Analyzing Groundwater Changes in the San Joaquin Valley 1910 – 2015

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Introduction

In this project I focused on comparing two datasets focused on the San Joaquin Central Valley geographical area which is comprised of the Sierra Nevada range to the east and a coastal range to the west. One dataset was collected in 1905-1910, while the other set is made up of modern data collected between 1995-2015. These datasets contain basic data mainly the amounts of sulfur, biocarbon, and chloride, silicates, calcium, and Total Dissolved Solids that were collected in 1910. The modern dataset contained more information about different kinds of contaminants including Nitrate however, the previous dataset was limited mostly due to the technology or knowledge available at the time. The SJV being one of the most agriculturally intensive and productive regions in the world relies on groundwater for a significant amount of its water source especially during drought years which California has been in for years. This as determined by Hansen et al. in his study on the San Joaquin Valley salinity changes, he states that the increased Total Dissolved Solids in groundwater has increased in most parts of the valley because of agricultural practices (125). Total Dissolved Solids refers to all of the dissolved solids comprised of ions in water (Hansen et al 126). TDS is used primarily to study water quality for streams, rivers, and lakes; however, TDS itself is not a pollutant or a threat to human health just an indicator of water quality. According to the EPA and California Secondary Maximum Contaminant Level set by the State Water Control Board of California, total dissolved solids concentrations should be limited to 500mg/L and an upper limit of 1,000 mg/L (Drinking 2017; California 2017).

Methods

The first step in this project of course was to acquire the data. After some research I found an interesting study done by Jeffrey A Hanson which was along the same lines of what I wanted to analyze. He had compiled historical and modern well data into two separate datasets (csv) files of well location, and attributes including TDS of each well. The 1910 dataset he used was originally put together by Medenhall and others ; Leighton 1905. This dataset described groundwater in the geographical area of the San Joaquin valley in terms of TDS, chloride, sulfate, biocarbonate, calcium, magnesium sodium potassium and silica. The dataset was transcribed into modern database format for future groundwater research and is available to the public. The 1993-2015 dataset he used was gathered from USGS National Water Information System database and also the California Groundwater Ambient Monitoring and Assessment (GAMA) Program Priority Basin Project as well as the National Water Quality Assessment (NAWQA) program. The dataset is available for future research and public information.

I also gathered a National Hydrology Dataset clipped it to California using the clip tool and a California Boundary shapefile. I also downloaded the San Joaquin Valley alluvial boundary in order to mark my area of interest. Additionally, I downloaded satellite imagery as well as Digital Elevation Models for the entire valley; over 15 different digital elevation model files were used to create my map. I used the mosaic to raster tool in order to merge all of my digital elevation model files into one.

The next step was to correctly define and project all of my different datasets, this included the state boundary, the hydrology dataset, the San Joaquin alluvial boundary, the digital elevation models, as well as the two well attribute datasets (csv). . To be able to map all the individual well sites I had to use the coordinates provided on the dataset and had to export as a point shapefile with the correct geographic coordinate system otherwise the points would not be on the map. After correctly defining the geographical coordinate systems and projections, I began to layer the different files on ArcMap and began to create a map

Finally I created a locator map with the California state boundary and the SJV alluvial boundary and a clipped Hydrology layer limited to SJV.

For my main maps, I used the point shapefile with the attributes provided with the different datasets to show the levels of TDS found in each well by category, the red category being anything over the EPA limit for TDS. I layered the points over a color schemed DEM with a hillshade applied as well. I outlined the SJV boundary and layered the hydrology set over it.

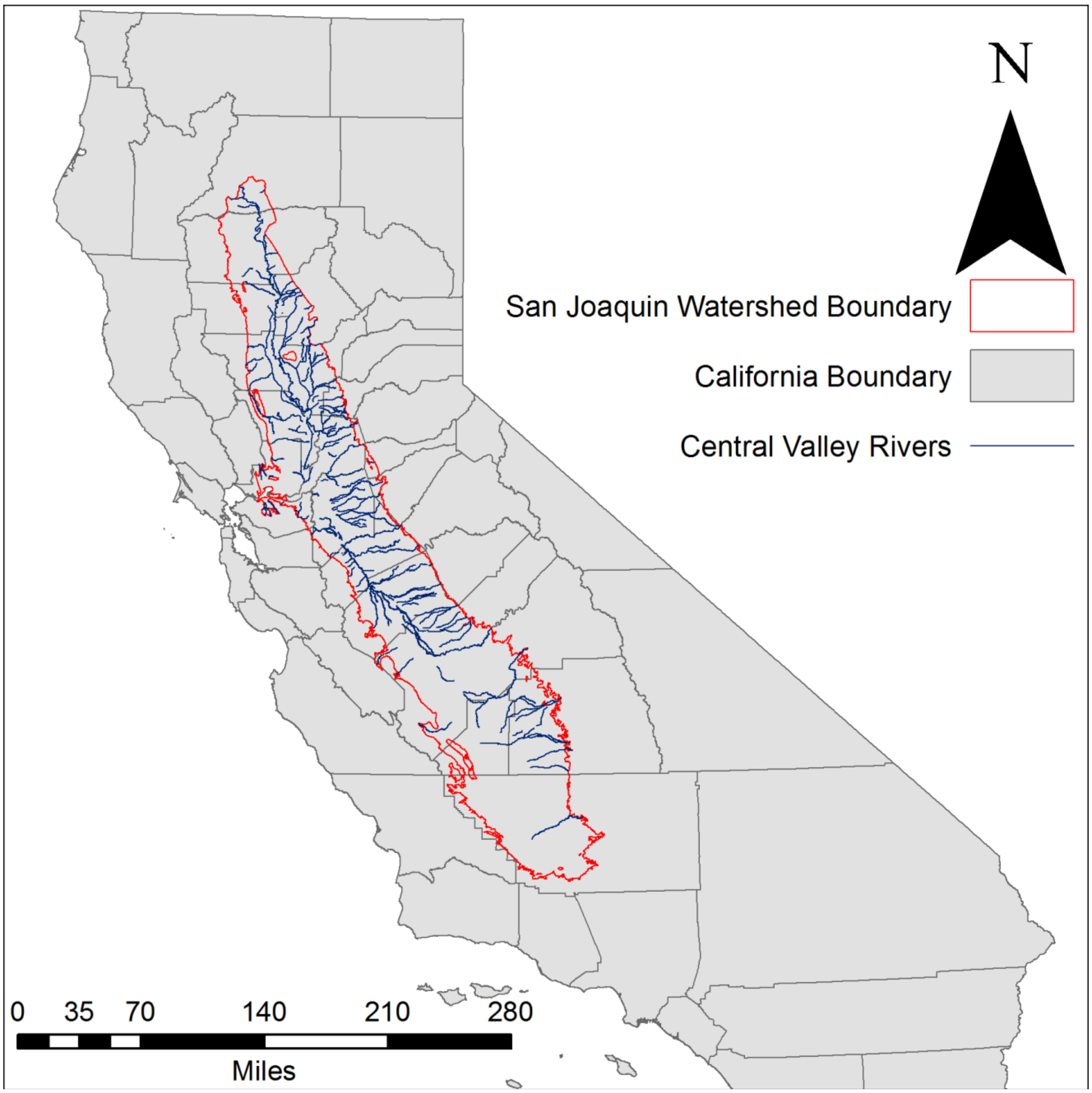

Figure 1. Locator Map of the region of interest (San Joaquin Valley). NAD_1983_California_Teale_Albers

Results

“TDS concentrations in NESJV and SESJV groundwater were statistically higher in wells surrounded by N70% agricultural land in comparison to wells surrounded primarily by land used for mixed or other purposes (Kruskal-Wallis rank-sum, p-value b 0.001) (Fig. 5). “ (Hansen, Jeffrey et. al pg. 7) As you can see from the figures provided, concentrations have increased simultaneously with monitoring different groundwater sites. It seems evident that the increased concentrations can be due to irrigated agriculture and different land uses in the surrounding areas.

Land use and groundwater recharge seems to have a large impact on groundwater quality over time, as observed over the last century, Total Dissolved Solid concentrations have increased in the central valley and this is due to recharge of runoff in areas that can and may be contributing various pollutants including but not limited to fertilizers, salts, organic material, chloride, carbonates,etc.

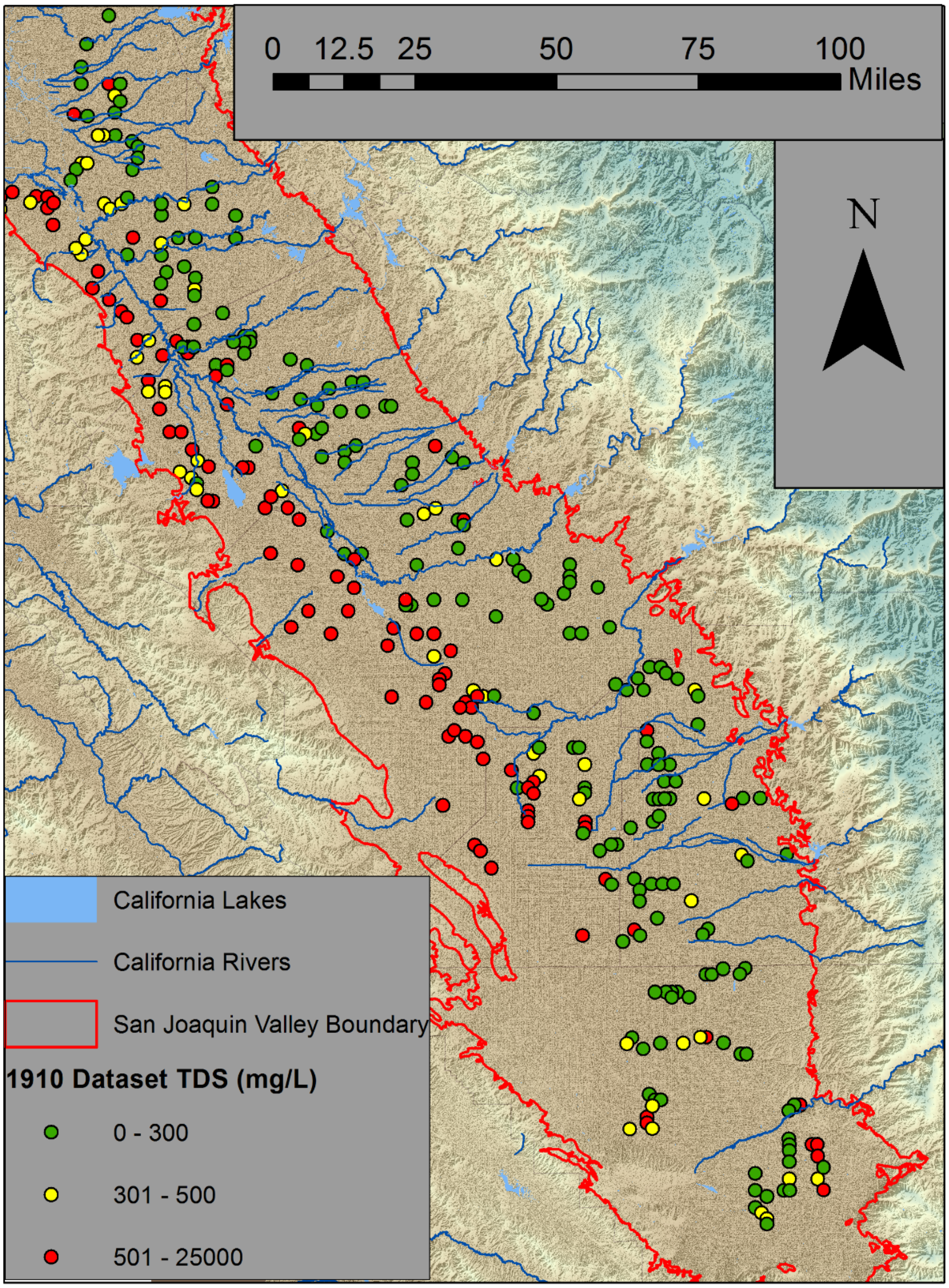

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Figure 2. 1905-1910 (Historical) well dataset mapped over the San Joaquin Valley with TDS levels for each well analyzed in this time period. NAD_1983_California_Teale_Albers

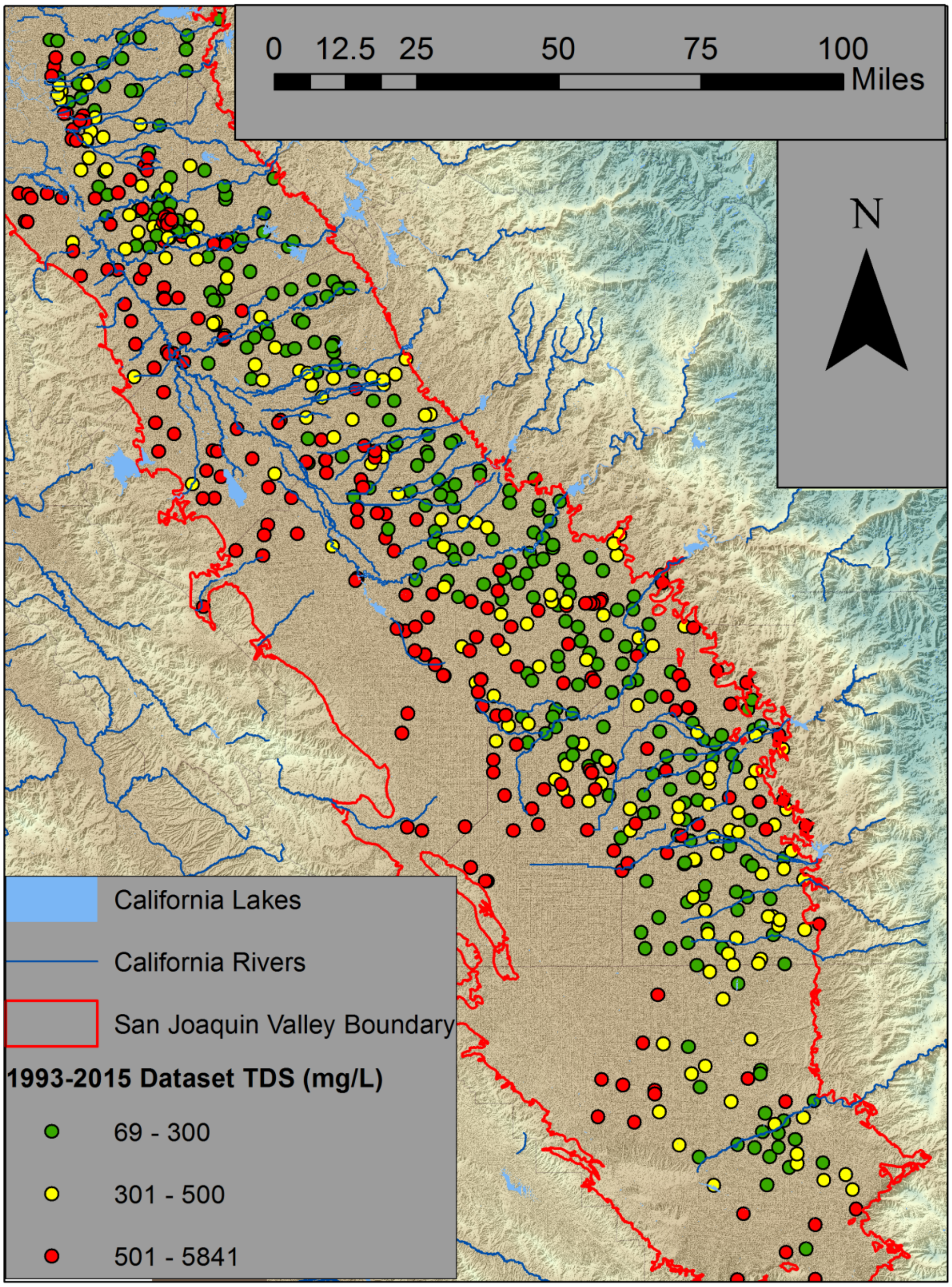

Figure 3. 1993-1015 (Modern) well dataset mapped over the San Joaquin Valley with TDS levels for each well analyzed in this time period. NAD_1983_California_Teale_Albers

Discussion / Conclusion

"This correlation indicates that agricultural land-use practices have likely affected TDS values to some degree in the eastern SJV. Wells surrounded primarily by natural, urban, and mixed (no single land-use type N 70%) land use likely capture more groundwater unaffected by agricultural recharge and contain lower TDS concentrations than those surrounded predominantly by agricultural land use (Fig. 5). However, even water sampled from wells surrounded by land with b70% agricultural land use have higher TDS than all groundwater in the Historic period (p-value b 0.001), which likely indicates that many of these wells also capture some agricultural recharge. This finding is not surprising since agricultural irrigation return is the primary form of recharge to the modern groundwater system in the eastern SJV (Faunt, 2009) so it might be expected that wells in largely urban areas capture water that originally recharged beneath irrigated, agricultural land. "(Hansen) Hansen brings up a good point in terms of the different land uses that may be contributing to the increase in groundwater contamination by various causes. Industrial agriculture predominantly occupies the central valley's land use and as a result, TDS concentrations have increased significantly over the last century.

Over the last century it is clear that TDS concentrations have increased in all regions of the San Joaquin Valley (**Fig.2 and Fig.3**). The results show that TDS in groundwater specifically in the Central Valley of California has significantly increased as a result of industrial agriculture and irrigation runoff which recharges groundwater systems. The recharge can contain many different types of ions ranging from fertilizers, soil amendments, salts, and mineral weathering which all increases water salinity. This is a significant aspect of future research for areas similar to the central valley that may be under great agricultural stress as well. For future research, this dataset should be very useful and this study should be used as an indicator that water demands continue to increase while water quality continues to increase because of human practices.

Acknowledgements

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