ACTUAL EVAPOTRANSPIRATION ANALYSIS
May - 2020

Prepared for

Eastern Tule Groundwater Sustainability Agency

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INTRODUCTION

The Eastern Tule Groundwater Sustainability Agency (ETGSA) has partnered with Land IQ to develop spatial datasets of monthly actual evapotranspiration (ETa) within their GSA boundaries. In this analysis, remotely sensed data from satellites are calibrated against in-situ measurements from ground-based climate stations to create a spatially continuous map of ETa within ETGSA for the month.

METHODOLOGY

The remote sensing method used to estimate ETa is the Land IQ Data Driven Model (LDDM). Land IQ uses the LDDM to interpret remotely sensed image data. The model also uses a rich set of ground station data. This approach yields more accurate results when repeated and representative ground calibration data are available. It is also less labor-intensive than other remotely sensing methods at this refined scale.

The LDDM approach can employ Landsat 8, RapidEye, and Sentinel 2 satellite imagery (freely available) as well as Planet Imagery. Satellite data are screened for cloud cover and corrected for the effects of terrain, or different topographic positions, on reflectance.

Ground measurements from Land IQ and other monitored stations are used to generate hourly ET data correlated to Landsat 8, RapidEye, Sentinel 2 and Planet Imagery satellite overpasses. The results are then used as a dependent variable in the modeling process. The data collected by the ground stations are used to calibrate remote sensing models for ET and extrapolate ET measurements across all fields to get a complete estimate of monthly ET and ET by crop type by field. Data stations are fully telemetered (remotely logged) by cellular communication systems to Land IQ servers. The system includes data flagging protocols to identify any inconsistencies in data collection or outages. A thorough QA/QC effort was conducted on all field collected data prior to remotely sensed analysis.

ANALYSIS

Consumptive use analysis is done in in two main parts:

1. Ground truthing measurements and calibration
2. Remotely sensed analysis and summarization

1. GROUND TRUTHING

Land IQ stations include full stations (using Eddy covariance) and Water IQ (WIQ) stations (Table 1). All three ground truthing station types (Full, WIQ, Tule Tech) integrated in Land IQ's evapotranspiration (ET) analysis use a residual balance approach. In this approach, ET is estimated using the residual energy of three other key energy components: solar and terrestrial radiation (net radiation), heat to and from the atmosphere (sensible heat flux), and heat to and from the soil surface (ground heat flux). The highest accuracy station, the "Full" station, directly measures the net radiation, sensible heat flux and ground heat flux. Land IQ's WIQ stations directly measure net radiation, calculate sensible heat flux from temperature measurements at the station and from calibration factors from similar canopies measured by the "Full" stations, and then assumes the ground heat flux to be near zero over the course of a full 24 hours. The Tule Tech stations estimate net radiation from a regional algorithm, directly measures sensible heat flux, and assumes that the ground heat flux to be zero over the course of 24 hours.

A current map of the stations showing all locations (Figure 1) along with the crop distribution across the district (Figure 2) demonstrates the variety of calibration data available for model building. Included in this month's report, Table 2 shows the daily precipitation totals for the month measured by Land IQ stations and California Department of Water Resources CIMIS stations.

For the month of May, ground truthing information recorded throughout EKGSA and surrounding areas was collected from 18 full stations, 4 Water IQ stations and 37 Tule Tech stations.

TABLE 1. SENSORS USED IN DAILY AND MONTHLY ETA ANALYSIS
**PARTIAL – INCOMPLETE MONTHLY TIME SERIES DUE TO SENSOR INSTALLATION/REMOVAL.*

Sensor	Crop	Active	Used in Model
Tule 4	Almonds	✔	✔
Tule 8	Small Grains	✔	✔
Tule 10	Almonds	✔	✔
Tule 12	Almonds	✔	✔
Tule 13	Alfalfa/Hay	✔	✔
Tule 17	Alfalfa/Hay	✔	✔
Tule 19	Pistachios	✔	✖
Tule 20	Pistachios NB	✔	✔
Tule 22	Grapes	✔	✔
Tule 23	Small Grains	✔	✔
Tule 28	Carrots	✔	✔
Tule 30	Pomegranates	✔	✔
Tule 31	Pistachios	Partial	✖
Tule EK2	Grape	Partial	✔
Tule EK3	Olives	Partial	✔
Tule EK4	Olives	Partial	✔
Tule EK6	Citrus	Partial	✔
Tule NK1	Almonds	✔	✔
Tule NK2	Almonds	✔	✖
Tule NK3	Potato	✔	✔
Tule NK4	Grapes	Partial	✔
Tule NK5	Almonds	✔	✔
Tule NK6	Almonds	✔	✔
Tule NK7	Grapes	✔	✖
Tule NK8	Pistachios	✔	✔
Tule NK9	Almonds	✔	✔
Tule NK10	Grapes	✔	✔

Sensor	Crop	Active	Used in Model
Tule NK11	Alfalfa	✔	✔
Tule SW1	Almonds	✔	✔
Tule SW2	Almonds	✔	✔
Tule SW3	Almonds	✔	✔
Tule SW4	Almonds	✔	✔
Tule SW5	Almonds	✔	✖
Tule SW7	Grapes	✔	✔
Tule SW8	Grapes	✔	✖
Tule SW9	Alfalfa	✔	✔
Tule SW10	Small Grains	Partial	✔
Full 1	Alfalfa/Hay	✔	✔
Full 2	Almonds	✔	✔
Full 3	Fallow	✔	✔
Full 4	Pistachios	✔	✔
Full 5	Almonds	✔	✔
Full 6	Navel	Partial	✔
Full 7	Mandarin	✔	✔
Full 8	Mandarin	✔	✔
Full 9	Navel	✔	✔
Full 10	Pistachios	✔	✔
Full 11	Pistachios	✔	✔
Full 12	Pistachios	✔	✔
Full 13	Almonds	✔	✔
Full 14	Tangerines	Partial	✖
Full 15	Table Grapes	✔	✔
Full 16	Wine Grapes	✔	✔
Full 17	Sumo Mandarin	Partial	✔
Full 18	Navel	Partial	✖
WIQ1	Alfalfa	✔	✔
WIQ2	Alfalfa	✔	✔
WIQ3	Almonds	✔	✔
WIQ4	Valencia Oranges	✔	✔

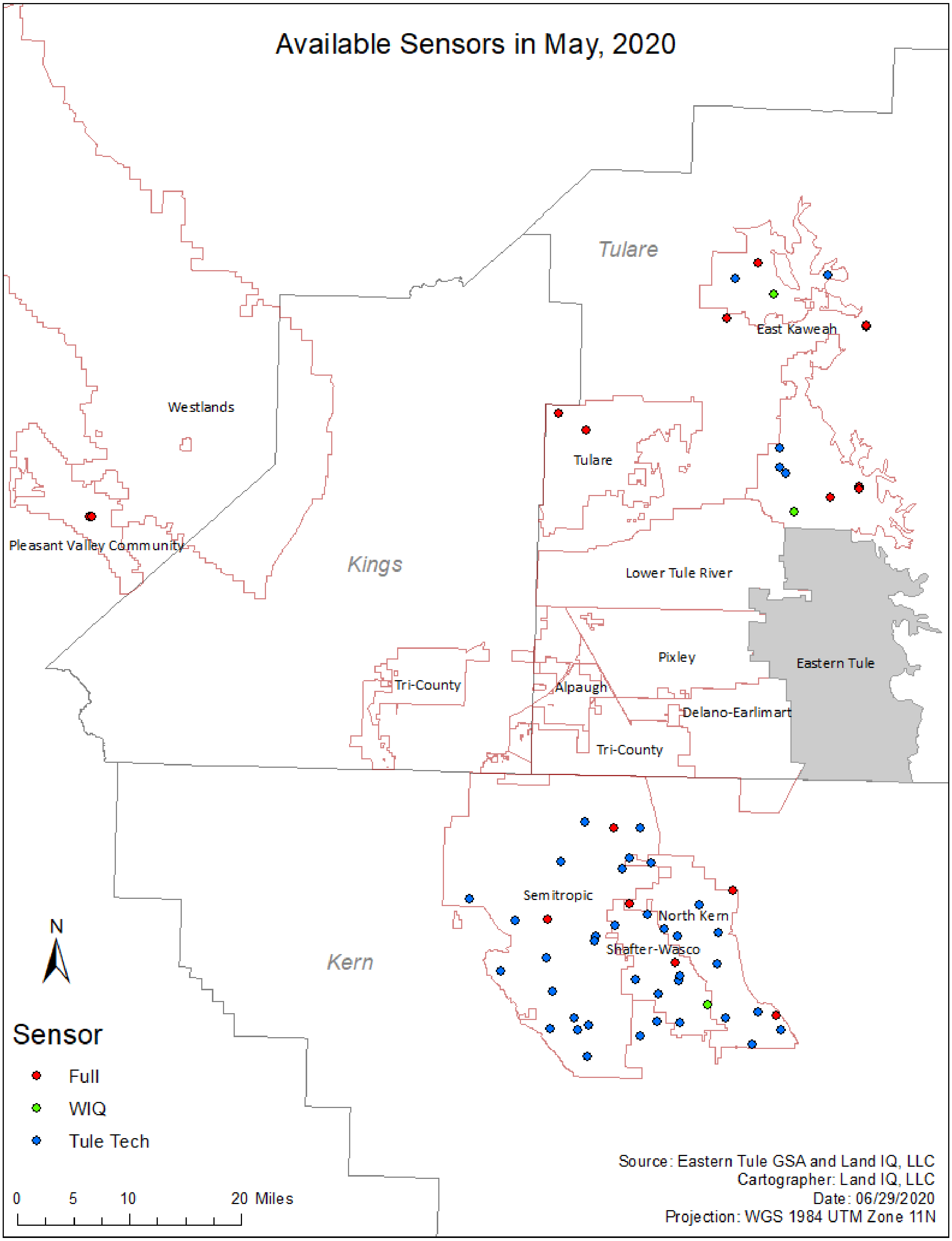

FIGURE 1. MAP OF STATION LOCATIONS

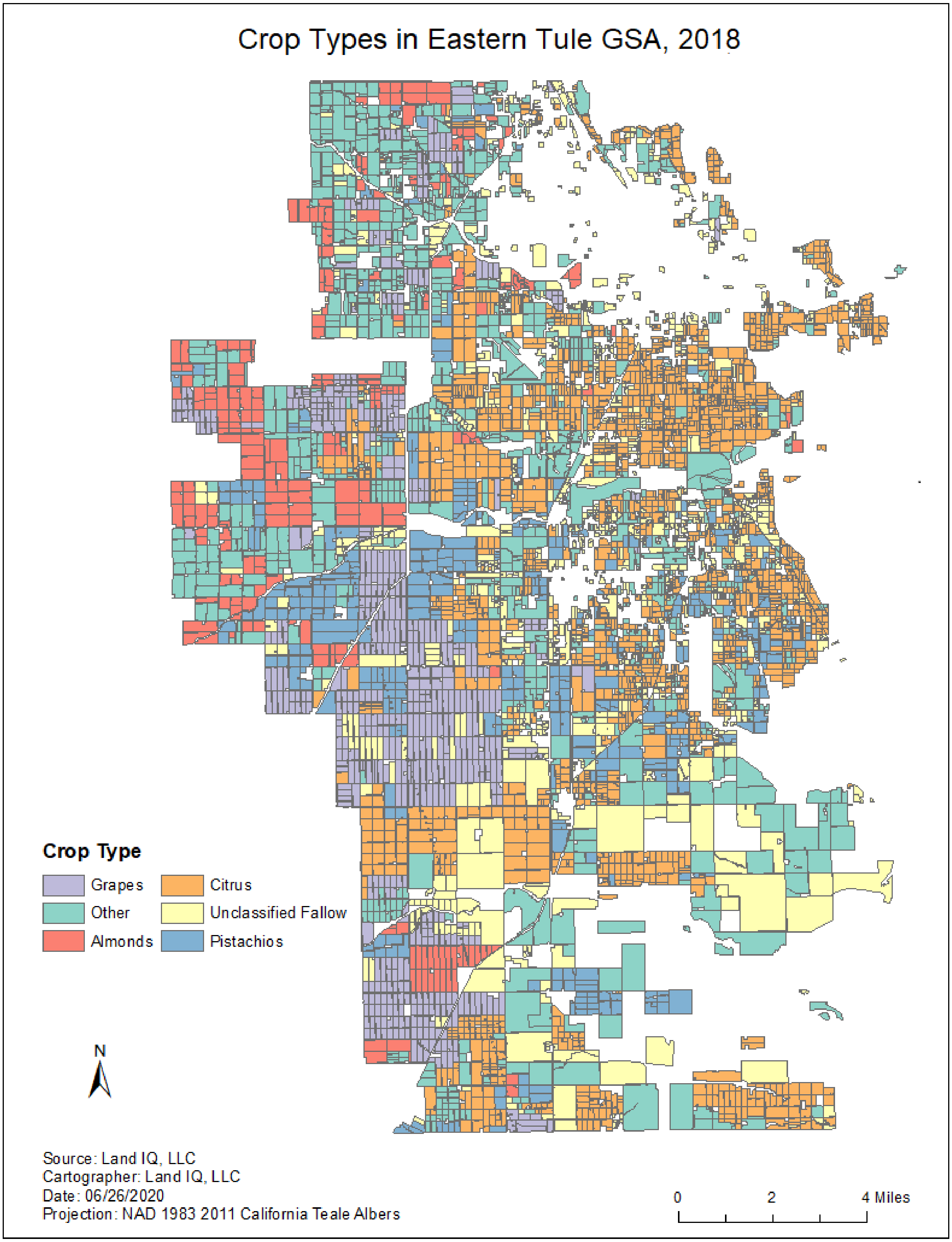

FIGURE 2. MAP OF CROP DISTRIBUTION

2. Remote Sensing

For this specific analysis, the image analysis dates and sources used are as follows:

- May 1, 2020 – Sentinel-2
- May 26, 2020 – Sentinel-2

Other imagery could not be used in the analysis because of cloud cover on the overpass dates.

May 2020 ETa Remote Sensing Results

Results from the remote sensing analysis to determine ETa for the month are presented in two ways:

1. Spatial monthly ETa map
2. Measured versus predicted monthly ETa

1. Spatial Monthly ETa Map

The spatial ETa map for the month is presented in Figure 3.

- The maximum pixel ETa was 208.26 mm (8.20 inches).
- The maximum field ETa for May was 190.24 mm (7.49 inches).
- The average field ETa was 118.78 mm (4.68 inches).

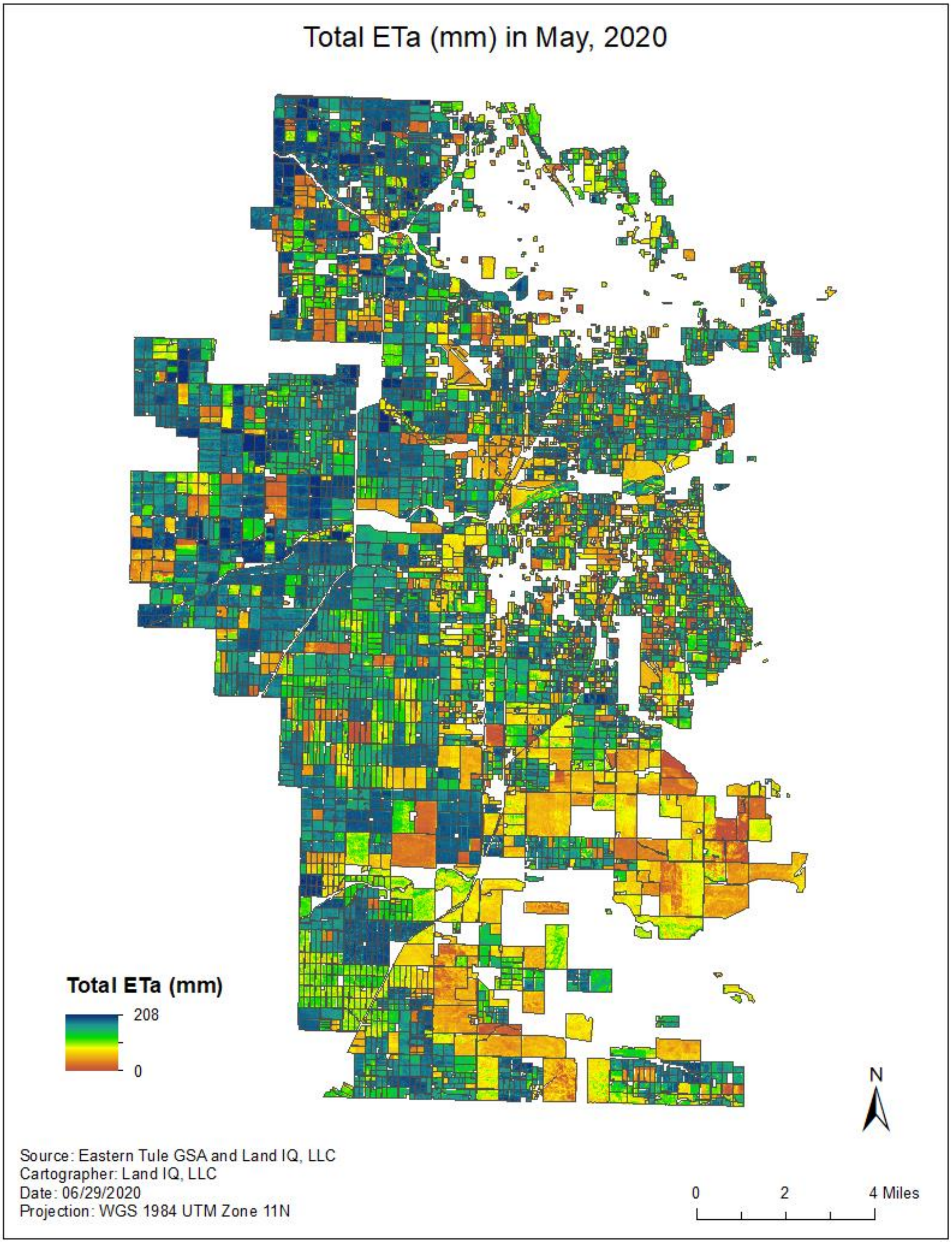

FIGURE 3. PIXEL LEVEL TOTAL ETA (MM) FOR THE MONTH

2. MEASURED VS. PREDICTED MONTHLY ETA

Measured versus predicted monthly ETa is presented in Figure 4. Measured values represent data from field stations, whereas predicted values represented those generated by the LDDM. The R^2 value is the relative measure of fit of the observed data to the predicted result, where a value of 1 indicates a perfect fit. RMSE can be interpreted as the standard deviation, where a value of 0 mm would indicate perfect fit to the observed data.

The R^2 for measured vs. predicted monthly ETa for May is 0.7. The root mean square error (RMSE) of the predicted data (blue points in Figure 4) is 21.7 mm, which is the absolute measure of fit.

Stations represented in this plot were used for the entire month.

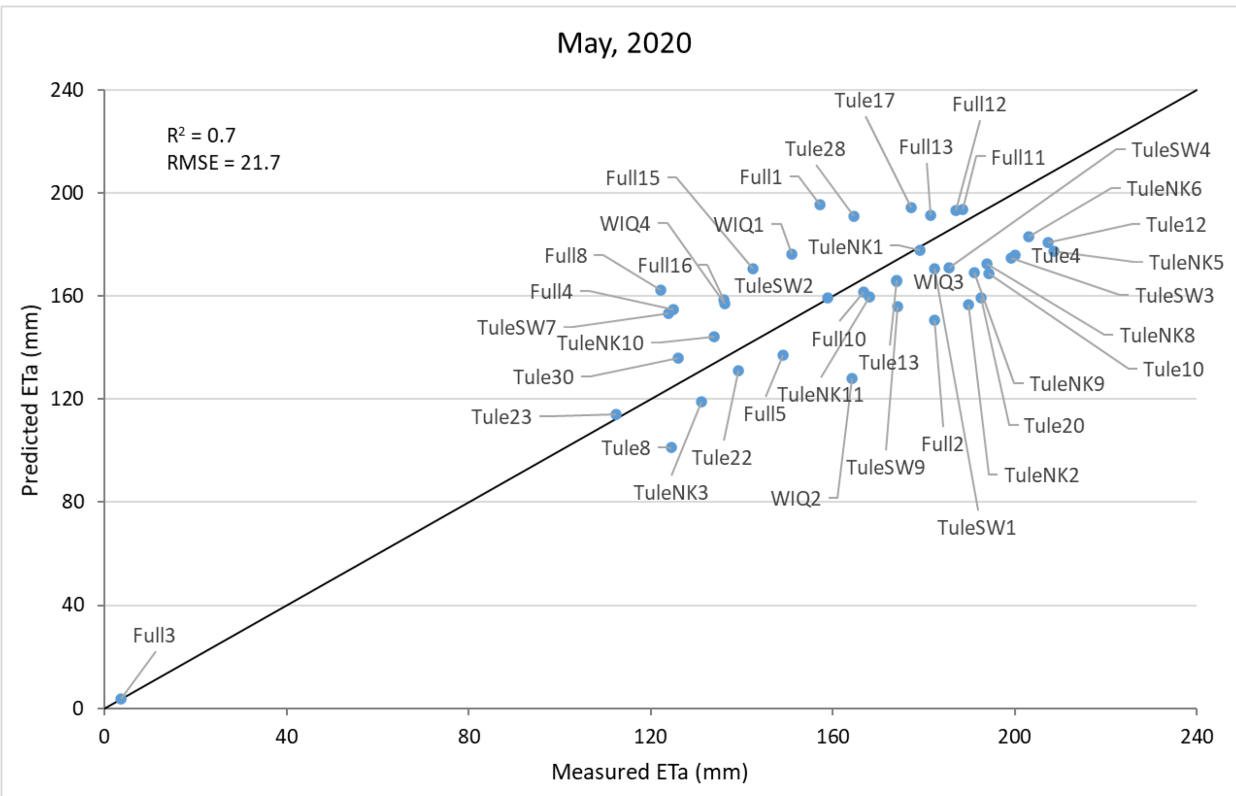

FIGURE 4. MEASURED VERSUS. PREDICTED ETA FOR THE MONTH