

This issue of *geo-data Hawai'i* is the last publication of this series. With the budget constraints felt everywhere in the state and the reorganization of the Office of State Planning, this part of OSP's work to survey and publicize geographic data of interest to the mapping, planning and GIS communities will have to take different venues. Interest in geographic decision making remains strong and growing in the state, but in these times of tight budgets, limited available funds must be concentrated in keeping core functions alive. Some of the less critical functions associated with geographic data must be set aside for the time being.

Mapping and GIS continues to undergo a rapid transition in Hawai'i as everywhere. This issue will attempt to resolve a long standing problem with Universal Transverse Mercator (UTM) coordinate grid variability in the state. Other digital products produced locally and by the US Geological Survey will also be highlighted.

The development and implementation of the state GIS, which has been the focus of so much broad interest in past years, has also felt the broad state agency budget cuts. The last article in this issue will be an update of the status of the State GIS.

New DEMs and DLGs

In an earlier newsletter, Volume 3, number 1, one article reviewed some of the problems with the Level 1 Digital Elevation Models (DEMs) that were in general use in the state. The main source of the problem was located in the software used to generate the original DEMs. These DEMs were prepared in a cooperative project with the Office of State Planning and the US Geological Survey. Level 1 DEMs are generally not designed for finished representational purposes. However, with their general state-wide availability and potential for all manner of visualization applications, they were widely used for "fishnet" views in spite of their problems. The "striping" and the mauka "pali" on Diamond Head in the corner cut below are representative of some of larger problems present especially in the O'ahu and Maui DEMs.

In 1994, the Office of State Planning contracted Geographic Decision Systems International (GDSI) to conduct a watershed modeling study. As a part of this study GDSI agreed to create Level 2 DEMs from USGS scanned contour data for O'ahu and parts of Maui County. Shortly thereafter, several local federal agencies including the National Park Service and the Water Resources Branch of the US Geological Survey requested that the USGS National Mapping Division complete the rest of the state in Level 2 status DEMs with the exception of Ni'ihau and Kaho'olawe. In response to this A-16 cooperative program request, the USGS agreed to prepare new DEMs for the rest of state to Level 2 standards, in order that agencies and other users would have almost complete Level 2 DEM coverage for its varied needs.

GDSI has completed the work on O'ahu, West Maui and is currently finishing Lana'i. When these quadrangles' data are quality checked by the USGS, they will be added to the USGS Catalog and will be available for distribution. The USGS has scheduled the completion of the balance of the state data by the end of their fiscal year, September 30, 1996. The availability of

these materials will allow much better visualization products, as well as promote much more accurate slope and aspect mapping. Hydrologists will also appreciate the much better watershed analyses made possible from these new DEMs.

Up to this time, Hawai'i has only had four of its 1:24,000 quadrangles with a Hypsography DLG (digital contours) available.

As a part of the preparation of each DEM, a clean contour network from the quad must be scanned and vectorized as a part of the production process. This edited network is then interpolated into a DEM grid by one of several different types of software. Scanning and vectorizing contours are steps in the production of a Hypsography DLG. In edited vector form, the contours are adequate for making a DEM but do not usually meet the cartographic production standards of a Hypsography DLG.

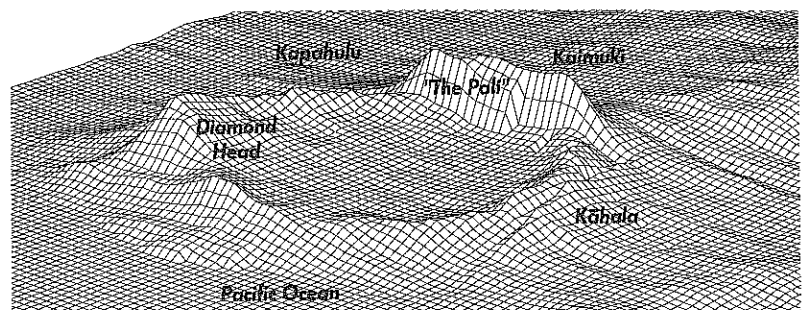
As a part of their work in preparation of Level 2 DEMs, the USGS is planning to complete cartographic grade Hypsography DLGs for their part of the DEM project which will make this important class of data available for approximately two-thirds of the state.

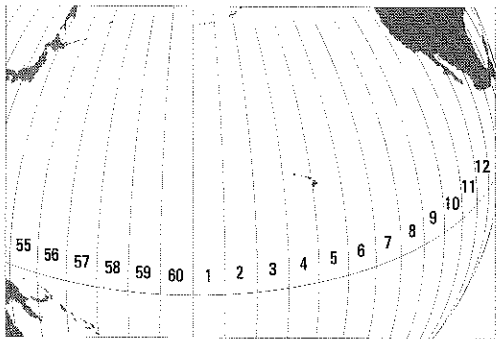
Hypsography layers are somewhat rare in most parts of the country and the USGS will no longer prepare this form of DLG given budgetary restraints. Hawai'i should count itself fortunate to have a almost complete Level 2 DEM set and Hypsography DLGs for a large part of the state for the great power they add to GIS, engineering, and planning operations.

The masthead illustration is a section of the Honolulu 1:24,000 quadrangle produced in the new USGS Digital Raster Graphic format. (See article in this issue) The first issue of *geo-data Hawai'i* included a similar area scanned at a higher resolution from a film copy of the quadrangle. Comparing the two will allow the reader to evaluate the resolution that will be available in the Hawai'i DRG series.

Which UTM Coordinate System are you using?

UTM Coordinates: The Universal Transverse Mercator (UTM) coordinate system is widely used in Hawai'i and abroad for recording and describing spatial data. It was adopted by the Defense Mapping Agency in 1947 as a worldwide plane coordinate system for military operations. The adoption of this system allowed locations,





are 60 UTM zones that encircle the globe, numbered from 1 to 60, moving eastward from the 180° meridian. Each zone is 6° wide and stretches from 84°N to 80°S latitude. Zone 1 covers from 180°W to 174°W; zone 2 from 174°W to 168°W; and so forth around the world.

Basically, each zone is a long, thin gore of the globe, about 400 miles wide at the equator by 11,300 miles long in a north-south direction. A square grid is overlain on each zone as a reference system for measurement. The grid ignores any curvature of the earth within a zone, curvature that would add a slight bend to the topographic map's latitude and longitude frames and accumulate as maps are mosaicked together in an east-west direction. This grid makes it quite easy to interpolate positions from maps located within a zone by simple arithmetic. Because of its ease of use, the federal government and many local agencies have adopted UTM coordinates for recording many types of position information. For example, any historical building that appears in the National Register of Historical Places will have a UTM coordinate associated with it and the UTM system is the basis for data recording of the USGS's digital map information.

An earlier issue of *geo-data Hawai'i* included an article on the implications of converting the Old Hawaiian Datum, long used in Hawai'i mapping, to the North American Datum (NAD83) system of latitude and longitude. After that article was printed, a very common error was discovered which affects the local use of UTM coordinates.

Each UTM grid is positioned according to the latitude and longitude system locally in use. The UTM system errors that exist on some Hawai'i maps are a result of the fact that the latitude and longitude system used for positioning the UTM grid was not the same one as used for topographic mapping.

Latitude and Longitude and spheroids: The earlier article and one of its illustrations noted that in mapping Hawai'i, the USGS used the International spheroid (ellipsoid) of 1909 as a base model for our current topographic maps and orthophotoquads. That statement was in error because; 1. the International spheroid is only used for the orientation of the UTM grid on USGS topographic maps; 2. the International spheroid is the incorrect UTM spheroid for use in Hawai'i; and 3. the USGS was not consistent in the use of the International on its orthophotoquad products.

Since UTM coordinates are based on latitude and longitude, this inconsistent use of the International spheroid means that we have several different systems of UTM coordinates in Hawai'i. While the transition to NAD83 will eventually resolve the problem, (since all mapping will be converted to this system some time in the future) some confusing problems remain in the application of Universal Transverse Mercator (UTM) coordinates.

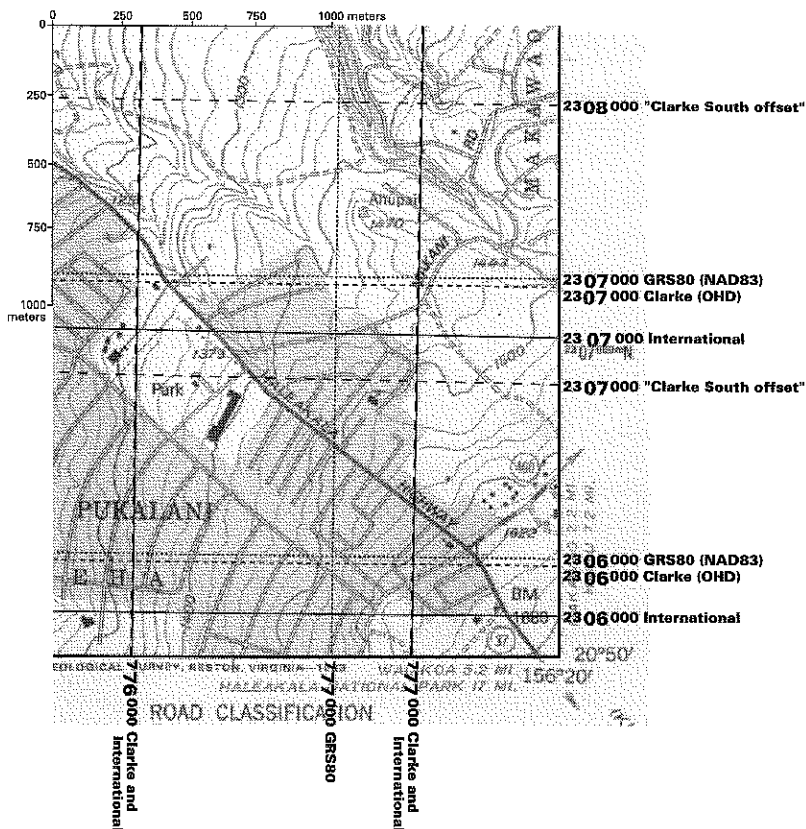
The information block that is printed in the lower left of all USGS topographic maps and orthophotoquads reveals the UTM

distances, routes, and targets to be easily computed without being forced to rely upon the cumbersome mathematical computations associated with the latitude and longitude system, the only seamless worldwide coordinate system. There

coordinate problem. On Hawai'i 1:24,000 topographic maps, one of the lines states: "Projection and 10,000-foot grid ticks: Hawaii coordinate system, zone 3 (Transverse Mercator) **Clarke spheroid 1866. Old Hawaiian Datum**". This statement is correct, the Old Hawaiian Datum was based on celestial methods of determining latitude and longitude using the Clarke spheroid model of the earth.

Before the establishment of the Old Hawaiian Datum in 1928 by the Hawaiian Government Survey, each of the islands had slight differences in their latitude and longitude systems due to the accuracy limits of the methods used to determine their separated baselines. When the slightly different latitude and longitude references of the islands were adjusted into one system, it was given the official name of the Old Hawaiian Datum of the Clarke Spheroid of 1866. This system remained the basis of our latitude and longitude until the adoption of the North American Datum of 1983, based on the World Geodetic System.

However, the UTM system that is present on Hawai'i topo-



UTM Coordinate System Reference Spheroid

- Clarke** -- (Clarke Spheroid of 1866 - Old Hawaiian Datum) Used on US Geological Survey 1:24,000 Paia Quadrangle advance print orthophotoquad (1977) and USGS-NMD Digital Line Graph Data, Paia, HI (1987).
- International** -- (International Spheroid of 1909) Used on US Geological Survey 1:24,000 Paia Quadrangle topographic map (1983) and 1:24,000 printed Paia Quadrangle orthophotoquad (1977).
- GRS80** -- (Geodetic Reference System 1980 - North American Datum 1983) Used on Defense Mapping Agency 1:50,000 Makawao Hawaii topographic sheet 5719 IV (1989).

graphic maps is based on the International Spheroid, not the Clarke spheroid as we would expect. The same information block continues: "1000-meter Universal Transverse Mercator grid ticks, zone 4, shown in blue. **International spheroid.**" All topographic map and orthophotoquad products have this statement or a slight variation of it. However, all products do not have the same orientation of the UTM grid as would be expected from this reference.

The use of the International spheroid is a mystery and also the root of the problem. Either someone in the Defense Mapping Agency who established the UTM grid OR the US Geological Survey, who adopted the grid for inclusion on topographic maps, chose an incorrect spheroid to define the origin of the grid. This selection error means that the UTM grid used in the Hawaiian Islands was shifted about 170 meters south of where it should be, while the east-west difference is only about 4 meters, an insignificant variation for most map usage. It has been suggested that the International was chosen since much of the rest of world of interest to the military in the 1940's was mapped on the International spheroid, but it has also been called a simple mistake.

Multiple UTM Orientations: The crux of the problem is that in some areas of Hawai'i, there are four different systems of UTM coordinates in use today; 1. UTM's based on the International spheroid; 2. UTM's based on the Clarke spheroid; 3. UTM's based on WGS80 (the new North American Datum spheroid); and 4. a strange orientation of the Clarke that is offset in the wrong direction on some orthophotoquad Advance Prints.

It is very hard to trace the heritage of the problems associated with UTM coordinates. For illustrative purposes, the Paia, Maui 1:24,000 Quadrangle on the previous page is used to compare the different systems. The Paia example is very interesting since it is one of the few quadrangles that has all four orientations in its products. There are additional problems in other quadrangles. For example, the Hana, Maui advance print orthophotoquad uses UTM zone 5 coordinates instead of the proper zone 4 and the Hana and Kipahulu, Maui topographic maps include both zone 4 and 5 UTM coordinate ticks.

If the USGS had been consistent in the use of the International origin of the UTM coordinates until the adoption of NAD83, there would be fewer problems, but there are a number of cases where they have shifted back and forth between systems without noting the spheroid shift in the information block on the sheets. The USGS is consistent in using the same form of UTM grid ticks on its 1:24,000 topographic maps in the 1959, 1969, and 1983 editions of the maps. However, the note about use of the International spheroid for the UTM grid only appears in the 1983 edition information block.

When the USGS 1:24,000 orthophotoquads were introduced in 1978, the consistency was lost. The orthophotoquads were first available to the public in photographic prints and in "Advance Print" blueprint copies. These blueprint orthophotoquad forms note the use of the International spheroid for the UTM coordinates in their information block, but on some quads, Clarke spheroid UTM's were used, shifted in either a north or south direction. However in most of the Advance Prints, the International was used keeping them consistent with the corresponding topographic maps.

Investigation of all the holdings in the University of Hawai'i map library produced the following exceptions table. At this time, it is not known if the USGS has changed any of the inconsistencies in later printings or newer advance print copies.

The USGS printed a number of Hawai'i's higher sales orthophotoquads lithographically, before the program was discontinued several years ago. With the exception of Paia, Maui, all of the lithographic sheets were converted to the proper Clarke spheroid UTM grid, but without noting the change in the information block. The Paia lithographic orthophotoquad is the only quad identified that uses the "consistent" International UTM's.

To add to the confusion, when the USGS began creating the Digital Line Graph (DLG) optional formats of Hawai'i's topographic maps, they appear to have shifted back to the correct Clarke spheroid origin of the UTM coordinates to code the data locations. This is harder to detect because of the digital form of the data. In this study, several point symbols (pumping stations) were selected from the Paia, Maui hydrography DLG and plotted on the topographic maps in both

EXCEPTIONS

All 122 1:24,000 Hawai'i Orthophotoquad Advance Prints that correspond to a 1:24,000 topographic map use the International spheroid (the UTM grid is the same as the corresponding topographic map version) except:

Hawaii	Akaka Falls	-170 m N -4 m E
	Ka Lae	+170 m N -4 m E
	Naohueleelua	-170 m N -4 m E
	Puu Hou	+170 m N -4 m E
Maui	Maalaea	-170 m N -4 m E
	Olowalu	-170 m N -4 m E
	Paia	-170 m N -4 m E

All 22 Hawai'i Orthophotoquad Lithographic Prints that were produced use the Clarke spheroid (the UTM grid is shifted 170 meters North and 4 meters West of the corresponding topographic map version) except Paia, Maui which uses the International spheroid (the UTM grid is the same as the corresponding topographic map).

Clarke and International UTM grid origins. They matched quite well when Clarke UTM quadrangle corners were chosen for the fitting but the locations were shifted over 160 meters north when the International corners were specified.

Throughout the years that the USGS has been producing large scale topographic maps of Hawai'i, the Defense Mapping Agency (DMA) has made use of the USGS materials to produce an almost identical series at 1:25,000. The main difference between the series was that DMA added a full grid overprint of the UTM coordinates and added more reference information on the collar outside of the map area. In their series, DMA maintained the Old Hawaiian Datum for the latitude and longitude and used the International spheroid for the location of the UTM coordinate grid.

When DMA decided that there was a need for an intermediate scale series of the Islands, they recompiled the USGS 1:24,000 series into a 1:50,000 series released in 1989. In this new series, they used the GRS80 spheroid, the ellipsoid model for the North American Datum of 1983. This adoption shifted the DMA UTM coordinates into the NAD83 system that is used for all federal mapping. It is curious that the USGS did not make a similar shift in the digital form of Hawai'i's quadrangles produced after 1983. Unfortunately this series, which was the only topographic maps incorporating the current correct UTM system overprint, was discontinued last year.

All UTM data bases should be converted to NAD83 coordinates with the NADCON conversion software available from the USGS as soon as possible so that new data collection can fit seamlessly into one system. At the very least, agencies who hold UTM files should include very detailed source heritage information with the files so that they can be converted accurately sometime in the future. Hawai'i users of the UTM coordinate system for coding data should be extremely careful to document coordinate sources and incorporate the offsets in their data when it is merged with a different system. Wherever possible, users should incorporate surveyed control point coordinates with their data sets so that a check is available for the conversion of their systems.

Special thanks to Allen Hoof, Hawai'i State Archives, for first pointing out the UTM coordinate discrepancy in Guam's topographic mapping to me; to Tom Fake, National Park Service, for noting the orthophotoquad discrepancies on Maui; and to Richard Stone, University of Hawai'i, for further detective work in identifying the complexity of the problem in his discussions with the National Geodetic Survey.

New Digital Raster Graphic Products for the State (DRGs)

Digital Raster Graphics: A further step in the transition to all-digital cartographic data storage is nearly upon us. In order to make access to the traditional printed topographic series easier, the USGS is racing to complete a new product called the Digital Raster Graphic (DRG) nation-wide by 1998. A DRG is a scanned and geo-referenced TIFF 6.0 format image of a color topographic map. All common scales for the US will eventually be available in this form: 1:24,000/1:25,000; 1:63,360 (Alaska); 1:100,000; and 1:250,000. The 7 1/2 minute 1:24,000/1:25,000 quads hold the first priority for completion.

The final format will be a CD-ROM containing all the quads in a one degree square. The CD will contain approximately 64 1:24,000 quads at 250 dpi, two 1:100,000 sheets and one 1:250,000 scale map. The map files will be issued in a compressed TIFF format with each sheet taking from 5 to 15 megabytes of space on the CD. Each file will be accompanied by an ESRI "TRF world" file containing the UTM coordinates of all the grid ticks on the map image. This data will allow the digital image to be geo-referenced and combined with a number of USGS and other products which use the UTM system as their base coordinate system.

Each file will contain maps with up to 13 colors that have been adjusted to standards that should reduce differences in color that currently exist between adjoining paper maps. In addition to digital intersections with other data, the files are designed to be used as backdrops for plotting other UTM coordinate data and for windowing for display use in a number of desktop publishing and other graphic applications.

There are many types of software already available for these image's manipulation and analysis. On the high-end, ESRI's Arc/Info and ArcView products are compatible with the DRGs, indeed ESRI's public domain ArcView version 1.0 for Windows will be shipped on each CD along with a DOS based viewing software, somewhat surprising, anticipating the high use of the products on UNIX platforms. Basic image manipulation and cropping can be done by Adobe Photo Shop and other image packages that can handle the large size of the files. In addition, there are other commercial and freeware image viewer packages on the Web, designed specifically for use with the DRGs.

At the present time, the purchase cost of each CD has not been announced for the two CD set that will cover Hawai'i. However, sample images of the Honolulu quadrangle have been available on the Web and the Hawai'i CDs are anticipated to be available for distribution by the end of the federal fiscal year, September 30, 1996.

Product Passings

In 1989, the Defense Mapping Agency (DMA) produced a 1:50,000 series of topographic maps for all of the state. The series was derived from the USGS 1:24,000 topographic series with updating from the USGS 1:100,000 series and other sources. Planners and map users welcomed this series for a number a reasons. It was a useful scale since it replaced the badly out-of-date 1:62,500 USGS island sheets; the maps were formatted at a convenient size for field and office work; the series had a full UTM grid overprint in the current NAD83/WGS84 positioning; plus a number of other features designed for military use such as red- and low- light reading design.

A lot of us immediately bought the full state set for convenient reference. Unfortunately, publication of the series has been discontinued due to federal budget cuts and will not be reprinted in the foreseeable future. Quickly following the abandonment of the USGS

analog orthophotoquads, the loss of the most up-to-date of the federal topographic products does not bode well for the future of inexpensive paper mapping products in Hawai'i and elsewhere.

Hikers and field workers, hold on to those old topo sheets and begin lobbying for the creation of a state service bureau or a private outlet for on-demand windowed and scaled plotted maps from the State GIS, likely the only state-wide system that will be regularly updated with the newest information.

State GIS Status

Everyone in government and private industry has been busy watching their backs during these last couple of years of deep budget cuts both at the federal and local level. One of the basic sources of GIS and mapping data, the National Mapping Center of the US Geological Survey has come under repeated assaults for elimination and still remains a likely target in the near-sighted eyes of some budget-cutters in Congress.

While the final outcome of the cuts will probably not become clear for years, it is unlikely that the paper 1:24,000 topographic sheet will be around much longer while the rapid production of Digital Raster Graphic forms of the sheets continue to increase. While no Hawai'i State agency passed unscathed, many of us were concerned about the status of the State GIS when the dust settled. The early loss of over 50% of their staff with rampant rumors about the dissection of the Office of State Planning, left many worried about the future direction of the unit that, with the cooperation of other agencies, has made great strides in developing a wide-reaching statewide decision tool and information management system.

As of this writing, the State GIS remains alive and well but considerably leaner. A core OSP staff of three keeps the system active, responding to queries, maintaining data and hardware, and conducting a range of analyses. However, the addition of new data layers and editing existing layers has, for all effective purposes, come to a halt.

The bill that was passed by the Legislature effectively moves the Office of State Planning and the resident GIS to the Department of Business, Economic Development, and Tourism and renames it the Office of Planning. As written, the move keeps the earlier OSP intact and provides an administrative home for the new OP. However, this bill remains to be signed by the governor. If the bill is not signed, it is expected that there will be more separation of the functions of OSP and their attachment to different venues. Further speculation is not appropriate here. The State GIS is intact and fulfilling at least part of its charge, but not growing as fast as it should to catch up with the data generation rate in the state.

Aloha

