



& GRIDS DATUMS

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REPUBLIC OF EL SALVADOR

The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on the Republic of El Salvador was originally printed in 2005 but contains updates to their coordinate system since then.

When the Spanish Conquistadores first entered into Central America in the early 16th century, Indians of the Pipil tribe occupied the area now known as El Salvador. The Pipil were a subgroup of a nomadic people known as the Nahua, who had migrated into Central America around 3,000 B.C. They eventually fell under the Maya Empire, which dominated Central America until about the 9th century A.D. According to the Library of Congress *Country Studies*, "Pipil culture did not reach the advanced level achieved by the Maya; it has been compared, albeit on a smaller scale, to that of the Aztecs in Mexico. The Pipil nation, believed to have been founded in the 11th century, was organized into two major federated states subdivided into smaller principalities." The Spaniards were initially defeated in 1524 when they attempted to enter the area, and it took until 1528 with two more expeditions to finally subdue the Pipil nation. The fierce warrior Atlacatl is revered to this day to the exclusion of Alvarado who finally overcame the natives. "In this sense, the Salvadoran ambivalence toward the conquest bears a resemblance to the prevailing opinion in Mexico, where Cortes is more reviled than celebrated."

El Salvador (The Savior) is the smallest Spanish-speaking nation in the Western Hemisphere. It is located on the western side of the Central American isthmus. The country is slightly smaller than Massachusetts, and its land boundaries are with Guatemala (203 km), and Honduras (342 km) (*PE&RS*, July 1999). El Salvador's coastline is 307 km on the Pacific Ocean and its terrain is mostly mountainous with a narrow coastal belt and central plateau. The lowest point



is the Pacific Ocean (0 m), and the highest point is Cerro El Pital (2,730 m). El Salvador is known as the "Land of Volcanoes," and is one of the most seismologically active regions on Earth, situated atop three large tectonic plates.

Topographic Mapping of the Americas, Australia and New Zealand states, "To 1930, the only detailed accurate surveying done in El Salvador – a country that became independent in 1821 – was the surveying done for the Intercontinental Railroad Commission and a few surveys related to possible road routes." However, Nicaragua and Honduras had been squabbling regarding their border for more than 30 years, and an arbitration agreement was signed in 1930 and soon thereafter surveyed by the U.S. Coast & Geodetic Survey. El Salvador, Guatemala, and Honduras signed a protocol on 26 March 1936 accepting Cerro Monte Cristo as the tripoint of the boundaries of the three states. It was during this era that the first geodetic surveys were performed on the border between El Salvador and Guatemala from 1937 to 1940. The Dirección General de Cartografía was established in 1946 to

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continue the geodetic surveys and to implement a topographic mapping of the country. The end of the following year 1947, the Inter American Geodetic Survey (part of the U.S. Army Map Service) signed a cooperative agreement with El Salvador. By 1958, all classical geodetic triangulation had been completed in the country, and topographic mapping was well underway. The national mapping agency is now known as the Instituto Geográfico Nacional “Ing. Pablo Arnoldo Guzmán.”

The original horizontal datum of El Salvador is the Ocotepeque Datum of 1935 which was established by the U.S.C.&G.S. at Base Norte (in Honduras) where $\phi_0 = 14^\circ 26' 20.168''$ North, $\lambda_0 = 89^\circ 11' 33.964''$ West of Greenwich, and $H_0 = 806.99$ meters above mean sea level. The defining geodetic azimuth to Base Sur is: $\alpha_0 = 235^\circ 54' 21.790''$, and the ellipsoid of reference is the Clarke 1866 where $a = 6,378,206.4$ meters and $1/f = 294.9786982$. The corresponding astronomic observations at that mountainous location are: $\Phi_0 = 14^\circ 26' 13.73''$ North ($\pm 0.07''$), $\Lambda_0 = 89^\circ 11' 39.67''$ West ($\pm 0.045''$), and the defining astronomic azimuth to Base Sur is: $\alpha_0 = 235^\circ 54' 20.37''$ ($\pm 0.28''$). The difference between these two sets of coordinates is due to the local gravimetric deflection of the vertical. The grid system used in El Salvador is based on the Lambert Conformal Conic projection where the Central Meridian, $\lambda_0 = 89^\circ 00' 00''$ West, the Latitude of Origin, $\phi_0 = 13^\circ 47' 00''$ North, the Scale Factor at Origin, $m_0 = 0.999967040$, the False Easting = 500,000 m, and the False Northing = 295,809.184 m. Sometime after that, the National Geospatial-Intelligence Agency (nee NIMA) computed all the classical triangulation of Central America on the North American Datum of 1927. The 1987 published datum shift parameters for Central America based on 19 stations (TR 8350.2) from NAD27 to WGS84 are: $\Delta X = 0 \text{ m} \pm 8 \text{ m}$, $\Delta Y = +125 \text{ m} \pm 3 \text{ m}$, $\Delta Z = +194 \text{ m} \pm 5 \text{ m}$.

After the disaster when Hurricane Mitch hit Central America, the U.S. National Geodetic Survey established a number of GPS Continuously Operating Reference Stations in the region. They observed a number of stations in El Salvador in order to establish and publish a High Accuracy Reference Network on the North American Datum of 1983. The National Geodetic Survey (NGS) has posted all of the data, including various other sources of geodetic coordinate data in El Salvador and the region on their website. The documentation of their geodetic observations is a superb resource for the researcher, and it is freely available. Thanks, NGS!

Update on the Republic of El Salvador

“The reference frame of El Salvador is a GPS base network of 38 stations. It was measured by the *Gerencia de Geodesia, Instituto Geográfico y del Catastro Nacional* (GG-IGCN using differential GPS positioning in partial sub-networks and in 36 daily sessions between October and December 2007. Most of the reference stations (28) were determined together with a secondary control point in order to ensure the long-term stability of the network. The GPS data were processed by *Deutsches Geodätisches Forschungsinstitut* (DGFI) within the SIRGASWGII (Geocentric Datum) activities. The analysis strategy is based on the double difference approach (Bernese Software V5.0, Dach *et al.* 2007).” As is typical of Latin American nations that relate their local coordinate systems to the SIRGAS, they do not publish the transformation parameters from their classical native coordinates to SIRGAS. https://www.sirgas.org/fileadmin/docs/Boletines/Bol14/35_Figueroa_SIRGAS-ES2007_8.pdf

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