APPENDIX 3.E. CHOWCHILLA SUBBASIN INFRASTRUCTURE ASSESSMENT

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

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Technical Memorandum

Date: 05/03/2023
To: Chowchilla Subbasin GSAs
From: Davids Engineering, Inc.
Topic: Chowchilla Subbasin Infrastructure Assessment

1 Introduction

This Infrastructure Assessment (Assessment) is intended to document insights about the characteristics of critical infrastructure in the Chowchilla Subbasin, including its proximity, orientation, and relative vulnerability to adverse effects of land subsidence (referred to herein as “subsidence”). This information has been used by the Chowchilla Subbasin Groundwater Sustainability Agencies (GSAs) to design Sustainable Management Criteria (SMC) in the Chowchilla Subbasin, with the goal of protecting this critical infrastructure from Undesirable Results (URs) of groundwater conditions during implementation of the Chowchilla Subbasin Groundwater Sustainability Plan (GSP).

This Assessment first identifies the location and characteristics of critical infrastructure that must be considered when developing SMC in the Chowchilla Subbasin, and then identifies recent subsidence conditions in areas of the Chowchilla Subbasin that may create risks of adverse impacts to the beneficial uses and users of those critical infrastructure.

Critical infrastructure in the Chowchilla Subbasin that were considered in this Assessment include:

- Roads and highway infrastructure
- Railroad infrastructure
- Waterways and water conveyance infrastructure
- Groundwater wells, including agricultural wells, domestic wells, and public supply wells
- Wastewater infrastructure

The Assessment considers how communities in and around the Chowchilla Subbasin access and use critical infrastructure, how subsidence has or could affect those uses and users, and identifies areas where subsidence has recently occurred and where critical infrastructure may be vulnerable to URs from subsidence in the future.

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2 Overview of Critical Infrastructure in the Chowchilla Subbasin

This section provides a brief overview of critical infrastructure categories that were considered when establishing SMC in the Chowchilla Subbasin. The location of all critical infrastructure categories were considered with respect to the Chowchilla Subbasin boundaries, the GSAs' boundaries, and the City of Chowchilla (Figure 1). The City of Chowchilla is the only incorporated city in the Chowchilla Subbasin, and operates the primary municipal water and wastewater systems in the Chowchilla Subbasin. The orientation of all critical infrastructure categories were also considered with respect to the overall topography of the Chowchilla Subbasin (Figure 2), where the ground surface elevation slopes downward from northeast (highest elevation) to southwest (lowest elevation).

Each subsection generally summarizes what is encompassed in each critical infrastructure category, the general location and characteristics of that critical infrastructure (including its structure and orientation), and other core considerations for the beneficial uses and users of that infrastructure. Maps referenced in these subsections are provided at the end of the Assessment.

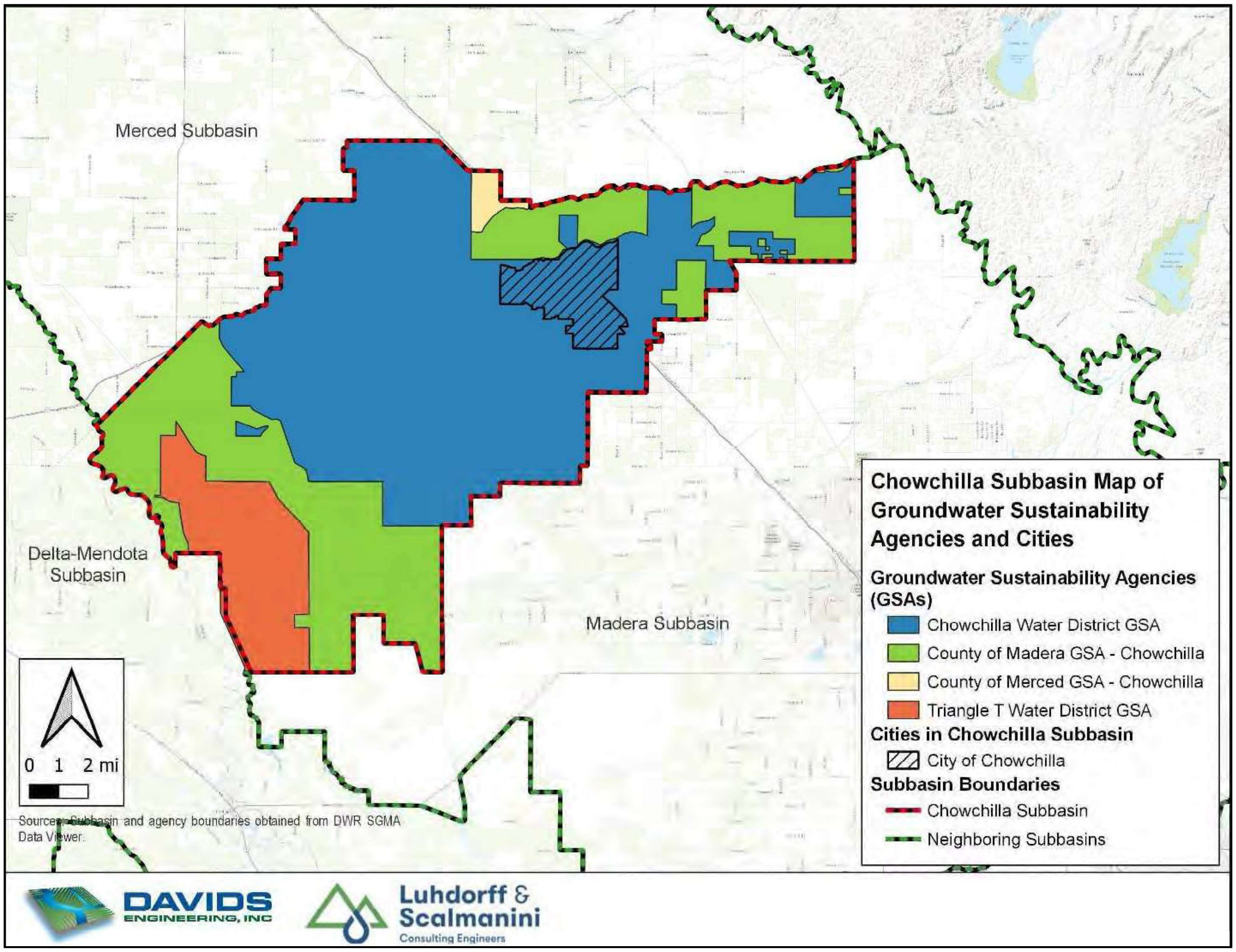

Figure 1. Map of Groundwater Sustainability Agencies and Cities in the Chowchilla Subbasin.

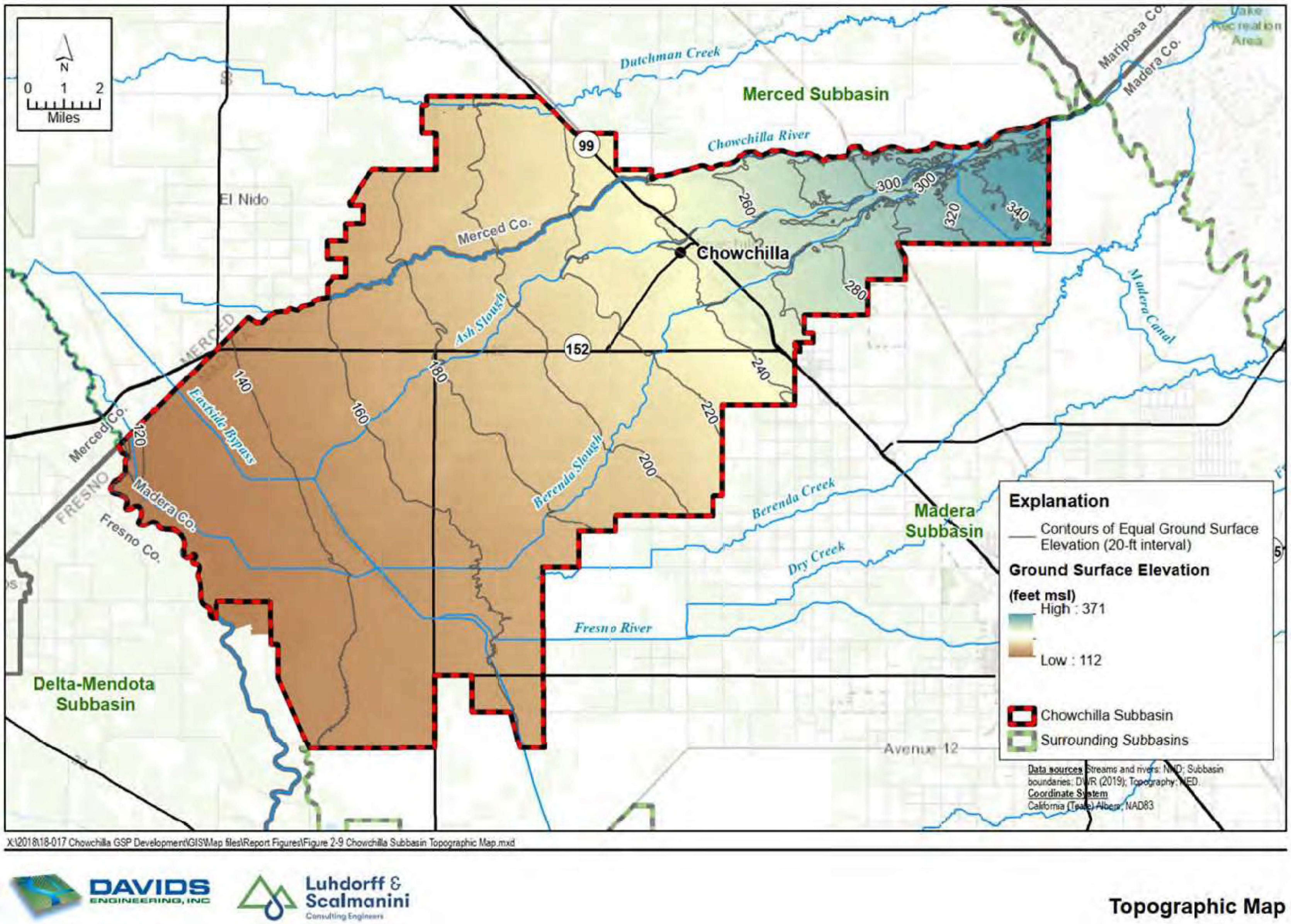

Figure 2. Chowchilla Subbasin Topographic Map (Source: Chowchilla Subbasin Revised GSP, Figure 2-9).

2.1 Roads and Highway Infrastructure

Road and highway infrastructure considered when setting SMC in the Chowchilla Subbasin primarily includes roadways and bridges within the boundaries of the Chowchilla Subbasin. Maintaining the integrity of highway infrastructure is important for securing transportation and freight corridors within and through the Chowchilla Subbasin.

Figure 3 shows the locations of major highways and highway bridges in the Chowchilla Subbasin, and Figure 4 shows the annual average daily traffic volumes on those major highways. The largest highway corridors in the Chowchilla Subbasin include California State Routes (SR) 99, 233, and 152. SR 99 crosses the eastern portion of the Chowchilla Subbasin, passing through the City of Chowchilla following a northwest-southeast path. SR 152 spans the Chowchilla Subbasin from east-west. SR 233 connects SR 99 and SR 152 along a northeast-southwest path. Other smaller, local roadways are generally located in the City of Chowchilla or traverse rural areas of the Chowchilla Subbasin.

According to data available from the California Department of Transportation (Caltrans), SR 99 features the majority of highway bridges in the Chowchilla Subbasin (13 of 20), and also experiences the majority of traffic (typically serving 40,000-60,000 vehicles per day, on average). The remaining highway bridges in the Chowchilla Subbasin are located on SR 152. Off of SR 99, traffic on SR 233 and SR 152 ranges from approximately 3,000-16,000 vehicles per day, on average, with higher volumes nearer to SR 99 and the eastern portion of the Chowchilla Subbasin.

2.2 Railroad Infrastructure

Railroad infrastructure was also considered in setting SMC in the Chowchilla Subbasin. Like highway infrastructure, maintaining the integrity of railroad infrastructure is important for securing transportation and freight corridors through the Chowchilla Subbasin. Figure 5 shows the location of railroad infrastructure in the Chowchilla Subbasin summarized from available Caltrans data. The Chowchilla Subbasin contains two railways: one through the City of Chowchilla, and one nearer to the eastern edge of the Chowchilla Subbasin. Both railways cross the eastern portion of the Chowchilla Subbasin following a northwest-southeast path.

2.3 Waterways and Water Conveyance Infrastructure

Waterways and water conveyance infrastructure considered when setting SMC in the Chowchilla Subbasin are shown in Figure 6. Maintaining the integrity of waterways and water conveyance infrastructure is important for flood protection, irrigation, recharge, and other beneficial uses and users of surface water in and around the Chowchilla Subbasin. More specific considerations for waterways and water conveyance infrastructure are described below.

2.3.1 General Flow Characteristics

Most waterways that flow into and through the Chowchilla Subbasin begin in upslope lands east and northeast of the Chowchilla Subbasin and flow downslope in a westerly or northwesterly direction. Besides the San Joaquin River, which flows along the western edge of the Subbasin, waterways in the Chowchilla Subbasin are considered intermittent or ephemeral streams, and have historically remained dry for at least several months each year.

Reaches of the Chowchilla River, Ash Slough, and Berenda Slough within the Chowchilla Subbasin are used primarily for conveyance of surface water (generally March-October when surface water supplies are available). Virtually all surface water flows on these three waterways originate from either Eastman Reservoir releases at Buchanan Dam or from Millerton Reservoir releases at Friant Dam that are delivered to Chowchilla Water District via the Madera Canal. These waterways are typically dry during the non-irrigation season except during storm runoff events and during periods when flood releases occur from the upstream reservoirs.

Inflows to the Chowchilla Subbasin on the Fresno River generally originate from Hensley Lake releases at Hidden Dam and Madera Canal deliveries to Madera Irrigation District, much of which first passes through the Madera Irrigation District conveyance system before reentering the Fresno River upstream of the Chowchilla Subbasin. The Fresno River is also typically dry during the non-irrigation season except during storm runoff events and during periods when flood releases occur from the upstream reservoirs.

Inflows to the Chowchilla Subbasin on the Chowchilla/Eastside Bypass[1] mainly originate from the San Joaquin River at the Chowchilla Bypass Bifurcation Structure (bifurcation structure). The majority of flows on the Chowchilla/Eastside Bypass have historically occurred during wet water years, approximately one in three years during the 1989-2014 historical water budget period (see the Chowchilla Subbasin Revised GSP Section 2.2.3, "Surface Water Available for Groundwater Recharge"). The Chowchilla/Eastside Bypass is mainly operated as a flood bypass channel for the San Joaquin River.

Flows on the San Joaquin River along the boundary of the Chowchilla Subbasin originate from various upstream sources, including Millerton Reservoir releases at Friant Dam. Streamgage data from the United States Geological Survey (USGS)[2] shows flows along the San Joaquin River during most times of year, with greater flows typically occurring during spring months of wet water years.

2.3.2 Waterways within the Purview of the Central Valley Flood Protection Board

Core considerations for waterways within the purview of the Central Valley Flood Protection Board (CVFPB) are the freeboard and design profile, as defined in the corresponding Federal and State Operation and Maintenance Manuals (O&M Manuals).

[1] The bypass channel is generally referred to as the Chowchilla Bypass downstream of the San Joaquin River until either the Fresno River or Ash Slough. Further downstream in the Chowchilla Subbasin, the bypass channel is referred to as the Eastside Bypass.

[2] USGS 11251000 SAN JOAQUIN R BL FRIANT CA. https://waterdata.usgs.gov/nwis/uv?site_no=11251000.

In their comments to the Chowchilla Subbasin GSAs, the CVFPB noted that any reduction in the freeboard or change to design profile, beyond the design criteria given in the O&M Manuals, may lead to increased flood risk and damage to Federal-State flood control facilities, and is considered unlawful for waterways in their purview.

The GSAs have recognized and considered the following design criteria of waterway reaches in the Chowchilla Subbasin when establishing the SMC for the Chowchilla Subbasin:

- Ash Slough, Berenda Slough, and Fresno River:
    - Bank levees freeboard of 3 feet
    - Design flows of 5,000 cfs, 2,000 cfs, and 5,000 cfs, respectively
- Chowchilla Bypass:
    - Bank levees freeboard of 4 feet
    - Design flows of 12,000 cfs from Ash Slough to Berenda Slough, and 10,000 cfs from Berenda Slough to Fresno River
- Eastside Bypass:
    - Bank levees freeboard of 4 feet
    - Design flow of 17,500 cfs

2.4 Groundwater Wells

Groundwater well infrastructure in the Chowchilla Subbasin encompasses the infrastructure of multiple types of wells, including agricultural wells, domestic wells, and public supply wells. Sustaining access to groundwater is crucial to upholding the Human Right to Water (as set forth in California Water Code § 106.3) and is also important to maintaining the economic vitality of the Chowchilla Subbasin.

Figure 7 through Figure 9 show the general locations of groundwater wells of each type (agricultural, domestic, and public supply), aggregated by section from Well Completion Report (WCR) data available from the California Department of Water Resources (DWR). WCR data includes only wells with well completion reports that have been submitted to DWR since 1970, and thus typically underestimates the total number of wells in each section. However, the data is expected to provide a reasonably accurate understanding of the relative location and distribution of wells in the Chowchilla Subbasin. Agricultural wells are the most uniformly distributed across the entire Chowchilla Subbasin, while domestic wells and public supply wells are distributed most densely in the eastern portion of the Subbasin, especially in sections surrounding the City of Chowchilla. Agricultural wells in the Chowchilla Subbasin are typically deeper than domestic and public supply wells (see the Chowchilla Subbasin Revised GSP Figures 2-43 through 2-45).

2.5 Wastewater Infrastructure

Wastewater infrastructure in the Chowchilla Subbasin primarily includes the gravity flow wastewater system operated within the City of Chowchilla. The City of Chowchilla service area is indicated in Figure 1. Like other municipal infrastructure, maintaining the integrity of wastewater infrastructure is important to maintaining sanitary conditions in urban communities. The importance of functional wastewater infrastructure is closely tied to the Human Right to Water.

3 Relationship between Subsidence Conditions and Infrastructure Concerns

This section summarizes the potential URs to critical infrastructure that may result from subsidence, and then evaluates the relationship between recent historical subsidence that has occurred in the Chowchilla Subbasin and the potential vulnerability of critical infrastructure in the Chowchilla Subbasin. Maps referenced in these subsections are provided at the end of the Assessment. **It is noted that the GSAs have set the subsidence minimum thresholds (MTs) and measurable objectives (MOs) at 0 feet/year in 2040 (see Sections 3.2.3 and 3.3.3 of the Revised GSP). Subsidence conditions in 2040 and thereafter are not expected to trigger undesirable results for any critical infrastructure or other land beneficial uses and users.**

Figure 3 through Figure 9 show the location of critical infrastructure and the historical cumulative subsidence between 2015-2020 in the Chowchilla Subbasin. These figures show cumulative subsidence conditions (reported as total vertical displacement from InSAR[3] data) starting with the first available InSAR data (June 2015) and extending through the beginning of GSP implementation in the Chowchilla Subbasin in January 2020. Figure 10 through Figure 16 similarly show the location of critical infrastructure and the historical cumulative subsidence between 2015-2022 in the Chowchilla Subbasin, extending the summary of subsidence conditions through the most recently available InSAR data available at the time of this analysis (through January 2022). The subsections below summarize relevant findings of each figure, in addition to other pertinent findings from other studies and surveys of subsidence impacts in the Chowchilla Subbasin.

3.1 Roads and Highway Infrastructure

In general, subsidence has the potential to cause URs to users of road and highway infrastructure by causing deterioration or loss of access and use of that infrastructure through fractures, unevenness, or other issues with structural integrity.

There is currently no known subsidence-related issue that has resulted in loss of access and use of road and highway infrastructure in the Chowchilla Subbasin. As shown in Figure 3, Figure 4, Figure 10, and Figure 11, SR 99 – the roadway with the greatest number of bridges and the highest volume of traffic in the Chowchilla Subbasin – is located in the eastern portion of the Chowchilla Subbasin where subsidence rates have generally been lowest, with less than 1.5 feet of total cumulative subsidence from 2015-2020 (less than approximately 0.3 feet per year over approximately five years). Along SR 152 and SR 233, the total cumulative subsidence from 2015-2020 was less than approximately 2.0 feet (approximately 0.4 feet per year over approximately five years) in most areas. As described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, the GSAs are working to mitigate subsidence in the Chowchilla Subbasin and do not expect residual subsidence conditions to cause URs to beneficial uses and users of roads and highway infrastructure. However, the GSAs will continue to monitor conditions and will adapt GSP

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[3] Interferometric Synthetic Aperture Radar (InSAR) data provides measurements of vertical ground surface displacement, and is available from the California Department of Water Resources (DWR) beginning in June 2015. https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence.

implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

3.2 Railroad Infrastructure

Similar to roads and highways, subsidence has the potential to cause URs to users of railroads by causing deterioration or loss of access and use of railways and related infrastructure through fractures, unevenness, or other issues with structural integrity.

There is currently no known subsidence-related issue that has resulted in loss of access and use of railroad infrastructure in the Chowchilla Subbasin. As shown in Figure 5 and Figure 12, railroads in the Chowchilla Subbasin are located in the eastern portion of the Chowchilla Subbasin where the cumulative subsidence from 2015-2020 was between 0.0 to 1.5 feet (approximately 0.0 to 0.3 feet per year over approximately five years). As described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, the GSAs are working to mitigate subsidence in the Chowchilla Subbasin and do not expect residual subsidence conditions to cause URs to beneficial uses and users of railroad infrastructure. However, the GSAs will continue to monitor conditions and will adapt GSP implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

3.3 Waterways and Conveyance Infrastructure

Subsidence in the Chowchilla Subbasin has the potential to cause URs to users of waterways and conveyance infrastructure by potentially causing changes in the design profile and slope of gravity flow channels, affecting freeboard and channel capacity. Changes that reduce capacity can impact the ability of surface water suppliers to use those conveyance channels to meet demands. Changes that reduce capacity and diminish freeboard can also cause flooding along waterways during times of peak flow. The GSAs considered potential impacts to waterways in the Chowchilla Subbasin resulting from subsidence in relation to the channel design criteria described in the respective O&M Manuals, including the channel freeboard and design profile.

3.3.1 East-West Oriented Waterways

As shown in Figure 6 and Figure 13, the majority of waterways in the Chowchilla Subbasin flow from east to west, in the same general direction as the cumulative “subsidence gradient” that has historically occurred in the Chowchilla Subbasin. Along these “east-west” oriented waterways – including the Chowchilla River, Ash Slough, Berenda Slough, and the Fresno River – higher subsidence rates in the western portion of the Chowchilla Subbasin have increased the existing slope of the ground surface (Figure 2), functionally increasing the capacity of those channels. Thus, despite there being significant rates of subsidence in the western portion of the Chowchilla Subbasin where these waterways flow – as much as 3.0 feet in some areas between 2015-2020 and as much as 4.0 feet in some areas between 2015-2022 (approximately 0.6 feet per year) – the GSAs do not anticipate that subsidence conditions will cause URs to beneficial uses and users of these east-west oriented waterways in the Chowchilla Subbasin in the near future.

For subsidence to substantially impact the freeboard and design profile of those east-west oriented waterways in opposition to the O&M Manuals, subsidence rates in the eastern portion of the Chowchilla Subbasin would need to significantly increase relative to the western portion of the Chowchilla Subbasin and reduce the existing ground surface slope. Considering historical subsidence conditions and differences in the underlying geologic structure of the Chowchilla Subbasin from east-to-west, the GSAs consider URs to beneficial uses and users of the east-west oriented waterways to be highly unlikely. Nevertheless, as described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, the GSAs are working to mitigate subsidence in the Chowchilla Subbasin, particularly the Western Management Area. The GSAs have also established SMC for subsidence in the Eastern Management Area (also described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP), which are expected to preclude significant future subsidence in the eastern portion of the Chowchilla Subbasin that would substantially impact the freeboard and design profile of those east-west oriented waterways. The GSAs will continue to monitor conditions and will adapt GSP implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

3.3.2 Other Conveyance Infrastructure

Besides those east-west oriented waterways that are used primarily for conveyance (Chowchilla River, Ash Slough, Berenda Slough), other conveyance infrastructure in the Chowchilla Subbasin that was evaluated includes the Madera Canal and canals operated within the Chowchilla Water District.

The Madera Canal flows along the far eastern portion of the Chowchilla Subbasin where the cumulative subsidence from 2015-2022 remained less than 0.5 feet in total (less than 0.1 feet per year). There is currently no known subsidence-related issue with capacity or flows along Madera Canal in the Chowchilla Subbasin, and the GSAs consider any future URs to the Madera Canal to be highly unlikely in light of recent historical subsidence rates.

Canals operated within the Chowchilla Water District have experienced varying levels of subsidence, although – like the Chowchilla River, Ash Slough, and Berenda Slough, where the canal inflows originate – the canals generally flow by gravity from east-to-west. There is currently no known subsidence-related issue with capacity or flows along those canals, and the GSAs consider any future URs to the canals to be highly unlikely for the same reasons given in Section 3.3.1, above. Nevertheless, as described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, the GSAs are working to mitigate subsidence in the Chowchilla Subbasin, particularly the Western Management Area. The GSAs will continue to monitor conditions and will adapt GSP implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

3.3.3 Chowchilla/Eastside Bypass and San Joaquin River

During development of the Chowchilla Subbasin GSP and during preparation of the Revised GSP, the GSAs reviewed past analyses of subsidence-related capacity concerns conducted by DWR in May 2018 for the San Joaquin River Restoration Program (SJRRP). These analyses are documented in a report titled "Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River" (DWR, 2018). The analyses were conducted to evaluate the subsidence-related impacts to the flow capacity of the Chowchilla/Eastside Bypass and the San Joaquin River under recent historical subsidence conditions (as of 2016) and projected future subsidence conditions through 2026. Flows under the different subsidence-related topography changes were simulated using HEC-RAS with consideration for the channel design criteria in the O&M Manuals (Section 2.3.2, above).

Table 3 of the analysis (shown in Table 1, below) summarizes the estimated flow capacity in the San Joaquin River Reach 4A (which flows along the boundaries of the Chowchilla Subbasin) and in the Chowchilla/Eastside Bypass, assuming a fixed freeboard set according to the design criteria in the O&M Manuals. The extent of each reach considered in the analysis is shown in Figure 17, below. These analyses found that:

- Flow capacity in all reaches of the Chowchilla/Eastside Bypass from the bifurcation structure to Ash Slough were within design flows in all historical and projected scenarios considered.
- Flow capacity in the San Joaquin River Reach 4A and in the Eastside Bypass from Ash Slough to Sand Slough were already considered to be below the design capacity beginning in the scenario considering historical subsidence conditions as of 2016.

These findings suggest that:

- The design profile and freeboard of the Chowchilla/Eastside Bypass in reaches upstream of Ash Slough (the southwestern portion of Chowchilla Subbasin) were not adversely impacted by subsidence conditions as of 2016, and were not anticipated to be impacted by future subsidence through 2026 (under the assumptions given below).
- The design profile and freeboard of the San Joaquin River Reach 4A and the Eastside Bypass from Ash Slough to Sand Slough were already impaired relative to the design criteria given in the O&M Manuals as of 2016. These impairments precede the formation of the GSAs, the GSP implementation period, and the GSAs' efforts to achieve sustainable management of the Chowchilla Subbasin.

The GSAs do recognize certain assumptions and limitations given for these analyses (DWR, 2018), mainly:

- Flows were modeled using HEC-RAS, and were validated by flows in 2017 (assuming that those flows were close to design flows). Flow capacities were evaluated for two conditions: a run-of-the-river condition in which there were no concurrent tributary flows, and a backwater condition in which there were concurrent flows in tributary channels that added to downstream flows. Tributary flows to the Chowchilla/Eastside Bypass from Ash Slough, Berenda Slough, and other waterways were assumed to concurrently reach their design flows (per the O&M Manuals) in backwater model scenarios. The GSAs cannot be sure of the validity of the model or these assumptions.
- Projected future subsidence rates through 2026 were estimated using the average annual subsidence rates reported by the United States Bureau of Reclamation from

2011 to 2017. Subsidence rates, especially those during the 2012-2016 drought, are now understood to overestimate the actual rates observed from InSAR data in 2017-2020 in the Western Management Area of the Chowchilla Subbasin. As described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, certain landowners in the Western Management Area entered into a Subsidence Measures Control Agreement in 2017 and have since made significant progress to reduce subsidence rates by reducing pumping from the Lower Aquifer. Those efforts have resulted in significantly reduced subsidence rates in the vicinity of the Chowchilla/Eastside Bypass and the San Joaquin River, as compared to rates prior to 2017.

- The conclusions of DWR’s study are planning-level modeled estimates that do not consider factors besides subsidence (e.g., sediment transport). Sediment deposition is another factor that affects capacity, although sediment management and maintenance of the Chowchilla/Eastside Bypass and the San Joaquin River is not the responsibility of the GSAs.

Considering these findings, the GSAs in the Chowchilla Subbasin do not expect that subsidence conditions during the early GSP implementation period will impair the design profile or freeboard of the Chowchilla/Eastside Bypass or San Joaquin River in the Chowchilla Subbasin beyond what conditions were already present prior to 2016. As described in Section 3.3.3 and Chapter 4 of the Chowchilla Subbasin Revised GSP, the GSAs are diligently working to mitigate subsidence in the Chowchilla Subbasin, particularly the Western Management Area, and have planned to implement several recharge projects in the near future (prior to 2030) that will help to mitigate subsidence to prevent any future URs from occurring. The GSAs will continue to monitor conditions and will adapt GSP implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

3.4 Groundwater Wells

In general, subsidence has the potential to cause URs to users of groundwater well infrastructure by causing deterioration or loss of access and use of that infrastructure through casing damage, collapse, or other issues with structural integrity. These potential issues are also affected or exacerbated by other factors besides subsidence, such as well age, construction, and materials.

As shown in Figure 7 and Figure 14, agricultural wells are generally distributed evenly throughout the Chowchilla Subbasin, in areas where both higher and lower rates of subsidence have occurred. A survey of agricultural well owners in the Chowchilla Water District found that wells in the western portion of the Chowchilla Subbasin were beginning to collapse, particularly in areas that have experienced approximately 3 feet of subsidence or more. However, agricultural well owners also indicated that these effects and the costs of well deepening and replacement were considered a necessary side effect of maintaining the economic viability of their businesses during the current drought and early GSP implementation efforts, while projects and management actions – including demand management – ramp up. Those agricultural well owners surveyed did not consider these effects to be "undesirable results." Nevertheless, as described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, the GSAs are working to mitigate subsidence in the Chowchilla Subbasin. The GSAs will continue to monitor conditions and engage with stakeholders, and will adapt GSP implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

As shown in Figure 8, Figure 9, Figure 15, and Figure 16, domestic wells and public supply wells in the Chowchilla Subbasin are distributed most densely in the eastern portion of the Chowchilla Subbasin, especially in sections surrounding the City of Chowchilla. While these areas of the Chowchilla Subbasin have historically experienced lower rates of subsidence, domestic wells in various parts of the Chowchilla Subbasin have already experienced URs from loss of access to groundwater. SMC and GSP implementation efforts were designed to address these issues, preserve the Human Right to Water, and balance the conflicting desires of stakeholders in the Chowchilla Subbasin, as described in Section 3.3.1 of the Chowchilla Subbasin Revised GSP.

Discussions and stakeholder input during public GSP development meetings indicated a clear desire to balance the water supply needs of all beneficial uses and users of groundwater to the greatest extent practicable. Stakeholders expressed clear intent to protect domestic well users that rely on groundwater, but also expressed a desire to protect the local agricultural economy – the economic lifeblood of the region – while GSP implementation ramps up. The GSAs considered many groundwater management approaches to achieve these goals of balancing diverse beneficial user interests. The minimum thresholds (MTs) established for groundwater levels in the Subbasin reflect the outcome of this balanced approach, allowing groundwater use for agricultural production to continue, albeit at a gradually reducing rate, while GSP implementation ramps up, and recognizing that this would likely result in lowered groundwater levels impacting some domestic, agricultural, and public water supply well users in the Chowchilla Subbasin. This approach was considered preferable to alternatives that would require immediate and substantial cutbacks in agricultural groundwater pumping in order to avoid significant and unreasonable adverse impacts on well users, especially domestic wells. Such an alternative would result in major economic impacts to the local communities and all stakeholders in the Subbasin, including domestic well users and disadvantaged communities. The GSAs evaluated the economic tradeoffs of these alternatives (Appendix 3.C of the Chowchilla Subbasin Revised GSP), and determined that the avoided costs (fewer domestic wells requiring replacement) resulting from immediate demand reduction would be comparatively small ($4.6 million) relative to the additional lost agricultural net return ($122.9 million) in the Chowchilla Subbasin, even after accounting for pumping cost savings ($82.5 million). These analyses considered the impacts of immediate demand reduction only on agricultural net return, but in reality the economic impacts would spread to other county businesses and industries, significantly increasing the net effect on all beneficial uses and users of groundwater in the Chowchilla Subbasin, including domestic well owners.

With these findings, the GSAs determined that implementing a Domestic Well Mitigation Program would provide the best and most economically reasonable outcome for beneficial uses and users of groundwater in the Subbasin by preserving the local economy and protecting domestic well users' access to groundwater. For this reason, the GSAs have elected to mitigate for potential impacts to domestic well users during the implementation period or until groundwater sustainability is achieved. Implementation of the Domestic Well Mitigation Program will allow the GSAs to establish lower MTs that avoid URs to other groundwater users, while still preserving access to critical water supplies for domestic well users.

The GSAs have expressed and formalized their clear commitment to fund and implement the Program beginning no later than January 1, 2023. GSA staff and representatives have already made substantial and material progress toward Program development and implementation by creating and executing a Domestic Well Mitigation Program Memorandum of Understanding (MOU).

3.5 Wastewater Infrastructure

Subsidence has the potential to cause URs to users of wastewater infrastructure by causing deterioration or loss of functionality of the gravity flow characteristics of those systems and by causing other issues with structural integrity.

There is currently no known subsidence-related issue that has resulted in loss of functionality of wastewater infrastructure in the Chowchilla Subbasin. The cumulative subsidence in the City of Chowchilla service area (Figure 1) was approximately 3.0 feet or less between 2015-2022 (approximately 0.4 feet per year or less over approximately seven years). As described in Section 3.3.3 of the Chowchilla Subbasin Revised GSP, the GSAs are working to mitigate subsidence in the Chowchilla Subbasin and do not expect residual subsidence conditions to cause URs to beneficial uses and users of wastewater infrastructure. However, the GSAs will continue to monitor conditions and will adapt GSP implementation if URs are found to occur. Future findings and adaptations to GSP implementation will be described in Annual Reports, as applicable.

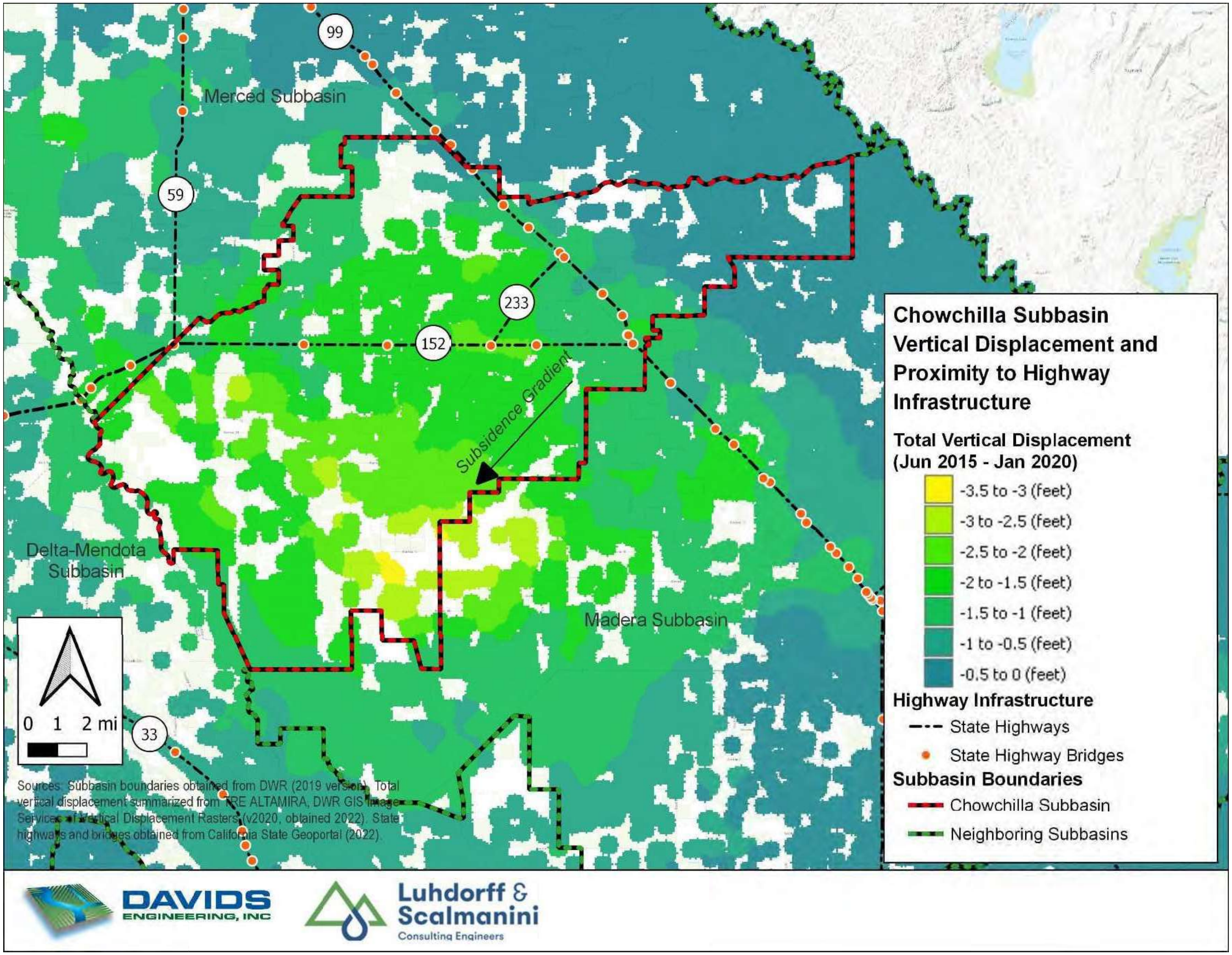

Figure 3. Vertical Displacement (June 2015 - January 2020) and Proximity to Highway Infrastructure.

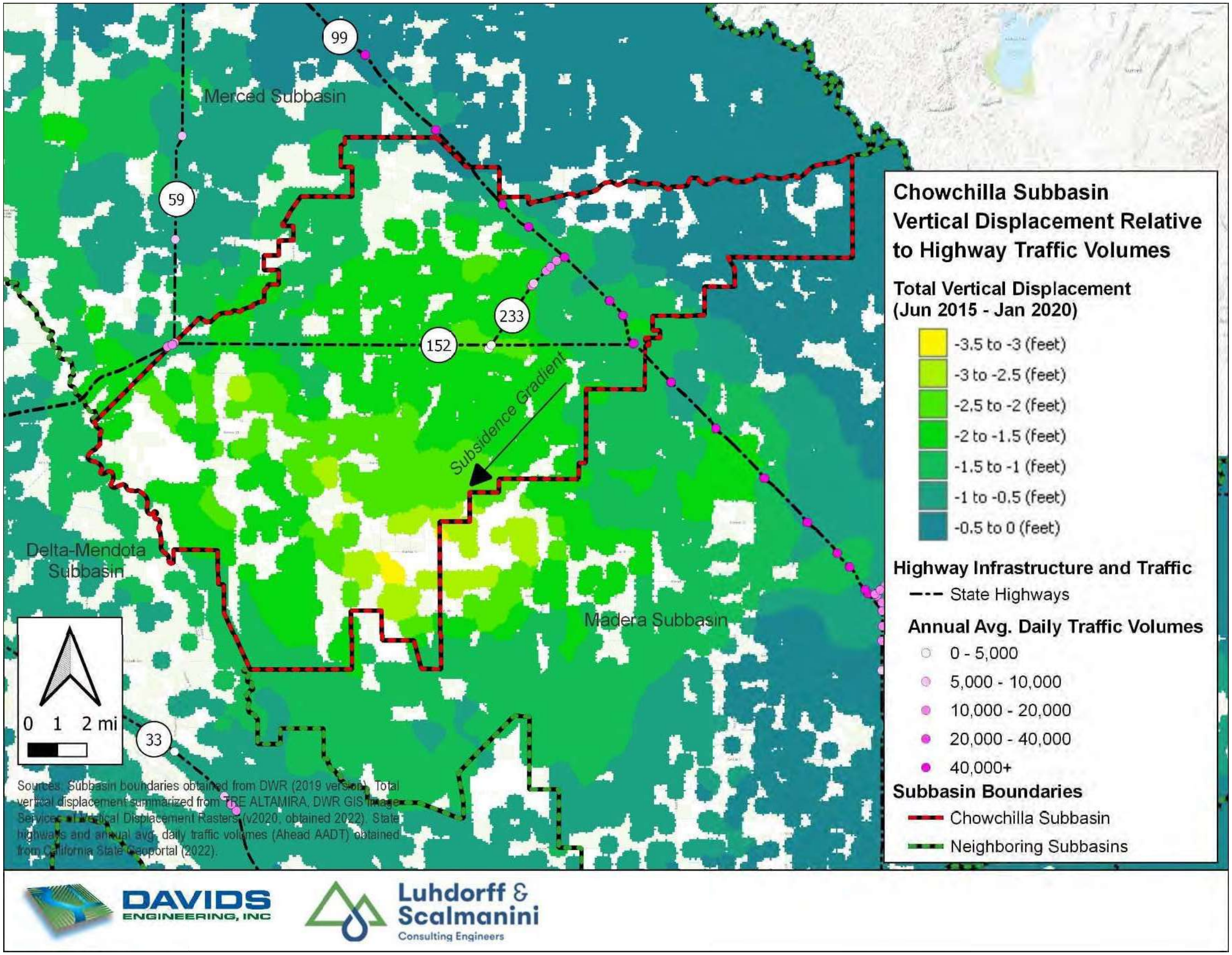

Figure 4. Vertical Displacement (June 2015 - January 2020) Relative to Highway Traffic Volumes.

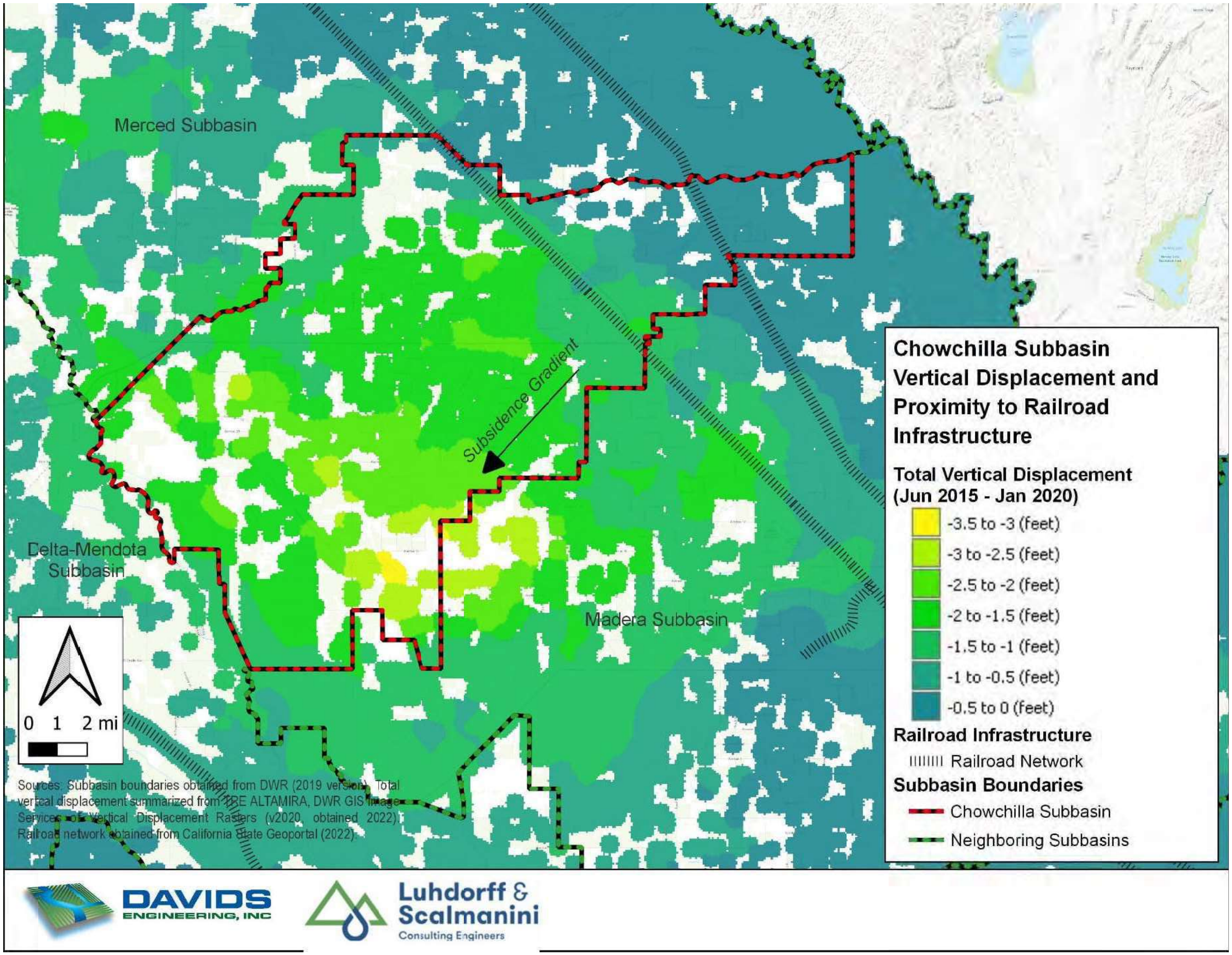

Figure 5. Vertical Displacement (June 2015 - January 2020) and Proximity to Railroad Infrastructure.

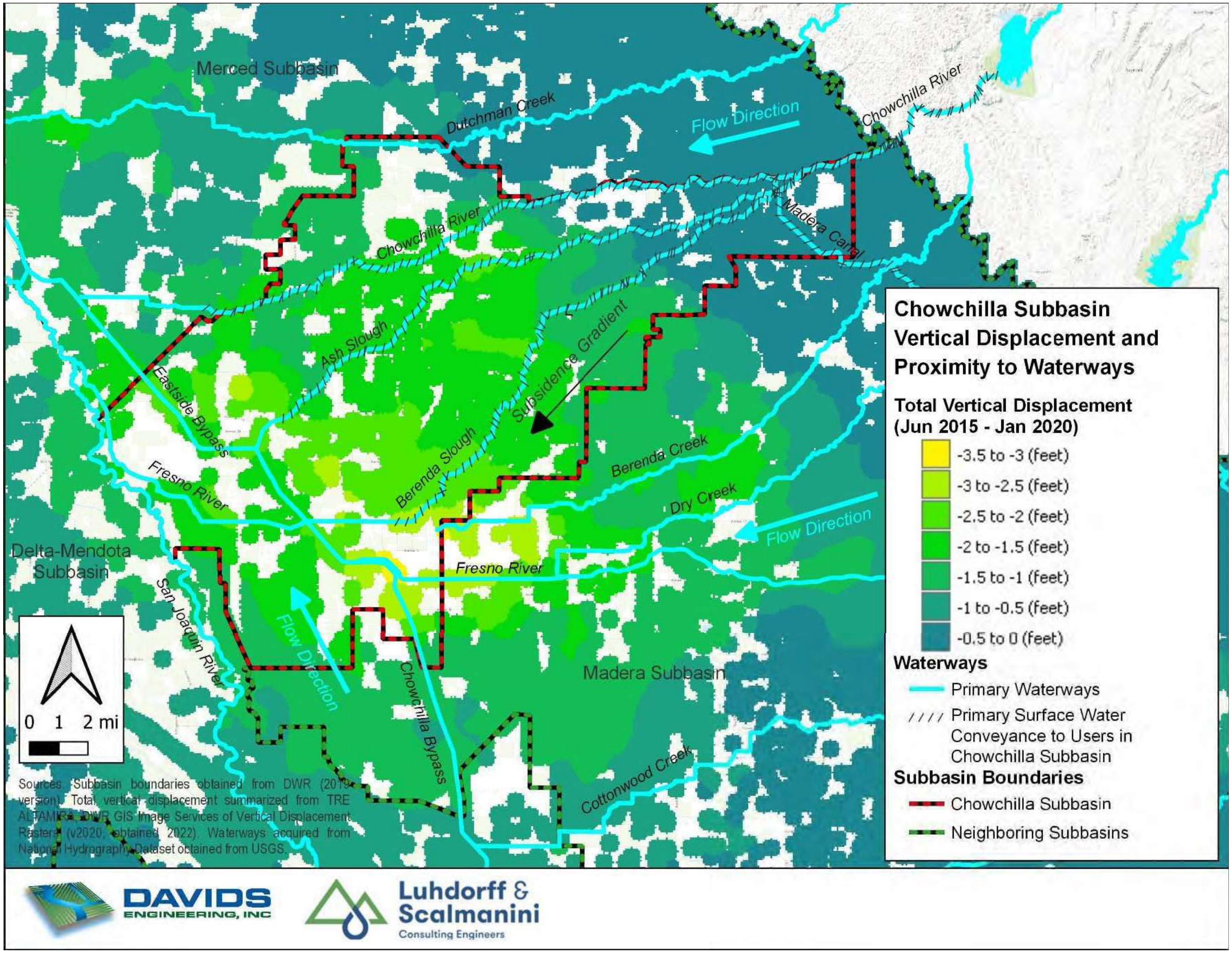

Figure 6. Vertical Displacement (June 2015 - January 2020) and Proximity to Waterways and Water Conveyance Infrastructure.

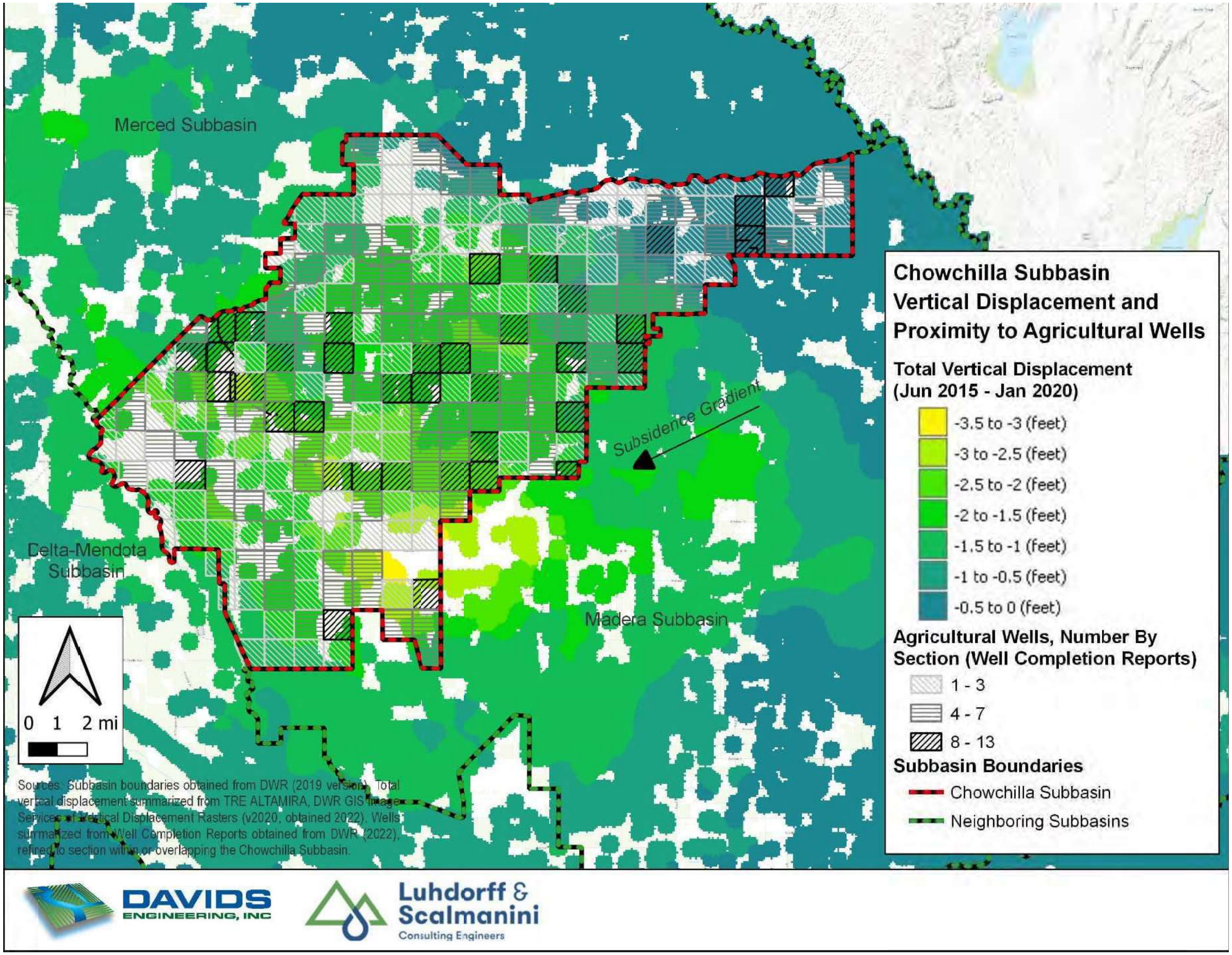

Figure 7. Vertical Displacement (June 2015 - January 2020) and Proximity to Agricultural Wells.

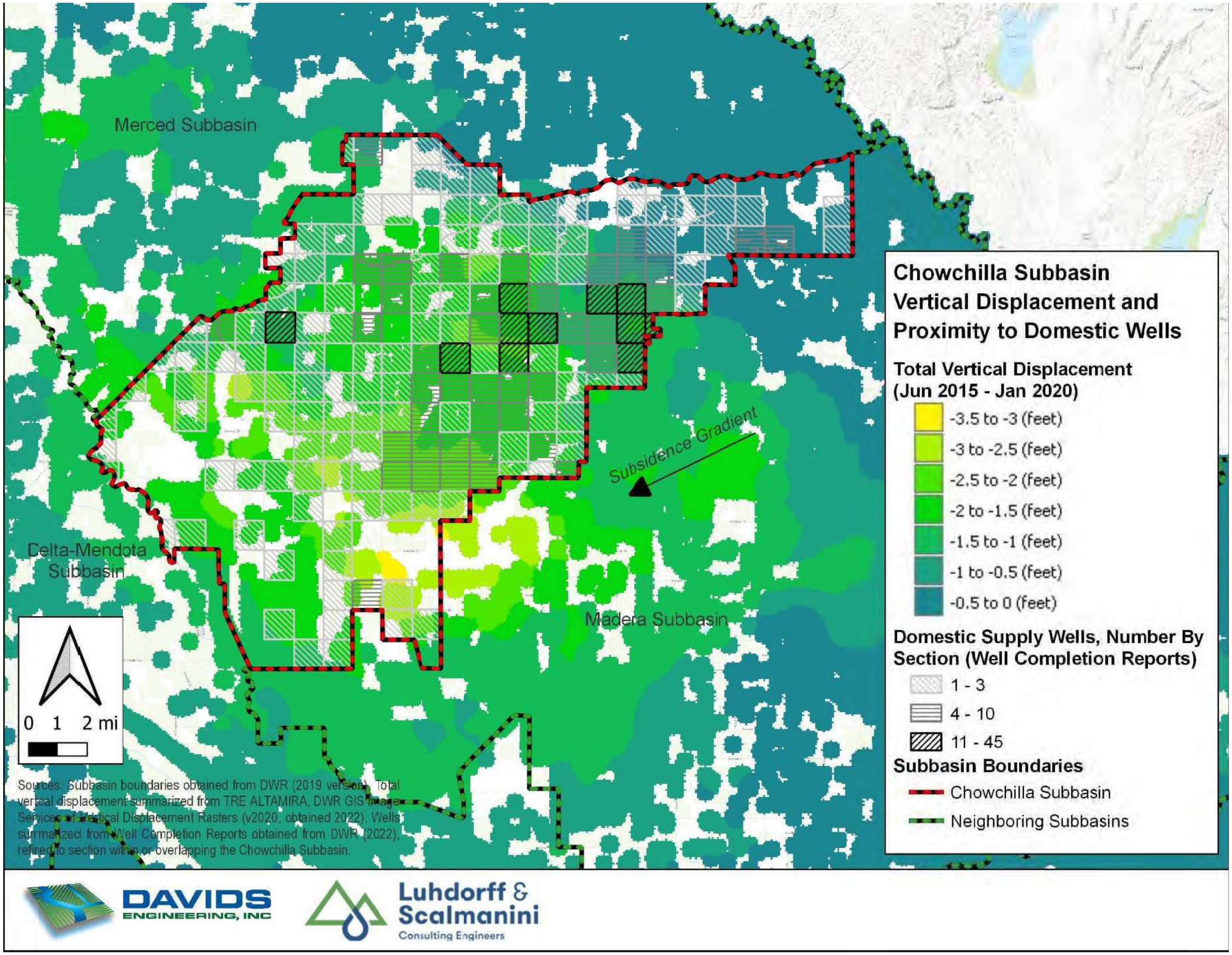

Figure 8. Vertical Displacement (June 2015 - January 2020) and Proximity to Domestic Wells.

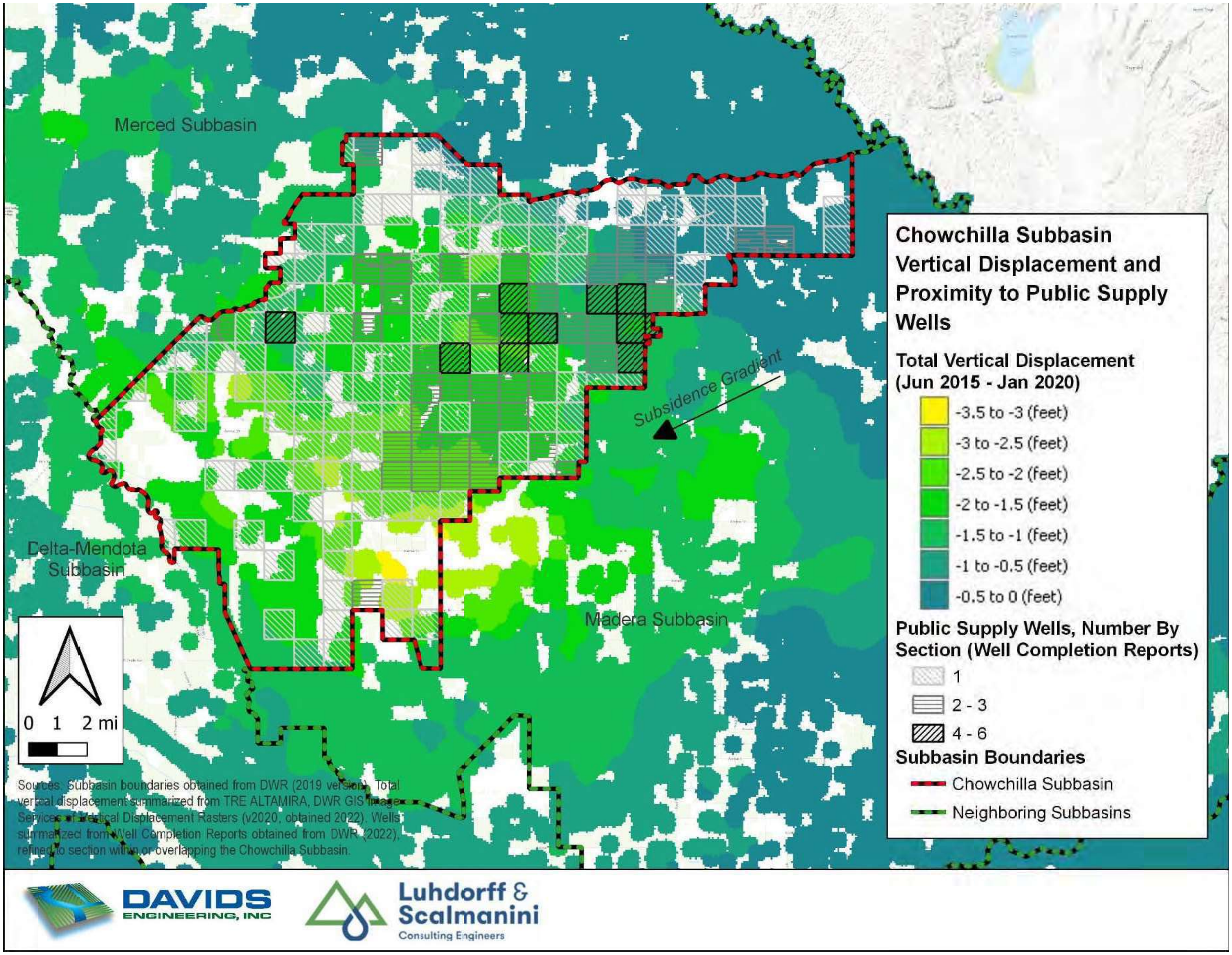

Figure 9. Vertical Displacement (June 2015 - January 2020) and Proximity to Public Supply Wells.

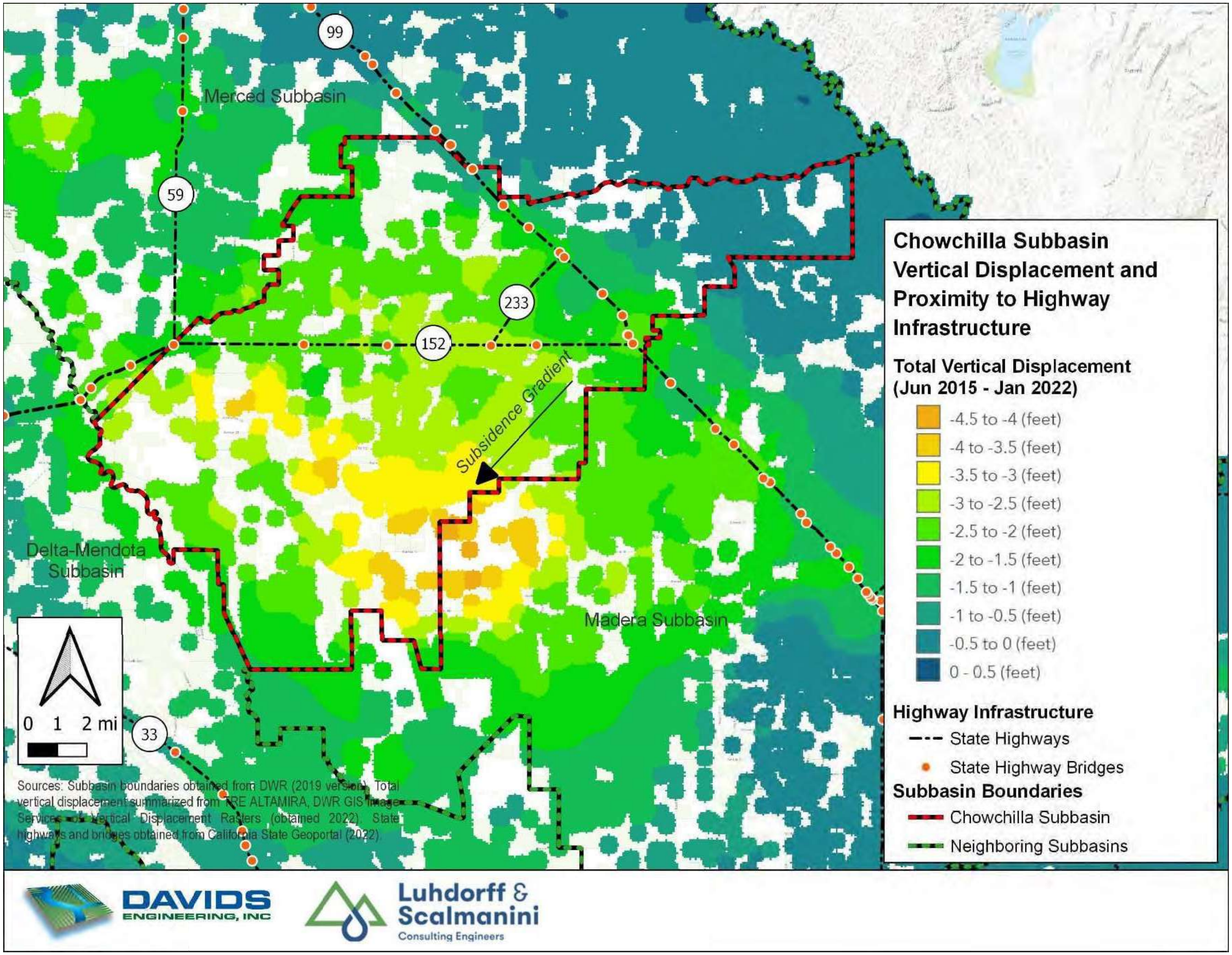

Figure 10. Vertical Displacement (June 2015 - January 2022) and Proximity to Highway Infrastructure.

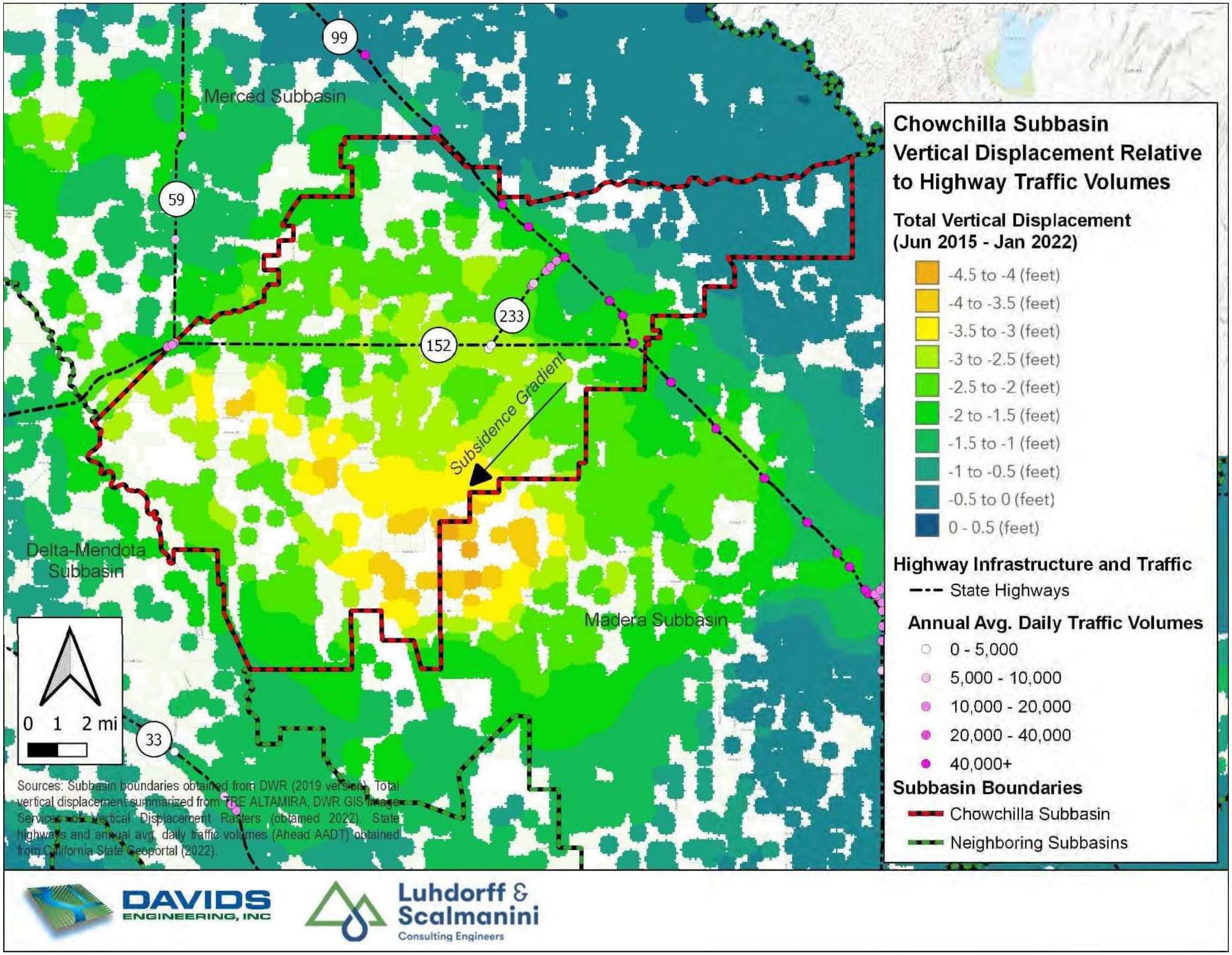

Figure 11. Vertical Displacement (June 2015 - January 2022) Relative to Highway Traffic Volumes.

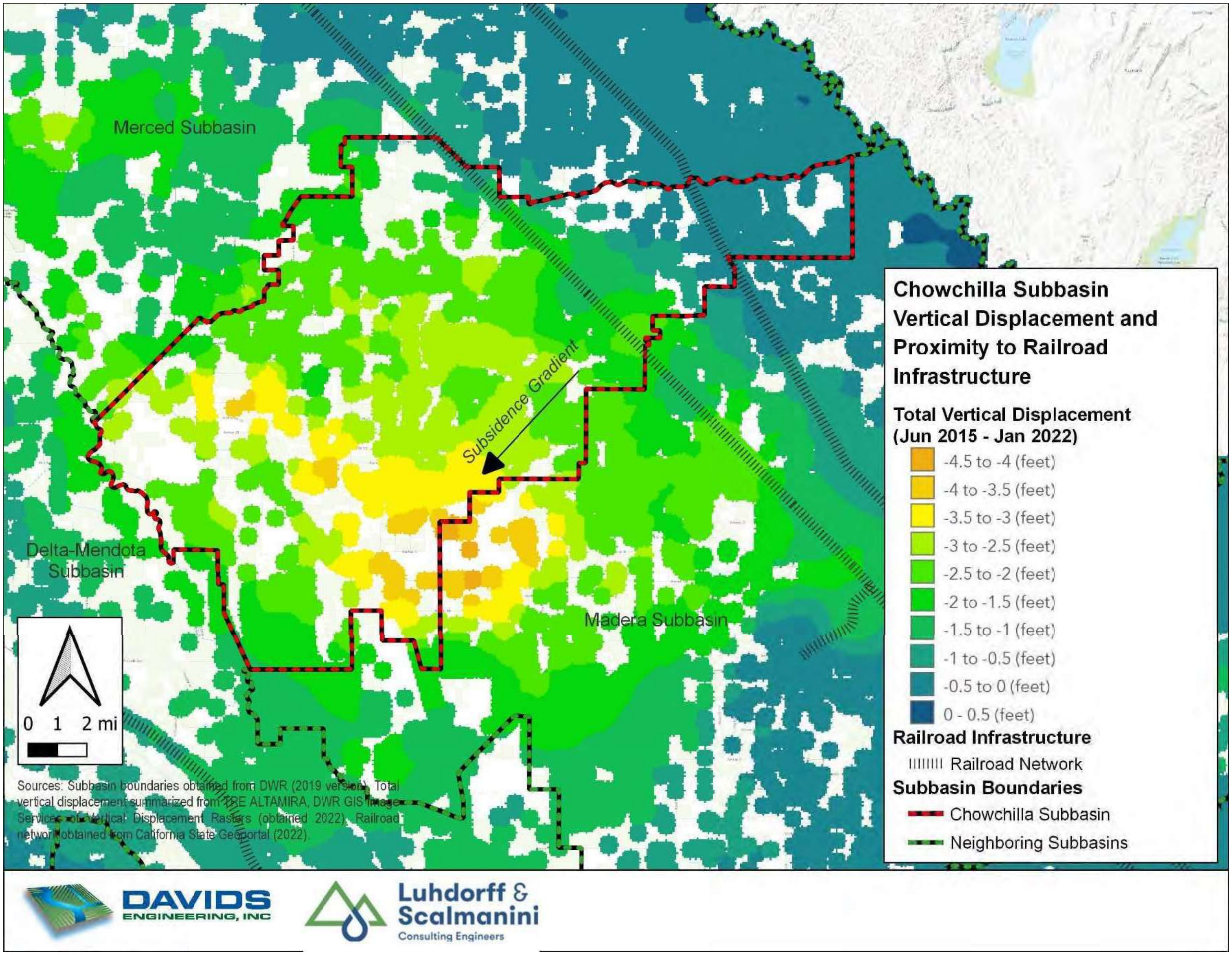

Figure 12. Vertical Displacement (June 2015 - January 2022) and Proximity to Railroad Infrastructure.

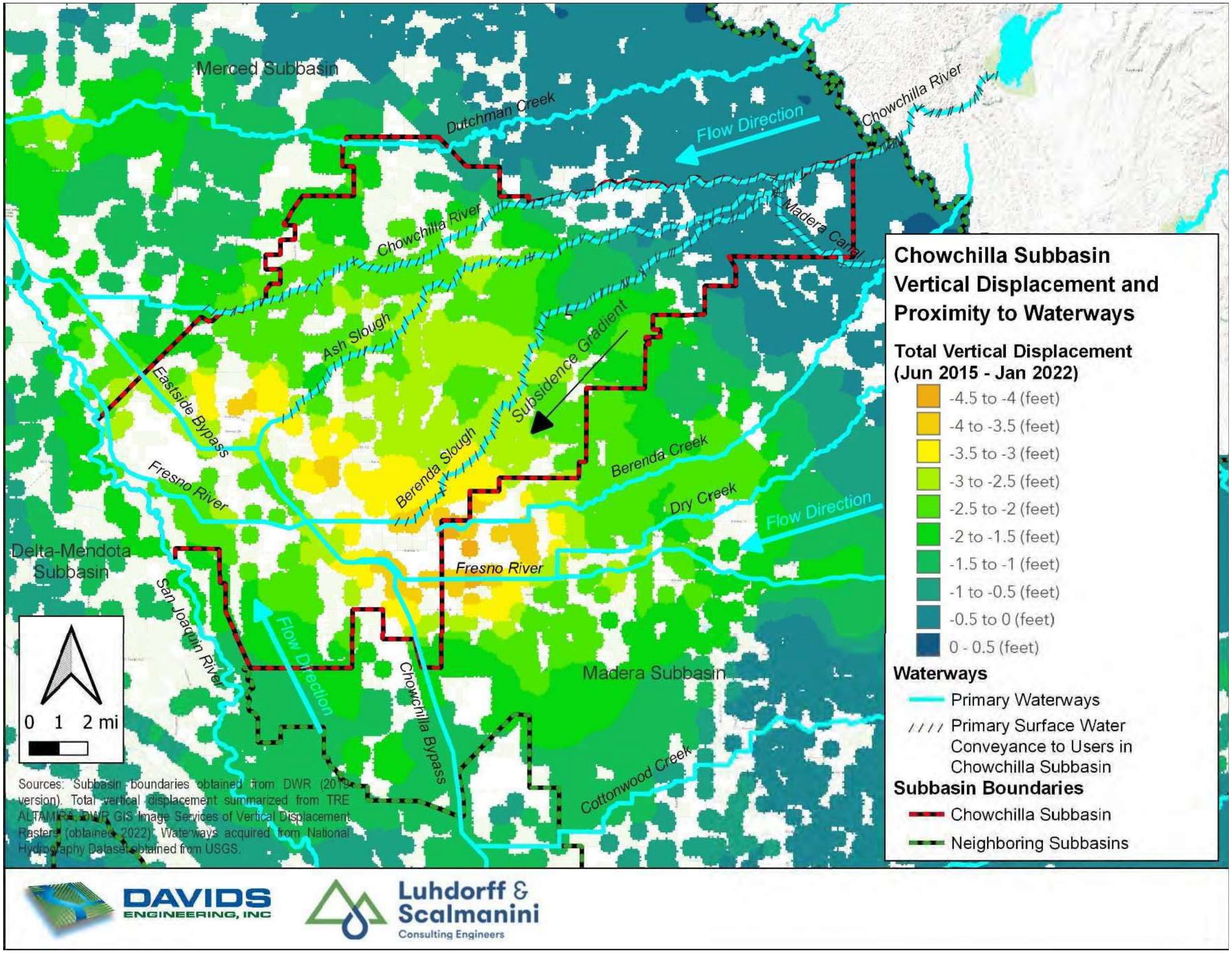

Figure 13. Vertical Displacement (June 2015 - January 2022) and Proximity to Waterways and Water Conveyance Infrastructure.

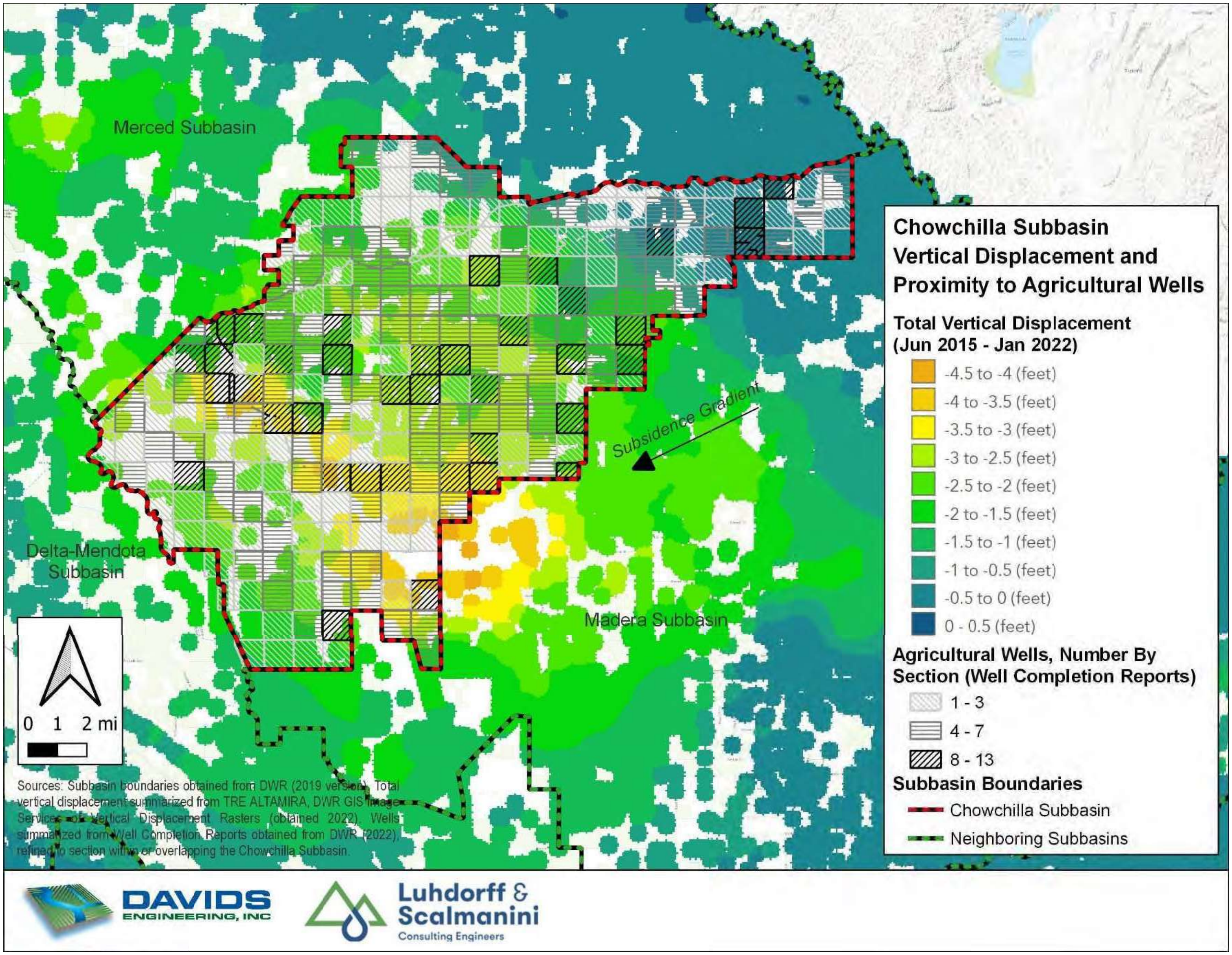

Figure 14. Vertical Displacement (June 2015 - January 2022) and Proximity to Agricultural Wells.

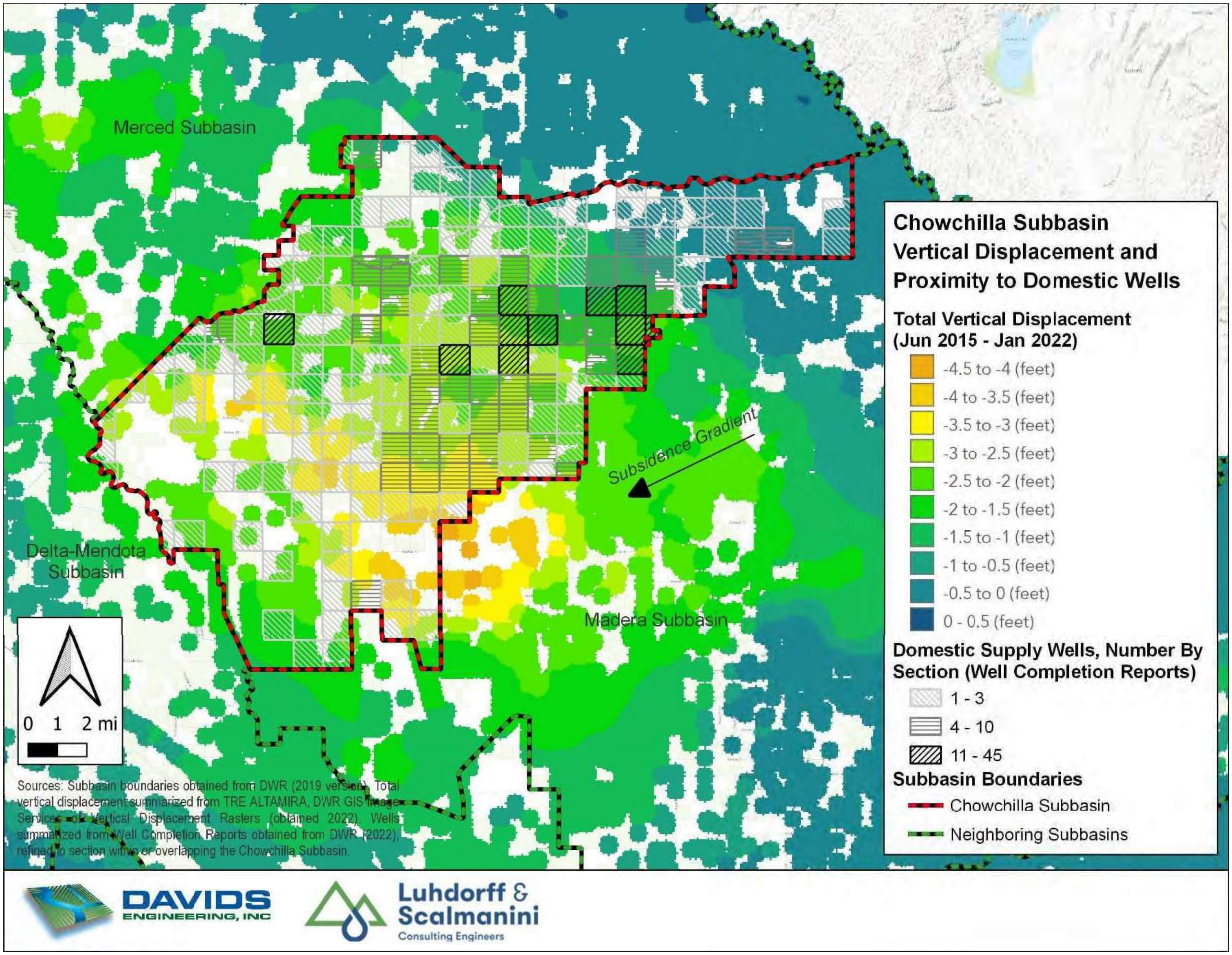

Figure 15. Vertical Displacement (June 2015 - January 2022) and Proximity to Domestic Wells.

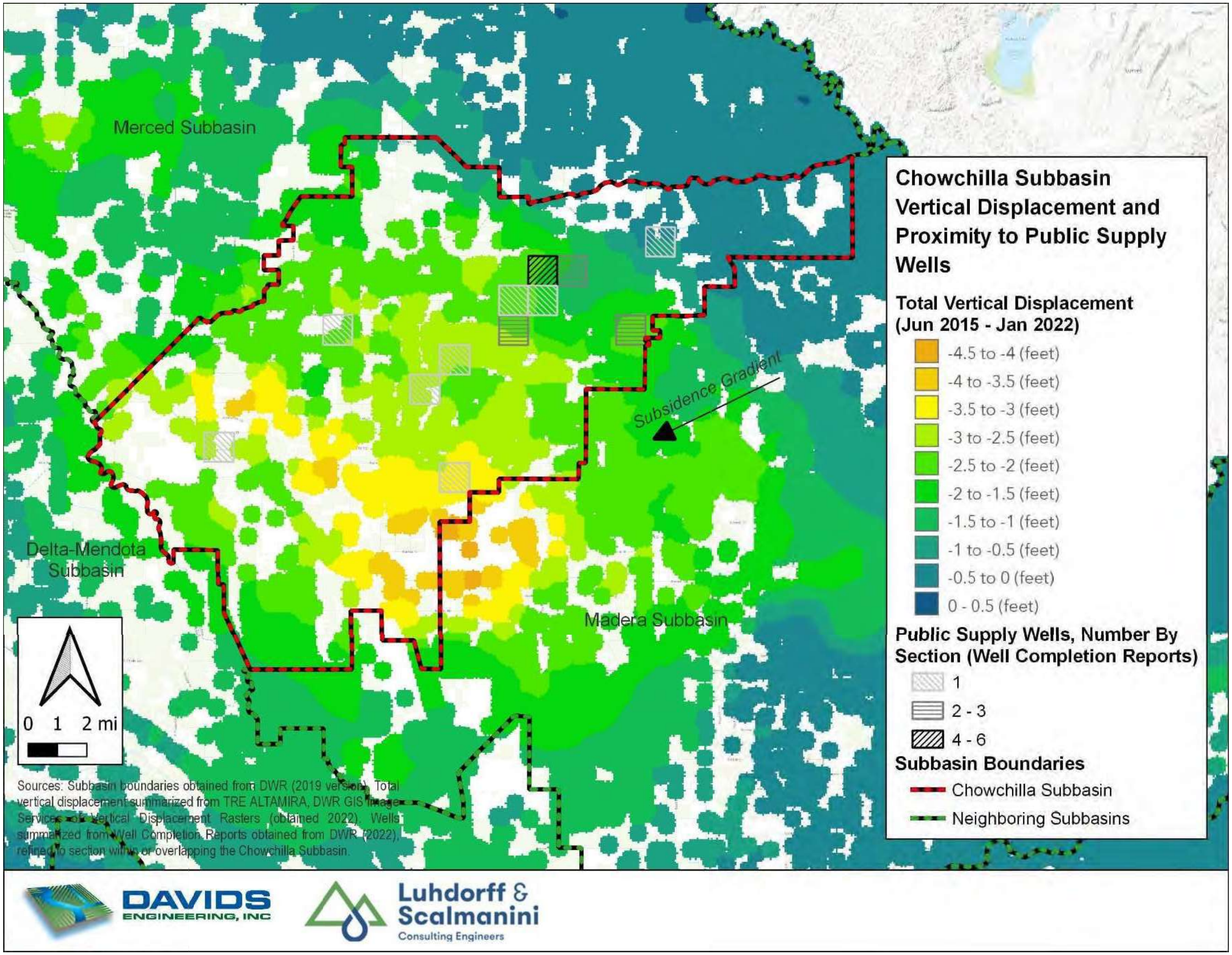

Figure 16. Vertical Displacement (June 2015 - January 2022) and Proximity to Public Supply Wells.

Figure 1 Study Area

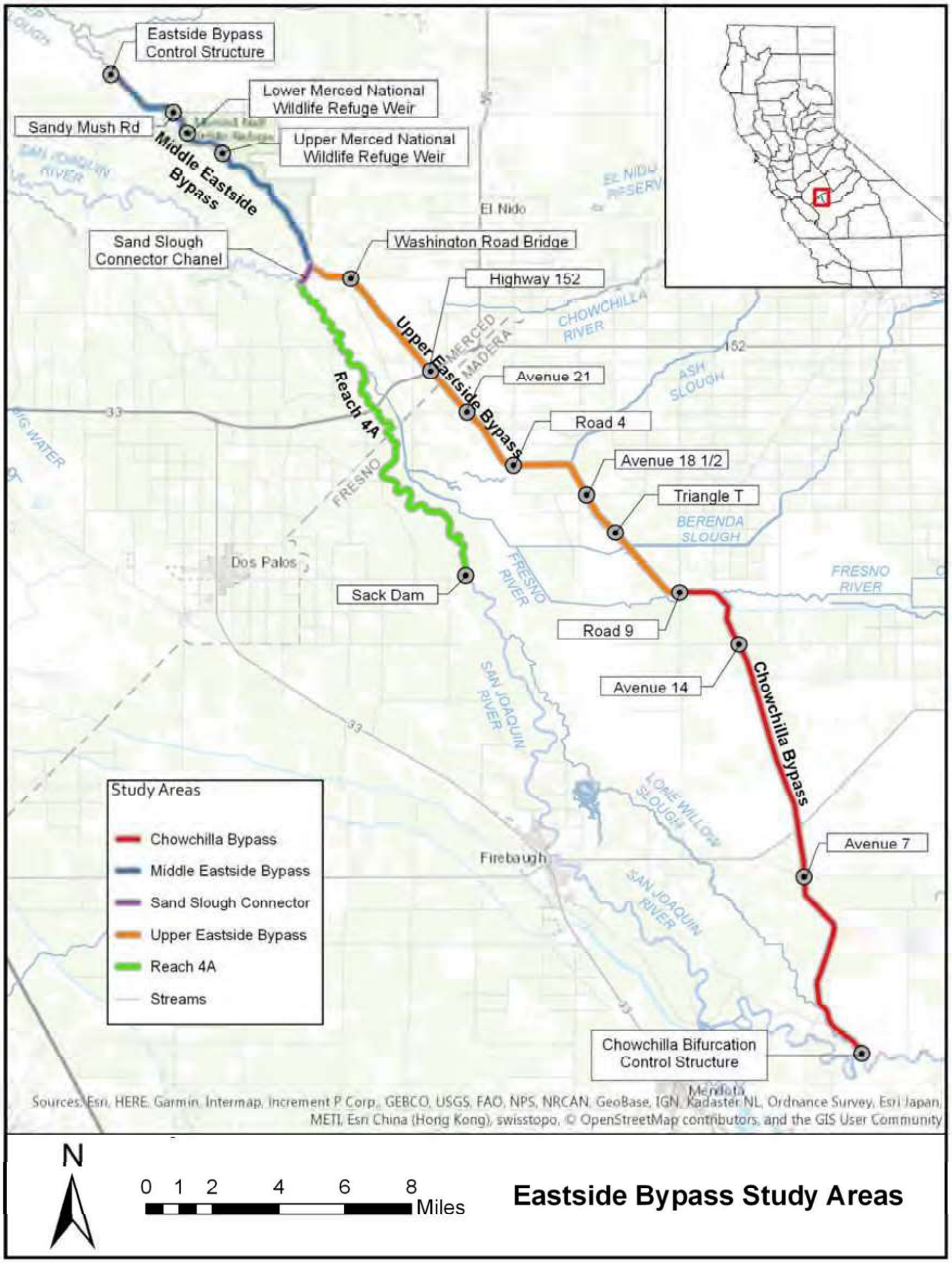

Figure 17. DWR Analysis Study Area, from "Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River" (DWR, 2018). The Upper Eastside Bypass flows through the Chowchilla Subbasin, and the San Joaquin River Reach 4A flows along the western boundaries of the Chowchilla Subbasin.

Table 1. DWR Analysis Results, from "Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River" (DWR, 2018). The Eastside Bypass flows through the Chowchilla Subbasin (beginning just downstream of the Fresno River and ending upstream of Sand Slough). The San Joaquin River Reach 4A flows along the western boundaries of the Chowchilla Subbasin.

Table 3 Estimated Flow Capacity in Reach 4A and the Chowchilla and Eastside Bypasses based on Freeboard Criteria (in cfs)

Channel Segment	Flood Design Flow[a]	2008[b]	2011[b]	2016	2026
Chowchilla Bypass					
Bifurcation Structure to Fresno River	5,500	>5,500	>5,500	>5,500	>5,500
Eastside Bypass					
Fresno River to Berenda Slough	10,000	>10,000	>10,000	>10,000	>10,000
Berenda Slough to Ash Slough	12,000	>12,000	>12,000	>12,000	>12,000
Ash Slough to Sand Slough	17,500	9,500[c] – 12,500	7,500[c] – 11,500	5,700[c] – 9,500	3,400[c] - 7,500
Sand Slough to Mariposa Bypass[d]	16,500	16,000	14,500	12,500	9,800
San Joaquin River					
Reach 4A	4,500	ND	ND	3,700[e] – 4,300	2,500[e] – 3,800
Sand Slough Connector Channel	ND	ND	ND	2,100[e] – > 4,500	0[e] – > 4,500

Notes: cfs = cubic feet per second, ND = not determined as part of this study

[a] Referenced from the Lower San Joaquin River Flood Control Project Operation and Maintenance Manual.

[b] Results obtained from a previous study done by DWR in 2013.

[c] Reduced capacity assumes contribution of 4,500 cfs from Reach 4A of the San Joaquin River (creating backwater conditions).

[d] Capacity assumes diversions into the Mariposa Bypass based on the O&M Manual operating rules.

[e] Reduced capacity assumes contribution of 12,000 cfs through the Bypass Channel (creating backwater conditions).

4 References

DWR. 2018. Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River. May 2018. In Technical Memorandum: Channel Capacity Report 2018 Restoration Year. San Joaquin River Restoration Program. January 2019.