Author: David T. Hansen

Delta Island Inter-Relationships: ArcGIS Schematics

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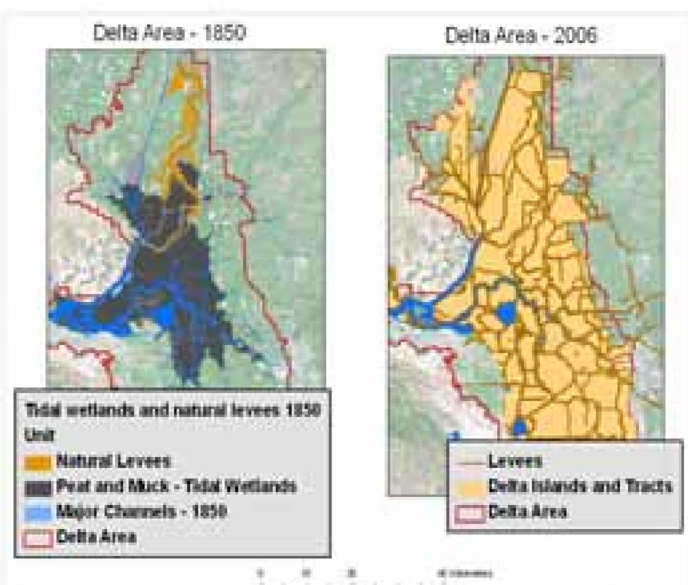
Abstract

The Sacramento San Joaquin Delta, California is composed of a set of networks. Channels and sloughs of the Sacramento and San Joaquin Rivers define a set of islands. These islands are protected from flooding by a network of levees. The Delta area is home to over 500,000 people. A network of roads connected by bridges provide access to and from these Delta communities. Changing climatic, hydrologic, environmental, seismic, and land use conditions jeopardize the Delta s natural and human infrastructure. This paper examines the use of ArcGIS Schematics in the analysis of the road network. This network which is often on the top of the levee system connects the various islands by bridges and in some cases by ferries. It is a complex system. The use of schematics assists in showing connections or the lack of connections for the network. These schematics can portray and communicate the relationships between the Delta islands to policy makers and the public.

Introduction

The delta of the Sacramento and San Joaquin Rivers (Delta) and Suisun Marsh area of California are major components of San Francisco Bay estuary. The system carries flows from the watersheds of the Central Valley. This includes the entire western slope of the Sierra Nevada. Figure 1 shows the extent of this watershed within California.

Water passing through the Delta provides drinking water for about two thirds of the State population and provides irrigation water for over 1.0 million hectares (2.5 million acres). The Delta is a key component in Federal and State water projects. The Delta and adjacent Suisun Marsh are constrained to one outlet at Carquinez Strait by coastal mountain chains. Instead of the common migration of fluvial and tidal sediments seaward to the bay, tidal and fluvial sediments are stratified upstream as sea levels rise and fall. Figure 2 shows the relative extent of tidal wetlands at about 1850 in the left panel. This also shows natural levee deposits along the stream channel for the Sacramento River at about the same time period (Atwater, 1982). Since 1850, these natural levees served as the basis for man made levees which have been expanded throughout the Delta and portions of Suisun Marsh. There are over 1,600 kilometers (1000 miles) of levees at the present time (URS Corp., 2007). These levees are shown on the right side of Figure 2 for the Delta area.



In the Delta, irrigated agriculture rapidly developed since 1850 with the construction of levees and drainage of tidal wetlands. Presently over 202,000 hectares (500,000 acres) of Delta lands are in agricultural production. Suisun Marsh is largely wetland. It and the remnant wetlands in the Delta represent about 10 percent of the existing wetland areas in California. Drainage and cultural practices of the highly organic soils of the Delta have led to significant subsidence. Some areas of the Delta are as much as 7.5 meters (25 feet) below current mean seal level (URS Corp., 2007).

Levees define the major stream channel network of the Delta and constrain flows during flood events. They also define many of the boundaries of islands and tracts. Many of the levees were initially constructed of local materials or dredge spoils to reclaim wetlands. Most have been raised over time to prevent flooding. Most are maintained by local reclamation or levee districts. The levee system is considered adequate for providing 100 year flood protection for only portions of the Delta. Since 1900, there have been 166 recorded levee failures (URS Corp, 2007).

There are two primary modes of transportation within the Delta, the network of river channels and sloughs and road network. The Stockton and Sacramento ship channels provide access for ocean ships. Most Delta towns have developed along both the road system and main river channels adjacent to levees. Figure 3 shows the main street of the historic town of Locke adjacent to the levee and highway.

Linking the road system between islands are over 50 bridges of which 30 are drawbridges crossing navigable waterways. Figure 4 shows one of these draw bridges for highway 160 crossing the Sacramento River.

There are two ferries linking portions of the State Highway system as well as three other ferries for local roads (URS Corp., 2007). Figure 5 shows the ferry landings for State Highway 220 on the left and a draw bridge for State Highway 160 crossing the Sacramento River.

The road network is complex linking the islands and separate tracts with bridges or ferries. This complex network is shown in Figure 6 and is based on U.S. Census line files. Within the Delta are six State Highways and a host of minor roads. Three of the State Highways (4, 12, and 160) are main links through the Delta. All of the roads are two lane roads. Many are winding roads that are on top of the levees. What is not clear in figure 6 is which islands or tracts are connected and type of connection (bridge or ferry). Figure 7 shows a portion of a delta road crossing a vineyard on a private levee.

Application of ArcGIS Schematics

The extension, ArcGIS Schematics, permits display and analysis of both the components of a geometric network and its schematic representation. Simplification of a network into a schematic focuses attention on major network elements. The schematics extension contains tracing tools to identify the connection between network elements. In this application of schematics to the delta road network, the intent is to identify which islands are associated with State Highways 4, 12, and 160.

The Schematics Process

The main geospatial features of interest for this application are the road network and the representation of islands or tracts. The source for the two base data layers are commonly available GIS themes from either the Delta Vision web site or the California Spatial Information Library (CaSIL - http://gis.ca.gov). The main data themes were brought into a common feature dataset in a file base geodatabase. These features were then edited and further simplified for use in generating schematics.

Geospatial Data Modification and Simplification

The road network was modified. The overall road network is shown in Figure 6. This dataset carried far more roads than could be effectively used in the analysis. Not clearly identified were bridges and ferries that link the islands. In addition, there was no clear association between the roads and the separate islands and tracts. State Highways and major roads were separated out from other roads on the separate islands. During this review, road sections that represent bridges or ferry routes were identified. Junction points were added as a point feature class to represent bridge ends or ferry landings. This point feature class was used to represent the junctions in Arc schematics. Since many of the highways and other roads in the delta are on top of the levees, many of the bridges show up as perpendicular intersections with levee roads. To clearly identify separate islands and tracts, centroids were generated with the island name and linked to the road network as junctions. As attributes of the linear features, the road name, island name, and a network level were identified. State Highways comprise the primary level. A secondary level are roads that link to a State Highway system over one or more bridges. Islands and tracts on the periphery of the delta and adjacent to other major road systems were excluded.

The focus is on primary island groups with a State Highway segment and secondary groups where additional bridges must be crossed to access a State Highway. The linear features and associated junctions for bridges, ferries, and centroids were carried into geometric networks. These geometric networks are the basis for generating schematics.

Schematic Setup

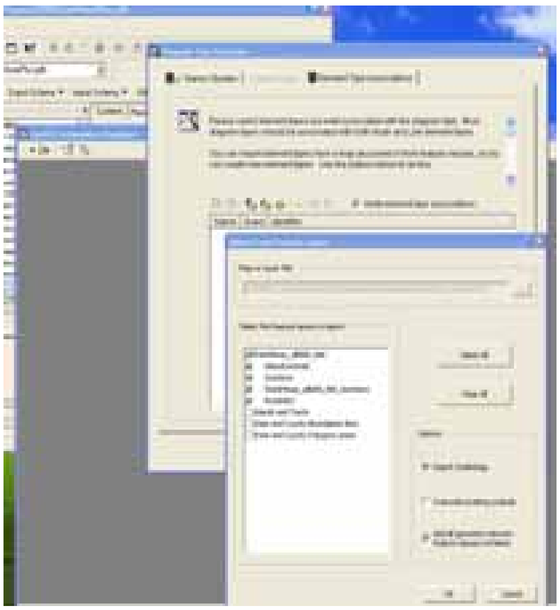
Generating schematics makes use of schematic builders. There are three builders, the standard builder, network dataset builder, and the custom query builder. For this initial application, the standard builder was used with the option of importing and referencing the geometric network from ArcMap layer files. Some initial work must be done before importing the ArcMap layers. A geometric network must be defined for the feature classes participating in the schematic with ArcCatalog. In ArcMap, the features should be symbolized for common display in both the data frame containing the features and the data frames for the generated schematics.

Since Arc Schematics is a relatively new extension, the process of generating a schematic from separate feature classes will be described in some detail. The process followed is located under ArcGIS Desktop Help (*Extensions>Schematics> Working with ArcGIS*

Schematics> Starting your schematic project conception using the Import From Feature Layers command).

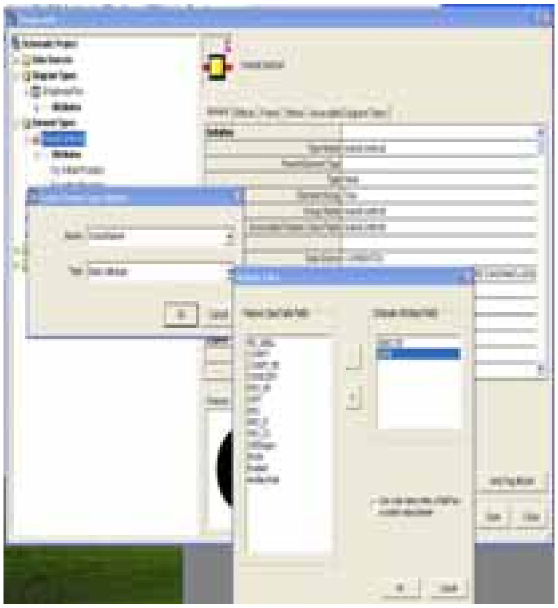
Step 1 Creation of a schematic dataset - ArcCatalog is used to generate a base schematic dataset and schematic diagram type with the standard builder. The diagram type is a new empty type that will be used in subsequent steps.

Step 2 - Importing feature layers from a map into the new schematic dataset and diagram type This method is used to carry in symbology and to identify relationships of the feature classes to be recognized in the schematic. Figure 8 shows the windows displayed when importing ArcMap layers into a schematic project of the Schematic Designer.

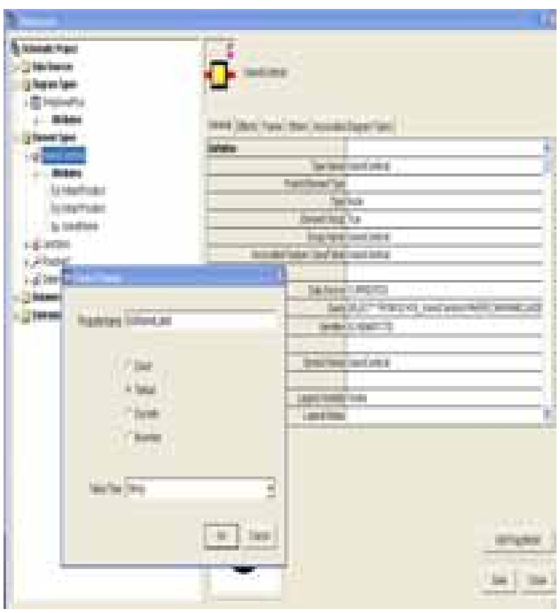


In ArcCatalog, right click the schematic project created in step 1 and edit the project. For the newly created diagram type, right click and select import from feature layers. Selecting the ellipsis button for Map or Layer File will allow you to path to the ArcMap document to select the layers to import symbology and initially identify the relationships to the feature class attribute tables. This will create the corresponding schematic element types. These element types will now show in the table of contents for the schematic project. The attributes may be edited as needed for each of the feature classes.

For this application, island or tract names are desired on the schematic. This is stored in a point feature class representing the centroids of islands or tracts. One method for capturing this attribute information is to modify the schematic dataset to associate this information to the nodes or links. In the schematic editor, an attribute is added to the nodes representing the island centroids as a stationary attribute. Two fields are recognized for this association, OID and IslandName. Figure 9 shows this step.



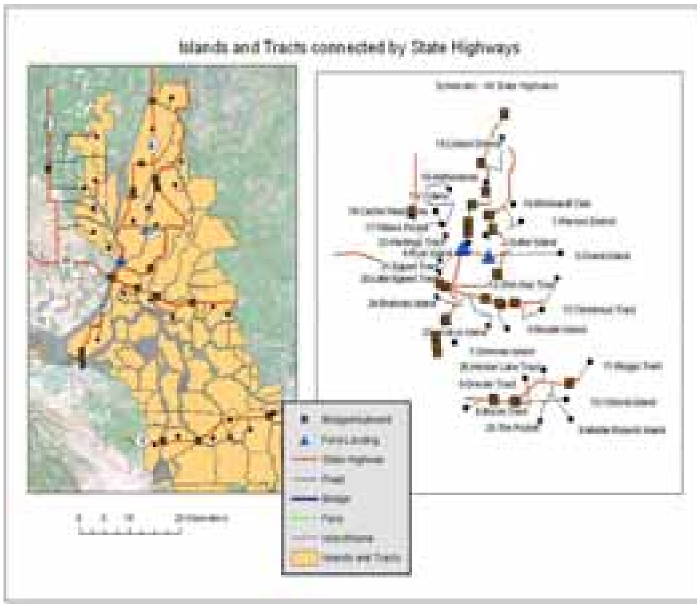
Next, a textual property is added to the nodes for display of these associated fields. This is shown in Figure 10. Other types of attributes may be used such as field attribute or query attribute described in the tutorial for the Schematics Designer extension.



Finally, it is possible to add node reduction rules to the diagram type with the schematic editor. This will further simplify the schematic display. For this application, a node reduction rule by priority was added to the network junctions. This rule was used to reduce the number of displayed nodes with 2 or more connections.

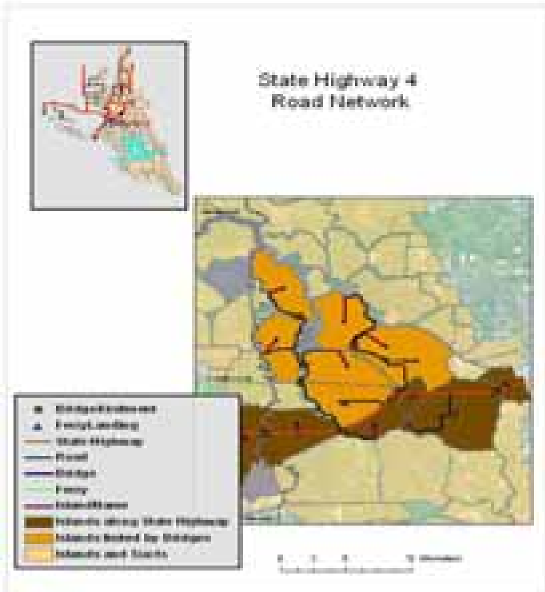
Generation of Schematics with the Road Network

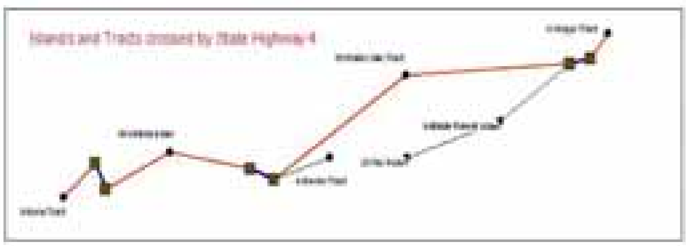
Step 3 Displaying the schema in ArcMap - In ArcMap, separate sections of the road network can then be selected for display based on the defined schematic dataset. These are shown in the following set of figures. Figure 11 shows all six State Highways and the islands or tracts that they cross displayed both as a map and as a schematic.

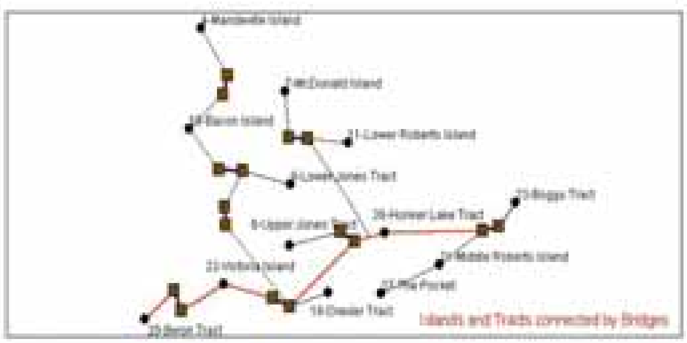


The schematic is still rather complex. Three State Highways serve as primary transportation corridors through the Delta and carry most of the traffic. These are highways 4, 12, and 160. These three State Highways were selected for displays in ArcMap to generate schematics.

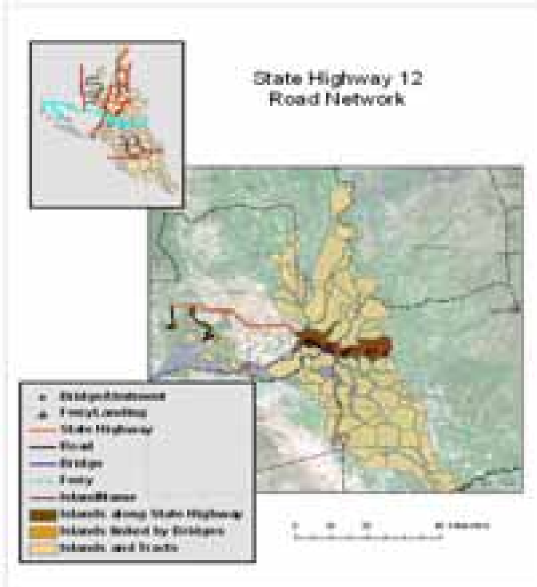
State Highway 4 - Highway 4 is a primary corridor between Stockton on the eastern side of the Delta to the San Francisco Bay area. Figure 12 shows the section of highway 4 that crosses the Delta. It shows the islands and tracts crossed by the highway. The Figure also shows the islands or tracts that are connected to this highway system by one or more bridges. Figure 13 displays the schematics for this portion of the road system with node reduction applied. The layout method used is the "Geo-Linear Dispatch" to separate the bridge junctions and links for display.

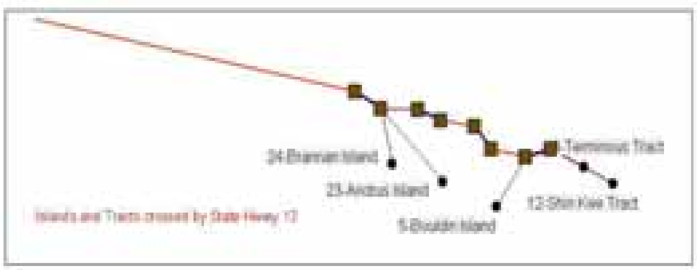


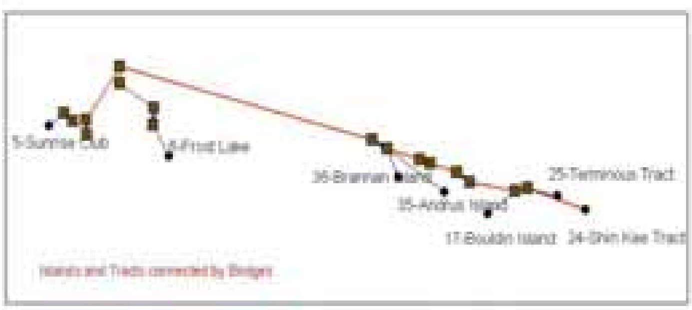




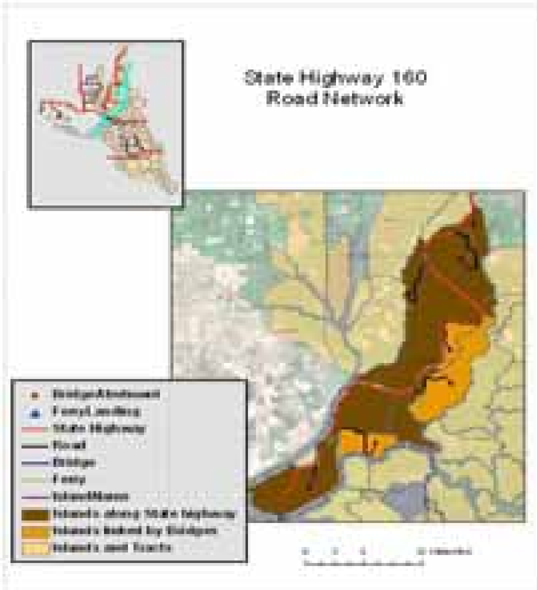
State Highway 12 - Highway 12 is a primary east - west corridor. This highway crosses the area from Lodi on the eastern side of the Delta to Suisun City and Fairfield to the north of Suisun Marsh. Figure 14 shows the section of highway 12 that crosses the Delta. It shows the islands and tracts crossed by the highway. The Figure also shows the islands or tracts that are connected to this highway system by one or more bridges. Figure 15 displays the schematics for this portion of the road system with node reduction applied. The layout method used is the "Geo-Linear Dispatch" to separate the bridge junctions and links for display.

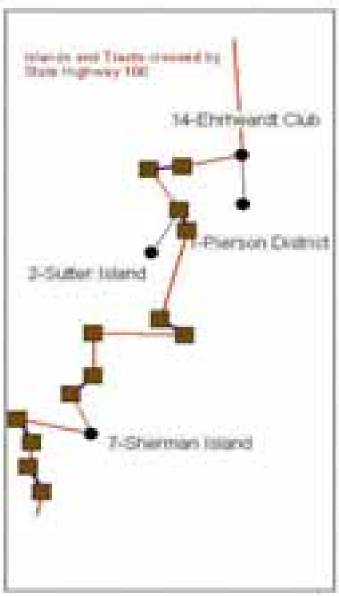


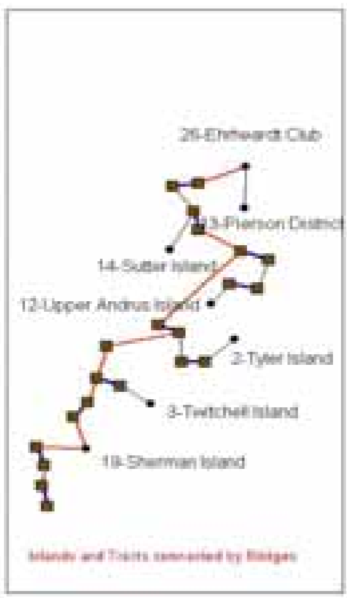




State Highway 160 - Highway 160 is a primary north - south corridor. This highway crosses the Delta from Sacramento at the northern end to Antioch at the southwestern edge of the Delta. It connects to both highways 4 and 12. It is a primary corridor for many of the Delta towns along the Sacramento River. Figure 16 shows the section of highway 160 that crosses the Delta. It shows the islands and tracts crossed by the highway. The Figure also shows the islands or tracts that are connected to this highway system by one or more bridges. Figure 17 displays the schematics for this portion of the road system with node reduction applied. The layout method used is the "Geo-Linear Dispatch" to separate the bridge junctions and links for display.







These are based on a simplified network. Not shown is these separate maps and schematics are the other local roads that link between the highway systems. There are also several islands and tracts on the periphery of the Delta that have nearly direct access to external road systems that are not shown. There are also islands that have either no access or a very extended access to external road systems.

Summary

The extension, ArcGIS Schematics, is an effective tool for display and evaluation of networks. In this application, the extension was used to simplify the display and analysis of the road network within the Sacramento San Joaquin Delta. Of major interest for this road system is the connection between islands by bridges or ferries. Schematics assist in visualizing the network and connections between the separate islands and tracts. In this particular application, all of the possible linkages across the road network between the islands were not explored. Also, isolated islands and tracts were not displayed. This extended network with the full set of roads can be explored at a later time.

The State of California has begun a planning process for the Delta and Suisun Marsh referred to as Delta Vision (Delta Vision, 2007). This process is examining risks from climate change, sea level rise, seismic events, urbanization, etc.. Based on this risk assessment, the Delta Vision process will be developing plans to address those risks and protect the services provided by the area. Schematics may be a useful tool in this process. This tool may also be applied to other network systems for the area such as the levee, utility, and pipeline systems. As a tool, the schematics extension is still rather complex to implement for an application.

References

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Authors:

David T. Hansen
GIS Specialist / Soil Scientist
MPGIS
Phone: (916) 978-5268
FAX: (916) 978-5290
Email: dhansen@mp.usbr.gov

The historic town of Locke recognizes it's location in the world for all to see (based on the North American Datum for 1927) - Figure 18