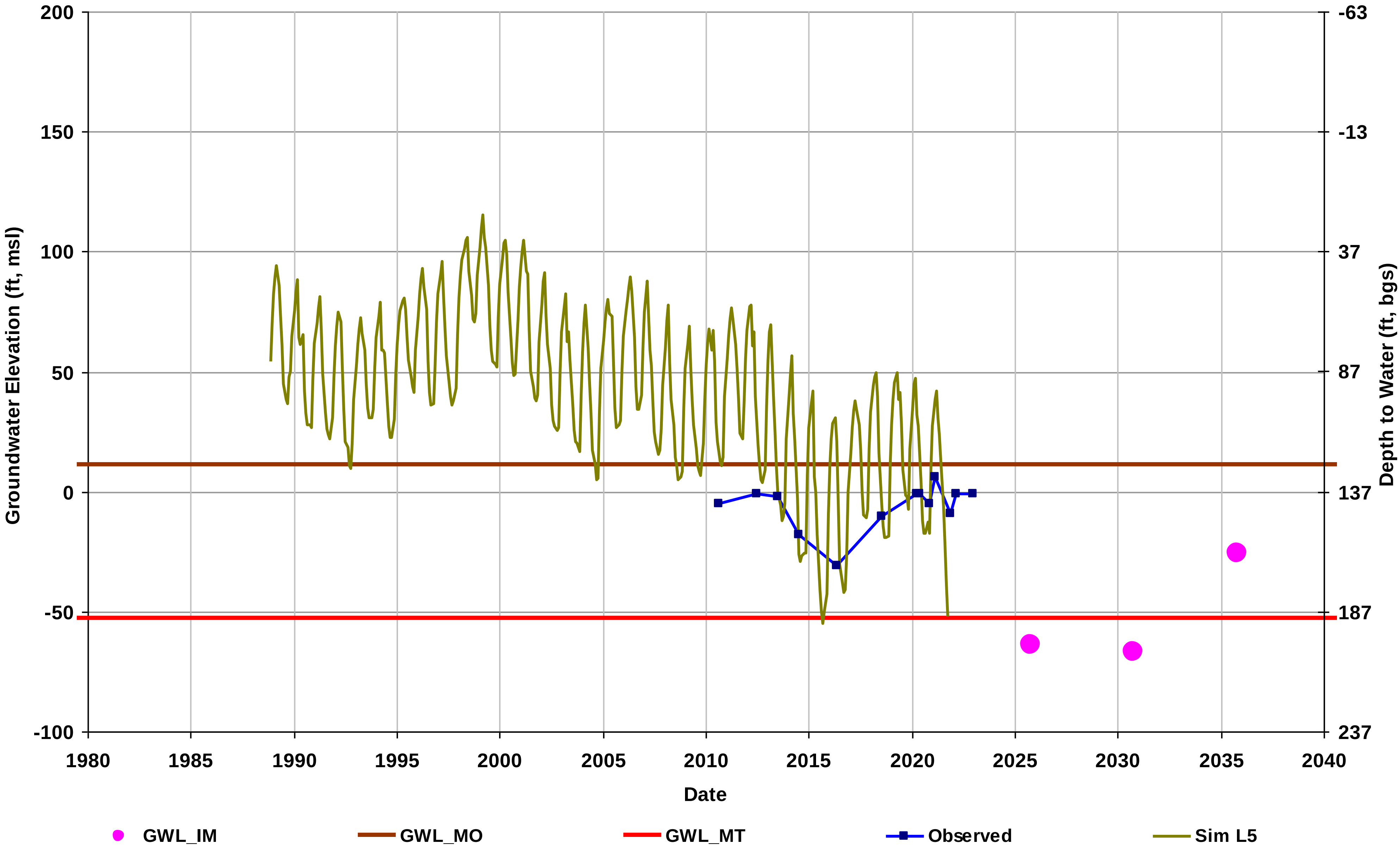


Well Name: TRT RMS-3
Depth Zone: Lower
Subbasin: Chowchilla
GSE (ft, msl): 137

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count:	6	Top Perf. Count:	3
Total Depth Average:	303	Top Perf. Average:	196
Total Depth Minimum:	150	Top Perf. Minimum:	130
Total Depth Maximum:	500	Top Perf. Maximum:	277

Total Depth (ft bgs): 799
Perf. Top (ft bgs): 168
Perf. Bottom (ft bgs): 790
Top Model Layer: 5
Bottom Model Layer: 5



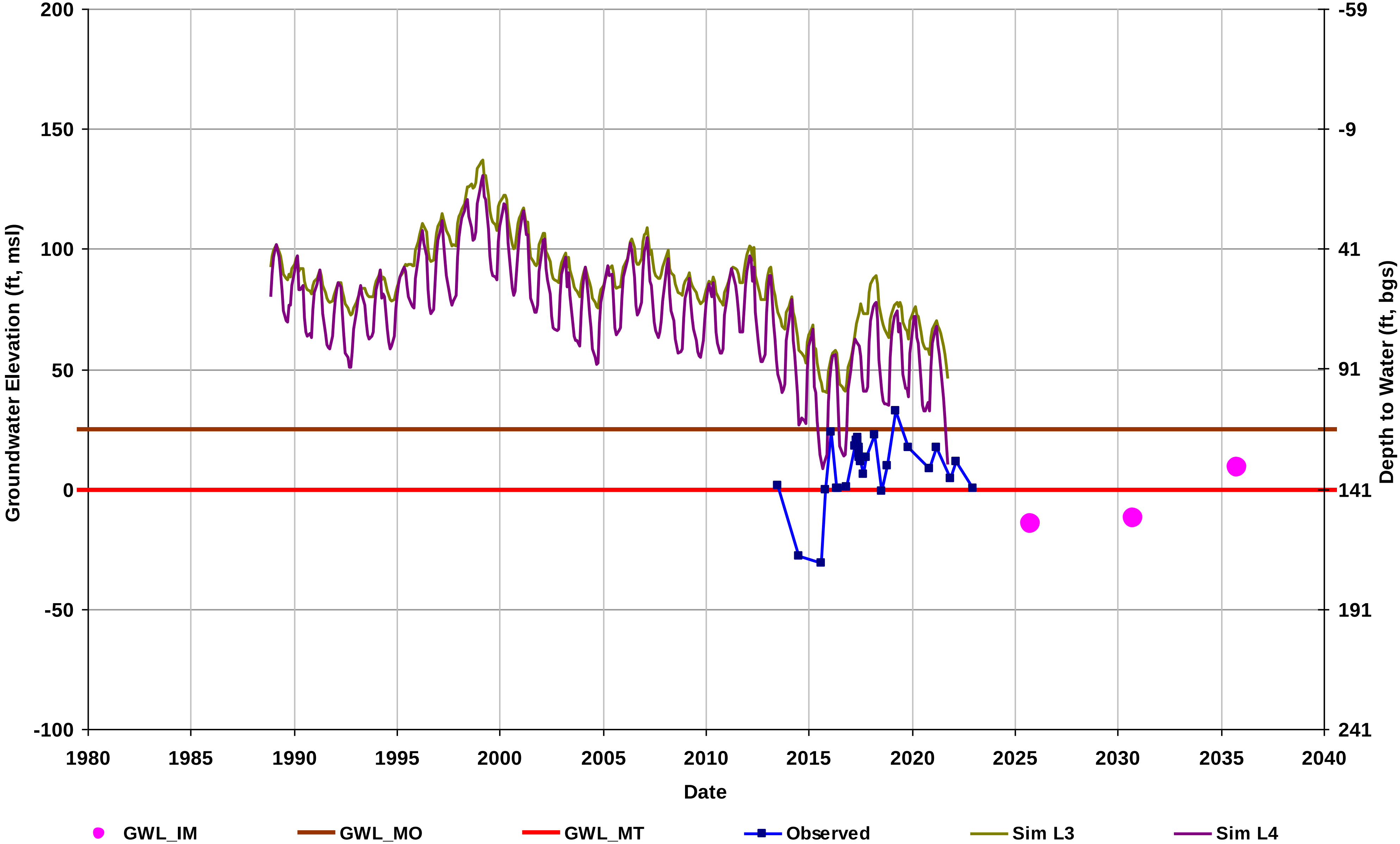
Well Name: TRT RMS-4
Depth Zone: Composite
Subbasin: Chowchilla
GSE (ft, msl): 141

Domestic Well Data: *Total Sections Included: 9*

Total Depth Count: 3
Total Depth Average: 275
Total Depth Minimum: 150
Total Depth Maximum: 444

Top Perf. Count: 1
Top Perf. Average: 180
Top Perf. Minimum: 180
Top Perf. Maximum: 180

Total Depth (ft bgs): 840
Perf. Top (ft bgs): 190
Perf. Bottom (ft bgs): 260
Top Model Layer: 3
Bottom Model Layer: 4



APPENDIX 3.B. MEASURABLE OBJECTIVES AND MINIMUM THRESHOLDS FOR GROUNDWATER QUALITY

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

Summary of Recent (Since January 2015) Results for Key Water Quality Constituents in Groundwater Quality Indicator Wells

	Arsenic Concentrations (µg/L)						Nitrate Concentrations (mg/L as nitrogen)						Specific Conductance (µS/cm)						TDS Concentrations (mg/L)					
Well ID	Minimum Result	Maximum Result	Average Result	Num. of Observations	Date First Observation	Date Last Observation	Minimum Result	Maximum Result	Average Result	Num. of Observations	Date First Observation	Date Last Observation	Minimum Result	Maximum Result	Average Result	Num. of Observations	Date First Observation	Date Last Observation	Minimum Result	Maximum Result	Average Result	Num. of Observations	Date First Observation	Date Last Observation
2000511-001*	1.4	1.4	1.4	1	1/9/2018	1/9/2018	4.8	5.4	5.1	4	1/7/2015	1/9/2018	490	560	525	2	1/7/2015	1/9/2018	330	330	330	1	1/9/2018	1/9/2018
2000597-001	0.0	0.0	0.0	1	12/17/2015	12/17/2015	2.9	7.0	4.4	9	3/12/2015	3/7/2019	910	910	910	1	12/21/2017	12/21/2017						
2000681-002	0.0	0.0	0.0	1	12/13/2017	12/13/2017	1.5	2.2	1.9	2	12/13/2017	12/20/2018	250	250	250	1	12/13/2017	12/13/2017						
2010001-010							4.8	5.9	5.3	6	3/9/2015	3/18/2019	660	680	670	2	8/3/2015	8/18/2015	440	440	440	1	8/4/2016	8/4/2016
2010001-011	0.0	0.0	0.0	1	3/28/2017	3/28/2017	0.6	0.6	0.6	1	8/18/2015	8/18/2015	210	210	210	1	7/27/2016	7/27/2016						
2400216-001	4.4	4.4	4.4	1	10/24/2016	10/24/2016	1.6	1.8	1.7	4	5/4/2015	8/20/2018												
ESJ11							7.1	7.1	7.1	1	10/30/2018	10/30/2018	740	740	740	1	10/30/2018	10/30/2018	520	520	520	1	10/30/2018	10/30/2018

* Well was deepened in 2009. Nitrate concentrations prior to 2009 were near or above the MCL of 10 mg/L as nitrogen. After the well deepening in 2009, concentrations dropped initially to just below 3 mg/L and have been increasing since with recent concentrations around 5 mg/L.

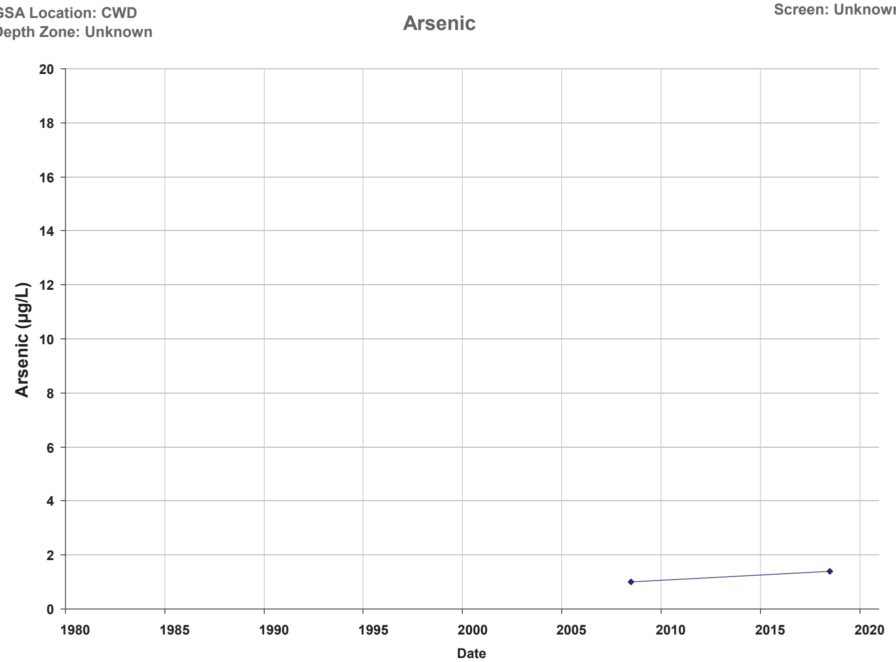
Summary of All Historical Results for Key Water Quality Constituents in Groundwater Quality Indicator Wells

	Arsenic Concentrations (µg/L)						Nitrate Concentrations (mg/L as nitrogen)						Specific Conductance (µS/cm)						TDS Concentrations (mg/L)					
Well ID	Minimum Result	Maximum Result	Average Result	Number of Observations	Date First Observation	Date Last Observation	Minimum Result	Maximum Result	Average Result	Number of Observations	Date First Observation	Date Last Observation	Minimum Result	Maximum Result	Average Result	Number of Observations	Date First Observation	Date Last Observation	Minimum Result	Maximum Result	Average Result	Number of Observations	Date First Observation	Date Last Observation
2000511-001*	1.0	1.4	1.2	2	5/27/2008	1/9/2018	2.6	13.1	6.6	38	2/22/2006	1/9/2018	490	970	745	4	3/4/2008	1/9/2018	300	330	315	2	8/9/2012	1/9/2018
2000597-001	0.0	1.0	0.7	3	6/5/2006	12/17/2015	1.3	7.0	3.7	16	2/14/2006	3/7/2019	280	910	595	2	12/17/2009	12/21/2017	154	190	172	2	2/18/2003	12/17/2009
2000681-002	0.0	0.0	0.0	3	1/23/2012	12/13/2017	1.5	2.2	1.8	3	3/3/2009	12/20/2018	250	260	255	2	5/7/2013	12/13/2017						
2010001-008	0.0	2.2	1.5	5	12/13/2000	7/29/2015	0.8	2.3	1.3	16	10/10/1991	10/23/2017	120	230	198	9	10/10/1991	8/18/2015	108	190	168	7	10/10/1991	8/25/2010
2010001-010	0.0	3.0	1.2	6	12/1/1994	7/12/2012	3.4	6.7	5.3	24	12/12/2000	3/18/2019	180	700	550	8	12/15/1999	8/18/2015	160	440	343	8	12/15/1999	8/4/2016
2010001-011	0.0	3.0	1.7	4	12/12/2000	3/28/2017	0.6	1.7	0.9	10	12/15/1999	8/18/2015	170	230	205	11	8/19/1996	7/27/2016	120	190	173	8	8/19/1996	7/31/2013
2400216-001	4.3	5.3	4.7	3	8/10/2010	10/24/2016	1.0	1.8	1.5	14	3/20/2003	8/20/2018	160	166	162	3	8/10/2010	10/10/2013	160	180	170	2	8/10/2010	8/22/2013
ESJ11							7.1	7.1	7.1	1	10/30/2018	10/30/2018	740	740	740	1	10/30/2018	10/30/2018	520	520	520	1	10/30/2018	10/30/2018

* Well was deepened in 2009. Nitrate concentrations prior to 2009 were near or above the MCL of 10 mg/L as nitrogen. After the well deepening in 2009, concentrations dropped initially to just below 3 mg/L and have been increasing since with recent concentrations around 5 mg/L.

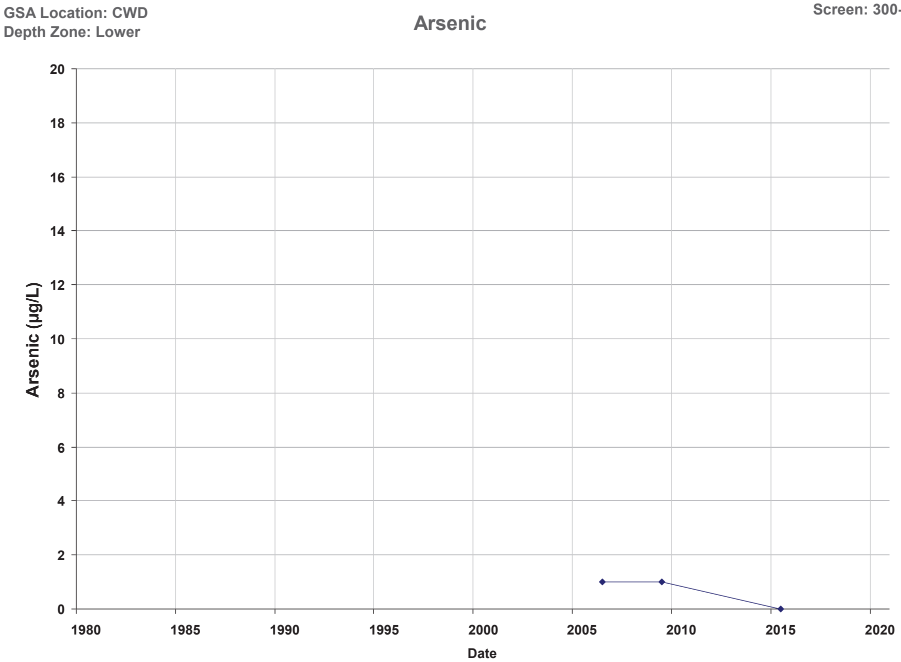
Well ID: 2000511-001
GSA Location: CWD
Depth Zone: Unknown

Well Depth: Unknown
Screen: Unknown



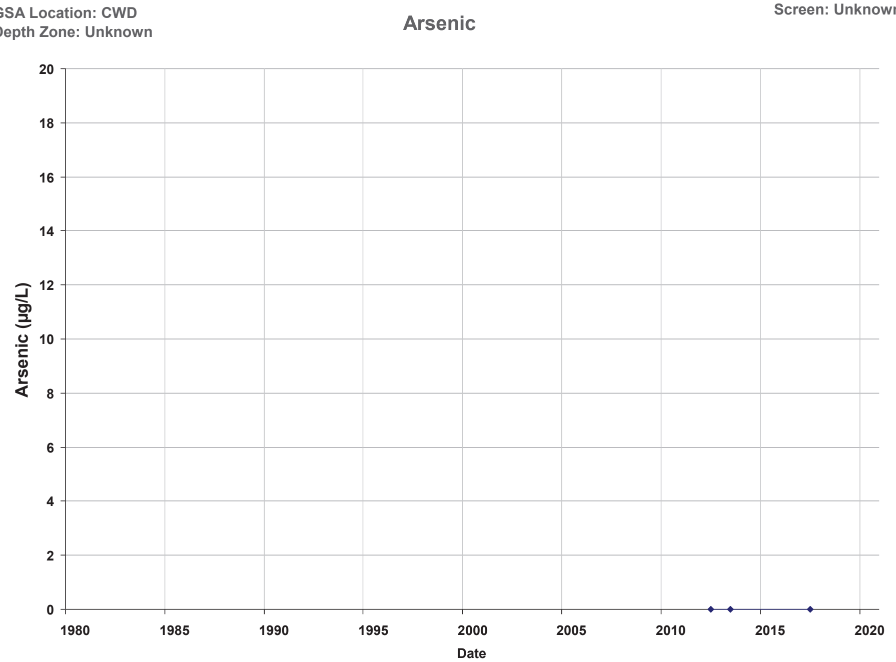
Well ID: 2000597-001
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 300-?



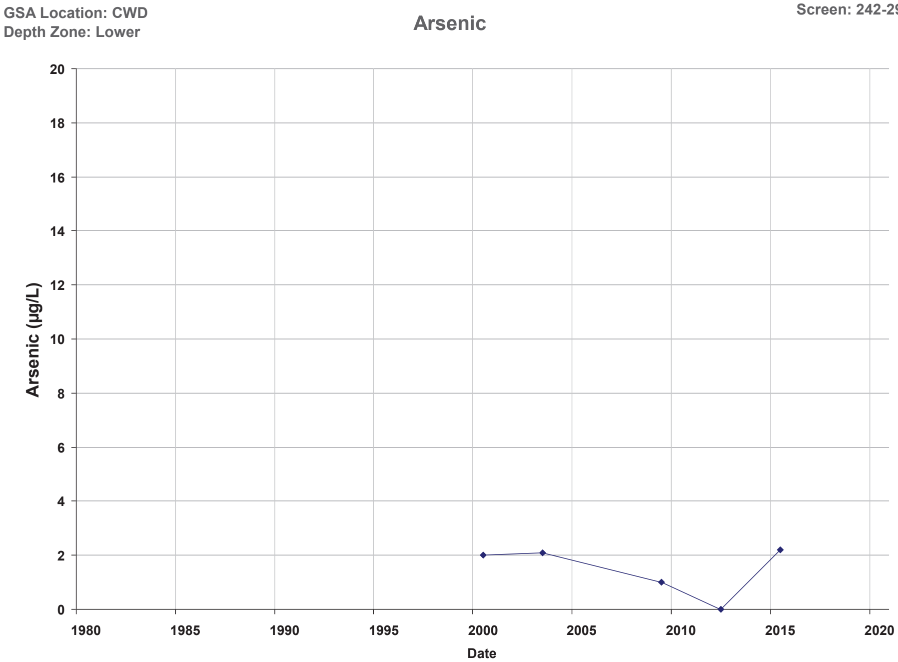
Well ID: 2000681-002
GSA Location: CWD
Depth Zone: Unknown

Well Depth: Unknown
Screen: Unknown



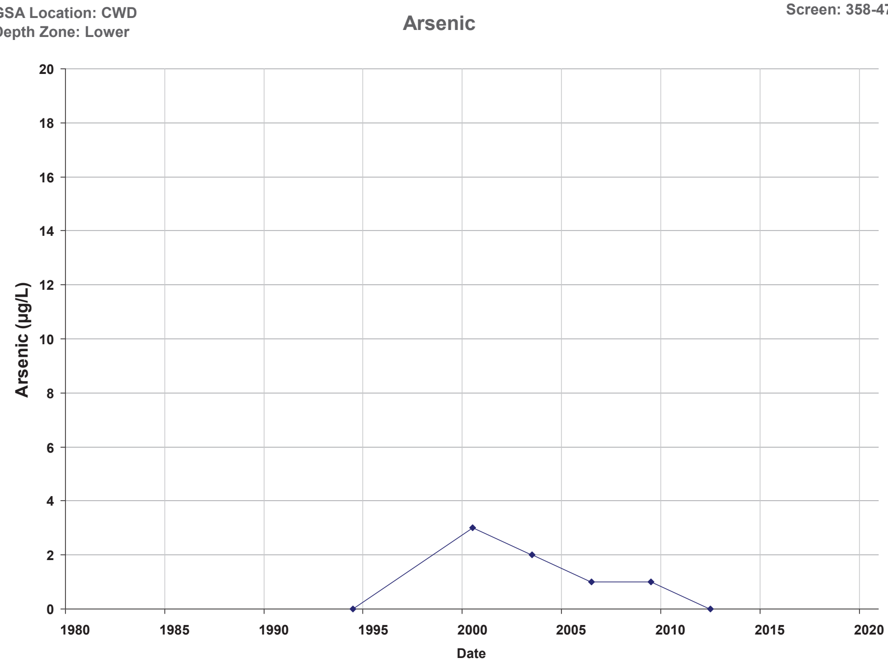
Well ID: 2010001-008
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 242-297



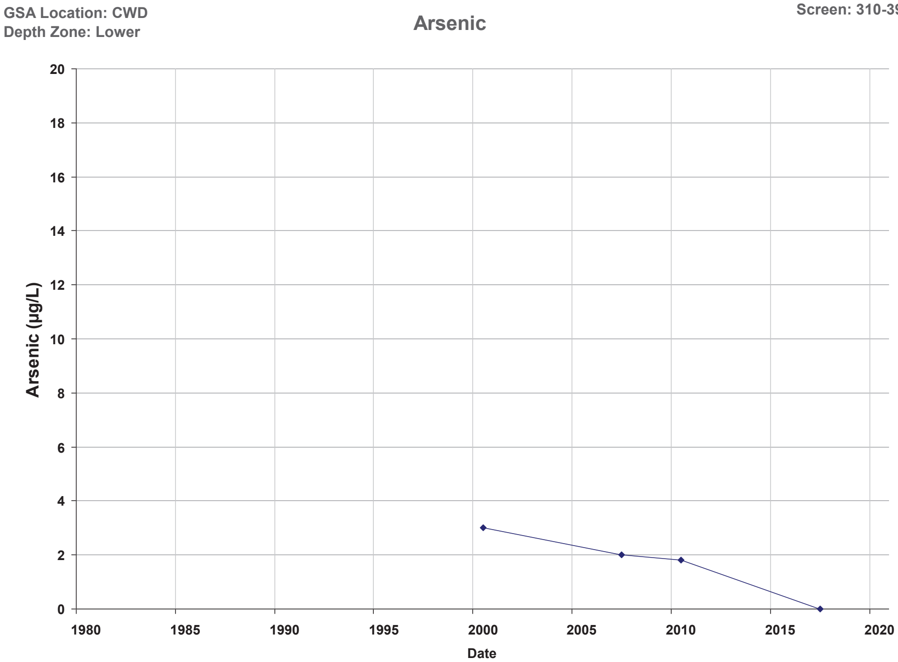
Well ID: 2010001-010
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 358-474



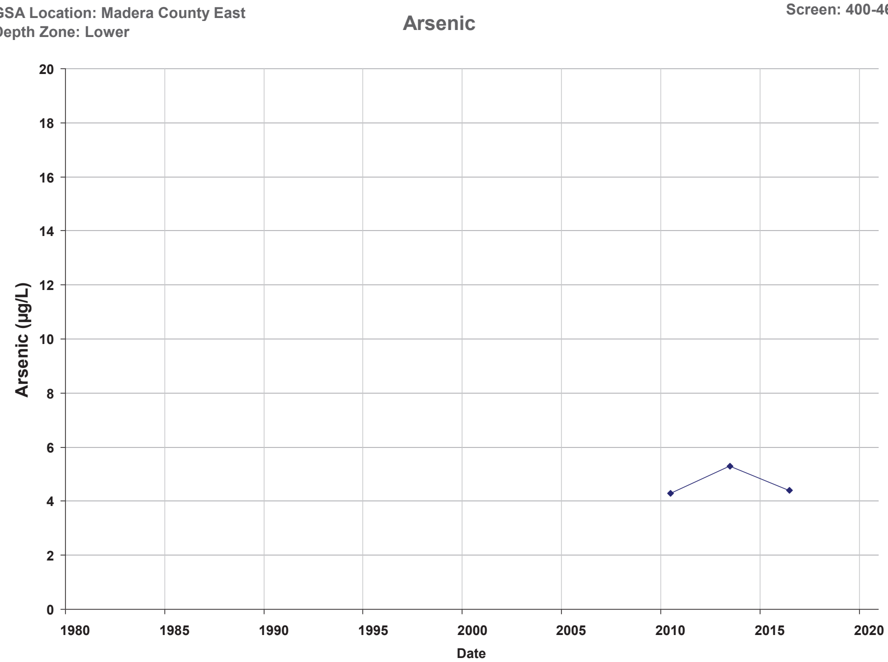
Well ID: 2010001-011
GSA Location: CWD
Depth Zone: Lower

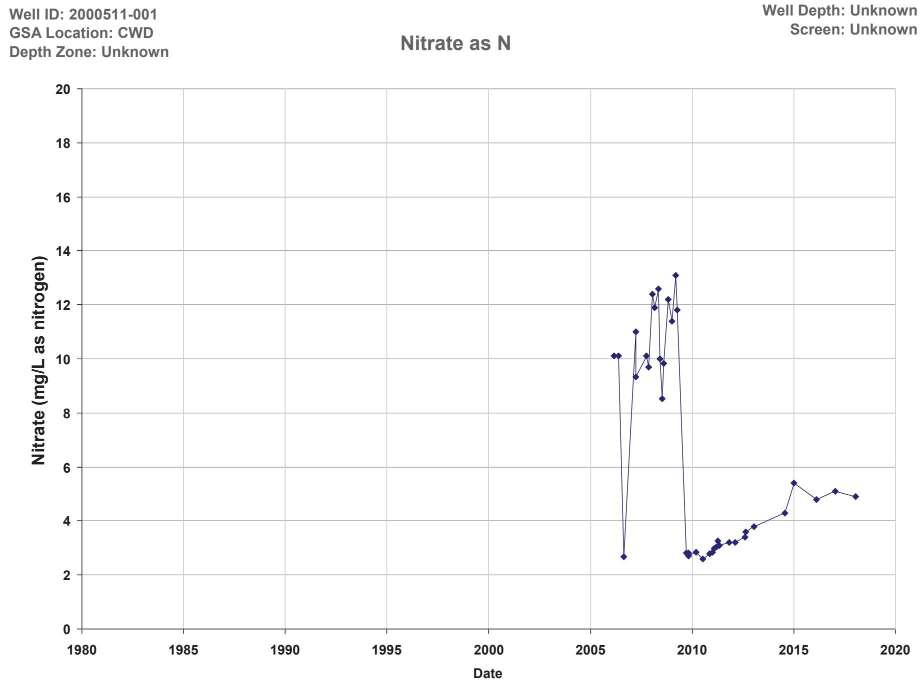
Well Depth: Unknown
Screen: 310-393

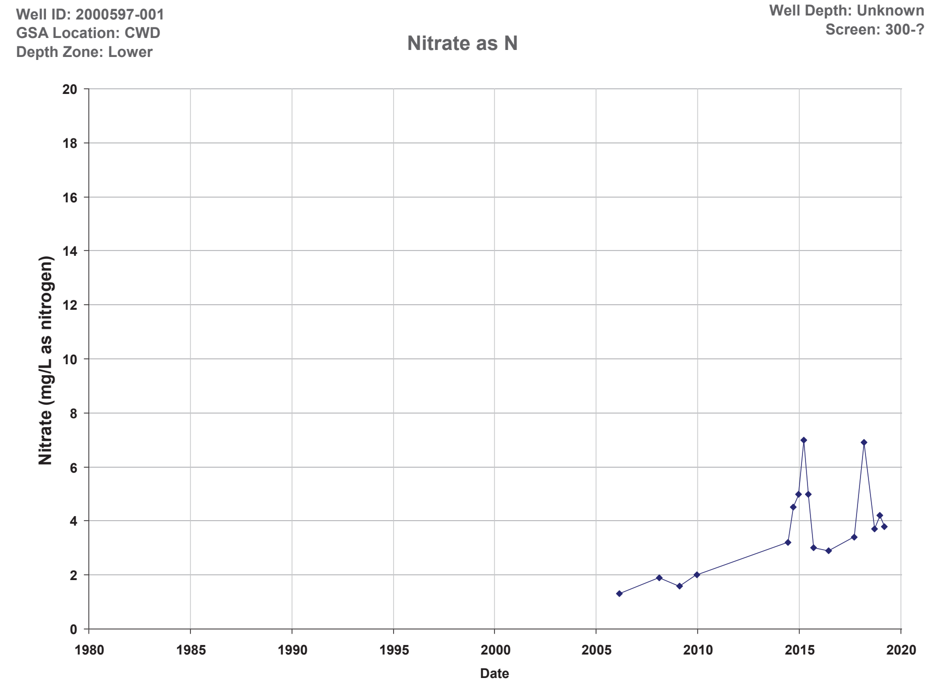


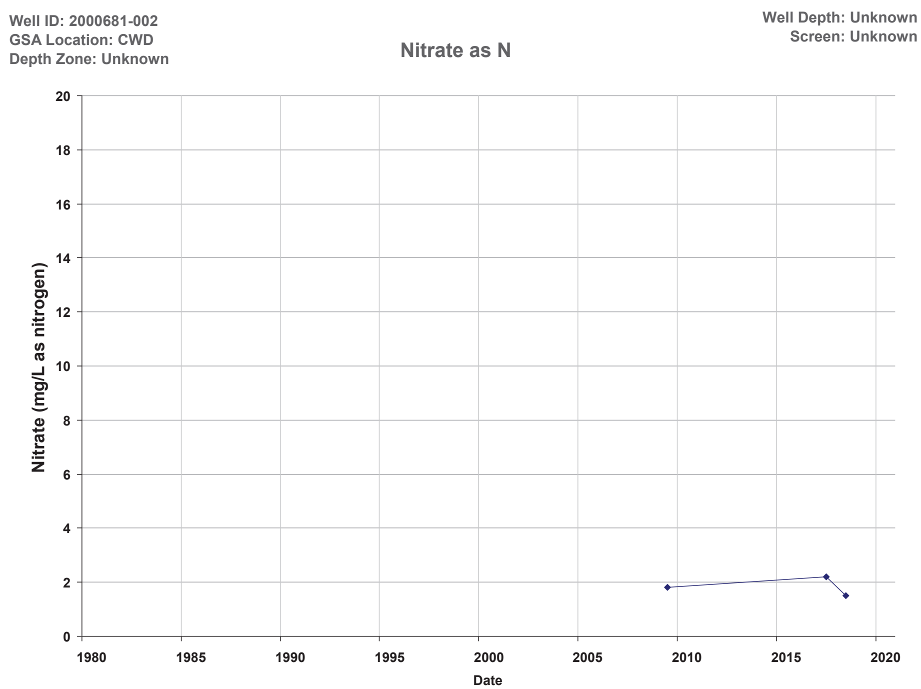
Well ID: 2400216-001
GSA Location: Madera County East
Depth Zone: Lower

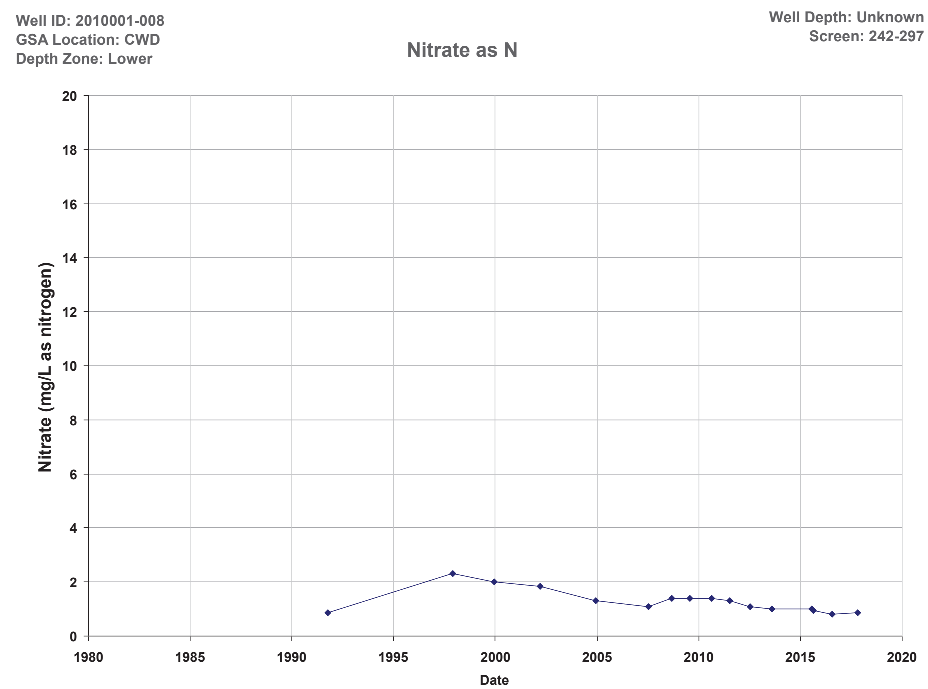
Well Depth: Unknown
Screen: 400-460




Well ID: 2000511-001
GSA Location: CWD
Depth Zone: Unknown
Well Depth: Unknown
Screen: Unknown
Nitrate as N
Nitrate (mg/L as nitrogen)
0
2
4
6
8
10
12
14
16
18
20
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

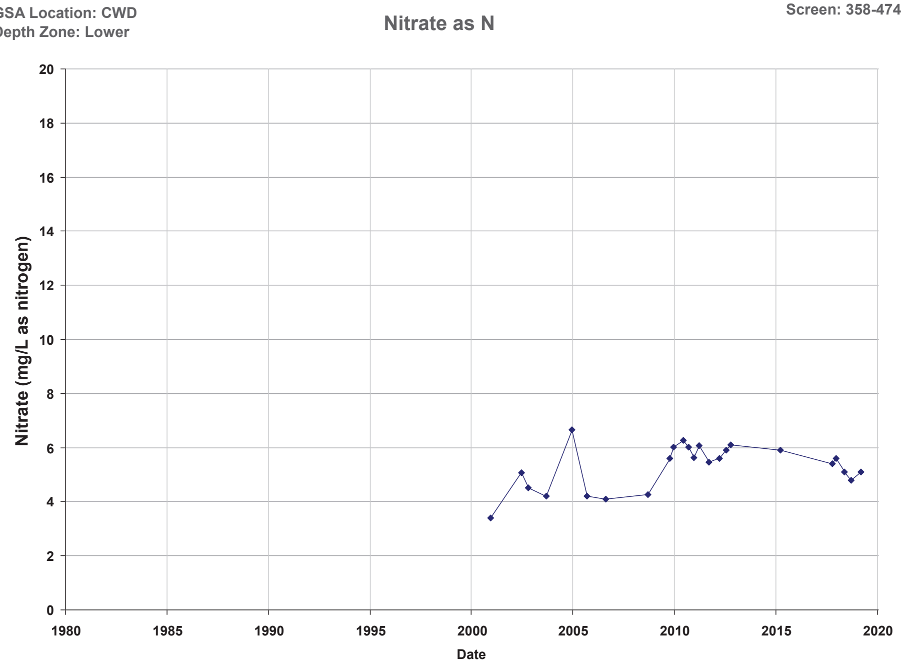

Well ID: 2000597-001
GSA Location: CWD
Depth Zone: Lower
Well Depth: Unknown
Screen: 300-?
Nitrate as N
Nitrate (mg/L as nitrogen)
0
2
4
6
8
10
12
14
16
18
20
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date


Well ID: 2000681-002
GSA Location: CWD
Depth Zone: Unknown
Well Depth: Unknown
Screen: Unknown
Nitrate as N
Nitrate (mg/L as nitrogen)
0
2
4
6
8
10
12
14
16
18
20
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date


Well ID: 2010001-008
GSA Location: CWD
Depth Zone: Lower
Well Depth: Unknown
Screen: 242-297
Nitrate as N
Nitrate (mg/L as nitrogen)
0
2
4
6
8
10
12
14
16
18
20
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

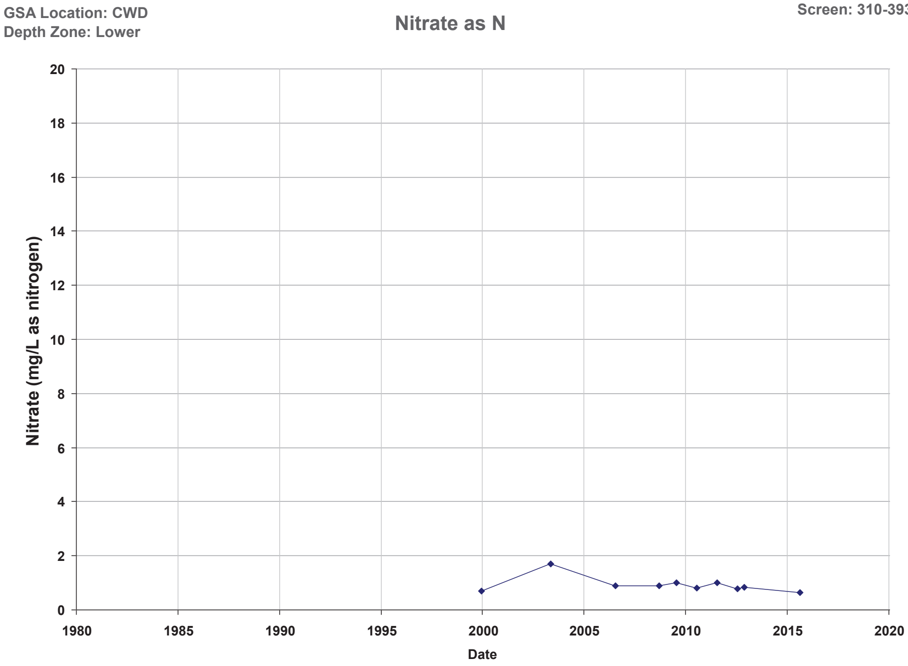
Well ID: 2010001-010
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 358-474



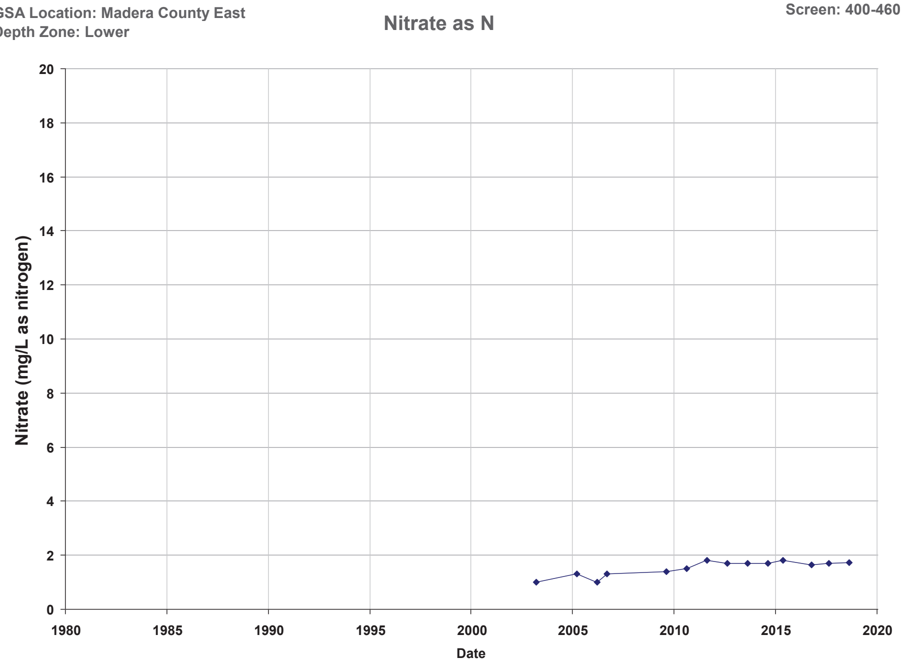
Well ID: 2010001-011
GSA Location: CWD
Depth Zone: Lower

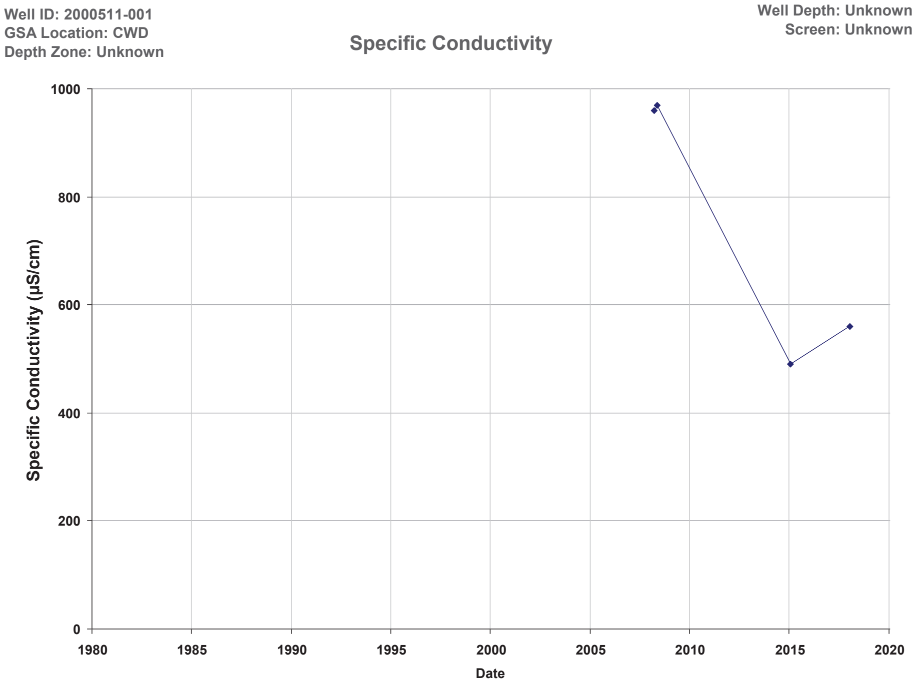
Well Depth: Unknown
Screen: 310-393

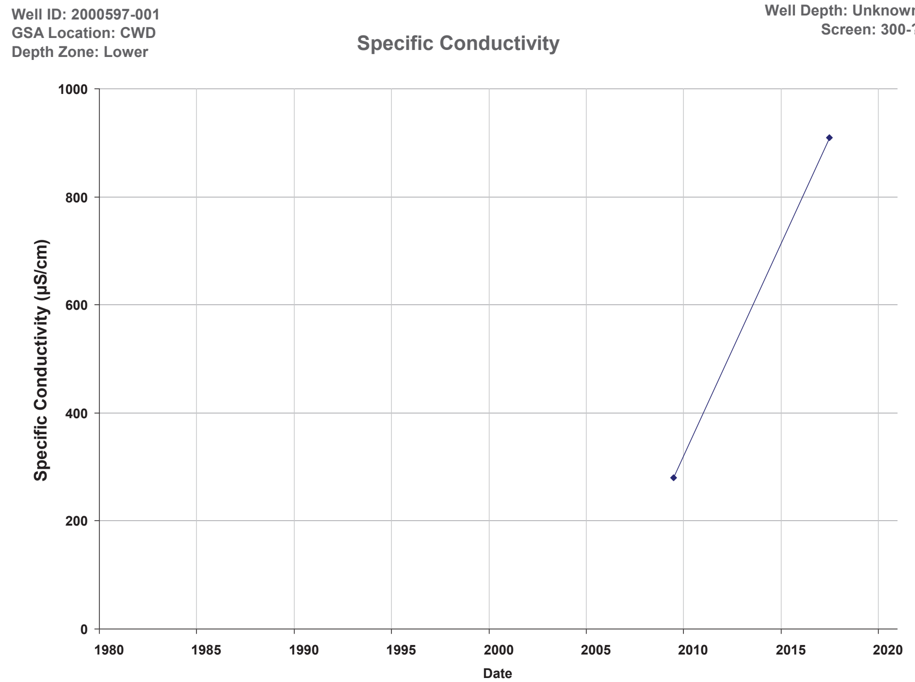


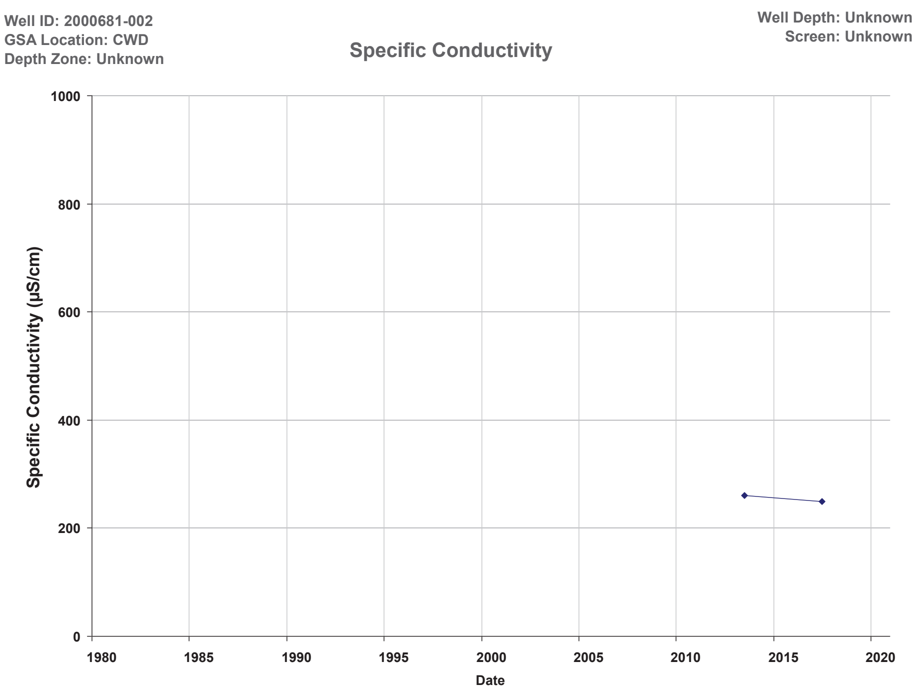
Well ID: 2400216-001
GSA Location: Madera County East
Depth Zone: Lower

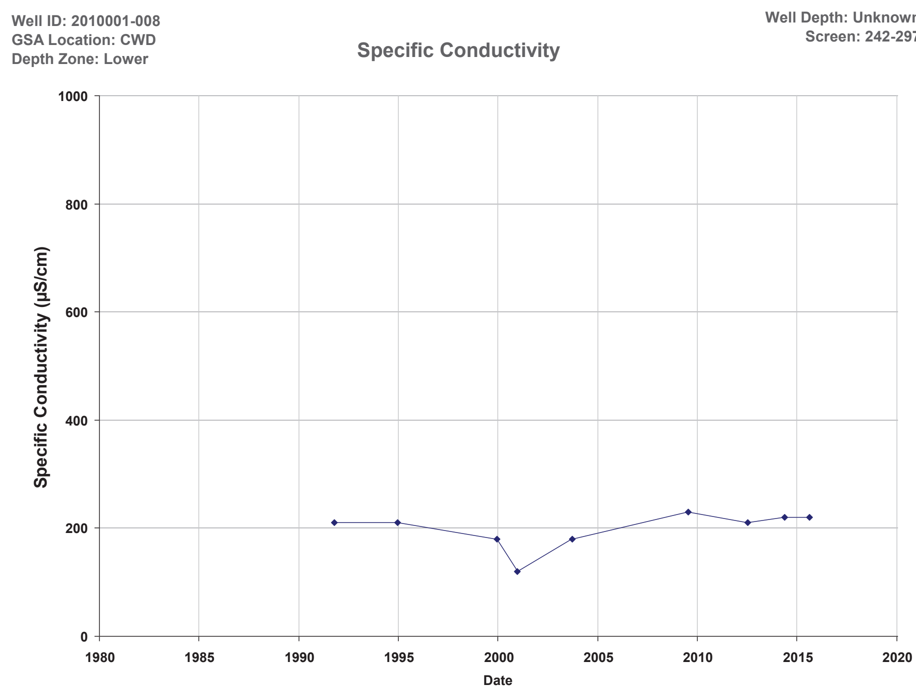
Well Depth: Unknown
Screen: 400-460




Well ID: 2000511-001
GSA Location: CWD
Depth Zone: Unknown
Well Depth: Unknown
Screen: Unknown
Specific Conductivity
Specific Conductivity (µS/cm)
Date

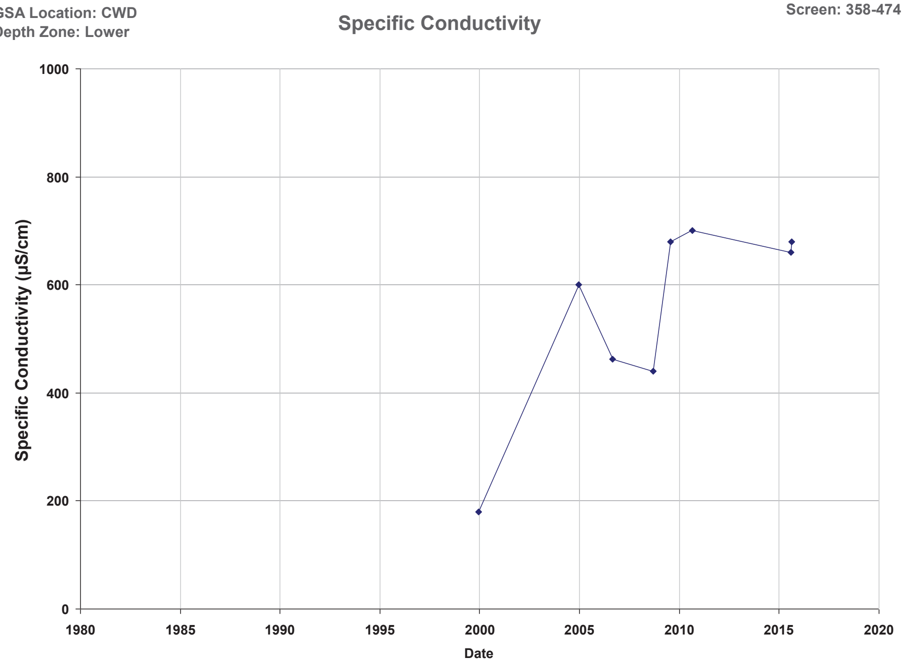

Well ID: 2000597-001
GSA Location: CWD
Depth Zone: Lower
Well Depth: Unknown
Screen: 300-?
Specific Conductivity
Specific Conductivity (µS/cm)
Date


Well ID: 2000681-002
GSA Location: CWD
Depth Zone: Unknown
Well Depth: Unknown
Screen: Unknown
Specific Conductivity
Specific Conductivity (µS/cm)
Date


Well ID: 2010001-008
GSA Location: CWD
Depth Zone: Lower
Well Depth: Unknown
Screen: 242-297
Specific Conductivity
Specific Conductivity (µS/cm)
Date

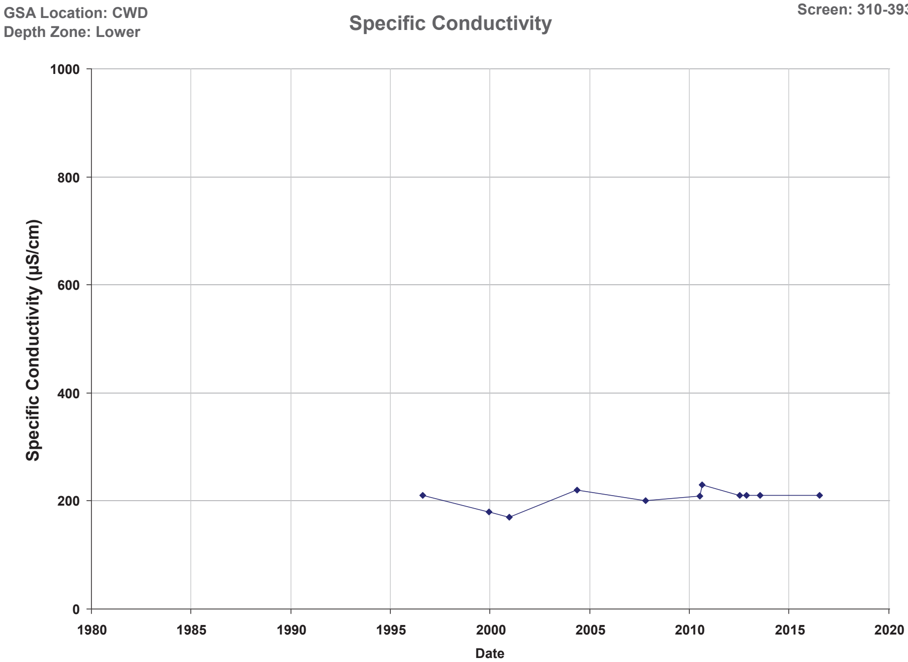
Well ID: 2010001-010
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 358-474



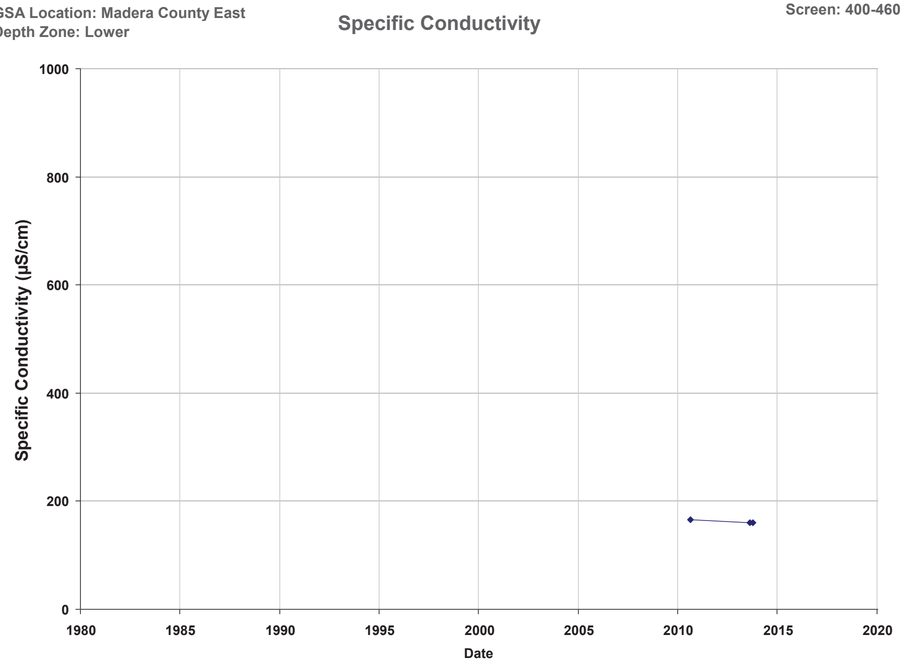
Well ID: 2010001-011
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 310-393



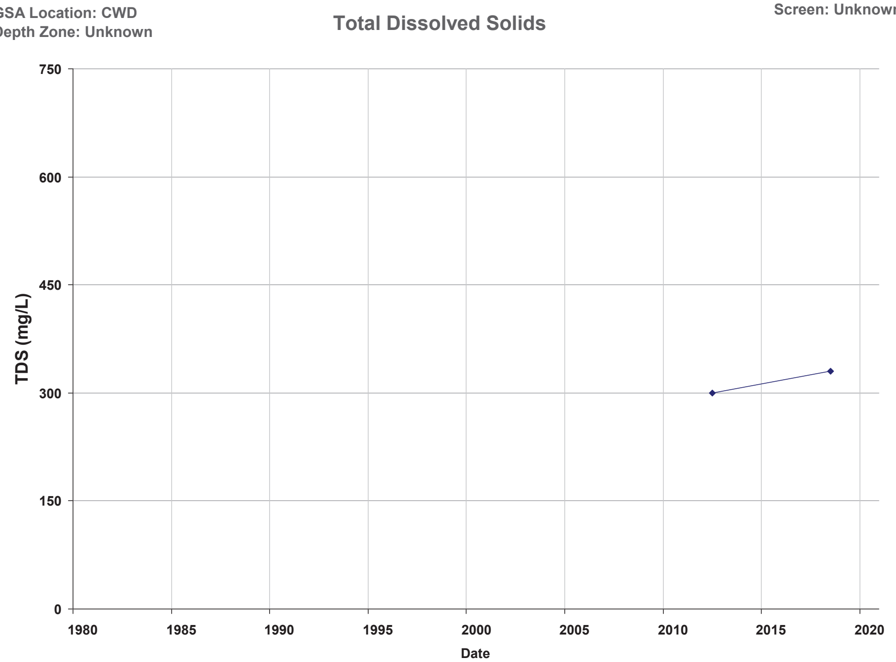
Well ID: 2400216-001
GSA Location: Madera County East
Depth Zone: Lower

Well Depth: Unknown
Screen: 400-460



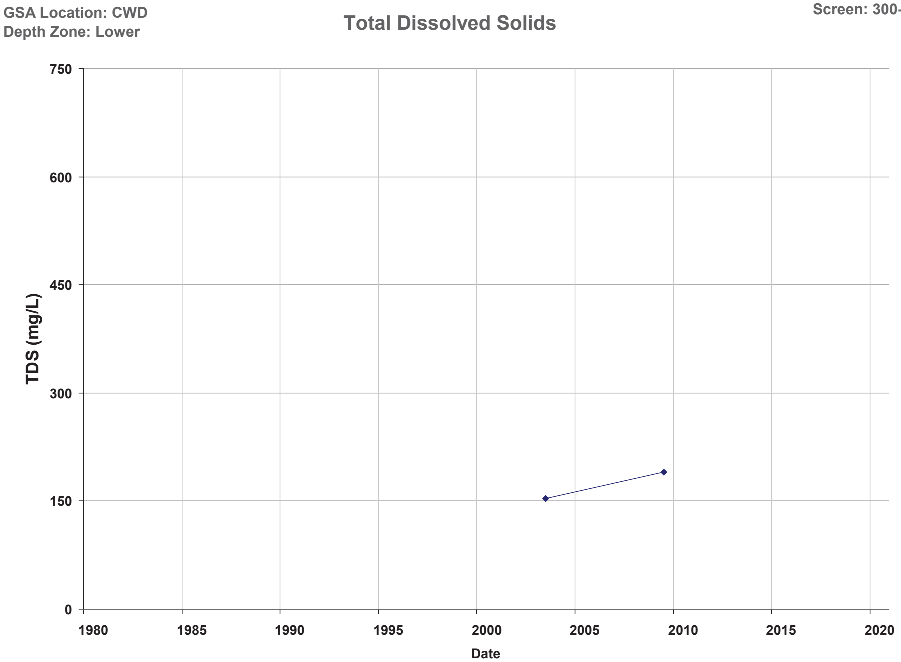
Well ID: 2000511-001
GSA Location: CWD
Depth Zone: Unknown

Well Depth: Unknown
Screen: Unknown



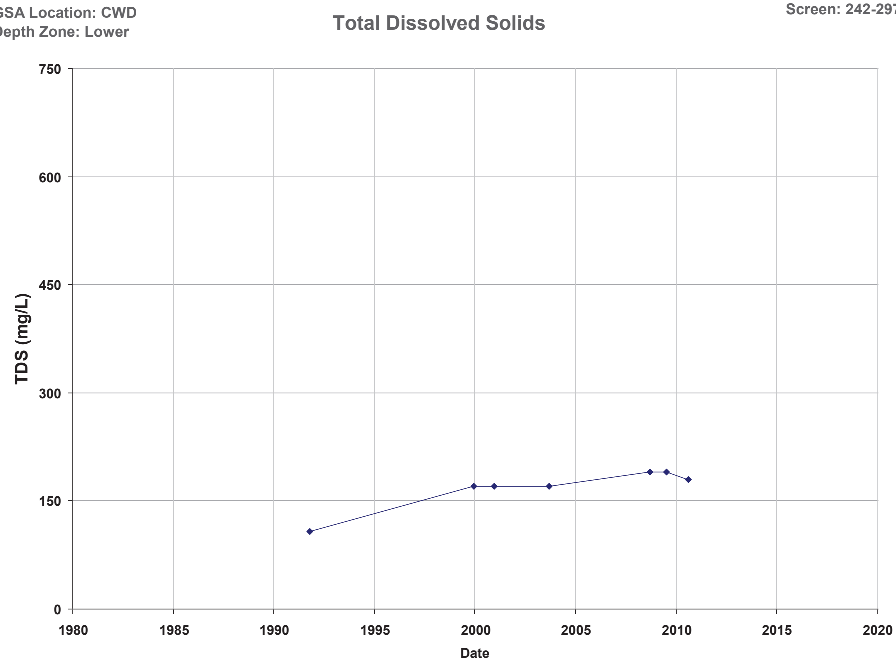
Well ID: 2000597-001
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 300-?



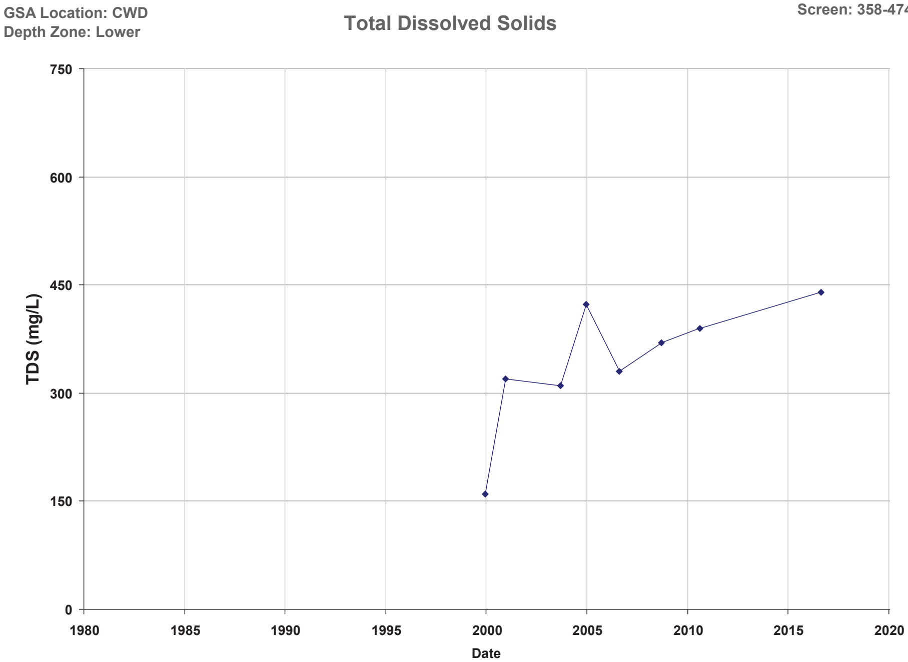
Well ID: 2010001-008
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 242-297



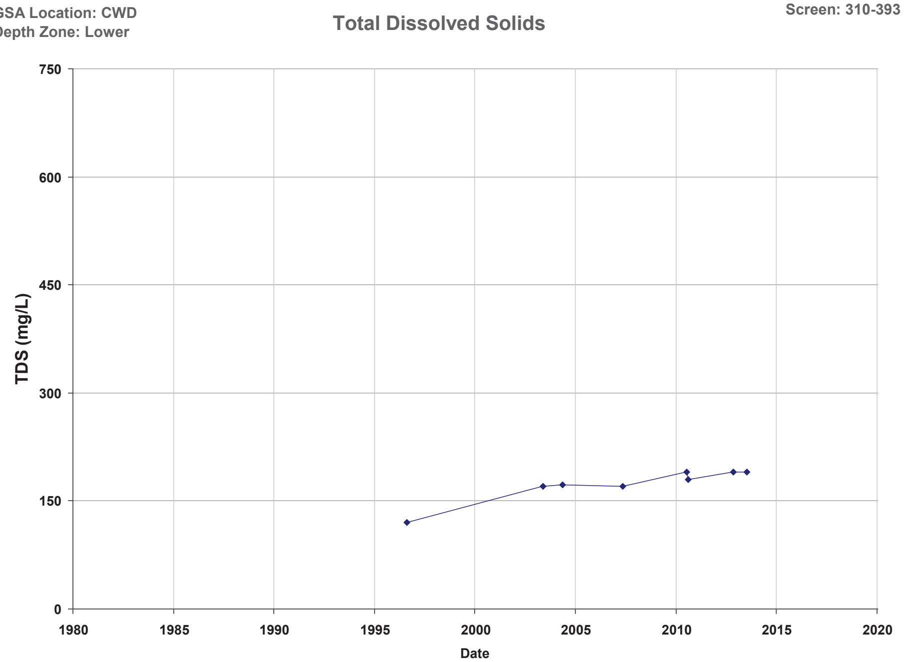
Well ID: 2010001-010
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 358-474



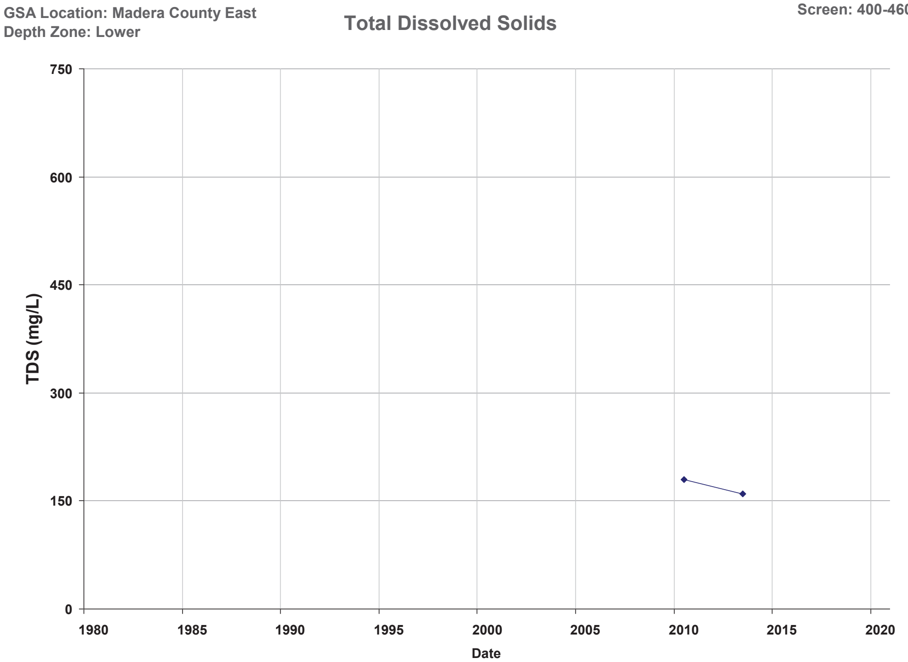
Well ID: 2010001-011
GSA Location: CWD
Depth Zone: Lower

Well Depth: Unknown
Screen: 310-393



Well ID: 2400216-001
GSA Location: Madera County East
Depth Zone: Lower

Well Depth: Unknown
Screen: 400-460



APPENDIX 3.C. ECONOMIC ANALYSIS AND FRAMEWORK FOR POTENTIAL DOMESTIC WELL MITIGATION PROGRAM

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020
Revised July 2022

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1 OVERVIEW

This appendix serves two purposes. The initial section, titled Benefits and Costs of Faster Implementation of Demand Management, assesses whether a faster trajectory toward sustainability during the implementation period would be economically justified. It compares the cost of implementing demand management more quickly against the benefits (avoided costs) of avoided well replacement and reduced pumping costs. The second section, titled Domestic Well Replacement Mitigation Program, estimates the total cost of replacing domestic wells potentially impacted by declining groundwater levels under the baseline conditions without SGMA and under the draft proposed SGMA implementation plan (with-SGMA). The second section can support discussions and consideration of potential mitigations for the cost of well replacement.

2 BENEFITS AND COSTS OF FASTER IMPLEMENTATION OF DEMAND MANAGEMENT

This section describes an initial analysis of how many domestic wells in the Chowchilla Subbasin might be impacted by the continued overdraft of groundwater during the transition from 2020 until full implementation of projects and management actions specified in the (draft) GSP and thereafter through 50 years of sustainable management[1]. The purpose of this reconnaissance-level analysis is to assess the costs to different stakeholder groups (agricultural pumpers and domestic well users) and to consider if a faster trajectory to sustainable management at higher groundwater levels would be cost-effective in the aggregate. If the initial analysis indicates that avoiding well replacement costs might be warranted, a more detailed analysis could be conducted.

In order to provide an initial answer, this analysis uses data inputs for and results from the Chowchilla Subbasin groundwater model. The units of analysis are domestic wells in each section (one square mile or 640 acres). Other key assumptions and simplifications for this initial analysis include:

- Projected depth to water simulated by the groundwater model for the 2020 – 2040 implementation period and subsequent 50-year sustainability period uses a single scenario of hydrology developed based on historical hydrology.
- The cost analysis only considers the cost of replacing domestic wells. It does not consider replacement of agricultural wells or the cost of declining well yields before a well is replaced.
- Well Completion Report (WCR) data from DWR are the basis for the quantity and characteristics of domestic wells in the Madera Subbasin used in the assessment. Wells not in DWR's WCR database are not included in the analysis. A sensitivity analysis is presented that evaluates how wells not in the WCR database may affect results of the analysis.
- As a simplification, for all Public Land Survey System (PLSS) sections in the Subbasin, the analysis compares the minimum depth to the top of the perforated interval for domestic wells with the average simulated September depth to water (DTW) in the Lower Aquifer.
- The timing, quantity, and location of projects is the same as the with-GSP scenario and no other alternatives are considered.

[1] For purposes of this memorandum, sustainable management means the state in which the long-term trend of declining groundwater levels has stabilized.

The analysis compares costs associated with groundwater pumping, well replacement, and management actions needed to reach sustainable management for two scenarios: 1) baseline conditions (without-SGMA) and 2) baseline conditions with the draft proposed GSP implementation plan (with-SGMA). Assuming that the GSP already includes implementation of water supply and recharge projects as soon as practical, the analysis focuses on demand management implementation as a possible means to speed the trajectory toward groundwater sustainability.

The following costs related to groundwater levels and management over time are considered:

- Costs to replace dewatered domestic wells.
- Changes in variable costs to pump groundwater, for both domestic and agricultural users.
- Costs to growers in foregone net return for demand management needed (if any) to achieve sustainable management after implementing supply and recharge projects.

2.1 Assumptions and Results

Assumptions and results below are summarized for each of the cost categories considered.

2.1.1 Costs to replace dewatered domestic wells.

For purposes of this analysis, a replacement cost of $25,000[2] per well is used. This cost is triggered when the groundwater level in the section the well is located in falls below the minimum depth to top perforation of the domestic wells in that cell. Once the wells in a section are replaced, that section is no longer tested against further changes in DTW. The simulated September depth to water value is used for each year's comparison, which typically reflects the lowest groundwater levels in a season. The process for each 2015-2090 scenario (without-SGMA and with-SGMA) is summarized as:

- For each section and year, compare the average DTW in the Lower Aquifer to the minimum depth to top of perforations of the domestic wells in that section.
- If DTW equals or exceeds the top perforation depth, all domestic wells in the section must be replaced.
- After a section's domestic wells are replaced, they are assumed to be drilled and screened deep enough to withstand any further increase in DTW.

In the Chowchilla subbasin, 127 domestic wells are impacted in the without-SGMA case, but 87 of those appear to be impacted prior to the 2020 implementation start (DTW is greater than minimum depth to top perforation). Therefore, 40 (127 minus 87) domestic wells are potentially affected in the comparison of scenarios. Thirty out of the 40 wells are impacted between 2021 and 2033, with the remaining 10 impacted by 2066. The present value (at 2020) of replacement costs for these 40 impacted domestic wells is $0.69 million. All but seven domestic well replacements are avoided in the with-SGMA scenario. The present value of replacement cost for these impacted domestic wells is $0.13 million. *The net domestic well replacement cost avoided by the draft proposed GSP implementation plan is $0.56 million in present value.*

[2] The cost of well replacement used in the analysis is based on feedback from well drillers that work in the area: (i) drilling a domestic well costs $35/foot, (ii) a sanitary seal for a domestic well is $2,000, and (iii) a pump for a domestic well is $4,500. This does not include permit costs. Assuming a well depth of approximately 500 feet results in an estimated cost of about $25,000 per well.

2.1.2 Changes in variable costs to pump groundwater, for both domestic and agricultural users.

This analysis applies an aggregate calculation of change in water depth and pumping cost, using an average depth over all sections (weighted by well count in each section). As DTW decreases in the with-SGMA scenario relative to without-SGMA, the benefit (reduced pumping lift and cost) grows year to year. Both domestic wells and agricultural users benefit from this, though the agricultural cost saving is many times greater simply due to volume pumped. A more precise estimate can be created using an estimate of agricultural and domestic pumping in each section. For the Chowchilla Subbasin, benefits after 10 years are about $105,000 per year in total for all domestic well pumping and $3.29 million per year for agricultural pumping. The present value of savings over the analysis period is about $5.94 million for domestic pumping and $169.84 million for agricultural pumping. *These savings are small relative to the loss of net return from demand management (see Table A3.C-1), so the benefit of achieving them sooner does not appear to be justified by implementing demand management sooner.*

2.1.3 Costs to growers in foregone net return for demand management needed (if any) to achieve sustainable management after implementing supply and recharge projects.

This analysis uses the estimated demand reduction in acre-feet needed to achieve sustainable management after accounting for the yield of supply and recharge projects. The cost of that reduction is based on a separate economic analysis of net return lost from crop production developed for the GSP. This loss increases with the level of demand management, and ranges from about $300 per AF to over $1,000 per AF. In this example analysis, a constant cost of $500 per AF of demand management is used, which represents the approximate cost of demand management in the Chowchilla Subbasin. The current water balance shows pumping to be approximately 309,000 AF/year on average. After implementation of projects specified in the GSP, pumping to maintain sustainable management is estimated to be about 246,000 AF/year. This analysis assumes that the difference – 63,000 AF per year – would be spread equally from 2021 to 2040 as a reduction of about 3,150 AF per year (note this is a simplifying assumption – actual demand reduction occurs unevenly in the GSP implementation plan). At $500 per AF, this adds a demand management cost of about $1.58 million per year, which accumulates, so that by 2040 the annual demand management cost is about $31.5 million per year. These values are discounted back to the start of implementation, resulting in a present value in 2020 of about $581 million (Table A3.C-1).

Table A3.C-1. Demand Management vs. Domestic Well Replacement - Summary Results for Chowchilla Subbasin, Present Value (PV) $ in Millions

	Without SGMA	With-SGMA	Difference
Domestic Well Repl. Cost			
Number of Domestic Wells Replaced	40	7	-33
PV of Cost	$0.69	$0.13	-$0.56
Pumping Cost (Savings), PV			
Domestic	NA	-$5.94	-$5.94
Agricultural	NA	-$169.84	-$169.84
Demand Mgmt. Cost, PV	NA	$580.96	$580.96

2.2 Discussion

Results indicate that the cost of implementing demand management on a faster trajectory (sooner in the implementation period) would not be cost effective from a subbasin-wide perspective. The avoided costs (fewer domestic wells requiring replacement) would be small, $0.13 million, relative to the lost agricultural net return, $581 (0.02 percent) million. The general conclusions are robust to the assumptions used – that is, results are not sensitive to reasonable ranges in key assumptions, including the loss in net return per AF of demand management, the total level of demand management, when demand management begins to scale in, or the cost of replacing a domestic well.

The analysis also considered different measures for comparing depth to water to well characteristics and different hydrologic sequences (one beginning with a wet period and one with a dry period), and the conclusions hold. Even doubling the number of affected wells (based on the possibility that some domestic wells in use are not logged in the WCR database) does not change the conclusion. The conclusions are strong enough that no further groundwater analysis is recommended for the sole purpose of evaluating whether more rapid demand management is justified by the aggregate avoided domestic well replacement.

Although the conclusion is that more rapid demand management is not cost-effective from a basin-wide or County-wide perspective, the distribution of the costs imposed on domestic well users should be acknowledged. Continued drawdown of groundwater levels during the GSP implementation period would be caused primarily by pumping for irrigation (because domestic wells are a smaller share of subbasin pumping), whereas the cost of domestic well replacement would be borne by domestic well users.

The above results use demand management as the policy variable to assess the tradeoff of its costs with the costs of domestic well replacement. Rather than use demand management for the cost comparison, another analysis could compare avoided well replacement and pumping costs with the cost of implementing supply or recharge projects sooner during the implementation period. However, that comparison is not possible with current information and the GSP implementation schedule already reflects an aggressive timeline for project implementation. The additional cost of accelerating a recharge project by, say 5 years, would be the increased present value of the capital and O&M cost stream. The benefit would be the change in expected present value of avoided well replacement and pumping costs. This benefit would need to be calculated based on a groundwater model analysis of the resulting expected DTW over time under the accelerated project implementation.

3 DOMESTIC WELL MITIGATION PROGRAM

Some GSAs in the Chowchilla Subbasin have discussed a program to replace domestic wells that are impacted by falling groundwater levels over the GSP implementation timeline. The May 29, 2019 GSP summary presentation outlined the general parameters of a domestic well mitigation program. The program is expected to be further developed during the first year of GSP implementation. Well owners would be required to sign up for the program and mitigation actions may include replacing or lowering existing wells, and in cases where it is feasible, connecting groups of wells to a community water system. The program would be funded by fees and external support including grants and low interest loan.

3.1 Chowchilla Subbasin Domestic Well Mitigation Program Costs

An analysis was developed to approximate the cost of a domestic well mitigation program in the Chowchilla Subbasin. The example program/analysis assumes:

- All pumpers pay into the program to fund full replacement of impacted domestic wells ($25,000/well).
- The number of affected wells is the total number affected under the with-SGMA scenario, including those potentially already impacted. Ninety-three wells are impacted in Chowchilla Subbasin based on the analysis described earlier in this memorandum (namely, uses the WCR data). The number of impacted domestic wells is doubled to account for potential under-reporting in the WCR data.
- The program cost ($/af) is based on the sustainable level of pumping. Pumping fees cover admin, replacement, and contingency program costs and are charged to every acre foot of groundwater pumped. The fee is calculated as an annual amount that will raise the required total expected mitigation program cost (in present value terms). A cash flow analysis has not been prepared at this time. All costs are expressed in real dollars.
- An annual program administration cost is assumed to cover staff time to run the program, manage the fund, and conduct technical review of any applications. For this estimate, the cost for Chowchilla Subbasin is estimated to be $100,000 per year plus $5,000 per replaced well.
- An additional program cost contingency of 30% is added to the average annual well replacement cost to account for higher than expected costs per well and unexpected impacts (e.g. longer drought cycles).
- A sensitivity analysis of well replacement cost, admin cost, and contingency cost is used to develop a program fee range ($/af). The actual program cost depends on the timing of well impacts, which depends on unknown future hydrologic sequences.

Summary results are as follows:

- **# impacted domestic wells**: 93 (doubled to 186 for cost estimation purposes)
- **Average annual program cost**: $198,000
- **Domestic well mitigation program fee per acre-foot** of sustainable yield: $1.44/AF (sensitivity range ~$1.05 - $3 per AF)

3.2 Draft Outline for Chowchilla Subbasin Domestic Well Mitigation Program

This section provides a general outline of a domestic well mitigation program for the Chowchilla Subbasin.

3.2.1 Domestic well mitigation program policy/purpose statement

Define the mission of the program. For example, the purpose of the Chowchilla Subbasin Domestic Well Mitigation program is to mitigate undesirable results on domestic wells due to GSP implementations.

3.2.2 Definition of undesirable results

Program should clearly define the types of impacts to domestic wells that will, and will not, be mitigated.

3.2.3 Inventory domestic wells

Develop a database and registration system and allow domestic well owners to sign up (if not already permitted/in the system). Initial information should include pumping level.

3.2.4 Mitigation measures

Define mitigation measures. Other well mitigation programs suggest the following potential mitigation measures:

- Deepen or replace well for domestic wells where municipal water service is not expected to exist in the near future
- Correct to municipal service for domestic wells near existing municipal water service
- Develop municipal system to serve the impacted community high density of domestic wells impacted within a small geographic area

The mitigation measures should consider and coordinate with any mitigation actions being undertaken by other programs such as the Nitrate Control Program and Salt Control Program being implemented by the State Water Resources Control Board and Regional Water Quality Control Board as part of the Central Valley's Water Quality Control Plans (i.e., Basin Plans). In areas of the Central Valley where drinking water supplies have been impacted by water quality, the Basin Plan includes new regulatory actions focused on managing nitrates locally while providing interim and long-term solutions for providing safe drinking water supplies.

3.2.5 Define mitigation costs

Define how the mitigation fund will pay for each type of impacted domestic well. Other well programs suggest the following examples:

- Establish payment of e.g. $/AF) to deepen wells. If well cannot be deepened, establish standard cost to replace well (e.g. $/well
- Decide how to compensate well owners that can connect to municipal system
- Establish "rapid response" approach for situations when wells go dry

3.2.6 Establish review process

Develop a board to review and approve domestic well mitigation claims consistent. Establish process for expedient review.

3.2.7 Financing

Financing program through groundwater extraction fees (see above for estimated costs).

3.3 Domestic Well Mitigation Programs Reviewed

A review of existing domestic well mitigation programs identified two examples that could be used as a policy template:

3.3.1 Truckee Meadows Water Authority

3.3.1.1 Motivation

Nevada Legislature identified a need to avoid, or mitigate, impacts to domestic wells and granted authority to the State Engineer to limit pumping in areas to avoid impacts. Impacts to domestic wells from several sources (too many wells in the same area, new deep wells, etc.) in Washoe County. Truckee Meadows Water Authority (TMWA) eventually developed and approved the Mt. Rose/Galena Fan Domestic Well Mitigation Program.

3.3.1.2 Program overview

The program compensates domestic well owners who can demonstrate impacts to their well operation. It is the responsibility of the well owner to report impacts and request compensation from TMWA (https://tmwa.com/doing-business-with-us/wellmitigation/). A Board is established to review claims and approve/deny each application. If the application is approved, the home owner is compensated out of an existing fund to deepen their well.

3.3.1.3 Program financing and implementation

Compensation is specified by the program – wells can be deepened by 150 ft. Compensation (as of FY 2013) was $66/ft – meaning ~$10,000 for each well. Property owners are responsible for covering the cost of any other appurtenances (estimated around $4,500/well). If a well cannot be deepened, then the program pays for a new well and covers the cost of all appurtenances.

3.3.1.4 Applicability to Chowchilla GSP

Very applicable to the Chowchilla GSP. The program is a result of similar issues identified in the GSP – continued pumping for the benefit of the entire region is causing impacts to some shallower domestic wells. A fund is established to pay for those impacts so that pumping can continue in other parts of the basin. All users fund the program and it is the responsibility of individual well owners to submit impact claims. An independent board reviews the claims and approves/denies payment. https://www.leg.state.nv.us/Interim/76th2011/Exhibits/OverseeWRWC/E062812B.pdf

3.3.2 Yuba County Water Agency

3.3.2.1 Motivation

Potential groundwater substitution water transfers under the Yuba River Accord, or other transfers out of the Yuba County Water Agency (YCWA) area, could cause third-party impacts to other water users, including impacts to domestic wells.

3.3.2.2 Program overview

The program goal is to compensate domestic well owners that are demonstrably impacted by groundwater substitution water transfers. It was specified as Mitigation Measure 6-2 in the Lower Yuba River Accord EIR/S. In general. well owners are required to report impacts and a process is established for validating each claim. Monitoring wells (specified in Mitigation Measure 6-1) measure groundwater elevations throughout the season which are used to assess whether water transfers resulted in third-party domestic well impacts. The program description includes provisions to compensate or fully replace affected wells.[3]

[3] http://www.hdrprojects.com/engineering/ProposedLowerYubaRiverAccord/Chapter%206%20-%20MMRP-ECP.pdf

3.3.2.3 Program financing and implementation

No information on program financing was identified. No information on number of affected wells or if the program was ever fully implemented beyond being specified as a Mitigation Measure.

3.3.2.4 Applicability to Chowchilla GSP

Limited applicability to the Chowchilla Subbasin GSP. The YCWA program deals with short-term water transfer impacts, whereas the GSPs are concerned with long-term planned overdraft and cumulative impacts to domestic wells. The general program guidelines are applicable (compensate well owners that are impacted). However, the financing strategy is different. Compensation for third-party impacts can be included in the cost of a groundwater substitution transfer (the source of the impact), whereas the planned overdraft in the GSP is a benefit to all groundwater users in the subbasin.

Domestic Well Replacement Economic Analysis for the Chowchilla Subbasin

Updated January 2022

As Part of the

Domestic Well Inventory for the Chowchilla Subbasin

(See Appendix 2.G for the Complete Domestic Well Inventory for the Chowchilla Subbasin)

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Technical Memorandum

Subject: Domestic Well Replacement Economic Analysis – Chowchilla Update

By: ERA Economics

To: LSCE and the Madera County GSA

Date: January 10, 2022

Purpose and Background

In June 2019 ERA provided a technical memorandum (TM) estimating the cost and benefit of more rapid implementation of demand management under the Chowchilla Subbasin GSP. The economic analysis was included as Appendix 3C to the Chowchilla Subbasin GSP. The analysis was prepared with the best available data and information at that time. After finalizing the GSP, the LSCE and DE consultant teams have continued to assist the Chowchilla Subbasin GSAs with GSP implementation and annual GSP reporting. LSCE was engaged by the Madera County GSA to prepare an updated domestic well inventory for the subbasin.

The economic analysis included as Appendix 3C to the Chowchilla Subbasin GSP estimated the total cost of replacing domestic wells potentially impacted by declining groundwater levels under baseline conditions without SGMA and under the draft proposed GSP implementation plan (so-called "with-SGMA" scenario).

This technical memorandum (TM) serves as an update to those estimates by: (i) updating the project and demand management schedule to reflect the adopted allocation in the Chowchilla Subbasin, (ii) incorporating updated data and analysis on potentially impacted wells from the domestic well inventory, (iii) updating all costs and benefits to current dollars (e.g., well replacement costs), and (iv) refining the economic analysis to compare the cost and benefit of accelerating demand management specified in the GSP. That is, the 2019 analysis compared the draft GSP implementation to baseline conditions without SGMA, whereas this analysis compares the proposed plan with phased implementation of projects and management actions (PMAs) to an accelerated, immediate implementation of PMAs, notably with immediate full demand management to avoid further domestic well impacts.[1]

These updates to the data affect the resulting economic analysis and results. The 2019 estimate of domestic wells needing to be replaced without increased demand management was 40 wells, which at that time was doubled to account for potential under-reporting. In addition, a sensitivity calculation as

[1] Whereas the cost of immediate demand management implementation has been included, the effect on cost of accelerating recharge and supply projects has not yet been estimated. A full cost estimate of projects for all GSAs in the subbasin is still under development. If this additional cost were included, it would strengthen the conclusion of this analysis.

part of the earlier analysis verified that the conclusions would have held even if the number of affected wells were substantially larger. The updated domestic well inventory puts the number of domestic wells potentially needing replacement at 176 over the 20-year GSP implementation period. This TM briefly summarizes the updated analysis, results, and summary conclusions.

Summary Conclusions

Results of this updated analysis comparing the cost of accelerated PMA implementation to the benefit of avoided domestic well replacement costs support the general conclusion of the 2019 analysis. The loss in agricultural value from more rapid demand management still greatly exceeds domestic well replacement costs even though the estimated number of potentially dewatered domestic wells has increased and the cost of replacement for each domestic well has increased by 20 percent. That is, the results of the economic analysis show that the additional cost of more rapid demand management is substantially greater than the cost of replacing potentially dewatered domestic wells and paying higher pumping costs due to lower water levels. This supports the phased implementation schedule and domestic well mitigation program defined in the GSP.

Updated Assumptions

Assumptions and results below are summarized for each of the cost categories considered. All costs (or savings) are expressed as constant 2021 dollars converted to present value using a 3.5 percent real (inflation-free) discount rate[2]. The two implementation scenarios compared are referred to as *GSP implementation* (the phased implementation as described in the GSP) scenario and the *immediate demand reduction* (full demand reduction to eliminate overdraft from 2021 onward) scenario.

1. **Number of dewatered wells needing replacement**. Revised estimates of dewatered wells are calculated and described in the Technical Memorandum prepared by LSCE for the Chowchilla Subbasin Domestic Well Inventory. For this analysis, a total of 176 wells were estimated to be dewatered, spread across four 5-year periods. The cost analysis further assumed that well impacts would be evenly divided by year within each 5-year period[3]. For the comparison scenario with immediate demand reduction, it was assumed that none of those wells would need replacement.
2. **Costs to replace dewatered domestic wells**. The 2019 estimate of an average $25,000 per replaced domestic well is updated to $30,000 per domestic well.
3. **Groundwater pumping depth to water (DTW).** The average DTW for the GSP implementation scenario was provided from groundwater model projections described in the Chowchilla Subbasin GSP. The immediate demand reduction scenario is intended to represent immediate elimination of average annual overdraft. A time series was created that followed the

[2] The current federal discount rate for water projects is 2.25%, but a real rate of 3.5% better reflects borrowing conditions in Madera County. A 1.5% increase or decrease in the real discount rate does not affect the conclusions of the analysis.
[3] The timing of the well replacement within each 5-year period does not affect the conclusions of this analysis.

general hydrologic variation estimated for the GSP implementation scenario but held the DTW the same on average during the 2021-2040 implementation period. The ending (2040) difference in DTW between the two scenarios was then carried forward beyond 2040. These pumping depth differences are the basis for the estimated annual pumping cost savings.

4. **Changes in variable costs to pump groundwater, for both domestic and agricultural users.** Energy prices, estimated using a mix of PG&E's latest electricity rates for agricultural pumping, have increased substantially. The analysis now uses an average of PG&E's 2021 AG-B and AG-C peak and off-peak summer rates, resulting in an estimate of $0.40 per acre-foot per foot of lift for the variable cost to pump groundwater. As a result, more rapid demand management provides greater savings (avoided pumping lift) for domestic and agricultural pumping. All agricultural and domestic groundwater pumping in the basin would receive this avoided lift benefit from faster demand reduction.

5. **Costs of demand management under GSP implementation**. Costs of demand reduction have been revised based on the latest estimates of the net return to agricultural water use developed for planning the SALC program. In addition, pumping volumes have been updated to reflect current conditions and the planned ramp-down adopted in the Madera County GSA groundwater allocation ordinance (applicable to the GSP implementation scenario only). These values do not represent average returns to all lands and crops in the subbasin but rather the lands and crops more likely to participate in a demand reduction program. For purposes of this analysis, the lost net return from demand reduction is valued at $200 per acre-foot[4].

Results

The following discussion compares costs between the GSP implementation scenario and the (alternative) immediate demand management scenario. General observations are:

- Demand management costs are greater in the immediate implementation scenario because demand management would be implemented sooner (immediately) and for more years during the GSP implementation period. Recharge and supply projects' costs have not been included in this analysis, but their present value costs would also increase because they would be implemented sooner.
- Pumping costs are lower in the immediate demand reduction scenario because, by definition, the average annual overdraft is eliminated immediately. The effect (smaller DTW and lower pumping cost) is carried throughout the remaining years of GSP implementation and in perpetuity.

[4] The value of water depends on future crop market conditions. Note that a higher value (greater than $200 per acre-foot applied in this TM) would further increase the cost of accelerated demand management relative to avoided well replacement and additional pumping costs.

- Well replacement costs occur in the GSP implementation scenario but are not required in the immediate demand reduction scenario.
- The net effect of these differences in costs results in the GSP implementation scenario having a substantial cost advantage (by about $36 million in present value, or 16 percent) over the immediate demand reduction scenario. In other words, the Chowchilla Subbasin is better off (i.e., realizes benefits that exceed costs) implementing its phased GSP implementation plan and developing/funding the domestic well mitigation program to replace impacted wells than it is if it were to implement immediate demand reduction to avoid dewatering any domestic wells.

Table 1 summarizes the results of the economic analysis. All values are expressed in present value terms. The first two rows show the number of and cost to replace wells estimated to go dry in each scenario. The next rows present the pumping cost savings of the immediate demand reduction scenario relative to the GSP implementation scenario, broken down by domestic pumping and agricultural pumping. The next row shows the demand management costs. For the GSP implementation scenario, demand management is phased in at two percent per year initially, increasing to 6 percent per year until full demand management is reached by 2040. In contrast, the immediate demand reduction scenario implements the full demand management required in 2020, resulting in substantially higher demand management costs.

Table 1. Costs of GSP Implementation Scenario Compared to Costs of Immediate Demand Reduction Scenario - Summary Results for Chowchilla Subbasin, Present Value ($ in Millions)

	GSP Implementation with Well Replacement	**Immediate Demand Reduction**	**Difference**
Domestic Well Replacement			
Number	176	0	176
Cost, PV	$4.60	$0.0	$4.60
Pumping Cost (Savings), PV			
Domestic	NA	-$2.87	$2.87
Agricultural	NA	-$79.58	$79.58
Demand Mgmt. Cost, PV	$219.43	$342.37	-$122.94
Total Cost, PV*	$224.03	$259.91	-$35.88

* Totals may not add exactly due to rounding.

Discussion

Results indicate that the cost of implementing demand management on a faster trajectory (in this case, in year one of the implementation period) would not be cost effective from a subbasin-wide perspective. The avoided costs (fewer domestic wells requiring replacement) would be small ($4.6 million) relative to the additional lost agricultural net return[5] from immediate implementation ($122.9 million) for the Chowchilla Subbasin, even after accounting for pumping cost savings ($82.5 million). The general conclusions are robust to the assumptions used. That is, results are not sensitive to reasonable ranges in key assumptions, including the loss in net return per acre-foot of demand management, the total level of demand management, when demand management begins to scale in, or the cost of replacing a domestic well.

This analysis only compares the cost of well replacement to net costs of immediate demand management implementation; it has not considered the timing of other projects such as new surface water supplies or groundwater recharge. That comparison is not possible with current information, and the GSP implementation schedule already reflects an aggressive timeline for project implementation. The cost (in present value) of accelerating implementation of projects has also not been included here.The additional cost of accelerating a recharge project by, say five years, would be the increased present value of the project's capital and O&M cost stream. Costs of new supply and recharge projects have not been accelerated, so the present value of costs for immediate implementation is underestimated. Simply stated, including these additional costs would further support the conclusions of the analysis.

[5] Note that demand management would result in additional economic impacts to other county businesses and industries. These additional indirect impacts are not considered in this updated analysis but would only further support its conclusions.