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Project No: 20-10008

Bryan Bondy, PG, CHG
Executive Director
Upper Ventura River Groundwater Agency
202 West El Roblar Drive
Ojai, California 93023
Via email: bbondy@uvrgroundwater.org

**Subject: Riparian Groundwater Dependent Ecosystems Monitoring Report for Water Year 2023
Upper Ventura River Groundwater Agency, Ventura County, California**

Dear Mr. Bondy:

In accordance with the Upper Ventura River Groundwater Agency (UVRGA) Groundwater Sustainability Plan (GSP) Section 5.3, Rincon Consultants, Inc. (Rincon) has prepared this letter report to summarize the monitoring of Riparian Groundwater Dependent Ecosystems (GDEs) in the Upper Ventura River Groundwater Basin (UVRGB) for Water Year 2023. This monitoring includes a desktop analysis of satellite-derived data, a comparison of this data to groundwater levels, and the assessment of available satellite imagery and aerial photography. These data were collected and reviewed in accordance with UVRGA's *Monitoring and Data Collection Protocols and Data Quality Control Review Procedures*.

Two Riparian GDE units within the basin are identified in the GSP, termed the South Santa Ana and Foster Park Riparian GDE Units. The GSP presents analysis of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) for each unit alongside groundwater level data and satellite imagery from 1985 through 2018. The GSP monitoring networks include ongoing monitoring of groundwater levels and vegetative health within these areas. The attachments include NDVI and NDMI Microsoft Excel data file (Attachment 1), a Riparian GDE location map (Figure 1) as well as figures presenting NDVI and NDMI trends in comparison to groundwater levels (Figure 2 and Figure 3). Orthoimagery collected during the 2023 Water Year for the Riparian GDE Units is provided as Figure 4 and Figure 5.

Riparian GDE Desktop Analysis

NDVI and NDMI are used to assess the relative health of the vegetation communities within the Riparian GDE Units. The Nature Conservancy's (TNC) "GDE Pulse" web application¹ has historically provided a convenient method to download NDVI and NDMI values from pre-processed satellite data based on a specific location. There are two parts to this workflow, the processing of Landsat satellite data² and the extraction of NDVI and NDMI data per selected area. The former is provided by a third party TNC contractor, and the latter is available as an open-source workflow on GitHub.

For Water Year 2023, TNC had not updated their portal with the NDVI and NDMI datasets, but TNC's Google Earth account held the processed satellite imagery, which Rincon was able to extract using

¹ <https://gde.codefornature.org/#/home>

² <https://landsat.gsfc.nasa.gov/data/>



TNC's existing open-source workflow using python scripts. The NDVI and NDMI data were extracted using polygons of vegetation communities derived by the TNC. Data from these polygons were averaged.

Overall, NDVI declined across both Riparian GDE Units compared to the previous year. This decline is likely due to a diminished canopy coverage of riparian vegetation throughout the area due to wide scale scouring caused by large storms, channel flooding, and elevated flows experienced through the rainy season. This type of scour-induced index value decline has been observed in the dataset during the flooding events in 2005 and is understood to be a naturally occurring ecological feature of the Ventura River watershed.

South Santa Ana Riparian GDE Unit

Figure 2 depicts the trends in groundwater level and average NDVI and NDMI values for the South Santa Ana Riparian GDE Unit from 1985 through 2023. As documented in Rincon's previous annual monitoring report, depth to water (DTW) varies widely at these groundwater monitoring wells (from a high of 6.8 feet in March 2023 to a low of 62.7 feet in December 2013). In addition, these wells do not reflect the actual DTW within the South Santa Ana GDE Unit, but rather provide insight to the changing groundwater conditions. No groundwater monitoring sites are located within the South Santa Ana Riparian GDE Unit, which is a data gap that will be addressed during GSP implementation.

Comparing historical groundwater levels to NDVI and NDMI values, we see that these indices fluctuate over time and generally decrease with decreasing DTW. During drought conditions that occurred between 2012 and 2016, NDVI and NDMI values showed a persistent decline. However, these values also rebounded as DTW increased again in 2017. A visual analysis of aerial imagery confirmed a decrease in vegetative growth during the severe drought of 2012 through 2016, followed by a resurgence of growth and canopy health in subsequent years with more rain.

Following heavy storms during the winter of 2023, groundwater levels at both wells increased. An analysis of satellite and aerial imagery between Water Year 2022 and 2023 reveals that large areas of riparian vegetation were scoured away by high flow events. Based on a comparative analysis of the leafy greenness captured by orthoimagery collected in December 2022, March 2023, and July 2023 (Figure 4), the vegetation was not experiencing water stress prior to the January 2023 scour event. The plant communities appeared to be healthy prior to the scouring, and surviving communities were healthy after the scouring event.. While average NDVI decreased from Water Year 2022 to 2023, average NDMI increased (Figure 2). This lack of direct correlation between NDVI and NDMI is consistent with NDVI decrease from vegetation removal and NDMI increase from addition water availability for vegetation respiration.

Foster Park Riparian GDE Unit

Figure 3 depicts trends in groundwater levels and average NDVI and NDMI values for the Foster Park Riparian GDE Unit from 1985 through 2023. DTW was measured at three wells within the Foster Park Riparian GDE unit³, varying from a high of 0 feet during a flooding event in January 2023, to a low of 29.6 feet in February 1991.

Similar to the Santa Ana Riparian GDE Unit, NDVI and NDMI values fluctuate over time and generally decrease with decreasing DTW. Between 2022 and 2023, NDVI decreased, likely due to scouring of

³ Foster Park MW-1 and Foster Park MW-4 high frequency pressure transducer records begin in November 2019



healthy vegetation. More broadly, the general increasing trend of NDVI and NDMI is observed for the Foster Park Riparian GDE Unit from 1985 to 2023, though the potential causes are currently unclear. According to Rincon's previous assessment, this could be related to influences of past floods or management actions in Foster Park. Aerial imagery confirmed the decrease in NDVI and NDMI values in 2005 and subsequent increase in NDVI and NDMI values from 2006 to 2012 correlated with vegetation scouring and subsequent revegetation following flood events that occurred in 2005. Following a period of increasing index values from 2006 to 2012, NDVI and NDMI values declined during recent drought conditions, but then increased again in 2017 following a water year with moderate precipitation.

Similar to the South Santa Ana Riparian GDE Unit, analysis of aerial imagery confirmed a decrease of vegetative growth during the severe drought of 2012 through 2016, followed by rebounding growth and canopy cover in subsequent years with more rain. In addition, a 2023 visual analysis shows that large areas of riparian vegetation were scoured away by the high flow events, but also that vegetation health appears vigorous when compared to previous water year conditions (Figure 5). While average NDVI and average NDMI decreased from Water Year 2022 to 2023, the decrease in NDMI was less pronounced and did not correlate as strongly with NDVI as it has in previous years (Figure 3). This lack of direct correlation between NDVI and NDMI is consistent with NDVI decrease from vegetation removal, rather than water stress.

We are pleased to support UVRGA on this important project and look forward to discussing any questions you may have regarding the data and evaluation presented in this report.

Sincerely,

Rincon Consultants, Inc.

A handwritten signature in black ink, appearing to read "Thomas Sanford".

Thomas Sanford
Watershed Scientist

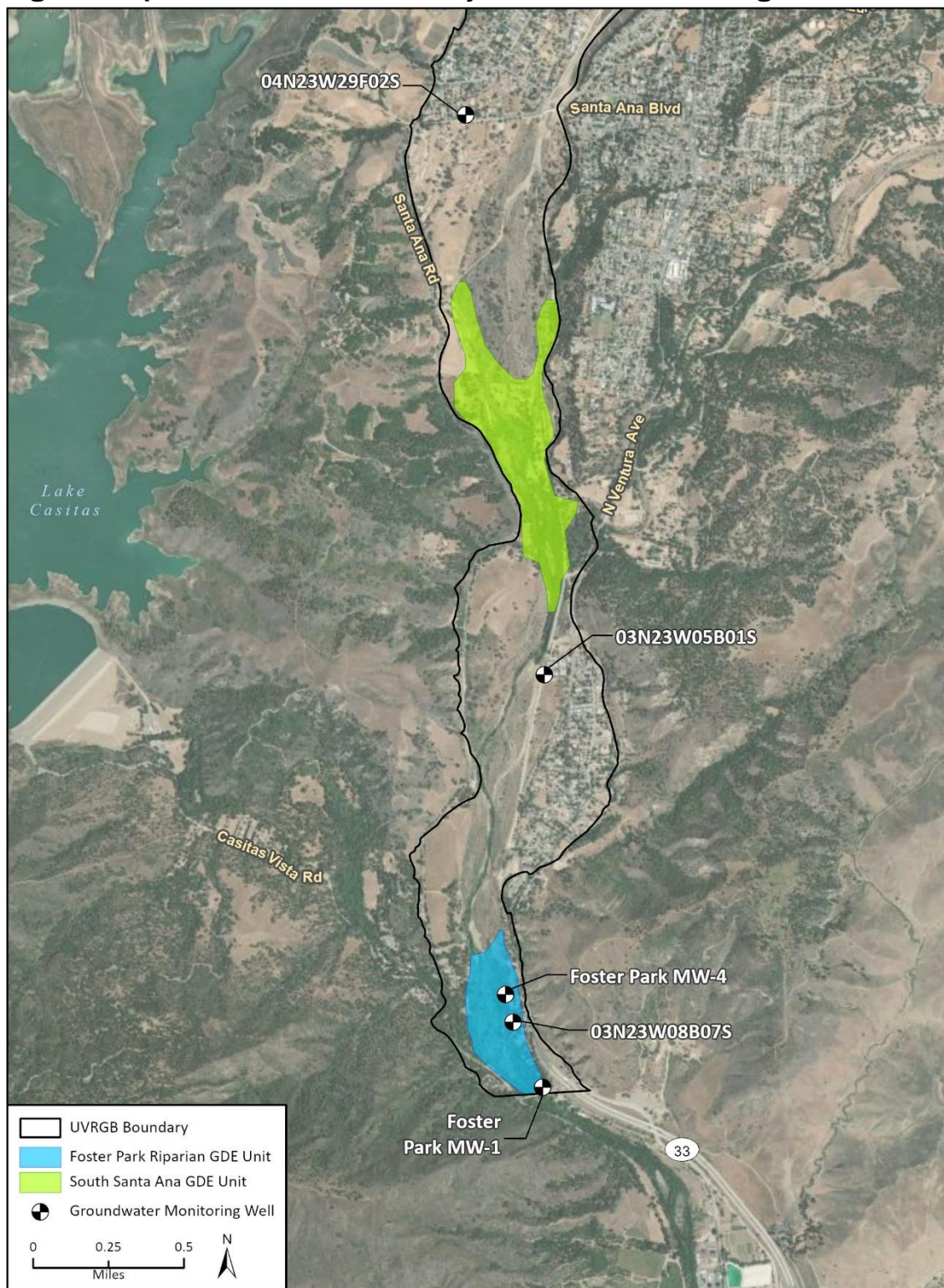
A handwritten signature in black ink, appearing to read "Kiernan Brtalik".

Kiernan Brtalik
Director Watershed Sciences

Attachments

Attachment 1 NDVI and NDMI Microsoft Excel Data File (provided electronically)

Figure 1 Riparian GDE Units and nearby Groundwater Monitoring Wells



Imagery provided by Esri and its licensors 2023© .

Aquatic GDE Assessment Figures
Figure 1 Riparian GDE Units and nearby Groundwater Monitoring Wells

Figure 2 Groundwater Level Compared to Average NDVI and NDMI for the South Santa Ana Riparian GDE Unit (1985 to 2023)

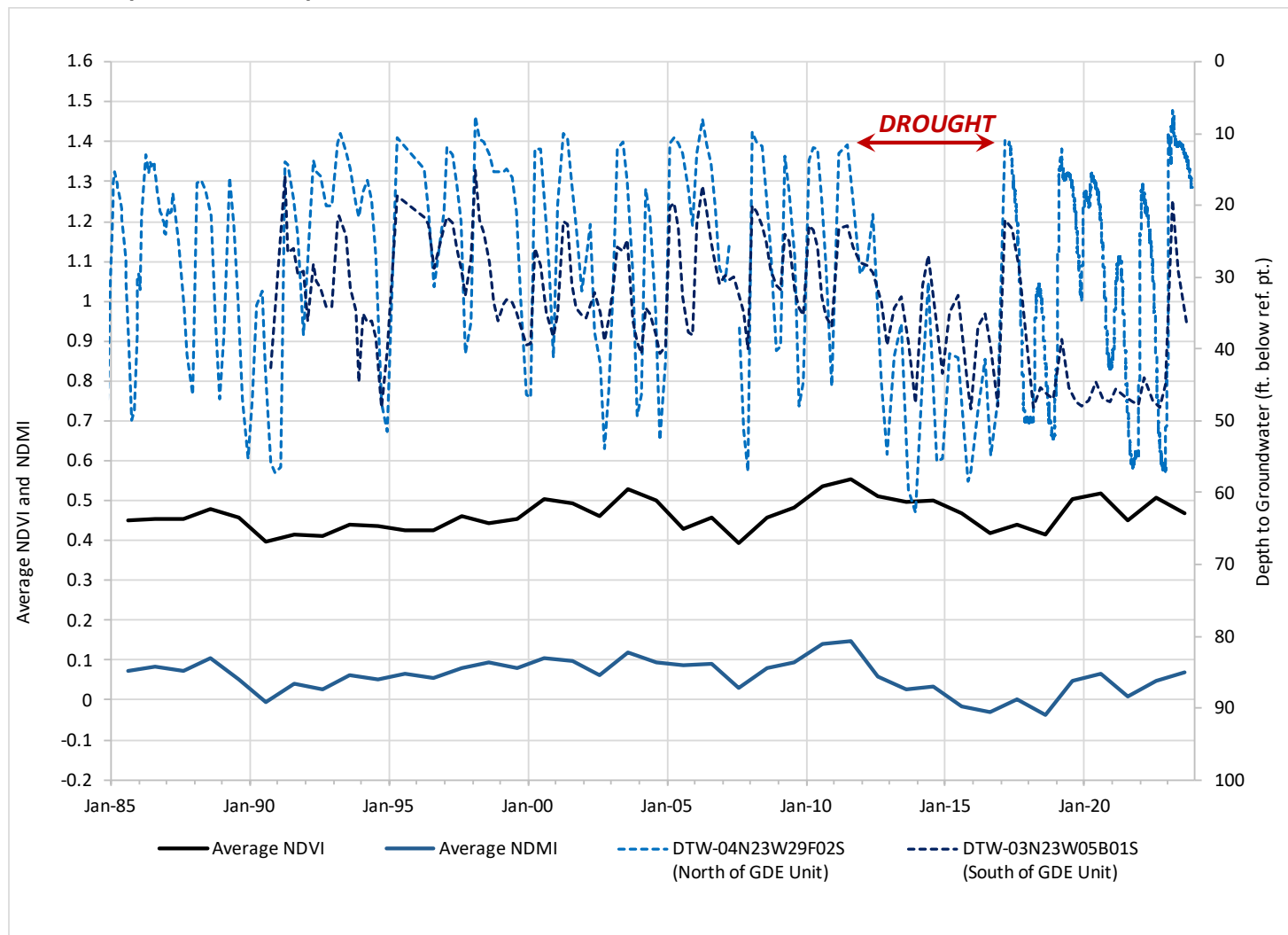


Figure 3 Groundwater Level Compared to Average NDVI and NDMI for the Foster Park Riparian GDE Unit (1985 to 2023)

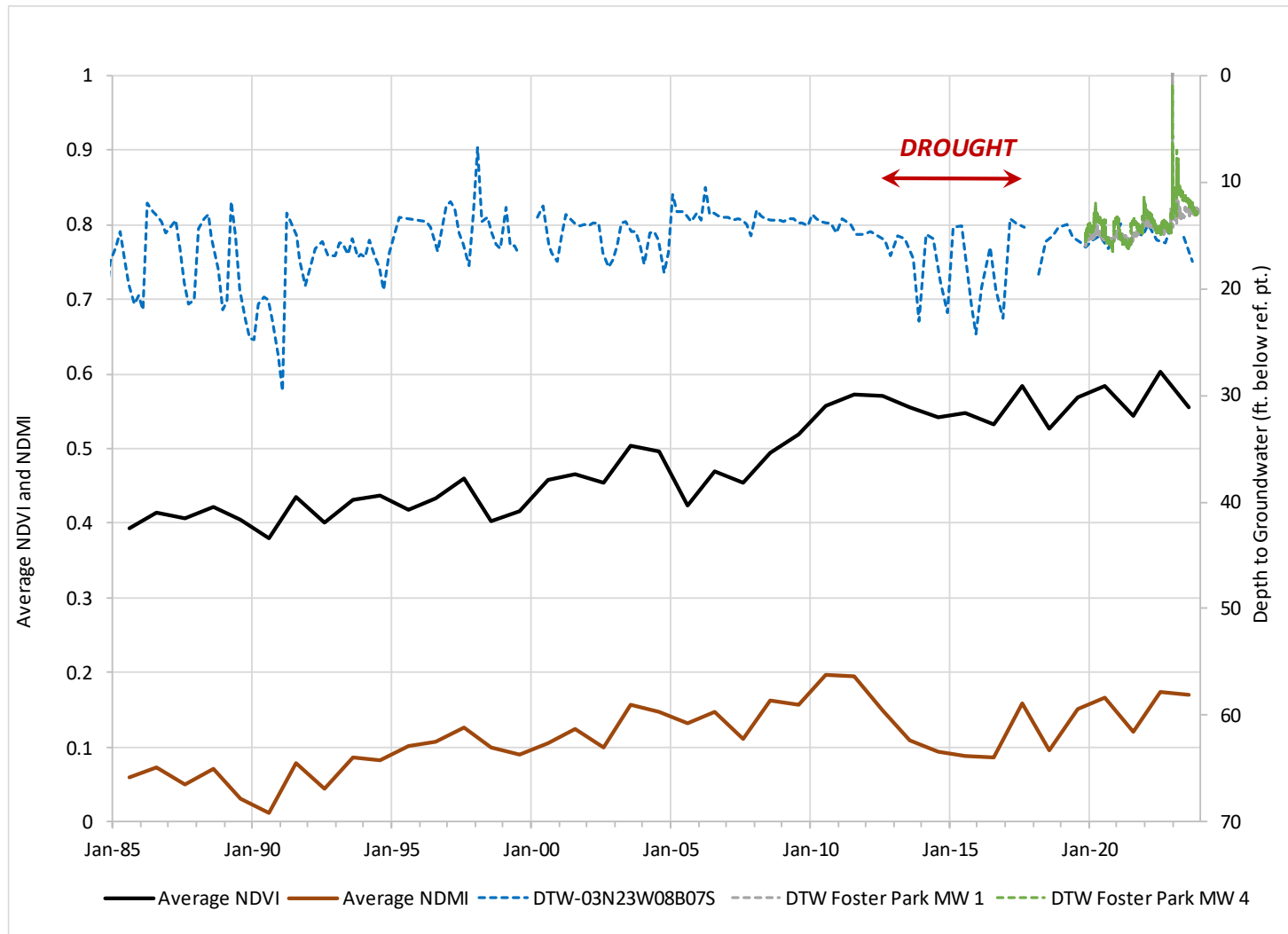
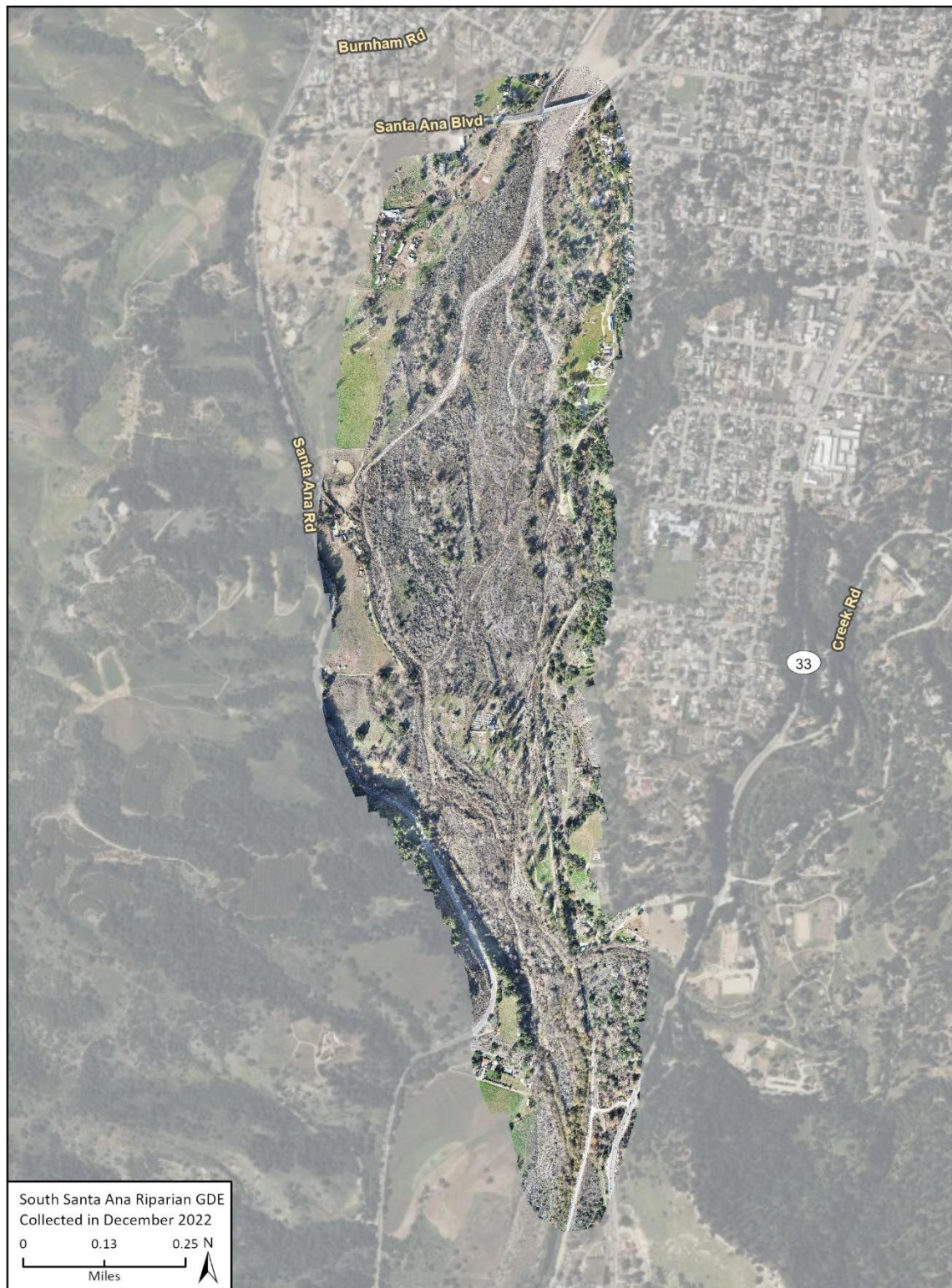


Figure 4a Drone Orthoimagery of the South Santa Ana GDE Unit, December 19, 2022



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Figure 4b Drone Orthoimagery of the South Santa Ana GDE Unit, March 24, 2023



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Ventura Upper Watershed
Fig X South Santa Ana Orthomosaic March 2023

Figure 4c Drone Orthoimagery of the South Santa Ana GDE Unit July 26, 2023



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Ventura Upper Watershed
Fig X South Santa Ana Orthomosaic July 2023

Figure 5a Drone Orthoimagery of the Foster Park GDE Unit, December 19, 2022



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Ventura Upper Watershed
Fig X Foster Park Riparian Orthomosaic December 2022

Figure 5b Drone Orthoimagery of the Foster Park GDE Unit, March 24, 2023



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Ventura Upper Watershed
Fig X Foster Park Riparian Orthomosaic March 2023

Figure 5c Drone Orthoimagery of the Foster Park GDE Unit, July 23, 2023



Imagery provided by Microsoft Bing and its licensors © 2023.

Ventura Upper Watershed
Fig X Foster Park Riparian Orthomosaic July 2023