

7. Monitoring Networks

The Subbasin has a well-established groundwater-level monitoring program that consists of dedicated monitoring, irrigation, and residential wells. Wells in the monitoring network include CASGEM program wells, ILRP-designated wells along with monitoring wells constructed by SAFCA and a few wells constructed by agencies and private entities to assess water quality near areas with releases of contaminants to the environment. They are monitored by various agencies including each of the GSAs, DWR, USGS, and consultants. Groundwater quality is monitored as part of compliance with drinking water standards and the ILRP.

Representative monitoring wells were selected from these monitoring networks to assess groundwater levels and water quality as related to the SGMA sustainability indicators. The representative monitoring well network includes those wells that will be used to track changes for each of the sustainability indicators in the Subbasin to assess short- and long-term trends for lowering of groundwater levels, reduction in storage, depletion of interconnected surface water, subsidence and water quality degradation. A monitoring network was not selected for sea water intrusion, as it is not likely to occur in the future (*refer to Section 5.9 – Seawater Intrusion* for further details).

Representative monitoring wells are discussed for each of the sustainability indicators in the following sections along with evidence that the wells are reflective of conditions in the principal aquifer.

7.1 Objectives

The objectives of the monitoring networks are to provide access to measure groundwater conditions that are representative of conditions throughout the Subbasin. The objectives of the monitoring well network is to:

- Have monitoring wells distributed throughout the Subbasin to assess changes in conditions and to determine if management actions are required
- Use dedicated monitoring wells, with known construction details, that will be present for the next 20 years and beyond, and that will provide measurements that are reflective of regional conditions
- Provide measurements of the groundwater conditions to demonstrate if the Subbasin is being sustainably managed within the locally established minimum thresholds and measurable objectives

- Provide measurements for future refinements of the groundwater model and water budgets
- Assess whether the pumping depression in the central area is deepening or expanding
- Track groundwater levels near surface water bodies to limit depletion and effects on groundwater dependent ecosystems (GDEs)
- Track and reduce the potential for land subsidence to occur
- Monitor groundwater quality to ensure it is not being degraded due to use of groundwater, projects, or management actions

To meet the monitoring objectives, groundwater levels and quality will be measured and compared to established minimum thresholds and measurable objectives to assess the groundwater conditions in the Subbasin and monitor progress toward achieving sustainable conditions. Monitoring protocols are provided, in detail, and that when followed, will ensure accurate and repeatable measurements.

The following sections provide a description of the 1) entire monitoring network, 2) selected representative monitoring well network along with its justification, and 3) frequency of measurement for each of the sustainability indicators.

7.2 Monitoring Network

The groundwater level monitoring network has changed over the years with a reduction in the number of production wells used for monitoring and movement towards dedicated monitoring wells.

The Subbasin has about 160 wells that are currently used to monitor groundwater levels, and most have known well construction details or at least the total constructed depth. **Table 7-1** summarizes the types of wells. Most of the 160 wells are dedicated monitoring wells. The locations of these wells are shown on **Figure 7-1**. There are over 100 nested and clustered monitoring wells that can be used to assess vertical groundwater gradients. These nested and clustered wells are located at over 30 sites distributed throughout the Subbasin and have been assigned a single map number to simplify the plotting of wells (**Figure 7-1** and subsequent figures). **Table 7-2** contains monitoring well attributes, well type, monitoring frequency, and other pertinent details. The table also lists wells currently being monitored and those that are no longer being monitored or are not recommended for monitoring. The monitoring well network is sufficient to monitor and demonstrate groundwater occurrence and flow directions, both horizontal and vertical gradients, and water table levels near surface water.

There are over 80 wells are constructed to shallow depths that are suitable to monitor unconfined groundwater conditions and can be used to evaluate surface water depletion, and groundwater levels near GDEs and domestic wells.

Table 7-1. Summary of Groundwater Level Well Types

| Groundwater Level Types of Wells ¹ | Number of Wells |
|--|-----------------|
| Observation (dedicated monitoring wells) | 125 |
| Residential | 14 |
| Irrigation | 20 |
| Additional Information | Number of Wells |
| Nested or Clustered Monitoring Wells (at 33 sites) ² | 101 |
| Wells with Unknow Construction Details ³ | 5 |
| Number of Shallow Wells (<200 feet) ⁴ | 80 |
| Notes: 1 = Only wells actively monitored 2 = Part of observation wells listed above 3 = Part of residential or irrigation wells listed above 4 = Extracted from monitoring, residential, and irrigation wells listed above | |

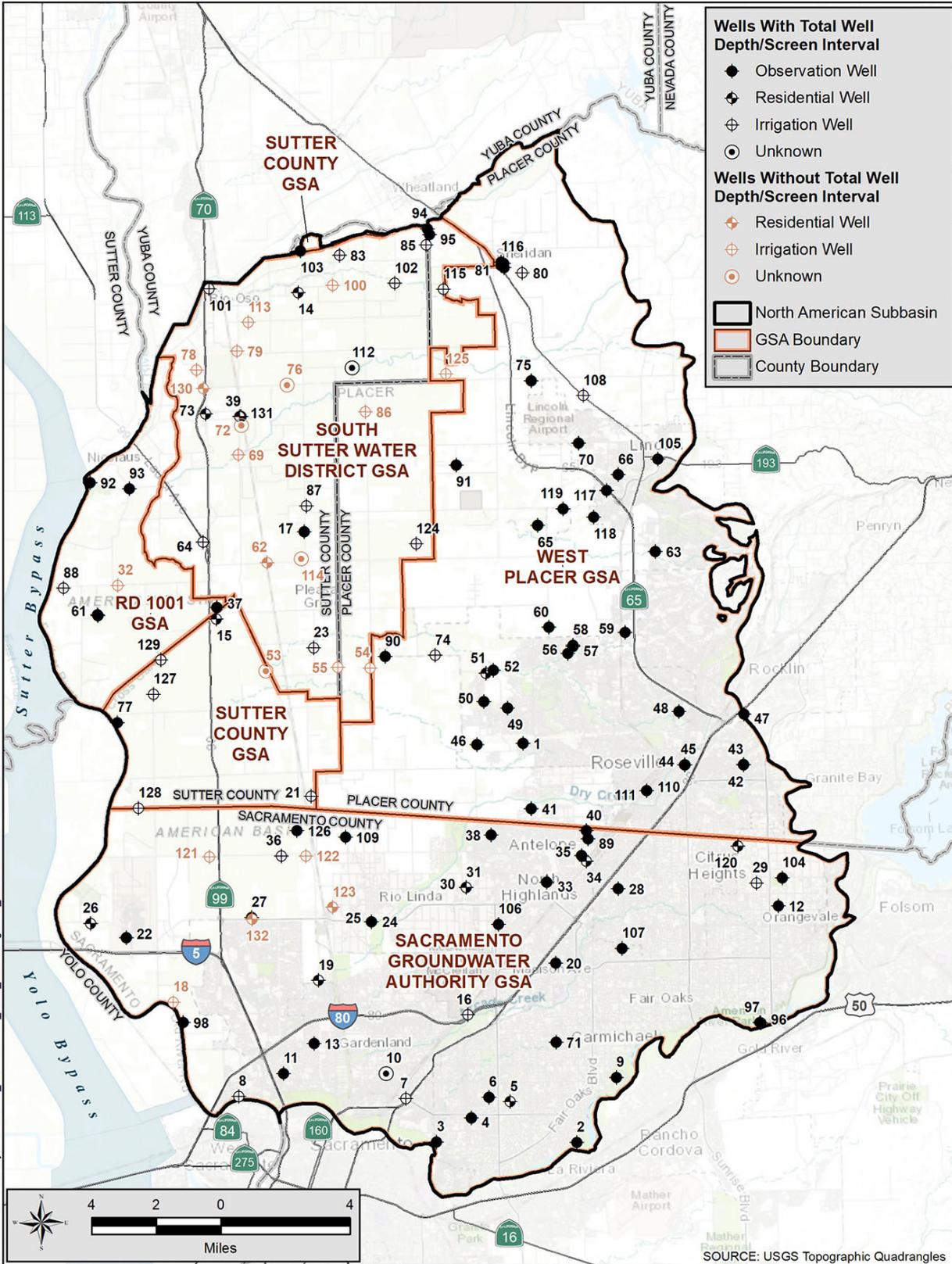


Figure 7-1. Groundwater Level Monitoring Network Wells

Table 7-2. Groundwater Level Monitoring Well Types and Distribution

| Map No. | CASGEM ID | Local Name | State Well Num | Latitud | Longitud | Reference Point Elevation (ft) | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Ty | Frequency of Monitoring |
|---------|--------------------|---------------------|----------------|----------|------------|--------------------------------|----------------------------|----------------------|---------|-------------------------|
| 1 | 387626N1213651W001 | SVMW East-2A | | 38.76263 | -121.3651 | 126.02 | 125-135 | 140 | M | Monthly |
| 1 | 381626N1213651W001 | SVMW East-2B | | 38.76263 | -121.3651 | 125.83 | 510-520 | 525 | M | Monthly |
| 1 | 387626N1213651W002 | SVMW East-2C | | 38.76263 | -121.3651 | 125.75 | 655-665 | 670 | M | Monthly |
| 2 | 385828N1213385W001 | SGA_MW06 | | 38.58281 | -121.33846 | 49.49 | 62-72 | 72 | M | Monthly |
| 3 | 385841N1214185W001 | SGA_MW04 | | 38.58414 | -121.41852 | 38.69 | 55-65 | 65 | M | Monthly |
| 4 | 385947N1213985W001 | MW12A | | 38.59472 | -121.39847 | 41.8 | 200-280 | 285 | M | Monthly |
| 4 | 385947N1213985W002 | MW12B | | 38.59472 | -121.39847 | 41.84 | 360-380 | 385 | M | Monthly |
| 4 | 385947N1213985W003 | MW12C | | 38.59472 | -121.39847 | 41.82 | 590-610 | 615 | M | Monthly |
| 4 | 385947N1213985W004 | MW12D | | 38.59472 | -121.39847 | 41.82 | 810-840 | 845 | M | Monthly |
| 4 | 385947N1213985W005 | MW12E | | 38.59472 | -121.39847 | 41.77 | 960-1000 | 1005 | M | Monthly |
| 5 | 386016N1213761W001 | DWR_SGA_004 | 09N05E25J001M | 38.6016 | -121.3761 | 66.7 | Unknown | 238 | R | Monthly |
| 6 | 386038N1213882W001 | MW11A | | 38.6038 | -121.38815 | 59.45 | 167-177 | 187 | M | Monthly |
| 6 | 386038N1213882W002 | MW11B | | 38.6038 | -121.38815 | 59.41 | 258-268 | 278 | M | Monthly |
| 6 | 386038N1213882W003 | MW11C | | 38.6038 | -121.38815 | 59.25 | 332-365 | 375 | M | Monthly |
| 7 | 386038N1214357W001 | DWR_SGA_005 | 09N05E28K001M | 38.6038 | -121.4357 | 36.84 | Unknown | 250 | I | |
| 8 | 386061N1215313W001 | SCWA_SGA_003 | 09N04E27F001M | 38.6061 | -121.5313 | 27.04 | Unknown | 320 | I | Monthly |
| 9 | 386117N1213150W001 | SCWA_SGA_004 | 09N06E27D001M | 38.6117 | -121.315 | 73.5 | Unknown | 200 | M | Monthly |
| 10 | 386151N1214467W001 | DWR_SGA_003 | 09N05E21M001M | 38.6151 | -121.4467 | 37.14 | Unknown | 89 | U | |
| 11 | 386160N1215054W001 | Bannon Creek Park | 09N04E23R002M | 38.61603 | -121.5054 | 13.76 | 33-48 | 48 | M | Monthly |
| 12 | 386874N1212206W001 | SGA_MW09 | | 38.68739 | -121.22058 | 231.27 | 150-160 | 160 | M | Monthly |
| 13 | 386292N1214877W001 | Chuckwagon Park | 09N04E13R001M | 38.62921 | -121.4877 | 11.71 | 27-37 | 52 | M | Monthly |
| 14 | 389669N1214897W001 | 13N04E23A002M | 13N04E23A002M | 38.9669 | -121.4897 | 59.28 | 56-83 | 83 | R | Monthly |
| 15 | 388208N1215397W001 | 11N04E09D002M | 11N04E09D002M | 38.8208 | -121.5397 | 30.87 | Unknown | 100 | R | |
| 16 | 386410N1213995W001 | DWR_SGA_002 | 09N05E14B001M | 38.641 | -121.3995 | 68.53 | Unknown | 550 | I | Monthly |
| 17 | 388593N1214885W003 | AB-2 shallow | 12N04E26J004M | 38.8593 | -121.4885 | 52.76 | 135-145 | 155 | M | Continuous |
| 17 | 388593N1214885W001 | AB-2 deep | 12N04E26J002M | 38.8593 | -121.4885 | 52.3 | 670-690 | 700 | M | Continuous |
| 17 | 388593N1214885W002 | AB-2 middle | 12N04E26J003M | 38.8593 | -121.4885 | 52.63 | 380-490 | 500 | M | Continuous |
| 18 | 386489N1215679W001 | SCWA_SGA_002 | 09N04E08L001M | 38.6489 | -121.5679 | 27.51 | Unknown | Unknown | I | Monthly |
| 19 | 386576N1214846W001 | SCWA_SGA_001 | 09N04E01R001M | 38.6576 | -121.4846 | 22.72 | Unknown | 17 | R | Monthly |
| 20 | 386635N1213486W001 | SGA_MW05 | | 38.66347 | -121.34859 | 121.87 | 205-215 | 215 | M | Monthly |
| 21 | 387404N1214870W001 | | 10N04E12A001M | 38.7404 | -121.487 | 45.54 | Unknown | 290 | I | Semi-Ann |
| 22 | 386782N1215943W004 | AB-4 shallow | 10N04E31M004M | 38.6782 | -121.5943 | 18.53 | 170-190 | 200 | M | Continuous |
| 22 | 386782N1215943W001 | AB-4 deep | 10N04E31M001M | 38.6782 | -121.5943 | 19.28 | 1060-1070 | 1080 | M | Continuous |
| 22 | 386782N1215943W002 | AB-4 middle-deep | 10N04E31M002M | 38.6782 | -121.5943 | 17.51 | 795-805 | 815 | M | Continuous |
| 22 | 386782N1215943W003 | AB-4 middle-shallow | 10N04E31M003M | 38.6782 | -121.5943 | 17.98 | 380-400 | 410 | M | Continuous |
| 23 | 388072N1214842W001 | | 11N04E13D001M | 38.8072 | -121.4842 | 49.96 | Unknown | 535 | I | Semi-Ann |
| 24 | 386836N1214536W001 | SGA_MW02 | | 38.68362 | -121.45363 | 52.39 | 100-110 | 110 | M | Monthly |
| 25 | 386836N1214536W002 | SGA_MW03 | | 38.68356 | -121.45362 | 51.82 | 285-305 | 305 | M | Monthly |
| 26 | 386848N1216146W001 | SCWA_SGA_005 | 10N03E35A001M | 38.6848 | -121.6146 | 23.09 | Unknown | 96 | R | Monthly |
| 27 | 386864N1215222W003 | AB-3 shallow | 10N04E27R004M | 38.6864 | -121.5222 | 28.31 | 190-210 | 220 | M | Continuous |
| 27 | 386864N1215222W001 | AB-3 deep | 10N04E27R002M | 38.6864 | -121.5222 | 27.84 | 745-995 | 995 | M | Continuous |
| 27 | 386864N1215222W002 | AB-3 middle | 10N04E27R003M | 38.6864 | -121.5222 | 28.09 | 470-500 | 500 | M | Continuous |
| 28 | 386964N1213120W001 | Twin Creeks Park | 10N06E27F001M | 38.6964 | -121.31203 | 121.8 | 183-193 | 193 | M | Monthly |
| 29 | 386979N1212329W001 | SCWA_SGA_012 | 10N07E29G001M | 38.6979 | -121.2329 | 219.57 | 150-240 | 240 | I | Monthly |
| 30 | 386982N1213992W001 | SCWA_SGA_008 | 10N05E14Q002M | 38.6982 | -121.3992 | 88.51 | 116-227 | 227 | R | Monthly |
| 31 | 386982N1213992W002 | SCWA_SGA_009 | 10N05E26B002M | 38.6982 | -121.3992 | 83.81 | Unknown | 150 | R | Monthly |
| 32 | 388361N1215959W001 | MLF Well #1 | 11N03E01D001M | 38.83664 | -121.59591 | 24.45 | Unknown | Unknown | I | Monthly |
| 33 | 387000N1213529W001 | Monument (A) | | 38.70005 | -121.35288 | 173.39 | 226-274 | 274 | M | |
| 33 | 387000N1213529W002 | Monument (B) | | 38.70005 | -121.35288 | 173.26 | 324-334 | 334 | M | |
| 33 | 387000N1213529W003 | Monument (C) | | 38.70005 | -121.35288 | 173.26 | 380-450 | 450 | M | |
| 33 | 387000N1213529W004 | Monument (D) | | 38.70005 | -121.35288 | 173.24 | 498-544 | 544 | M | |
| 34 | 387092N1213300W001 | SCWA_SGA_010 | 10N06E21F002M | 38.7092 | -121.33 | 161.51 | Unknown | 144 | R | Monthly |
| 35 | 387117N1213327W001 | Poker (A) | | 38.71174 | -121.33271 | 151.74 | 104-124 | 134 | M | |
| 35 | 387117N1213327W002 | Poker (B) | | 38.71174 | -121.33271 | 151.77 | 156-166 | 176 | M | |
| 35 | 387117N1213327W003 | Poker (C) | | 38.71174 | -121.33271 | 151.76 | 274-310 | 320 | M | |
| 35 | 387117N1213327W004 | Poker (D) | | 38.71174 | -121.33271 | 151.75 | 370-460 | 470 | M | |
| 36 | 387138N1215047W001 | SCWA_SGA_006 | 10N04E23A001M | 38.7138 | -121.5047 | 17.97 | Unknown | 85 | I | Monthly |
| 37 | 388260N1215394W004 | SUT-P1 | 11N04E04N004M | 38.826 | -121.5394 | 32.31 | 110-120 | 120 | M | Continuous |
| 37 | 388260N1215394W001 | SUT-P4 | 11N04E04N001M | 38.826 | -121.5394 | 31.81 | 880-890 | 890 | M | Continuous |
| 37 | 388260N1215394W002 | SUT-P3 | 11N04E04N002M | 38.826 | -121.5394 | 31.95 | 295-305 | 305 | M | Continuous |
| 37 | 388260N1215394W003 | SUT-P2 | 11N04E04N003M | 38.826 | -121.5394 | 32.13 | 185-195 | 195 | M | Continuous |
| 38 | 387216N1213842W001 | Lone Oak Park | 10N05E13F001M | 38.72163 | -121.38417 | 105.77 | 151-161 | 166 | M | Monthly |
| 39 | 389116N1215238W003 | AB-1 shallow | 12N04E03N004M | 38.9116 | -121.5238 | 50.58 | 170-180 | 190 | M | Continuous |
| 39 | 389116N1215238W001 | AB-1 deep | 12N04E03N001M | 38.9116 | -121.5238 | 49.83 | 950-970 | 980 | M | Continuous |
| 39 | 389116N1215238W002 | AB-1 middle-deep | 12N04E03N002M | 38.9116 | -121.5238 | 50.23 | 680-700 | 710 | M | Continuous |
| 39 | 389117N1215238W001 | AB-1 middle-shallow | 12N04E03N003M | 38.9116 | -121.5238 | 50.37 | 390-520 | 530 | M | Continuous |
| 40 | 387228N1213298W001 | Antelope North (A) | | 38.7228 | -121.32976 | 133.68 | 253-273 | 283 | M | |
| 40 | 387228N1213298W002 | Antelope North (B) | | 38.7228 | -121.32976 | 133.71 | 328-468 | 473 | M | |
| 41 | 387331N1213610W001 | WPMW-5A | | 38.73311 | -121.36099 | 100.42 | 80-100 | 100 | O | Continuous |
| 41 | 387331N1213610W002 | WPMW-5B | | 38.73311 | -121.36099 | 100.35 | 630-650 | 650 | O | Continuous |
| 42 | 387510N1212390W001 | WPMW-8A | | 38.75099 | -121.23895 | 234.17 | 30-50 | 50 | O | Continuous |
| 42 | 387510N1212390W002 | WPMW-8B | | 38.75099 | -121.23895 | 234.09 | 95-115 | 115 | O | Continuous |
| 43 | 387512N1212390W001 | WPMW-7A | | 38.75119 | -121.239 | 225.97 | 35-45 | 45 | O | Continuous |
| 44 | 387515N1212725W001 | WPMW-10A | | 38.75149 | -121.27251 | 153.21 | 26-36 | 36 | O | Continuous |
| 44 | 387515N1212725W002 | WPMW-10B | | 38.75149 | -121.27251 | 153.18 | 80-100 | 100 | O | Continuous |

| Map No | CASGEM ID | Local Name | State Well Num | Latitud | Longitud | Reference Point Elevation (ft) | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Ty | Frequency of Monitoring |
|--------|--------------------|----------------------|----------------|-----------|------------|--------------------------------|----------------------------|----------------------|---------|-------------------------|
| 44 | 387515N1212725W003 | WPMW-10C | | 38.75149 | -121.27251 | 153.12 | 240-260 | 260 | O | Continuous |
| 45 | 387517N1212727W001 | WPMW-9A | | 38.75167 | -121.27266 | 154.66 | 26-36 | 36 | O | Continuous |
| 46 | 387623N1213915W001 | SVMW West - 1A | | 38.76232 | -121.39153 | 94.25 | 120-140 | 145 | O | Monthly |
| 46 | 387623N1213915W002 | SVMW West - 1B | | 38.76233 | -121.39153 | 94.17 | 535-555 | 560 | O | Monthly |
| 46 | 387623N1213915W003 | SVMW West - 1C | | 38.76233 | -121.39153 | 94.05 | 725-745 | 750 | O | Monthly |
| 47 | 387739N1212382W001 | WPMW-6A | | 38.7739 | -121.23818 | 207.61 | 35-65 | 65 | O | Continuous |
| 48 | 387755N1212753W001 | WPMW-4A | | 38.77554 | -121.27525 | 181.67 | 120-140 | 145 | O | Monthly |
| 48 | 387755N1212753W002 | WPMW-4B | | 38.77554 | -121.27526 | 181.52 | 275-295 | 300 | O | Monthly |
| 49 | 387786N1213737W002 | WPMW-1B | 11N05E25 | 38.7786 | -121.3737 | 107.31 | 460-480 | 480 | O | Monthly |
| 49 | 387786N1213737W001 | WPMW-1A | | 38.7786 | -121.3737 | 107.83 | 110-120 | 120 | O | Monthly |
| 49 | 387786N1213737W003 | WPMW-1C | | 38.7786 | -121.3737 | 106.75 | 535-545 | 545 | O | Monthly |
| 50 | 387816N1213870W001 | W-77MW-A | | 38.78158 | -121.38702 | 97.2 | 486-506 | 516 | O | Monthly |
| 50 | 387816N1213870W002 | W-77MW-B | | 38.78158 | -121.38702 | 97.2 | 584-594 | 604 | O | Monthly |
| 51 | 387943N1213856W001 | O'Brien well | 11N05E23B001M | 38.7943 | -121.3856 | 90.86 | Unknown | 195 | R | |
| 52 | 387957N1213813W001 | CVMW-1A | | 38.79566 | -121.38126 | 87.11 | 260-280 | 285 | O | Monthly |
| 52 | 387957N1213813W002 | CVMW-1B | | 38.79566 | -121.38126 | 86.95 | 460-490 | 495 | O | Monthly |
| 52 | 387957N1213813W003 | CVMW-1C | | 38.79566 | -121.38126 | 86.84 | 565-585 | 590 | O | Monthly |
| 53 | 387971N1215119W001 | | 11N04E15Q001M | 38.7971 | -121.5119 | 35.98 | Unknown | Unknown | U | |
| 54 | 387977N1214521W001 | | 11N05E18R001M | 38.7977 | -121.4521 | 64.37 | Unknown | Unknown | I | |
| 55 | 387982N1214704W001 | | 11N04E13R001M | 38.7982 | -121.4704 | 53.37 | Unknown | Unknown | I | |
| 56 | 388027N1213384W001 | DCMW-3 | | 38.80271 | -121.33843 | 99.82 | 400-515 | 520 | O | Monthly |
| 57 | 388058N1213355W001 | DCMW-1 | | 38.80576 | -121.3355 | 119.94 | 320-450 | 455 | O | Monthly |
| 58 | 388063N1213354W001 | DCMW-2 | | 38.80629 | -121.33542 | 120.22 | 322-432 | 437 | O | Monthly |
| 59 | 388116N1213054W001 | Tinker MW | | 38.81159 | -121.30539 | 132.2 | 117-177 | 177 | O | Monthly |
| 60 | 388145N1213491W001 | WPMW-2A | | 38.8145 | -121.34914 | 108.2 | 215-225 | 230 | O | Monthly |
| 60 | 388145N1213491W002 | WPMW-2B | | 38.8145 | -121.34914 | 108.09 | 400-420 | 425 | O | Monthly |
| 61 | 388235N1216079W001 | Sutter County MW-5A | 11N03E02Q002M | 38.82324 | -121.60763 | 26.45 | 130-160 | 170 | O | Continuous |
| 61 | 388235N1216079W002 | Sutter County MW-5B | 11N03E02Q003M | 38.82324 | -121.60763 | 26.28 | 655-675 | 675 | O | Continuous |
| 61 | 388235N1216079W003 | Sutter County MW-5C | 11N03E02Q004M | 38.82324 | -121.60763 | 26.22 | 910-920 | 930 | O | Continuous |
| 61 | 388235N1216079W004 | Sutter County MW-5D | 11N03E02Q005M | 38.8235 | -121.6079 | 26.12 | 1205-1215 | 1225 | O | Continuous |
| 62 | 388458N1215100W001 | | 12N04E34H001M | 38.8458 | -121.51 | 42.83 | Unknown | Unknown | R | |
| 63 | 388476N1212872W001 | WPMW-3A | | 38.84761 | -121.28719 | 150.95 | 48-53 | 53 | O | Monthly |
| 63 | 388476N1212872W002 | WPMW-3B | | 38.84761 | -121.28719 | 150.34 | 130-140 | 140 | O | Monthly |
| 64 | 388555N1215468W001 | | 12N04E29J001M | 38.8555 | -121.5468 | 34.84 | Unknown | 285 | I | |
| 65 | 388604N1213544W003 | MW 1-3 | | 38.86038 | -121.35438 | 113.81 | 184-204 | 204 | O | Monthly |
| 65 | 388604N1213544W001 | MW 1-1 | | 38.86038 | -121.35438 | 113.6 | 378-398 | 398 | O | Monthly |
| 65 | 388604N1213544W002 | MW 1-2 | | 38.86038 | -121.35438 | 113.76 | 298-318 | 318 | O | Monthly |
| 65 | 388604N1213544W004 | MW 1-4 | | 38.86038 | -121.35438 | 113.61 | 82-92 | 92 | O | Monthly |
| 66 | 388826N1213078W001 | MW 5-1 | | 38.88258 | -121.30775 | 148.7 | 80-100 | 100 | O | Monthly |
| 66 | 388826N1213078W002 | MW 5-2 | | 38.88258 | -121.30775 | 148.65 | 52-62 | 62 | O | Monthly |
| 69 | 388944N1215257W001 | | 12N04E16A004M | 38.8944 | -121.5257 | 42.82 | Unknown | Unknown | I | |
| 70 | 388971N1213301W001 | MW 3-1 | | 38.89713 | -121.33008 | 130.5 | 118-133 | 133 | O | Monthly |
| 70 | 388971N1213301W002 | MW 3-2 | | 38.89713 | -121.33008 | 130.5 | 65-75 | 75 | O | Monthly |
| 71 | 386280N1213493W001 | WCMSS | | 38.62799 | -121.34925 | 90.74 | 130-150 | 170 | O | Monthly |
| 71 | 386280N1213493W002 | WCMSS | | 38.62799 | -121.34925 | 90.53 | 230-270 | 290 | O | Monthly |
| 71 | 386280N1213493W003 | WCMSD | | 38.62799 | -121.34925 | 90.23 | 490-510 | 530 | O | Monthly |
| 72 | 389075N1215237W001 | | 12N04E10D002M | 38.9075 | -121.5237 | 51.32 | Unknown | Unknown | U | |
| 73 | 389130N1215441W001 | | 12N04E05R004M | 38.913 | -121.5441 | 44.32 | Unknown | 90 | R | Semi-Ann |
| 74 | 388029N1214145W001 | | 11N05E16H001M | 38.8029 | -121.4145 | 90.36 | 135-460 | 460 | I | Semi-Ann |
| 75 | 389255N1213566W003 | MW 2-3 | | 38.92547 | -121.35663 | 127.67 | 75-85 | 85 | O | Monthly |
| 75 | 389255N1213566W002 | MW 2-2 | | 38.92547 | -121.35663 | 127.67 | 160-170 | 170 | O | Monthly |
| 75 | 389255N1213566W001 | MW 2-1 | | 38.92547 | -121.35663 | 127.7 | 290-310 | 310 | O | Monthly |
| 76 | 389255N1214969W001 | | 13N04E35Q002M | 38.9255 | -121.4969 | 57.9 | Unknown | Unknown | U | |
| 77 | | SREL-1-27-F1 | | 38.77491 | -121.59754 | | Unknown | 46.32 | O | Continuous |
| 78 | 389328N1215489W001 | | 13N04E32G001M | 38.9328 | -121.5489 | 48.32 | Unknown | Unknown | I | |
| 79 | 389410N1215254W001 | | 13N04E28R001M | 38.941 | -121.5254 | 51.31 | Unknown | Unknown | I | |
| 80 | 389740N1213606W001 | Cemetery | | 38.97403 | -121.36062 | 135.28 | 70-111 | 111 | I | Monthly |
| 81 | 387432N1215588W001 | MW 1 | | 38.97846 | -121.37132 | 109.71 | 30-40 | 40 | O | Monthly |
| 81 | 389764N1213710W001 | MW-2 | | 38.97643 | -121.371 | 113.69 | 24.3-44.3 | 45 | O | Monthly |
| 81 | 389774N1213728W001 | MW-3 | | 38.97741 | -121.37284 | 103.41 | 19.5-34.5 | 35 | O | Monthly |
| 82 | 387222N1212920W001 | Whyte A | | 38.722168 | -121.29196 | 167.31 | 200-220 | 226 | O | Monthly |
| 82 | 387222N1212920W002 | Whyte B | | 38.722168 | -121.29196 | 167.35 | 280-300 | 306 | O | Monthly |
| 83 | 389834N1214655W001 | South Sutter WD | 13N05E18C001M | 38.9834 | -121.4655 | 71.85 | Unknown | 210 | I | Semi-Ann |
| 84 | 389867N1213654W002 | Spencer (SVWQC00008) | | 38.986724 | -121.36542 | 134.5 | 96-107 | 107 | R | Monthly |
| 85 | 389873N1214156W001 | 13N05E09R001M | 13N05E09R001M | 38.9873 | -121.4156 | 86 | Unknown | 150 | I | Semi-Ann |
| 86 | 389128N1214522W001 | | 12N05E06R001M | 38.9128 | -121.4522 | 71.3 | Unknown | Unknown | I | |
| 87 | 388710N1214870W001 | | 12N04E24M002M | 38.871 | -121.487 | 54.32 | Unknown | 340 | I | Semi-Ann |
| 88 | 388357N1216273W001 | | 11N03E03C002M | 38.8357 | -121.6273 | 28.79 | Unknown | 97 | I | Semi-Ann |
| 89 | | Roseview Park - 315 | | 38.71912 | -121.32879 | 156.84 | 295-305 | 315 | O | Monthly |
| 89 | | Roseview Park - 370 | | 38.71912 | -121.32879 | | 350-360 | 370 | O | Monthly |
| 89 | | Roseview Park - 465 | | 38.71912 | -121.32879 | 156.76 | 445-455 | 465 | O | Monthly |
| 90 | 388026N1214432W002 | WPMW-12A | 11N05E17 | 38.80264 | -121.44322 | 69.62 | 260-280 | 300 | O | Continuous |
| 90 | 388026N1214432W004 | WPMW-12B | 11N05E17 | 38.80264 | -121.44322 | 69.57 | 508-528 | 550 | O | Continuous |
| 91 | 388882N1214005W002 | WPMW-11A | 12N05E15 | 38.88816 | -121.40046 | 92.07 | 132-152 | 162 | O | Continuous |
| 91 | 388882N1214005W004 | WPMW-11B | | 38.88816 | -121.40046 | 91.7 | 264-304 | 309 | O | Continuous |
| 92 | | RDMW-101 | | 38.88294 | -121.61105 | 30.18 | 28-43 | 48 | O | Continuous |

| Map No | CASGEM ID | Local Name | State Well Num | Latitud | Longitud | Reference Point Elevation (ft) | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Ty | Frequency of Monitoring |
|--------|--------------------|-------------------|----------------|----------|------------|--------------------------------|----------------------------|----------------------|---------|-------------------------|
| 92 | | RDMW-101 | | 38.88294 | -121.61105 | 30.18 | 28-43 | 48 | O | Continuous |
| 93 | | RDMW-102 | | 38.87987 | -121.58853 | 30.47 | 28-43 | 48 | O | Continuous |
| 94 | 389950N1214148W002 | RDMW-103 | 13N05E10 | 38.99461 | -121.41479 | 89.38 | 28-43 | 48 | O | Continuous |
| 95 | 389919N1214141W002 | RDMW-104 | 13N05E10 | 38.99195 | -121.4135 | 87.68 | 28-43 | 48 | O | Continuous |
| 96 | | 1516 | | 38.63487 | -121.23192 | 88.38 | 13-33 | 40 | O | Continuous |
| 97 | | 1518 | | 38.63513 | -121.23231 | 130.71 | 55-75 | 80 | O | Continuous |
| 98 | | URS71000-700+00C | | 38.6397 | -121.56244 | 41.7 | Unknown | 45.24 | O | Continuous |
| 99 | | URS71000-700+00F | | 38.63954 | -121.56154 | 24.2 | Unknown | 45.14 | O | |
| 100 | | 13N04E13R001M | 13N04E13R001M | 38.97 | -121.4697 | 71.57 | Unknown | Unknown | I | |
| 101 | | 13N04E16N001M | 13N04E16N001M | 38.9692 | -121.5408 | | Unknown | 500 | I | Semi-Ann |
| 102 | 389704N1214340W001 | 13N05E17R001M | 13N05E17R001M | 38.9704 | -121.434 | | Unknown | 480 | I | Semi-Ann |
| 103 | 389857N1214880W001 | BR-1B | 13N04E11R002M | 38.9857 | -121.488 | | 78-98 | 98 | O | Continuous |
| 103 | 389857N1214880W004 | BR-1A | 13N04E11R005M | 38.9857 | -121.488 | | 28-48 | 48 | O | Continuous |
| 103 | 389857N1214880W002 | BR-1C | 13N04E11R003M | 38.9857 | -121.488 | | 215-245 | 245 | O | Continuous |
| 103 | 389857N1214880W003 | BR-1D | 13N04E11R004M | 38.9857 | -121.488 | | 320-331 | 331 | O | Continuous |
| 104 | 387000N1212180W001 | SGA_MW08 | | 38.69998 | -121.21795 | 218.06 | 130-140 | 140 | O | Monthly |
| 105 | 388893N1212847W001 | MW 4 | | 38.88928 | -121.28468 | 183.87 | 15-25 | 25 | O | Monthly |
| 106 | 386814N1213809W001 | MW-15 | 09N06E06A001M | 38.68144 | -121.38093 | | 205-481 | 486 | O | Monthly |
| 107 | 386697N1213106W001 | MW-N28 | 09N06E03C001M | 38.66967 | -121.31058 | | 170-452 | 454 | O | Monthly |
| 108 | 389185N1213268W001 | Swainson | | 38.91846 | -121.32684 | 140.65 | 44.1-91.9 | 92 | I | Monthly |
| 109 | 387218N1214677W001 | SGA_MW01 | | 38.72178 | -121.46771 | 47.59 | 100-110 | 110 | O | Monthly |
| 110 | | Dpool A | | 38.74034 | -121.29462 | | 190-210 | 245 | O | Monthly |
| 111 | | Dpool B | | 38.74034 | -121.29462 | | 310-330 | 336 | O | Monthly |
| 112 | 389327N1214594W001 | | 13N05E31K001M | 38.9327 | -121.4594 | 70.29 | Unknown | 393 | U | |
| 113 | 389539N1215186W001 | | 13N04E27C003M | 38.9539 | -121.5186 | 54.47 | Unknown | Unknown | I | |
| 114 | 388473N1214905W001 | 12N04E35H001M | 12N04E35H001M | 38.8473 | -121.4905 | 50.73 | Unknown | Unknown | U | |
| 115 | 389674N1214063W001 | | 13N05E22C003M | 38.9674 | -121.4063 | | Unknown | 400 | I | |
| 116 | 389791N1213727W001 | Old Well #2 | 13N05E13D003M | 38.97913 | -121.37269 | 107 | 144-209 | 209 | O | Monthly |
| 117 | 388755N1213144W001 | SLC-1 | | 38.87548 | -121.3144 | 145 | 142-249 | 249 | O | Monthly |
| 118 | 388637N1213222W001 | SLC-2 | | 38.86373 | -121.32218 | 126.47 | 144-293 | 293 | O | Monthly |
| 119 | 388677N1213397W001 | SLC-3 | | 38.86768 | -121.33973 | 117.98 | 132-311 | 311 | O | Monthly |
| 120 | 387141N1212431W001 | SCWA_SGA_011 | 10N07E20D001M | 38.71469 | -121.2431 | 207.57 | Unknown | 185 | R | Monthly |
| 121 | 387139N1215459W001 | 10N04E21B002M | 10N04E21B002M | 38.7139 | -121.5459 | 18.97 | Unknown | Unknown | I | Semi-Ann |
| 122 | 387137N1214906W001 | SCWA_SGA_007 | 10N04E24B001M | 38.7137 | -121.4906 | 30.17 | Unknown | Unknown | I | Monthly |
| 123 | 386904N1214757W001 | 10N05E30L001M | 10N05E30L001M | 38.6904 | -121.4757 | 38.99 | Unknown | Unknown | R | Semi-Ann |
| 124 | 388531N1214244W001 | | 12N05E33C001M | 38.8531 | -121.4244 | 69.33 | Unknown | 610 | I | |
| 125 | 389292N1214056W001 | 35633 | 13N05E34P001M | 38.9292 | -121.4056 | 89.3 | Unknown | Unknown | I | |
| 126 | 384330121293901 | | 10N04E13F001M | 38.72512 | -121.49544 | 22 | Unknown | 50 | O | Monthly |
| 127 | 387874N1215764W001 | Spangler | | 38.7874 | -121.5764 | 27 | 150-170 | 252 | I | Monthly |
| 128 | 387363N1215862W001 | TNBC Atkinson | | 38.73631 | -121.5862 | 31.39 | 110-288 | 288 | I | Semi-Ann |
| 129 | 388028N1215720W001 | TNBC Lucich North | | 38.8028 | -121.57205 | 28.91 | 150-160 | 226 | I | Semi-Ann |
| 129 | 388028N1215720W001 | TNBC Lucich North | | 38.8028 | -121.57205 | 28.91 | 150-160 | 226 | I | Semi-Ann |

Notes: Wells destroyed, no longer monitored or not recommended for monitoring
O = observation well (dedicated monitoring well)
I = irrigation well
R = residential well
U = unknown

7.3 Representative Monitoring Network

Representative monitoring wells were selected to represent general conditions for areas within the Subbasin for each of the sustainability indicators and where minimum thresholds and measurable objectives will be established. Monitoring will continue at the monitoring network wells for a more thorough analysis of conditions and groundwater contour development. Representative monitoring networks are discussed by sustainability indicators in the following sections along with evidence that the locations reflect general conditions in the areas.

The entire monitoring well network (*refer to Figure 7-1*) was evaluated and a subset of the monitoring sites were selected to be representative of the groundwater level conditions in the Subbasin.

Criteria considered for selecting representative monitoring wells included:

- Dedicated monitoring wells were selected over voluntary wells which may be being used for water supply and measurements may be affected by pumping.
- Wells with known construction details or at least the total depth.
- Wells near sensitive beneficial users (e.g., GDEs, domestic wells, and wells in areas solely supplied by groundwater). Protection of these sensitive beneficial users would then be protective of agriculture and municipal beneficial users as their wells are typically deeper.
- Ability to monitor the pumping depression depth and extent.
- Wells that are constructed to similar depths as beneficial users.
- A geographic distribution of monitoring wells over the entire Subbasin.

The selection criteria were used to select a representative monitoring network. **Figure 7-2** illustrates the selected groundwater level representative monitoring wells for chronic lowering of groundwater levels, reduction in groundwater storage and for surface water depletion and their geographic distribution in the Subbasin. Monitoring wells were not selected in the area north or Lincoln and east of Old Highway 65 because this area has perched groundwater resting on top of marine deposits. Table 7-3 provides a list of the representative monitoring wells, their construction details and their purpose for monitoring.

Representative monitoring wells for chronic lowering of groundwater levels were selected based on sensitive beneficial users (GDEs and domestic wells), areas that rely on groundwater and a few supplemental wells to provide complete coverage over the Subbasin. Figures 7-3 through 7-7 illustrate the distribution of the groundwater level representative monitoring wells as they relate to these beneficial users and are discussed in more detail in the following sections.

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Table 7-3. Representative Groundwater Level Monitoring Wells

| Map No. | CASGEM ID | Local Name | State Well Number | Latitude | Longitude | Reference Point Elevation (ft) | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Type | Frequency of Monitoring | GDE Representative Wells | Domestic Well Density Representative Wells | Areas Solely Reliant on Groundwater Representative Wells | Surface Water Depletion |
|---------|--------------------|---------------------|-------------------|----------|------------|--------------------------------|----------------------------|----------------------|-----------|-------------------------|--------------------------|--|--|-------------------------|
| 2 | 385828N1213385W001 | SGA_MW06 | | 38.58281 | -121.33846 | 49.49 | 62-72 | 72 | O | Monthly | | X | | X |
| 3 | 385841N1214185W001 | SGA_MW04 | | 38.58414 | -121.41852 | 38.69 | 55-65 | 65 | O | Daily | X | X | | X |
| 11 | 386160N1215054W001 | Bannon Creek Park | 09N04E23R002M | 38.61603 | -121.5054 | 13.76 | 33-48 | 48 | O | Monthly | X | X | | X |
| 13 | 386292N1214877W001 | Chuckwagon Park | 09N04E13R001M | 38.62921 | -121.4877 | 11.71 | 27-37 | 52 | O | Monthly | | X | | X |
| 14 | 389669N1214897W001 | 13N04E23A002M | 13N04E23A002M | 38.9669 | -121.4897 | 59.28 | 56-83 | 83 | R | Semi-Annual | X | | | X |
| 17 | 388593N1214885W003 | AB-2 shallow | 12N04E26J004M | 38.8593 | -121.4885 | 52.76 | 135-145 | 155 | O | Daily | | X | | |
| 20 | 386635N1213486W001 | SGA_MW05 | | 38.66347 | -121.34859 | 121.87 | 205-215 | 215 | O | Semi-Annual | | X | | |
| 22 | 386782N1215943W004 | AB-4 shallow | 10N04E31M004M | 38.6782 | -121.5943 | 18.53 | 170-190 | 200 | O | Daily | X | X | | X |
| 24 | 386836N1214536W001 | SGA_MW02 | | 38.68362 | -121.45363 | 52.39 | 100-110 | 110 | O | Monthly | | X | X | |
| 27 | 386864N1215222W003 | AB-3 shallow | 10N04E27R004M | 38.6864 | -121.5222 | 28.31 | 190-210 | 220 | O | Daily | | | | X |
| 28 | 386964N1213120W001 | Twin Creeks Park | 10N06E27F001M | 38.6964 | -121.31203 | 121.8 | 183-193 | 193 | O | Monthly | | X | | |
| 37 | 388260N1215394W004 | SUT-P1 | 11N04E04N004M | 38.826 | -121.5394 | 32.31 | 110-120 | 120 | O | Daily | X | | | X |
| 38 | 387216N1213842W001 | Lone Oak Park | 10N05E13F001M | 38.72163 | -121.38417 | 105.77 | 151-161 | 166 | O | Monthly | | X | | |
| 39 | 389116N1215238W003 | AB-1 shallow | 12N04E03N004M | 38.9116 | -121.5238 | 50.58 | 170-180 | 190 | O | Daily | X | X | X | X |
| 44 | 387515N1212725W001 | WPMW-10A | | 38.75149 | -121.27251 | 153.21 | 26-36 | 36 | O | Daily | X | | | X |
| 45 | 387517N1212727W001 | WPMW-9A | | 38.75167 | -121.27266 | 154.66 | 26-36 | 36 | O | Daily | | | | X |
| 46 | 387623N1213915W001 | SVMW West - 1A | | 38.76232 | -121.39153 | 94.25 | 120-140 | 145 | O | Monthly | | | X | |
| 48 | 387755N1212753W001 | WPMW-4A | | 38.77554 | -121.27525 | 181.67 | 120-140 | 145 | O | Monthly | X | | | |
| 60 | 388145N1213491W001 | WPMW-2A | | 38.8145 | -121.34914 | 108.2 | 215-225 | 230 | O | Monthly | | | X | |
| 61 | 388235N1216079W001 | Sutter County MW-5A | 11N03E02Q002M | 38.82324 | -121.60763 | 26.45 | 130-160 | 170 | O | Daily | X | | | X |
| 63 | 388476N1212872W001 | WPMW-3A | | 38.84761 | -121.28719 | 150.95 | 48-53 | 53 | O | Monthly | | | | X |
| 65 | 388604N1213544W003 | MW 1-3 | | 38.86038 | -121.35438 | 113.81 | 184-204 | 204 | O | Monthly | | X | X | |
| 66 | 388826N1213078W002 | MW 5-2 | | 38.88258 | -121.30775 | 148.65 | 52-62 | 62 | O | Monthly | | X | | X |
| 71 | 386280N1213493W001 | WCMSS | | 38.62799 | -121.34925 | 90.74 | 130-150 | 170 | O | Monthly | | X | | |
| 75 | 389255N1213566W003 | MW 2-3 | | 38.92547 | -121.35663 | 127.67 | 75-85 | 85 | O | Monthly | | | X | X |
| 77 | | SREL-1-27-F1 | | 38.77491 | -121.59754 | | Unknown | 46 | O | Daily | X | | | X |
| 89 | | Roseview Park - 315 | | 38.71912 | -121.32879 | 156.84 | 295-305 | 315 | O | Monthly | | X | | |
| 90 | 388026N1214432W002 | WPMW-12A | 11N05E17 | 38.80264 | -121.44322 | 69.62 | 260-280 | 300 | O | Daily | | | X | |
| 91 | 388882N1214005W002 | WPMW-11A | 12N05E15 | 38.88816 | -121.40046 | 92.07 | 132-152 | 162 | O | Daily | | X | X | |
| 92 | | RDMW-101 | | 38.88294 | -121.61105 | 30.18 | 28-43 | 48 | O | Daily | | | | X |
| 93 | | RDMW-102 | | 38.87987 | -121.58853 | 30.47 | 28-43 | 48 | O | Daily | X | | | X |
| 94 | 389950N1214148W002 | RDMW-103 | 13N05E10 | 38.99461 | -121.41479 | 89.38 | 28-43 | 48 | O | Daily | | | | X |
| 95 | 389919N1214141W002 | RDMW-104 | 13N05E10 | 38.99195 | -121.4135 | 87.68 | 28-43 | 48 | O | Daily | X | | | X |
| 96 | | 1516 | | 38.63487 | -121.23192 | 88.38 | 13-33 | 40 | O | Daily | | | | X |
| 97 | | 1518 | | 38.63513 | -121.23231 | 130.71 | 55-75 | 80 | O | Daily | | | | X |
| 98 | | URS71000-700+00C | | 38.6397 | -121.56244 | 41.7 | Unknown | 45 | O | Daily | | | | X |
| 103 | 389857N1214880W001 | BR-1B | 13N04E11R002M | 38.9857 | -121.488 | 65.57 | 78-98 | 98 | O | Daily | X | X | | X |
| 104 | 387000N1212180W001 | SGA_MW08 | | 38.69998 | -121.21795 | 218.06 | 130-140 | 140 | O | Semi-Annual | | X | | |
| 109 | 387218N1214677W001 | SGA_MW01 | | 38.72178 | -121.46771 | 47.59 | 100-110 | 110 | O | Semi-Annual | | X | X | |
| 116 | 389791N1213727W001 | Old Well #2 | 13N05E13D003M | 38.97913 | -121.37269 | 107 | 144-209 | 209 | O | Semi-Annual | | X | X | |
| 126 | 384330121293901 | 10N04E13F001M | 10N04E13F001M | 38.72512 | -121.49544 | 22 | Unknown | 50 | O | Monthly | X | | | |

Notes: O = Monitoring well
R = Residential well

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7.4 Chronic Lowering of Groundwater Levels

The Subbasin has a long history of groundwater management and has developed an extensive groundwater monitoring network capable of collecting data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the Subbasin and to evaluate changing conditions. Representative wells have been selected to demonstrate groundwater occurrence, flow directions, and hydraulic gradients within the Subbasin.

Declining groundwater levels in the Subbasin have been a concern for local water resource managers for decades. Groundwater levels were dropping on a long-term average of about 3 feet per year for several decades prior to 1980 (refer to Section 5.2 – Groundwater Levels). A cone of depression formed in the center of the Subbasin that, although it is smaller than it once was, it still remains. The current state of this depression is a substantial improvement over the situation in the mid-1990s when the depth to groundwater at the center of the depression was about 20 feet deeper than it is now. This improvement is largely the result of local groundwater management, especially conjunctive use operations. Groundwater levels along the western and eastern portions of the Subbasin have remained stable for nearly 100 years.

Currently, the groundwater depression is being managed to benefit the groundwater cleanup efforts associated with groundwater contamination at the former McClellan AFB. The depression has benefits to water resources management as it can be used to store groundwater (groundwater banking). In general, the remainder of the Subbasin does not show distinctive regional groundwater elevation patterns other than to mimic the local topography. This results in groundwater generally flowing from the edges of the Subbasin from the east and west towards the central groundwater depression.

7.4.1 GDE Representative Monitoring Network

Representative groundwater level monitoring wells were selected to be protective of GDEs. **Section 5.12 – Groundwater Dependent Ecosystems** provide details of the evaluation of the process to refine potential GDEs to those that are likely to be supported by groundwater from the principal aquifer. Since GDEs in the Subbasin typically have shallow rooting depths (less than 30 feet), representative monitoring wells were selected near likely GDEs that monitor water table conditions (wells with depths less than 200 feet). **Figure 7-3** show the locations of likely and less likely GDEs and selected representative shallow monitoring wells in the Subbasin. A 3-mile radius around each well is also shown to approximate a minimum density of about three monitoring wells per 100 square miles, to illustrate whether there is sufficient monitoring coverage. **Table 7-3** provides a list of the representative monitoring wells, their screen intervals, and well depths.

7.4.2 Domestic Well Representative Monitoring Network

Representative groundwater level monitoring wells were also selected to be protective of domestic well owners. Selected representative monitoring wells have similar or shallower depths as the domestic wells and are located near high densities of domestic wells. Representative wells were also selected to provide coverage throughout the Subbasin where lower densities of domestic wells are present. **Figure 7-4** shows the density of the domestic wells in the Subbasin and locations of selected representative monitoring wells. A 3-mile radius around each monitoring well is shown to illustrate the Subbasin has an adequate monitoring network for this beneficial user. Representative monitoring wells listed in **Table 7-3** were selected with similar or shallower depths as the shallowest top of well screens in domestic wells. **Figure 7-5** provides the top of domestic well screen depths and the locations of the representative monitoring wells, which along with **Table 7-3** illustrates the selected monitoring wells are representative for domestic wells.

Figure 7-6 shows domestic well minimum depths (DWR, 2019) in comparison to both agriculture and municipal well depths using DWR's database to illustrate that selection of representative monitoring wells for domestic wells would be protective of municipal and agricultural wells, which are typically deeper than domestic wells.

7.4.3 Groundwater Only Area Representative Monitoring Network

Some portions of the Subbasin rely solely on groundwater as their source of water (**Figure 7-7**). **Table 7-3** lists these selected representative wells. Representative monitoring wells were selected in these areas to be protective of domestic and irrigation wells owners. The approach to select representative monitoring wells for these areas was the same as used for selection of representative monitoring wells for domestic well owners.

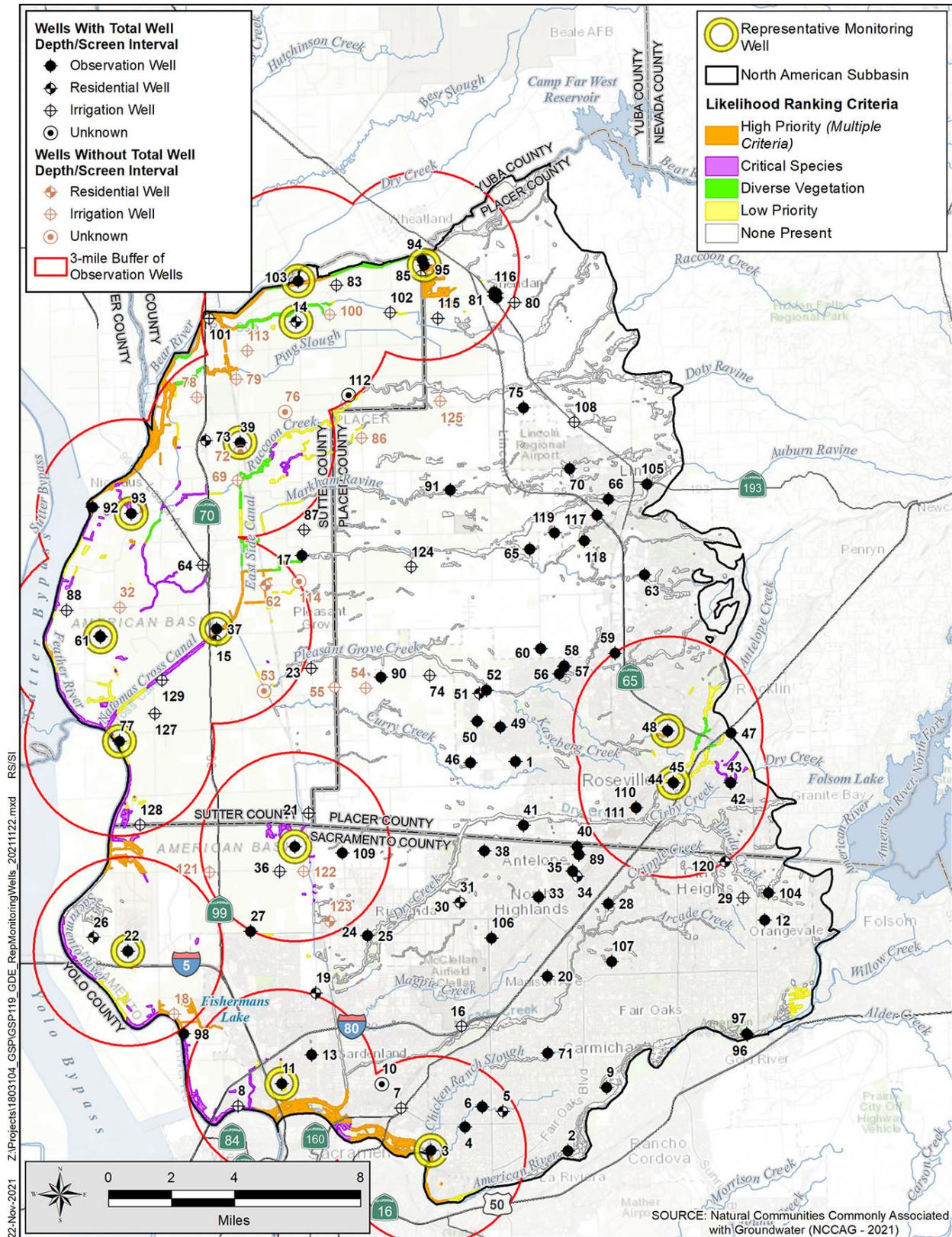


Figure 7-3. Representative Groundwater Level Monitoring Wells for GDEs

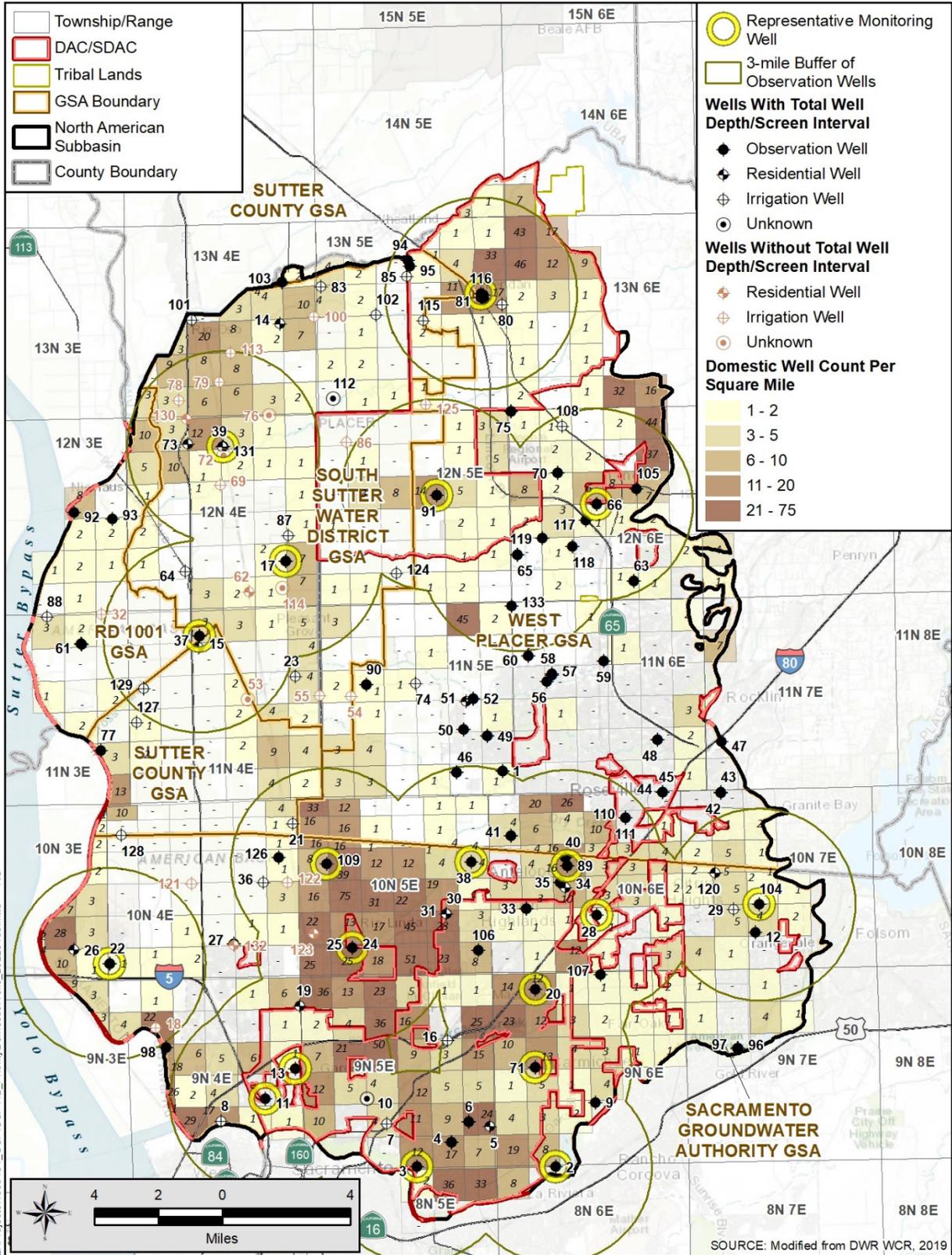


Figure 7-4. Representative Monitoring Wells Selection for Domestic Wells

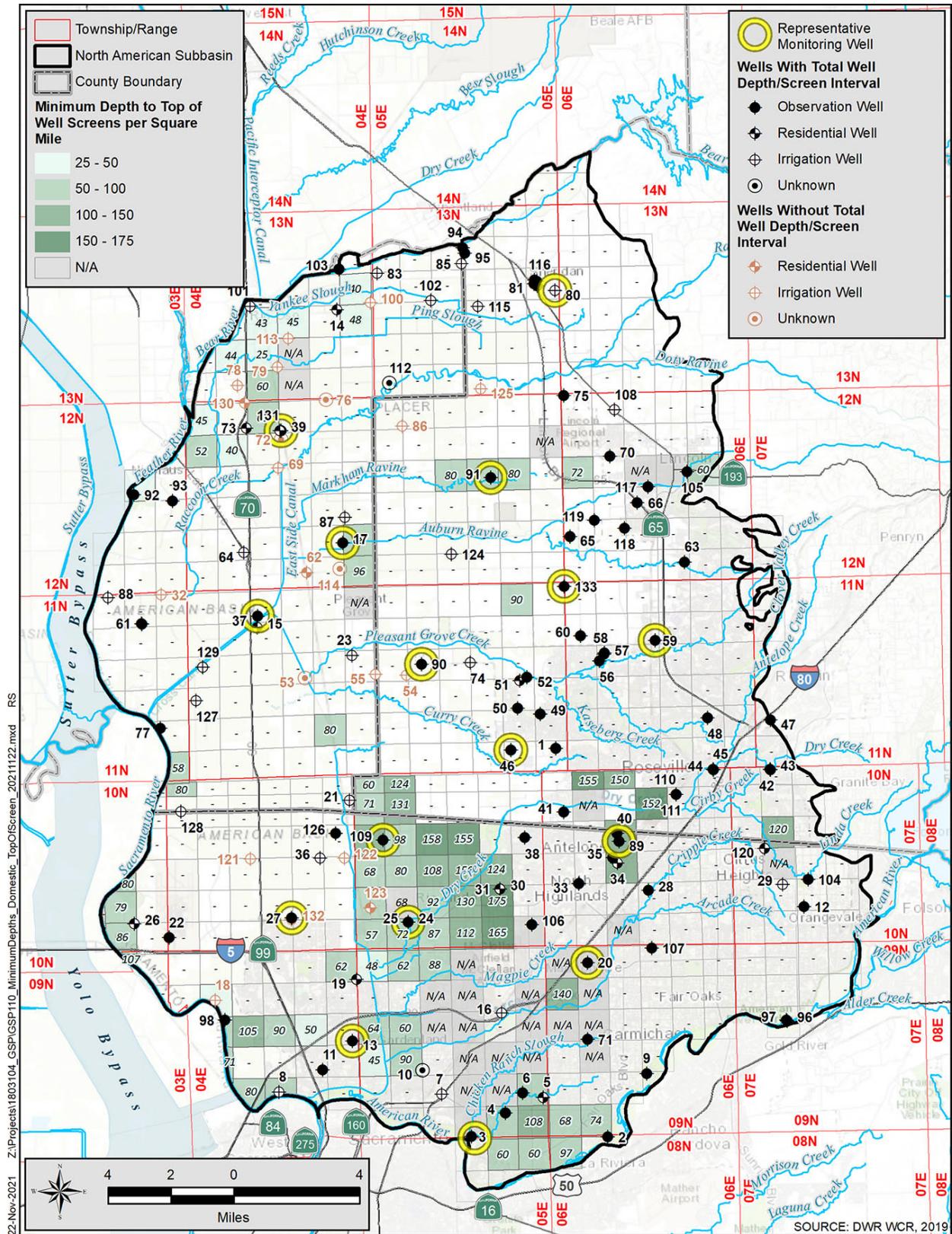


Figure 7-5. Depth to Domestic Well Top of Screens and Representative Monitoring Wells

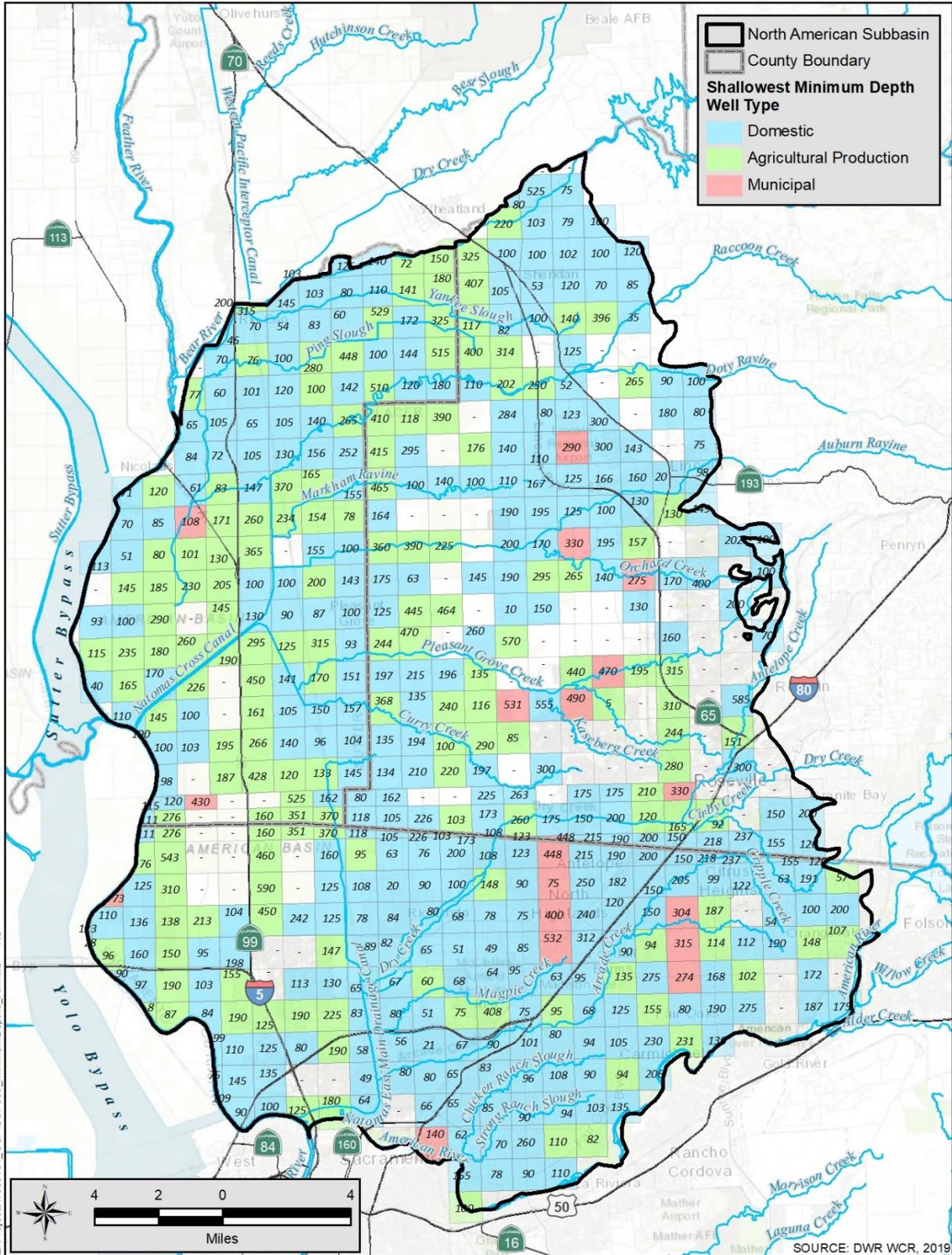


Figure 7-6. Comparison of Domestic Well Minimum Depths to Agricultural and Municipal Well Depths

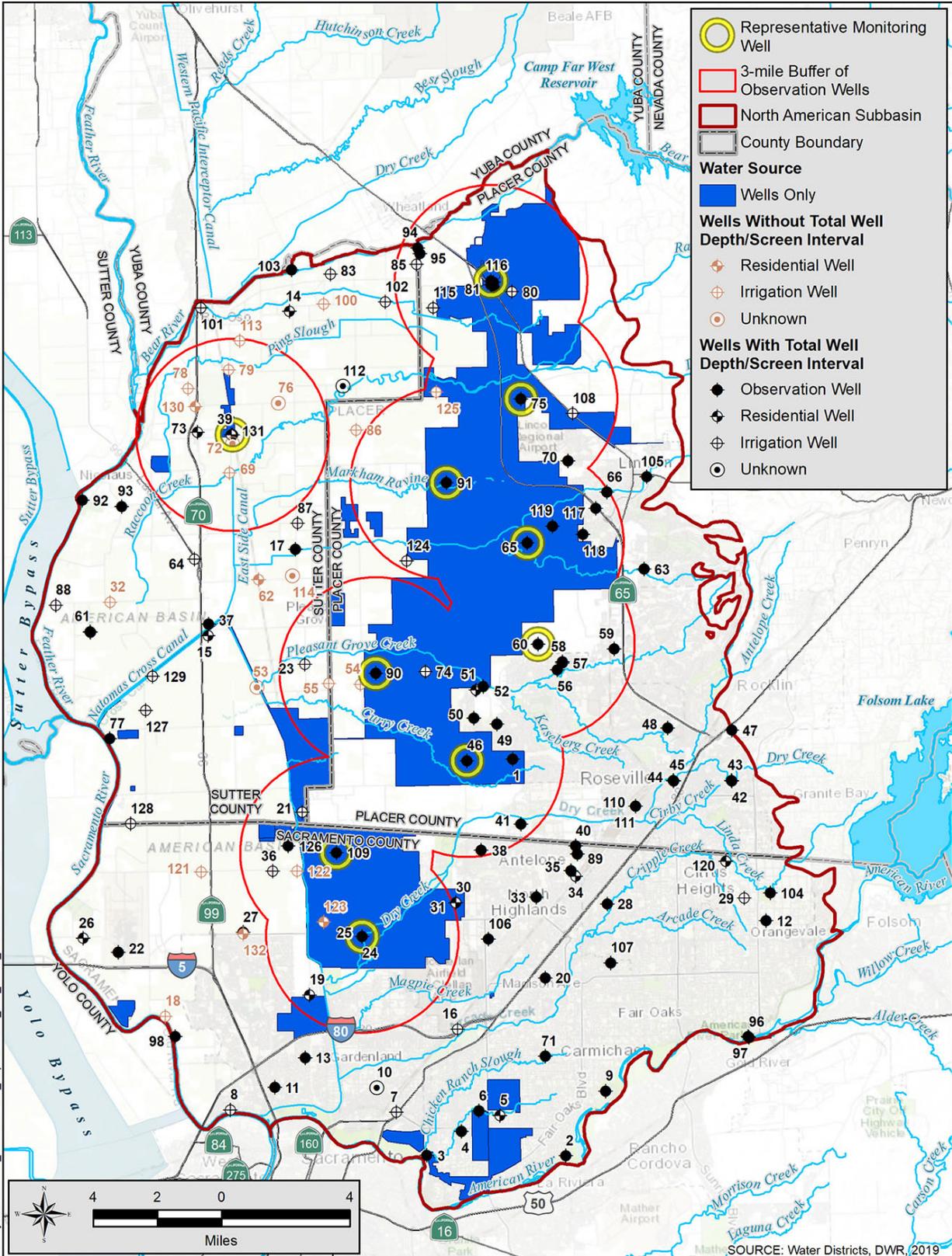


Figure 7-7. Representative Monitoring Wells for Areas Solely Dependent on Groundwater

7.4.4 Groundwater Level Monitoring Frequency

Frequency of groundwater level monitoring is cited in the Draft Monitoring Networks and Identification of Data Gaps Best Management Practice (DWR, 2016a), which presents guidance on monitoring frequency based on the type of monitoring, aquifer type, confinement, recharge rate, hydraulic conductivity, and withdrawal rate. Historically, DWR has monitored groundwater levels on a semi-annual basis. Because groundwater levels are being used to assess sustainability indicators, more frequent monitoring at some locations is warranted. Sampling frequencies were developed based on this guidance in combination with a consideration of monitoring costs.

Based on the analysis of groundwater level monitoring data in the Subbasin, dating back several decades, the GSA's have determined that semi-annual groundwater level measurements are sufficient to identify groundwater level trends in the Subbasin. However, at some representative wells, the frequency of monitoring has been increased to monthly or daily near areas with groundwater dependent ecosystems and surface water depletion to better define seasonal variations. **Table 7-3** provides the monitoring schedule for each representative monitoring well (note that where daily is listed as the frequency the well is equipped with a pressure transducer that can be set at daily or to match the measurement frequency at nearby surface water gaging stations).

Semi-annual groundwater levels will be collected in the Spring and Fall at all wells (*refer to Figure 7-2*). In the Spring, groundwater levels are typically higher than any other time of the year and groundwater pumping stresses are usually minimal. The Spring levels are reflective of regional high groundwater levels after recharge to the aquifer from winter rains. Fall measurements are taken after the heaviest pumping has occurred during the summer months and before substantial recharge has occurred from precipitation. The fall measurement is considered to be the regional minimum groundwater level for a given year. The work will be completed during a 2-week window on either side of target dates (April 15 and October 15) to accommodate for inclement weather and scheduling conflicts. This frequency of monitoring is more than sufficient to demonstrate seasonal, short-term (1-5 years), and long-term (5-10 years) trends in groundwater and related surface conditions and yield representative information about groundwater conditions.

Under some conditions, groundwater level measurements may be increased. For example, if agencies are participating in water transfers, groundwater level measurements are required to be collected weekly to monthly, from the beginning of the water transfer pumping until groundwater levels recovered to their seasonal highs the following Spring.

The monitoring frequency at representative monitoring wells have been adjusted to better track the groundwater levels near sensitive beneficial users that may be more effected by short-term groundwater level fluctuations. Wells monitoring more sensitive areas, such as GDE's and surface water interaction areas, have been increased to monthly (when measurements are made

manually) or daily (using pressure transducers) to track groundwater levels that semi-annual monitoring would not capture.

7.4.5 Groundwater Level Monitoring Spatial Density

The Subbasin extends over an area of about 535 square miles (342,000 acres) and supplies about 208,000 acre-feet of groundwater annually for drinking water and irrigation (DWR, BMP 2019). This equates to about 39,000 AFY per 100 square miles.

A groundwater level well monitoring density goal ranges from 0.2 to 10 wells per 100 square miles (DWR, 2016a). The monitoring well density goals can also be based on the amount of groundwater use. For basins where groundwater pumping more than 10,000 AFY per 100 square miles, four wells per 100 square miles is recommended. Professional judgement is also essential to determining an adequate level of monitoring, frequency, and density based on the need to observe aquifer response near high pumping areas, cones of depression, significant recharge areas, and specific projects.

There are 37 representative monitoring wells selected to monitor for chronic lowering of groundwater levels in the Subbasin, equating to a density of about seven wells per 100 square miles. **Figure 7-8** shows the distribution of representative wells in the Subbasin. Of these 37 representative monitoring wells, 16 were selected to monitor areas with GDEs, which are present in about a 200-square-mile area, equating to a density of about eight wells per 100 square miles. The density of these representative monitoring wells exceeds the recommended density goals of four wells per 100 square miles and are therefore sufficient to provide representative groundwater levels throughout the Subbasin to assess groundwater lowering.

7.4.6 Data Gaps

As illustrated on **Figures 7-3 through 7-8**, there is an adequate density of representative monitoring wells in most of the Subbasin. However, two additional dedicated shallow monitoring wells are needed near high priority GDEs close to the Sacramento River (near well 128) and near the junction of the Bear and Feather rivers (near well 78) (*refer to Figure 7-3*). Alternatively, surface water observation stations may be established along Ping Slough at road crossings as groundwater and surface water are interconnected in this area. Another data gap area is present near well 112, (*refer to Figure 7-8*). A new monitoring well should be constructed in this vicinity.

7.5 Reduction in Groundwater Storage

Change in groundwater storage will use the same wells as designated for the representative groundwater level monitoring network (*refer to Section 7.3 – Representative Monitoring Network*), for the chronic lowering of groundwater levels. For decades, DWR has utilized changes in groundwater elevations, along with specific yield, to estimate changes in storage.

The Subbasin will use groundwater levels as a proxy for the change in groundwater storage. Groundwater storage changes will be calculated by evaluating the volumetric difference between changes in groundwater surfaces created based on groundwater level data collected in the Spring of each year.

Because groundwater levels will be used as a proxy for groundwater storage changes, discussions of monitoring frequency and spatial density will be the same as for chronic lowering of groundwater levels (*refer to Section 7.4.4 – Groundwater Level Monitoring Frequency and Section 7.4.5 – Groundwater Level Monitoring Spatial Density*).

7.6 Seawater Intrusion

As stated previously, in **Section 5.9 – Seawater Intrusion**, the Subbasin is more than 80 miles inland from the Pacific Ocean which precludes the consideration of seawater intrusion as a sustainability indicator. Saline water intrusion into waterways is more than 40 miles south of the Subbasin. Therefore, seawater intrusion is not likely to occur in the vicinity of the Subbasin and a representative monitoring network and monitoring is not required for this sustainability indicator.

7.7 Groundwater Quality

The groundwater quality in the Subbasin is good and meets the needs of urban, municipal, industrial, and agricultural uses based on salinity and nitrate concentrations. The concentrations of salinity and nitrate, for the most part, are below drinking water standards and agricultural water quality objectives. Poorer groundwater quality (higher salinity) has been noted in a few wells:

- In the western portion of the Subbasin, adjacent to the Sacramento and Feather rivers, due to this area historically being a slough and a salt sink or due to migration groundwater from adjacent subbasins
- Along the eastern portion of the Subbasin, near Lincoln, Roseville and Lincoln, due to shallow marine sediments

Between 2013 and 2017, water quality samples were collected by the USGS from 24 domestic wells with screen intervals ranging from 129 to 178 feet below ground surface (bgs). The results showed TDS ranged between 70 and 459 milligrams per liter (mg/L). Nitrate (as nitrogen) ranged between 0.1 and 1.4 mg/L (Bennett, 2019). The concentrations indicate the water is suitable for drinking water with all concentrations below the primary and recommended secondary drinking water standards. However, about 15 percent of the wells had arsenic and manganese above the MCL (Bennett, 2019). The locations and owners of these wells are confidential and cannot be released to the GSAs so they cannot be used as part of the monitoring network.

7.7.1 Monitoring Network

Groundwater quality in the Subbasin is monitored in 247 public water supply wells (PWS) and in one well designated for the ILRP water quality trend monitoring program. Groundwater quality is also monitored by agencies and private entities to assess water quality near areas with releases of contaminants to the environment. Groundwater quality monitoring is also required during water transfers.

An extensive record of water quality data from the PWS wells, dating from as far back as 1964 to the present, is available. Every PWS well is required by the California DDW to collect and analyze water quality samples. However, wells used by the small community systems are only required to collect samples for nitrate, with infrequent electrical conductivity measurements or TDS. A list of the PWS locations and attributes is not provided due to them being critical infrastructure.

As part of ILRP Water Quality Trend monitoring program, the Sacramento Valley Water Quality Coalition, collects samples from one monitoring well to be representative of water quality in the Subbasin. The well is screened in the upper portions of the aquifer to provide a regional representation of groundwater quality within a time frame that enables the evaluation of trends in groundwater quality resulting from the effects of agricultural practices and changes in land use practices. The well is required to be sampled annually for TDS and nitrate. The California Rice Commission has no monitoring wells in the Subbasin.

The USGS, National Water-Quality Assessment Program (NAWQA) has one well (monitoring well number 126) in the Subbasin that was sampled to assess groundwater quality near rice growing areas. This well has historically been sampled 10 times since 1997 and was last sampled in 2017. The next time the well is to be sampled is unknown. As part of the NAWQA, 25 domestic wells were sampled. The USGS attempts to resample wells about once every 5 years dependent upon funding. The USGS does not release domestic well location information to allow sampling of these wells by the GSAs.

As described in **Section 7.2 – Monitoring Network**, dedicated groundwater monitoring wells have been constructed in the Subbasin by the GSAs, DWR, and the USGS. These monitoring wells are used to measure groundwater levels but can be used to collect water quality samples, but at a higher cost as they are not equipped with pumps. The location of these wells is shown on **Figure 7-1**.

Additional dedicated monitoring wells have been constructed by agencies and private entities to assess water quality near areas with releases of contaminants to the environment. These monitoring wells were not considered during preparation of this GSP as water quality from these wells is reported to regulatory agencies who manage investigation and cleanup of groundwater.

There are a couple of areas of poorer quality groundwater with TDS greater than the drinking water MCL of 500 mg/L, in the western and eastern portions of the Subbasin. A groundwater

quality sentry monitoring network was developed using selected groundwater level monitoring wells that are downgradient of these occurrences of poorer quality water. They were selected to assess if the poorer quality groundwater is migrating into the Subbasin and affecting water quality. Some of the sentry wells were also selected to monitor near the base-of-fresh water to assess for the potential upwelling of saline water from underlying marine sediments. These sentry wells are not being designated as representative wells. **Figure 7-9** shows the location of the sentry wells, with several of the wells being nested monitoring wells which can monitor various depths in the aquifer. **Table 7-4** lists the sentry monitoring well construction details. Sentry wells are planned to be sampled once every 2 years, in the fall.

Table 7-4. Sentry Monitoring Wells

| Map No. | CASGEM or PWS ID | Local Name | Latitude | Longitude | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Type | Monitoring Frequency |
|-------------------------|--------------------|----------------|----------|------------|----------------------------|----------------------|-----------|----------------------|
| Monitoring Wells | | | | | | | | |
| 17 | 388593N1214885W003 | AB-2 shallow | 38.8593 | -121.4885 | 135-145 | 155 | O | Biennial |
| 17 | 388593N1214885W002 | AB-2 middle | 38.8593 | -121.4885 | 380-490 | 500 | O | Biennial |
| 17 | 388593N1214885W001 | AB-2 deep | 38.8593 | -121.4885 | 670-690 | 700 | O | Biennial |
| 27 | 386864N1215222W002 | AB-3 middle | 38.6864 | -121.5222 | 470-500 | 500 | O | Biennial |
| 37 | 388260N1215394W004 | SUT-P1 | 38.826 | -121.5394 | 110-120 | 120 | O | Biennial |
| 37 | 388260N1215394W003 | SUT-P2 | 38.826 | -121.5394 | 185-195 | 195 | O | Biennial |
| 37 | 388260N1215394W002 | SUT-P3 | 38.826 | -121.5394 | 295-305 | 305 | O | Biennial |
| 65 | 388604N1213544W001 | MW 1-1 | 38.86038 | -121.35438 | 378-398 | 398 | O | Biennial |
| 65 | 388604N1213544W002 | MW 1-2 | 38.86038 | -121.35438 | 298-318 | 318 | O | Biennial |
| 65 | 388604N1213544W003 | MW 1-3 | 38.86038 | -121.35438 | 184-204 | 204 | O | Biennial |
| 65 | 388604N1213544W004 | MW 1-4 | 38.86038 | -121.35438 | 82-92 | 92 | O | Biennial |
| 75 | 389255N1213566W002 | MW 2-2 | 38.92547 | -121.35663 | 160-170 | 170 | O | Biennial |
| 75 | 389255N1213566W003 | MW 2-3 | 38.92547 | -121.35663 | 75-85 | 85 | O | Biennial |
| 90 | 388026N1214432W002 | WPMW-12A | 38.80264 | -121.44322 | 260-280 | 300 | O | Biennial |
| 90 | 388026N1214432W004 | WPMW-12B | 38.80264 | -121.44322 | 508-528 | 550 | O | Biennial |
| 91 | 388882N1214005W002 | WPMW-11A | 38.88816 | -121.40046 | 132-152 | 162 | O | Biennial |
| 91 | 388882N1214005W004 | WPMW-11B | 38.88816 | -121.40046 | 264-304 | 309 | O | Biennial |
| 131 | | SSWD- supply | 38.91158 | -121.52438 | 85-140 | 140 | R | Biennial |
| 132 | | NCMWC - supply | 38.68561 | -121.52211 | Unknown | Unknown | R | Biennial |

Notes: O = Monitoring well
R = Residential well

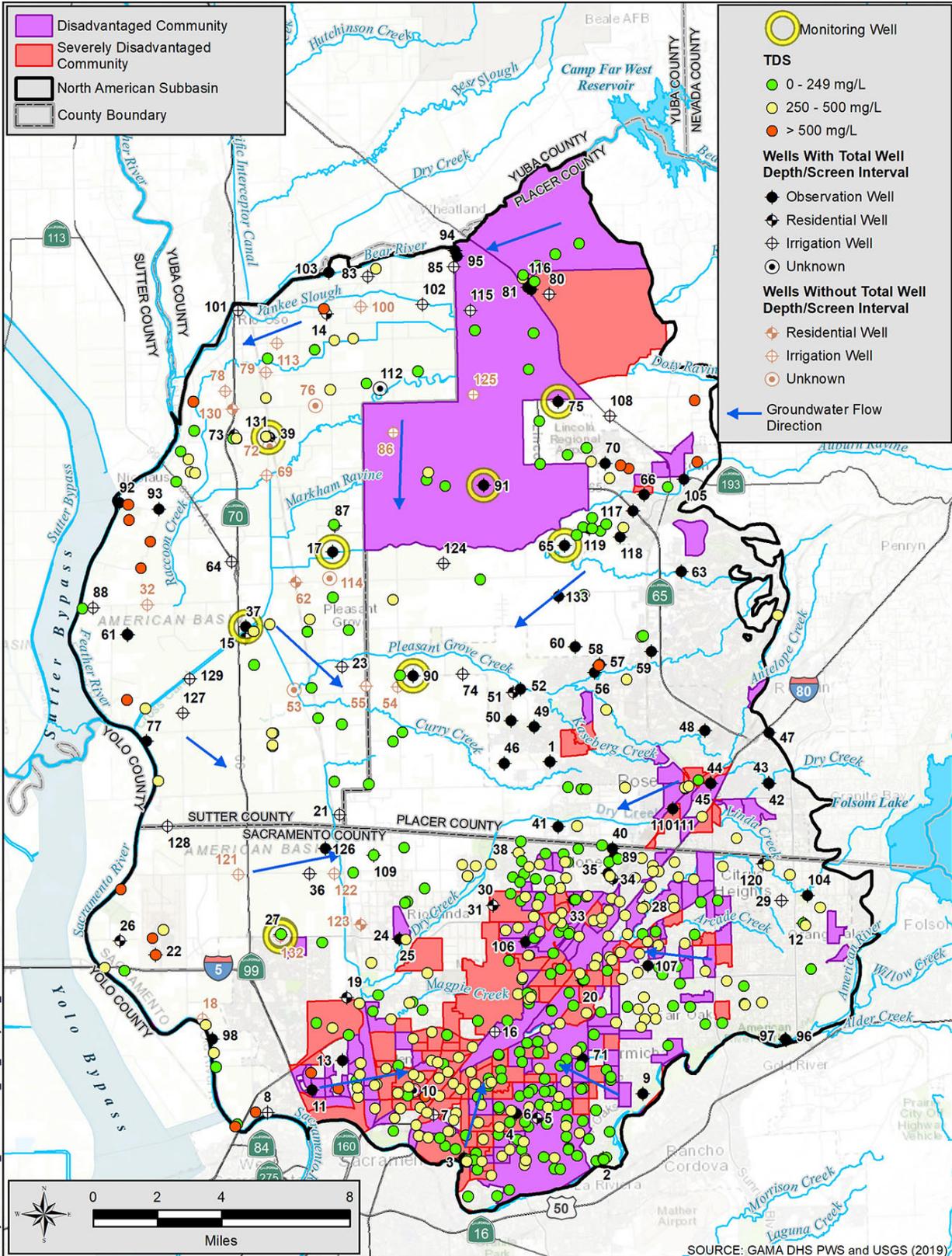


Figure 7-9. Sentry Monitoring Well Network

7.7.2 Representative Monitoring Wells

Representative monitoring wells were selected for groundwater quality degradation in the Subbasin where minimum thresholds and measurable objectives will be established to be protective of domestic, agricultural, and municipal well beneficial users.

The entire groundwater level monitoring well network and PWS wells were evaluated and a subset of the monitoring and PWS wells were selected to be representative of the groundwater quality conditions in the Subbasin.

Criteria used to select the representative monitoring well network for the Subbasin is based on:

- Wells with construction details
- Whether the wells are part of another regulatory program that requires sampling, reducing the overall costs
- The distribution of wells throughout the Subbasin
- Whether they are representative of beneficial users
- Whether the wells are located near or downgradient of known areas of poorer quality groundwater to assess degradation of water quality

Based on these considerations two representative monitoring networks were selected one for the shallow portions of the aquifer and one for the deeper portions of the aquifer.

The shallow portion of the aquifer is used by domestic wells. **Figure 7-10** shows the location of representative monitoring wells selected in relation to areas where high densities of domestic wells are present and for distribution across the entire Subbasin. Monitoring wells and a few shallow PWS wells with well screen intervals at depths at about the average depth of domestic wells (about 175 feet bgs; *refer to Appendix B*), were selected to be representative wells for the shallow portion of the aquifer. **Table 7-5** provides the attributes for these shallow aquifer representative wells.

There are 247 PWS wells in the Subbasin and construction details have been acquired for 205 of the wells. The details show that the average well depth is about 420 feet bgs, deeper than the average domestic wells depths. There are some PWS wells, about 20, with known well construction details and up to 42 wells with unknown details, with total well depths about the same as the domestic wells, but overall, the PWS wells are mostly reflective of the deeper portions of the aquifer. As illustrated on **Figure 7-11**, there is a high density of PWS in the southern portion of the Subbasin with lesser density in the northern portion of the Subbasin. All of the PWS wells will be used as a representative monitoring network.

Table 7-5. Shallow Aquifer Water Quality Representative Monitoring Wells

| Map No. | CASGEM or PWS ID | Local Name | Latitude | Longitude | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Type | Monitoring Frequency |
|----------------------------------|--------------------|---------------------|----------|------------|----------------------------|----------------------|-----------|----------------------|
| Monitoring Wells | | | | | | | | |
| 17 | 388593N1214885W003 | AB-2 shallow | 38.8593 | -121.4885 | 135-145 | 155 | O | Biennial |
| 20 | 386635N1213486W001 | SGA_MW05 | 38.66347 | -121.34859 | 205-215 | 215 | O | Biennial |
| 24 | 386836N1214536W001 | SGA_MW02 | 38.68362 | -121.45363 | 100-110 | 110 | O | Biennial |
| 27 | 386864N1215222W003 | AB-3 shallow | 38.6864 | -121.5222 | 190-210 | 220 | O | Biennial |
| 37 | 388260N1215394W004 | SUT-P1 | 38.826 | -121.5394 | 110-120 | 120 | O | Biennial |
| 39 | 389116N1215238W003 | AB-1 shallow | 38.9116 | -121.5238 | 170-180 | 190 | O | Biennial |
| 46 | 387623N1213915W001 | SVMW West - 1A | 38.76232 | -121.39153 | 120-140 | 145 | O | Biennial |
| 80 | 389740N1213606W001 | Cemetery (IRLP) | 38.97403 | -121.36062 | 70-111 | 111 | O | Annual |
| 89 | | Roseview Park - 315 | 38.71912 | -121.32879 | 295-305 | 315 | O | Biennial |
| 90 | 388026N1214432W002 | WPMW-12A | 38.80264 | -121.44322 | 260-280 | 300 | O | Biennial |
| 91 | 388882N1214005W002 | WPMW-11A | 38.88816 | -121.40046 | 132-152 | 162 | O | Biennial |
| 109 | 387218N1214677W001 | SGA_MW01 | 38.72178 | -121.46771 | 100-110 | 110 | O | Biennial |
| 133 | | LW-1 | 38.83731 | -121.35831 | 68-108 | 108 | O | Annual |
| Public Water Supply Wells | | | | | | | | |
| 298 | 3110025-014 | Tinker Road Well | | | 117-177 | 177 | M | Tri annual |
| 99 | 3400396-001 | Main Well | | | 53-71 | 73 | M | Tri annual |
| 177 | 3410002-013 | Well 22 - Northrop | | | 113-225 | 265 | M | Tri annual |

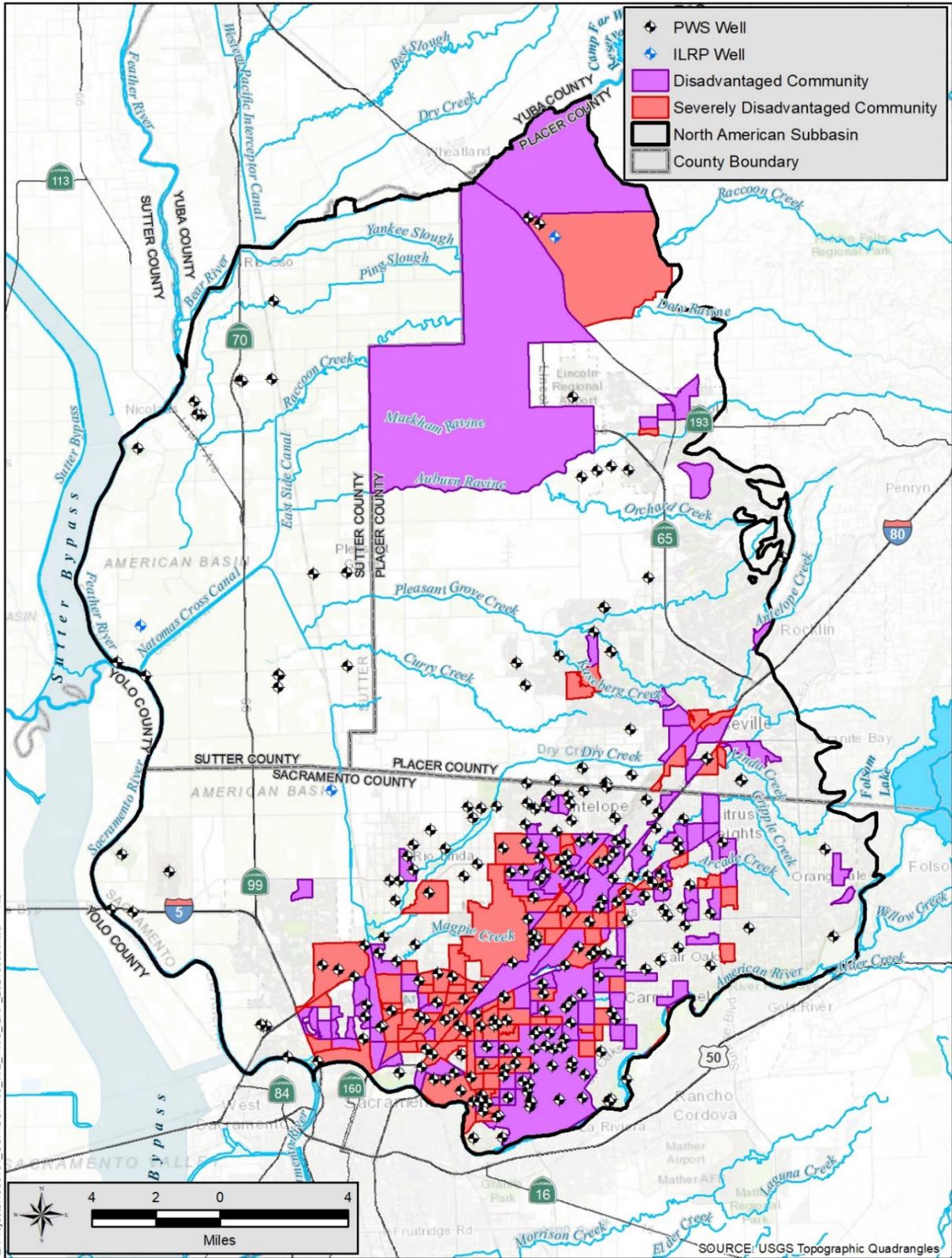


Figure 7-11. Deep Aquifer Groundwater Quality Representative Monitoring Network

7.7.3 Groundwater Quality Monitoring Frequency

The water quality monitoring frequency will vary based on the type of well. DDW requires monitoring of community PWS wells for Title 22 requirements (such as organic and inorganic compounds, metals, microbial, and radiological analytes). Salinity (TDS) is typically required to only be monitored once every 3 years. Nitrate sampling frequency varies from monthly to annually. For small community water systems, the frequency and the list of analytes is typically different than community PWS wells. The sampling schedule varies by PWS and well and does not occur in all wells in a single year.

ILRP wells are monitored on an annual basis, typically in the fall of each year. Well LW-1 is part of a water quality compliance program and is sampled in the fall of each year.

Shallow aquifer monitoring wells are planned to be sampled once every 2 years, in the fall. The frequency of monitoring is provided in **Table 7-5**.

7.7.4 Groundwater Quality Monitoring Spatial Density

DWR's Monitoring Networks and Identification of Data Gaps BMP identifies different sources and calculations for establishing water quality monitoring network densities (DWR, 2016a). A specific density of water quality monitoring wells per 100 square miles was not provided by DWR, but methods are available to assess an adequate density by performing a water quality needs assessment. The Groundwater Assessment Reports prepared for the ILRP and subsequent Water Quality Trends Monitoring Programs designated one monitoring well in the Subbasin, or one well per 535 square miles.

As demonstrate in **Table 7-4**, the 17 designated shallow representative monitoring wells has a density of about three wells per 100 square miles. As demonstrated on Figure 7-10, the monitoring wells are located specifically near areas with high densities of domestic wells and for distribution across the Subbasin and therefore is sufficient to assess trends for water quality degradation.

This GSP is proposing to use 247 PWS representative monitoring wells, or about 70 wells per 100 square miles, for monitoring the deeper portion of the aquifer. This is higher than the density recommended for groundwater level monitoring well densities. The water quality well density for the deeper portions of the aquifer in the Subbasin, is sufficient to assess trends for water quality degradation.

7.7.5 Data Gaps

At this time there is abundant water quality data through DDW, IRLP, and other regulatory compliance programs to assess water quality in the shallow and deeper portions of the aquifer and along with the sentry wells to detect movement of poorer quality water in the Subbasin. Construction details will be acquired for well 132 in the near future using a video survey. There are no data gaps for the water quality monitoring network.

7.8 Land Subsidence

The subsidence monitoring network will consist of using groundwater levels as a proxy for the rate of land subsidence. **Section 5.10, Land Subsidence** provided hydrographs in comparison to benchmark surveys and an extensometer. A historical analysis showed about 0.01 foot of subsidence per foot of groundwater level decline occurred between 1950s and 1970s during the development of the pumping depression beneath the central portion of the Subbasin. Benchmark surveys that include the period during the 2012 to 2016 drought did not detect subsidence exceeding the instrumentation accuracy.

7.8.1 Land Subsidence Monitoring Network

Subsidence has been monitored using benchmarks established by DWR in 2007. The benchmark network is shown on **Figure 7-12** along with the difference in elevations (in feet) from 2007 to 2018.

DWR constructed the Sutter extensometer (SUT-Ext) and nested monitoring wells (SUT-P1 through SUT-P4) in the western area of the Subbasin and is shown on **Figure 7-12**. DWR is also using satellite-based data (InSAR) to assess subsidence throughout the Central Valley.

The Subbasin has a network of groundwater level monitoring wells that can be used as a proxy to subsidence rates, as listed in **Table 7-1** and shown on **Figure 7-1**.

7.8.2 Representative Monitoring Locations

The subsidence representative monitoring network will consist of using groundwater levels as a proxy to limit the potential for subsidence. Groundwater levels will be made on a monthly basis and provide greater assurance in a timely manner that land subsidence will not create undesirable results. The rate of land subsidence will be tracked at an existing extensometer (SUT-Ext) which is located near nested representative monitoring wells (SUT-P1 through SUT-P4).

Criteria used to select representative monitoring wells were selected based on their proximity to:

- Major transportation infrastructure (highways and freeways)
- Sacramento Metropolitan International Airport

- Levees near rivers
- The existing groundwater depression
- Proximity to the SUT-Ext extensometer

Twelve representative monitoring wells were selected to monitor groundwater levels to be used to avoid the undesirable result of land subsidence associated with groundwater pumping. **Figure 7-13** shows the representative monitoring well locations, infrastructure and the pumping depression (a groundwater surface topographic map). **Tables 7-3** and **7-6** lists the representative groundwater level monitoring wells to be used to assess subsidence. **Table 7-6** lists their purpose and relation to major infrastructure in the area. All wells other wells are positioned to assess the potential for deepening or expansion of the pumping depression and increasing the potential for subsidence.

Table 7-6. Land Subsidence Representative Monitoring Wells

| Map No. | CASGEM ID | Local Name | Latitude | Longitude | Screened Interval (ft bgs) | Total Depth (ft bgs) | Well Type | Near Infrastructure | Frequency of Monitoring |
|---------|--------------------|------------------|----------|------------|----------------------------|----------------------|-----------|---------------------|-------------------------|
| 4 | 385947N1213985W001 | MW12A | 38.59472 | -121.39847 | 200-280 | 285 | O | B80 | Monthly |
| 17 | 388593N1214885W003 | AB-2 shallow | 38.8593 | -121.4885 | 135-145 | 155 | O | | Continuous |
| 22 | 386782N1215943W002 | AB-4 middle-deep | 38.6782 | -121.5943 | 795-805 | 815 | O | SIA, I5, L | Continuous |
| 24 | 386836N1214536W001 | SGA_MW02 | 38.68362 | -121.45363 | 100-110 | 110 | O | | Monthly |
| 27 | 386864N1215222W003 | AB-3 shallow | 38.6864 | -121.5222 | 190-210 | 220 | O | Hwy 99, L | Continuous |
| 28 | 386964N1213120W001 | Twin Creeks Park | 38.6964 | -121.31203 | 183-193 | 193 | O | I80 | Monthly |
| 37 | 388260N1215394W001 | SUT-P4 | 38.826 | -121.5394 | 880-890 | 890 | O | Hwy 70, L | Continuous |
| 49 | 387786N1213737W002 | WPMW-1B | 38.7786 | -121.3737 | 460-480 | 480 | O | | Monthly |
| 71 | 386280N1213493W001 | WCMSS | 38.62799 | -121.34925 | 130-150 | 170 | O | I80 | Monthly |
| 90 | 388026N1214432W004 | WPMW-12B | 38.80264 | -121.44322 | 508-528 | 550 | O | | Monthly |
| 91 | 388882N1214005W002 | WPMW-11A | 38.88816 | -121.40046 | 132-152 | 162 | O | | Monthly |
| 109 | 387218N1214677W001 | SGA_MW01 | 38.72178 | -121.46771 | 100-110 | 110 | O | | Monthly |

Notes: O = monitoring well
 B80 = Business 80
 SIA = Sacramento International Airport
 I5 = Interstate 5
 I80 = Interstate 80
 Hwy 99 = Highway 99
 Hwy 70 = Highway 70
 L = Levees

The GSAs intend to use these representative monitoring wells in the Subbasin to track the potential for subsidence. Should groundwater levels indicate levels have gone below the historical lows, the GSAs would then implement land surveys of the nearest surrounding benchmarks as shown on **Figure 7-12**.

The GSAs will review annual satellite-based (InSAR) subsidence results when it is made available. This program is currently funded by DWR. Subsidence will also be tracked on a semi-annual basis at the SUT-Ext and compare the subsidence to SUT-P4. Its location is shown on **Figure 7-12**.

7.8.3 Land Subsidence Monitoring Frequency

Groundwater levels in the representative monitoring wells will be made either on a monthly or daily basis. Continuous measuring stations will be downloaded in the Spring and Fall of each year. The groundwater levels will be plotted annually with benchmark survey results or from other sources to assess subsidence.

7.8.4 Land Subsidence Monitoring Spatial Density

Figure 7-13 provides the distribution of the 12 representative groundwater level monitoring wells. The density of the stations is 2 wells per 100 square miles.

A groundwater level well monitoring density goal ranges from 0.2 to 10 wells per 100 square miles (DWR, 2016a). The monitoring well density goals can also be based on the amount of groundwater use. For basins were groundwater pumping more than 10,000 AFY per 100 square miles, four wells per 100 square miles is recommended. Professional judgement will be essential to determining an adequate level of monitoring cones of depression, significant recharge areas, and specific projects. Based on professional judgement the subsidence network has sufficient density.

7.8.5 Data Gaps

At this time there are no data gaps. As necessary, the subsidence monitoring network may be adjusted.

7.9 Surface Water Depletion

Temporal changes in river flows volumes from gaging stations cannot be used to assess surface water depletion due to the relatively small volumes of groundwater gains and losses in comparison to the volume of water in the rivers. The uncertainty in the accuracy of the volume increases due to the complex nature of merging rivers, ungagged small tributaries, wastewater discharges, and tail water return.

As described and illustrated in **Section 5.11 – Interconnected Surface Water**, groundwater levels in monitoring wells in the aquifer near rivers and creeks correlate to changes in elevations of surface water at river gages. Increasing the depth to groundwater will increase groundwater gradient away from the rivers and increase the amount of surface water depletions. Therefore, use of groundwater levels and gradients as a proxy for surface water depletion is appropriate.

As describe in **Section 5.3 – Historic Groundwater Levels**, groundwater levels near the rivers have been stable along the Bear, Feather and Sacramento rivers since the early 1900s. Changes have occurred in the groundwater levels along the American River and portions of the Sacramento River near its confluence with the American River indicating surface water depletion along these portions increased between 1950 and 1990. Since 1990, levels have stabilized and risen reducing the depletion.

7.9.1 Monitoring Network

The Subbasin has monitoring wells placed near river and creek stage gages to assess if the groundwater gradient changes outside of its historic range, indicating greater surface water depletion. The monitoring wells have a short period of record due to most wells being recently constructed. **Figure 7-1** shows the locations of the monitoring wells.

7.9.2 Surface Water Representative Monitoring Locations

Twenty-four shallow monitoring wells are located along the American, Bear, Feather and Sacramento rivers and various creeks and also near surface water gages to track surface water/groundwater interaction in the Subbasin. All wells have construction details. Eighteen wells are less than 80 feet while the other six wells are deeper but still reflect the unconfined aquifer conditions in the Subbasin. **Table 7-3** provides the well construction details and attributes. **Figure 7-14** shows the surface water depletion monitoring wells which in most cases are paired with river or creek gaging stations. At all gage and monitoring well locations, except Bear River Near Wheatland (BRW) gage, observations of water surface/groundwater elevations

trend closely during high flow/stage events in the rivers, demonstrating a hydrologic connection between the groundwater in the shallow portion of the aquifer and surface water. The wells are suitable for monitoring surface water depletion.

Table 7-7 lists the river stage gages that will be used as part of the representative monitoring network, the type and frequency of the measurements, responsible monitoring agency along with the associated monitoring wells. **Table 7-8** list the wells that can be used to assess gradients from the surface water and also those wells where only levels will be used to assess surface water depletion.

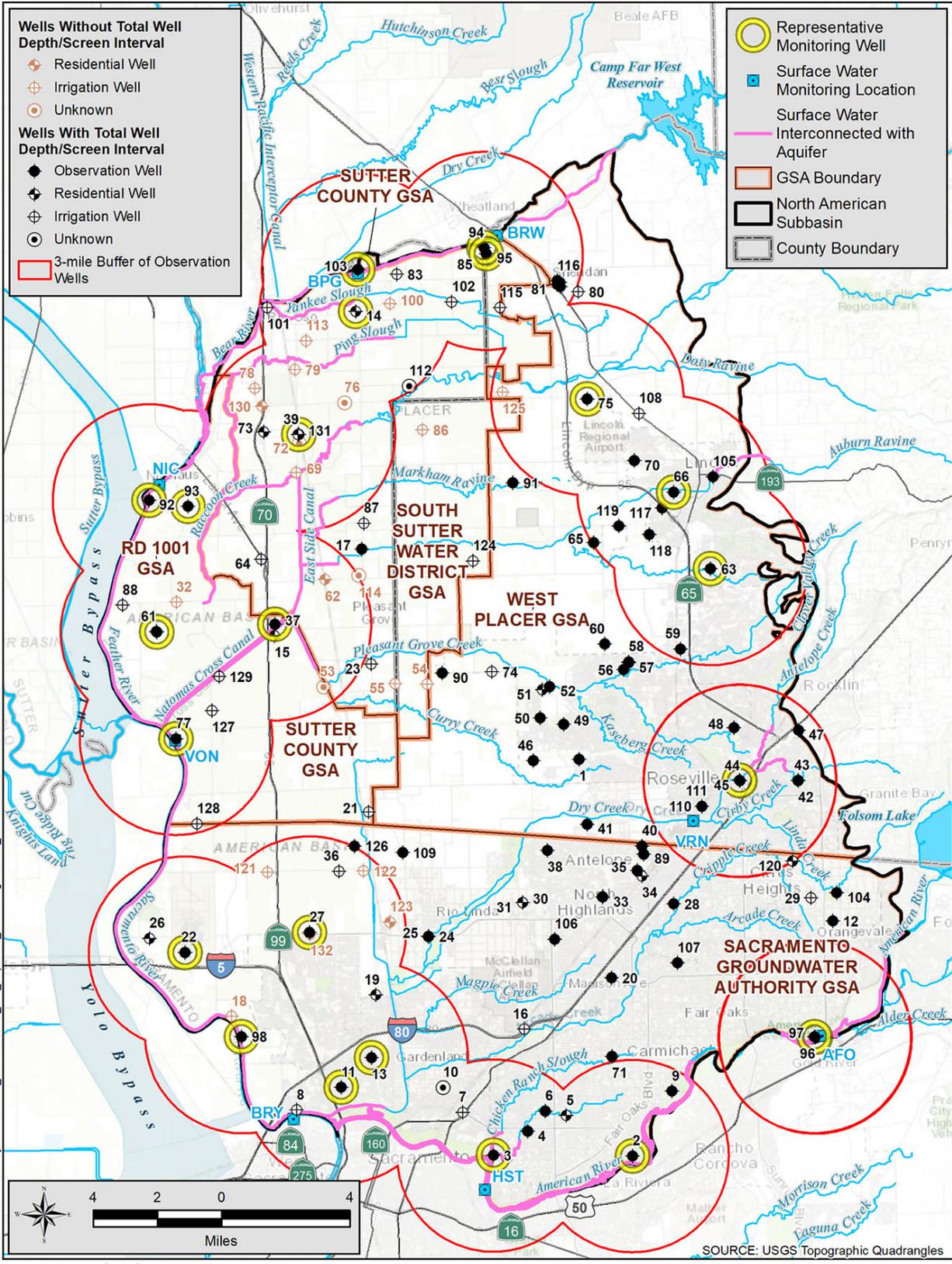


Figure 7-14 Surface Water Depletion Monitoring Network

Table 7-7. Surface Water Gaging Stations

| Abbreviation | Name | Operating Agency | Type | Frequency of Measurements | Associated Representative Monitoring Wells (Map No.) |
|---------------------|--|---|---|----------------------------------|---|
| AFO | American River at Fair Oaks | USGS | River Stage (feet [ft]), Flow River Discharge (cubic feet per second [cfs]) | 15 minutes | 96, 97 |
| HST | American River at H Street Bridge | CA Dept of Water Resources/Operations and Maintenance | River Stage (ft) | Hourly | 3 |
| BPG | Bear River at Pleasant Grove Road | CA Dept of Water Resources/North Region Office | River Stage (ft), Flow River Discharge (cfs) | Hourly | 103 |
| BRY | Sacramento River at Bryce Maintenance Yard | CA Dept of Water Resources/North Region Office | River Stage (ft) | Hourly | 98, 99 |
| VRN | Dry Creek @ Vernon St. | City of Roseville | River Stage (ft) | Hourly | 44, 45 |
| NIC | Feather River at Nicolaus | CA Dept of Water Resources/Flood Management | River Stage (ft) | Hourly | 92, 93 |
| BRW | Bear River Near Wheatland | USGS and DWR | River Stage (ft), Flow River Discharge (cfs) | 15 minutes | 94, 95 |
| VON | Sacramento River at Verona | DWR & USGS | River Stage (ft), Flow River Discharge (cfs) | Hourly | 77 |

Table 7-8. Paired Monitoring Wells and Gages for Gradients

| Map No. or Gage Name | CASGEM ID | Local Name | Latitude | Longitude | River or Creek |
|---------------------------------|--------------------|---------------------------|----------|-----------|-------------------|
| Gradient Wells and Gages | | | | | |
| AFO | | | 38.63546 | -121.228 | Am |
| 96 | | 1516 | 38.63487 | -121.232 | Am |
| 97 | | 1518 | 38.63513 | -121.232 | Am |
| BRY | | Sacramento River At BRYTE | 38.602 | -121.533 | Sac |
| 11 | 386160N1215054W001 | Bannon Creek Park | 38.61603 | -121.505 | Am |
| 13 | 386292N1214877W001 | Chuckwagon Park | 38.62921 | -121.488 | Am |
| BPG | | | 38.9841 | -121.488 | Br |
| 103 | 389857N1214880W004 | BR-1A | 38.9857 | -121.488 | Br |
| 14 | 389669N1214897W001 | 13N04E23A002M | 38.9669 | -121.49 | Br |
| BRW | | | 38.99993 | -121.407 | Br |
| 94 | 389950N1214148W002 | RDMW-103 | 38.99461 | -121.415 | Br |
| 95 | 389919N1214141W002 | RDMW-104 | 38.99195 | -121.414 | Br |
| NIC | | | 38.88984 | -121.605 | Fr |
| 61 | 388235N1216079W001 | Sutter County MW-5A | 38.82324 | -121.608 | Fr |
| 37 | 388260N1215394W004 | SUT-P1 | 38.826 | -121.539 | Fr |
| NIC | | | 38.88984 | -121.605 | Fr |
| 92 | | RDMW-101 | 38.88294 | -121.611 | Fr |
| 93 | | RDMW-102 | 38.87987 | -121.589 | Fr |
| VON | | | 38.77416 | -121.598 | Sac |
| 77 | | SREL-1-27-F1 | 38.77491 | -121.598 | Sac |
| 22 | 386782N1215943W004 | AB-4 shallow | 38.6782 | -121.594 | Sac |
| 27 | 386864N1215222W003 | AB-3 shallow | 38.6864 | -121.522 | Sac |
| VRN | | | 38.734 | -121.301 | Dry |
| 44 | 387515N1212725W001 | WPMW-10A | 38.75149 | -121.273 | Dry |
| 45 | 387517N1212727W001 | WPMW-9A | 38.75167 | -121.273 | Dry |
| Groundwater Levels Only | | | | | |
| 2 | 385828N1213385W001 | SGA_MW06 | 38.58281 | -121.338 | Am |
| 3 | 385841N1214185W001 | SGA_MW04 | 38.58414 | -121.419 | Am |
| 63 | 388476N1212872W001 | WPMW-3A | 38.84761 | -121.287 | Or |
| 66 | 388826N1213078W002 | MW 5-2 | 38.88258 | -121.308 | Ab |
| 75 | 389255N1213566W003 | MW 2-3 | 38.92547 | -121.357 | Ra |
| 98 | | URS71000-700+00C | 38.6397 | -121.562 | Sac |
| 105 | 388893N1212847W001 | MW 4 | 38.88928 | -121.285 | Ab |

Notes: Ab = Auburn Ravine
Am = American River
Br = Bear River
Dry = Dry Creek

Fr = Feather River
Or = Orchard Creek
Ra = Raccoon Creek
Sac = Sacramento River

7.9.3 Monitoring Frequency

The stage in the rivers and creeks are monitored on a minimum of 15-minute intervals. The measurements are reported either to the CDEC) database or to the city of Roseville, where the measurements are archived.

Groundwater levels in the monitoring wells are being monitored with transducers that obtain measurements at the same frequency of measurements as the gaging stations, but no less than once every 15 minutes. Groundwater levels will be measured, using water level sounders twice per year, in the Spring (March) and Fall (October) of each year to confirm the accuracy of the transducers. **Table 7-3** provides the frequency of measurements (designated as continuous because they are outfitted with transducers) in groundwater monitoring wells which will correspond with the frequency of measurements at the surface water gaging stations listed in **Table 7-7**.

The frequency of the groundwater measurements may be reduced to daily after further assessment of the data.

7.10 Groundwater Well Monitoring Spatial Density

No specific density of monitoring well spatial density guidance has been provided by DWR for wells associated with surface water depletion. Using a radius of 3-miles (*see* **Figure 7-14**) which is equal to about five wells per 100 square miles illustrates the Subbasin has sufficient density along the rivers.

7.10.1 Data Gaps

Two monitoring wells noted under **Section 7.4.6** as gaps for chronic lowering of groundwater levels would improve the surface water monitoring network.

7.11 Monitoring Protocols

The following technical protocols provide guidance based upon existing professional standards and are commonly adopted in various groundwater-related programs. The protocols provide clear techniques to yield quality data for use in the various components of this GSP. The following monitoring protocol were developed using DWR's Best Management Practices for Monitoring Protocols, Standards and Sites (DWR, 2016b) with additions from other existing programs.

7.11.1 Groundwater Levels

The following monitoring protocols were developed for the CASGEM monitoring programs by the GSAs and will be used to measure groundwater levels in the monitoring wells using a water level sounder or pressure transducers.

7.11.1.1 Water Level Sounders

Groundwater level measurements must be collected with consistency and with sufficient additional data that those who use the data understand its usefulness and limitations. Field notes which document the data collection are therefore required.

To assure that the same well is being measured each time, the monitoring entity will create a Well Identification Sheet, which will be used to track the monitoring at each well site. The following information will be recorded on the Well Identification Sheet: well number, date of survey, latitude and longitude, reference point (RP) elevation and description, location description and map, well type and use, well completion type, and, if available, total depth, screened intervals, and well completion report number. A close-up photo of the well showing the access port for measuring groundwater levels and a photo of the well from a distance should be included for confirmation that the correct well is being monitored and that measurements are made consistently at the same locations.

The following data is collected on standard forms in the field to establish a dependable groundwater level measurement:

- Name of person collecting data and agency association
- Well name/identification
- Date and time of measurement
- Type of equipment used to measure the depth to water
- RP used at each well
- Nearby conditions which confirm (or not) that measurement is static water level and are noted by a Questionable Measurement Code
- Measurement from the RP to the water surface (RPWS)
- Weather and other conditions that may affect the ability to obtain a good measurement
- If a measurement cannot be made information is provided using a No Measurement Code (NM)

Additional steps are taken in the field to:

- Ensure the safety of staff collecting the data
- Ensure the integrity of the data collection process
- Maintain hygienic conditions in the wells
- Maintain good relations with property owners

Groundwater level measurements will be made using the following protocol (DWR, 2016b):

- Depth to groundwater will be measured from an established RP on the well casing. The RP will be identified with a permanent marker, paint spot, or a notch in the lip of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.
- The sampler will remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a pressure release is evident, the measurement will be delayed for a short period of time to allow the water level to equilibrate.
- Measurements of depth to groundwater and land surface will be measured and reported in feet to an accuracy of at least 0.01 feet and the method of measurement will be noted on the record (i.e., electric sounder, steel tape, acoustic sounder).
- The sampler will replace any well caps or plugs and lock any well buildings or covers after taking a measurement.
- The water level probe should be cleaned after measuring each well.
- All data will be entered into the North American Subbasin data management system (DMS) as soon as possible. Care will be taken to avoid data entry mistakes and the entries will be checked by a second person for accuracy.

By following these monitoring protocols, the GSAs ensure that its groundwater level measurements are appropriate for use in conjunction with other groundwater level data from other groundwater management entities. Monitoring protocols shall be reviewed at least every 5 years as part of the periodic evaluation and update of this Plan and modified as necessary.

7.11.1.2 Pressure Transducers

Groundwater levels may be measured using pressure transducers. When relying on pressure transducers and data loggers, manual measurements of groundwater levels will be taken during installation to synchronize the transducer system and, periodically (semi-annually), to ensure monitoring equipment does not allow a “drift” in the actual values.

The following protocols from DWR *Monitoring Protocols* BMP, 2016 will be followed when installing a pressure transducer in a monitoring well and during routine monitoring and downloads:

- The sampler will use an electronic sounder or chalked steel tape to measure the depth to groundwater level from the RP. The groundwater elevation will be calculated by subtracting the depth to groundwater from the RP elevation. These values will be used as references to synchronize the transducer system in the monitoring well.

- The sampler will record the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and other pertinent information in the log.
- The sampler will record whether the pressure transducer uses a vented or non-vented cable for barometric compensation. Vented cables are preferred, but non-vented cables are acceptable if the transducer data are properly corrected for natural fluctuations in barometric pressure, which requires commensurate logging of barometric pressures.
- Transducers will be able to record groundwater levels with an accuracy of at least 0.1 feet. Various factors will be considered in the selection of the transducer system, including battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers.
- Follow manufacturer specifications for installation, calibration, battery life, correction procedure (for non-vented cables), and anticipated life expectancy to ensure optimal use of the equipment.
- Secure the cable to the wellhead with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker to allow estimates of future cable slippage.
- The transducer data will be checked periodically against hand-measured groundwater levels to monitor electronic drift or cable movement. This check will not occur during routine site visits, but at least annually.
- The data will be downloaded regularly to ensure data are not lost and entered into the DMS following the QA/QC program established for the GSP. Data from non-vented cables will be corrected for atmospheric barometric pressure changes, as appropriate. After ensuring the transducer data have been downloaded and stored in the DMS, the data will be deleted from the data logger to ensure that adequate data logger memory remains for future measurements.

7.11.2 Water Quality

Water quality samples will be collected from PWS, ILRP wells, shallow monitoring wells and sentry wells. The samples will be collected by various agencies.

All designated water quality monitoring wells are part of public water supply systems. The state of California requires that public water systems maintain a level of water quality monitoring that ensures the public is provided with a safe, reliable drinking water supply. Specifically, system operators must collect and analyze samples from their producing wells to determine the concentration of a broad range of constituents on a scheduled basis as detailed in Title 22 of the California Code of Regulations. The sampling events are carried out under detailed sampling plans which comply with state requirements. Wells are typically pumped for about 15 minutes prior to acquiring water quality samples to ensure the wells are adequately purged.

All public water system operators have been trained for water quality sampling to obtain certifications. PWS wells are required to be pumped for a minimum of 15 minutes prior to collection of samples, the samples are collected from dedicated sampling ports near the well head, the samples will be collected directly into laboratory prepared bottles, cooled to 4° degrees Celsius and then transported (shipped) to a state Environmental Laboratory Accreditation Program (ELAP) certified laboratory under standard chain of custody.

Water quality samples collected from selected ILRP wells will be performed using protocol described in their Water Quality Trends Monitoring Programs.

Water quality samples collected from dedicated monitoring wells will be collected using the following protocol obtained from DWR's Groundwater Monitoring Protocols, Standards, and Sites BMP, 2016 and as modified for the well types to be sampled:

- Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Each well has a unique identifier as contained in **Table 7-4** and will be used to record field measurements and on the sample bottles.
- Laboratory bottles labels will be filled out prior to collection of the samples. The labels are to include: the well name, sampler initials, date, and time of collection of the samples, preservative used, and the type of analysis to be performed.
- The groundwater elevation in the well will be measured prior to being purging of the wells using following appropriate protocols described above in the groundwater level measuring protocols.
- The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples. The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants.
- In the NASb most sentry wells are not equipped with sampling pumps and therefore a temporary sampling pump will be installed to purge the wells. The purge time will be calculated using the well construction details and the depth to water. Three well volumes will be purged prior to collection of a sample.
- While purging the wells: pH, temperature, and electrical conductivity (EC) will be monitored at select intervals using a calibrated multi-parameter meter and noted on the field groundwater sampling records.
- In the case of wells with dedicated pumps, samples will be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.

- All samples will be collected from the pump discharge or sampling port directly into laboratory prepared bottles, cooled to 4 degrees Celsius and then transported (shipped) to an ELAP certified laboratory under standard chain of custody.
- All analyses will be performed by a California State certified ELAP laboratory.

7.12 Data Reporting

All of the groundwater level measurements collected will either be reported to CASGEM and or stored in the DMS developed for the Subbasin. Water quality data will be reported to the GAMA database.

A DMS has been developed for the Subbasin that access publicly available data (DWR, CASGEM, GAMA, and USGS databases) and to store historic and future local data including water supply information. All data is recorded in standard units for water volumes and flow and depths and elevations (NAVD88). All measurement locations are geographic referenced.

The data will be analyzed and reported in annual reports and shared with Stakeholders. The data will be used to provide annual updates and to support revisions to the groundwater model.

7.13 Monitoring Network Improvements

An assessment of the existing monitoring network and representative monitoring wells shows the monitoring network is sufficient for assessment of the sustainability indicators.

Monitoring well network improvements, to be completed within the next 5-years, include:

- Two additional dedicated shallow monitoring wells are needed near high priority GDEs close to the Sacramento River (near the Sutter and Sacramento counties lines) and near the junction of the Bear and Feather rivers (along Ping Slough). Alternatively, surface water observation stations may be established along Ping Slough at road crossings as groundwater and surface water are interconnected in this area.
- Construct a new monitoring well near in the vicinity of monitoring well 112 to improve the monitoring network for chronic lowering of groundwater levels.

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