



DIGITAL ATLAS OF NORTHERN GUAM

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WATER AND ENVIRONMENTAL RESEARCH INSTITUTE

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<http://www.hydroguam.net>

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TABLE OF CONTENTS

	Page
ABSTRACT	1
ACKNOWLEDGEMENTS.....	2
Natural Resources Atlas of Northern Guam.....	3
Description of the Digital Atlas of Northern Guam.....	3
Key Feature of the Atlas.....	4-6
Dedicated Internet Domain, Attractive Design, User–Friendly Interface, Easily Updatable, Scope of Maps, GIS and Google Earth Integration, Download Options, Geographic Information System (GIS)	
METHODOLOGY	6-7
Action I. Acquisition of existing data, Action II. Development of new data, Action III. Harmonization of format, projection, and extent, Action IV. Metadata and quality control, Action V. Development of pre-formatted maps, Action VI. Development of other materials to populate the Atlas, Action VII. Development of the digital resource center and user interface (website),	
APPENDIX SCREENSHOTS.....	8-11

ABSTRACT

Sustainable utilization of natural resources requires an effective management plan. An effective management plan requires accurate baseline information. Baseline information often exists but is often not readily available to those who need it. It is, therefore, important that what is considered baseline information be stored and formatted in such a way that it can be readily available to anyone involved in resource management and studies. In addition, such information should be standardized and widely compatible; equipped with metadata regarding sources, techniques, and restrictions; and easily updatable.

After creating a successful and frequently accessed and utilized web-based digital atlas known as “Natural Resources Atlas of Southern Guam”, which covers southern Guam and is available at south.hydroguam.net, researchers at WERI have now created a sister resource that covers the northern half of the island with Guam coastal area imagery database. It is entitled “Digital Atlas of Northern Guam” and is available at north.hydroguam.net. The sites rely on geographical information system (GIS) technology to disseminate geospatial data on various aspects of natural and man-made features of the area. This brief report summarizes the development of the atlas and outlines some of its aspects.

Keywords: Southern and Northern Guam Natural Resources, Watershed, Hydrology, GIS, Management and Planning, Education

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NATURAL RESOURCES ATLAS OF NORTHERN GUAM

Effective management of natural resources requires accurate information of the physical, environmental, and anthropogenic components of the system. WERI has been studying Northern Guam for decades, focusing on a wide range of issues, including research and mapping of coastal zone habitats, monitoring of health of coral reef and near shore ecosystems, investigating point-source and non-point-source pollution, modeling of groundwater system, hydrogeology, and structural geology, etc. Much of our work has a major geospatial dimension. WERI researchers and students have collected geospatial data by field mapping, remote sensing, and aerial photography, and developed numerous and highly significant data sets, cartographic resources, and digital models. Additional collaborative projects with different institutions and agencies have also produced a wealth of data, much of which also has geospatial significance. However, applying the results of research to actual management and sustainable development on Guam requires wide and easy access to the relevant data.

The digital version of the Natural Resources Atlas of Northern Guam is designed as a comprehensive and user-friendly web-based information server. It is freely accessible on the Internet at www.hydroguam.net address and offers a wide range of textual, graphical, statistical, and geographic information to any interested user. It allows advanced operations such as viewing and manipulation of GIS data yet requires no special programs or browser plug-ins to be installed by the user in addition to the standard web browsing software. It is the foundation and an integral part of a planned series of products dedicated to dissemination of information and rising of awareness regarding the diversity, current state, sustainable use, and critical threats to natural features of northern Guam.

DESCRIPTION OF THE DIGITAL ATLAS OF NORTHERN GUAM

The Digital Atlas of Northern Guam is a reference and an educational tool that provides a comprehensive picture of the natural resources, environment, and man-made features found in the northern half of Guam. The Atlas was inspired by the success of the previously developed sister resource entitled “Natural Resources Atlas of Southern Guam” and was initiated in direct response to the need for up-to-date information required for sustainable development and protection of the Northern Guam Lens Aquifer (NGLA), Guam’s main source of fresh water.

The rich collection of geospatial data, maps, and other information in the atlas is accessible through a web-based information server through a user-friendly interface. It is freely accessible on the Internet at ***www.hydroguam.net*** address and offers a wide range of textual, graphical, statistical, and geographic information to any interested user. It allows advanced operations such as viewing and manipulation of GIS data yet requires no special programs or browser plug-ins to be installed by the user in addition to the

standard web browsing software. It is the foundation and an integral part of a planned series of products dedicated to dissemination of information and rising of awareness regarding the diversity, current state, sustainable use, and critical threats to natural features of northern Guam.

KEY FEATHURE OF THE ATLAS

The Atlas in its current form is completely digital. It resides on a high-speed and reliable Internet server. All the pages comprising the Atlas are publicly available and their viewing requires no registration or filling of forms and has no access restrictions. The server does not utilize cookies or track visitors. Contents of the Atlas are entirety indexed by Google and other major search engines and are searchable and easily accessible. The Atlas offers numerous advanced features yet requires no special software or browser plug-ins to be installed by the user. All that is required is Internet connection and standard web browsing software. The Atlas works with any commonly used operating system and web browsing software.

Dedicated Internet Domain:

The Atlas is accessed via a dedicated domain name. As such, it is perceived by users as a stand-alone, self-contained, and comprehensive product, as opposed to merely a series of pages on an already existing website. The domain name was selected in order to be intuitive and easily remembered and reads: ***www.hydroguam.net***. This domain was previously used for the “Natural Resources Atlas of Southern Guam” but has now become an umbrella for that product as well as the new northern Guam atlas discussed here. Both are accessible through options available at address *www.hydroguam.net* but can also be directly entered via sub domains: ***south.hydroguam.net*** for the “Natural Resources Atlas of Southern Guam” and ***north.hydroguam.net*** for the “Digital Atlas of Northern Guam”.

Attractive Design:

Every page of the Atlas is designed in a consistent fashion, including a fixed layout, attractive color schemes, characteristic fonts, and unvarying appearance. This allows the users to experience it as a well-integrated product that every page and portion is clearly part of the same “brand”. Every page is identified by a banner-type graphic that bears the name.

User–Friendly Interface:

User interface of the Atlas is formatted in a consistent and convenient way that makes it inherently easy to use and requires virtually no time getting used to. The various menu and sub-menu options are available via navigation bars found at the top, bottom, left, and right hand sides of the screen. The left and right hand size menu bars are most extensive and important: the left links to pages with mostly textual information, and the right leads to pages with mostly geospatial information. The menus are organized logically and hierarchically and stay fixed no matter what page or information the user is viewing in the dynamic central portion of the screen.

Easily Updatable:

The pages in the Atlas were created using PHP approach which allows easy updates of hundreds of pages simultaneously. Any change whatsoever to the content of the Atlas is easily implemented and immediately effective. The Webmaster accesses the server hosting the Atlas via File Transfer Protocol (FTP) connection, download the page or part of the website that requires change, makes the change on local machine, and uploads the updated files back to the server. Any existing page, map, graphic, programming script, or any other portion of the site is thus modifiable.

Scope of Maps:

One of the primary goals of the digital Atlas is to provide access to up-to-date information and data to users who need it for their own purposes and other applications. For that reason the Atlas offers a wide range of download options, through which the users can save textual, graphical, and most importantly, geospatial information on their own computers. A range of maps, other documents, and high quality color photographs are all available. The maps are the central feature of the Atlas and currently form an extended series of 78 pre-formatted and nicely designed maps in high resolution. The maps cover a wide range of natural and man-made features of northern Guam geography (e.g., detailed geology, or land use, or aquifer zones, etc.) and are all available for download and use.

GIS and Google Earth Integration:

One of the primary purposes of the digital Atlas is to act as a distribution center of GIS data. Therefore, a significant portion of it is focused on GIS information and applications. Every map presented in the atlas is accompanied by download links where users can obtain original GIS data used to create the map in question. This includes all types of GIS data (as relevant to a particular map), such as point, polyline and polygon shape files, grid coverage, geo-referenced images, etc. All bits of geospatial information are consistently in WGS84 projection, align perfectly with each other, and are accompanied by full sets of metadata.

In addition, many GIS layers can be browsed and pre-viewed on-line without actually downloading it, using an HTML5-based application fully integrated into the user interface. Finally, in order to make a greater range of geospatial capabilities accessible to users with no GIS experience or software, most GIS data is also downloadable in KML versions for use with the increasingly popular Google Earth software. For added convenience, links where users can download free geospatial software are also provided.

Download Options:

Each of the 78 pre-formatted maps is available in 3 standard image versions, 3 georeferenced image versions, and 3 sets of raw data. The standard image versions are: JPG, PNG, and a text-searchable PDF. The georeferenced files are: GeoTIFF full map, GeoTIFF overlay with mapped features only, and Geospatial PDF. Finally, the raw data include all geospatial files that were used in the creation of the Atlas and are, with just a few exceptions for confidential information, also available for direct download in three versions: GIS files clipped to northern Guam, full version of GIS for entire Guam, and a KML file covering entire Guam and intended for use in Google Earth applications.

Geographic Information System (GIS):

During 1990s, geographical information system (GIS), with its ability to pull spatial data from different sources into an integrated environment, emerged as a significant tool for management of natural resources. GIS provided valuable sets of tools and set the standards for work in a range of disciplines, including modeling of aquifers. A GIS can be visualized as a series of transparent overlays placed over a map of an area being investigated. Each overlay contains data describing a particular parameter of interest, e.g. one overlay for rainfall amount, a second for ground slope, etc. The relationship and interactions between parameters can be easily modeled and explored. Of course, in order that GIS users investigate interrelationships between different layers, it is essential that they 1) have access to the data that is not always easy to find and that 2) the data are all accurately positioned in geographic space and projected in a common projection.

The main purpose of creating the digital atlas was two address these two prevalent problems. In general, geospatial data is held and updated and modified by many different agencies, so users have difficulties finding the information they need. Even when managing to pull the data together from various sources, differing amounts of error in the way data layers match up and the inconsistencies in map projections have often precluded their easy use. This atlas addresses the two challenges by providing to the community at large an easily accessible digital hub from which to quickly obtain the data and ensuring that all information is formatted in GIS layers that are in the same geographic projection and match up perfectly.

METHODOLOGY

The work on this digital atlas of northern Guam followed previously completed work on a similar resource of southern Guam. It was implemented in several distinct but often concurrent lines of action, as explained below.

Action I. Acquisition of existing data

Databases at the Water and Environmental Research Institute of the Western Pacific (WERI) and the Bureau of Statistics and Plans (BSP) were inventoried for spatial datasets suitable for use in the atlas. The majority of data was acquired from the BSP. Most data sets related to hydrogeology were acquired from WERI. Few data sets were acquired from additional sources.

Action II. Development of new data

Data sets that were not available were either created from scratch by online digitizing or derived from existing data layers by means of geoprocessing such as extraction, merging, surface analysis, reclassification, etc.

Action III. Harmonization of format, projection, and extent

The data sets were checked for correctness, completeness, consistency, and projection. If necessary, datasets were re-projected to UTM Zone 55 North WGS84, which was selected as the common projection for all data in the atlas. Geometric attributes such as

area for polygons and longitude/latitude for points were added. Additional attributes were added as necessary and appropriate. Fields with no information were deleted from attribute tables. The spatial extent of all datasets was clipped to the limits of northern Guam.

Action IV. Metadata and quality control

Metadata were updated or, if necessary, created for all existing datasets, and created for all new datasets. Each dataset was thoroughly examined to correct any errors, deficiencies, and inconsistencies. A final quality control was conducted before each data set was exported to files for end users. The files were organized into different folders and compressed for on-line distribution to end users via the atlas download options.

Action V. Development of pre-formatted maps

Each dataset was featured in an individual map especially created for the purposes of this atlas. Certain additional maps were made to include several distinct datasets that represent related features and whose joint evaluation is advantageous. The maps are designed to be consistent with each other and are all identified as being integral parts of the atlas. Each map was formatted in several downloadable image and georeferenced image formats.

Action VI. Development of other materials to populate the Atlas

Additional materials, including informative texts, downloadable factsheet-type summaries, illuminating diagrams, and thematic sets of quality photographs were developed and included as supplementary materials in the atlas.

Action VII. Development of the digital resource center and user interface (website)

A user interface for the atlas was developed in the form of a website that resides on a permanently on-line server accessible via address *www.hydroguam.net*. The website served all information developed by the project, including all pre-formatted maps and raw geospatial data. The website also provides access to free applications such as Arc Explorer for use by the general public who may not have more complex GIS software available.

APPENDIX 1: SCREENSHOTS

On the following pages is a series of six screenshots of the user interface of the Digital Atlas of Northern Guam. They are an arbitrarily chosen small group and do not aim to show the scope of the atlas or its capabilities, but simply give an idea of the overall look and presentation of the user interface. The screenshots are numbered 1 through 8 and represent the following: 1) Index (opening) page; 2) One of many information pages accessible through the menu on the left; 3) A page with one pre-formatted map and the download options for its versions and data; 4) A page showing in list-form downloadable files available for Google Earth; 5) A screenshot of the on-line viewer of GIS layers; 6) A page showing pre-formatted maps in gallery format; 7) A page showing one of the available photo galleries; 8) A page presenting relevant documents available for download.

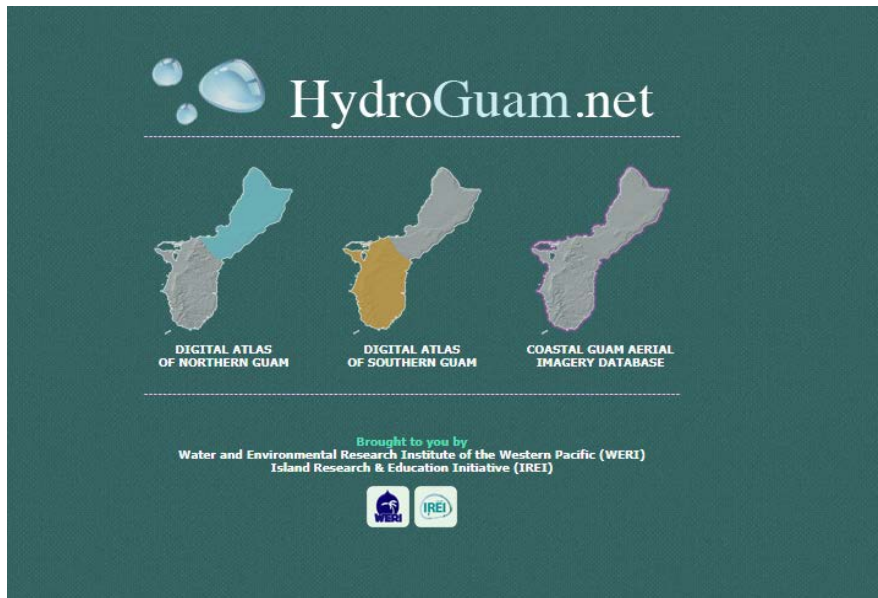


Figure 1. <http://www.hydroguam.net>




DIGITAL ATLAS OF NORTHERN GUAM

OF GUAM




BACKGROUND	Northern Guam geospatial information server	MAPS
<ul style="list-style-type: none"> Key concepts What is NGLA? Basic facts about NGLA What is here? Glossary of terms 	<p>Welcome to the Digital Atlas of Northern Guam</p> <p>This website is a digital resource center for data related to the physical and environmental characteristics of northern Guam. Its purpose is to provide accurate and easily accessible baseline information to government agencies, environmental specialists, educators, students, and all interested parties. The geographic scope of the atlas is northern Guam, which is defined as all land area north of the Pago-Adelup geologic fault (see map below.)</p>	<ul style="list-style-type: none"> Topography Geology Climate Soil Drainage Groundwater Vegetation Marine Population Infrastructure
<ul style="list-style-type: none"> Overview General geology General hydrology Climate Soil Vegetation 		<ul style="list-style-type: none"> ON-LINE MAP VIEWER Data files for GIS Data files for Google Earth Downloaded software
<ul style="list-style-type: none"> Overview Limestone units Volcanic units Other units 		<ul style="list-style-type: none"> Landscapes Features Aerials Photo gallery
<ul style="list-style-type: none"> Overview Aquifer zones Aquifer "plumbing" Recharge Water pathways Discharge Water quality 		<ul style="list-style-type: none"> Publications Project documentation Summaries and handouts Field trip guides WERI, USGS, and EPA reports
<ul style="list-style-type: none"> Overview Carbonate island karst Karst features Coastal geomorphology 	<p>The information provided by this website comprises a geo-database that includes physical, environmental, and socio-economic information about the northern Guam and the aquifer that it contains (Northern Guam Lens Aquifer, NGLA). We encourage the use of such information provided by this website in any environmental study involving northern Guam, particularly in water resources studies such as sustainable use of groundwater, evaluation of impact of anthropogenic activities on the quality and quantity of water in the aquifer, etc.</p>	<ul style="list-style-type: none"> OUTSIDE LINKS WERI IREI GovGuam GovGuam BIP USGS NGLA NGLA DCRM
<ul style="list-style-type: none"> Overview Forests 		

Figure 2. a. Digital Atlas of Northern Guam



DIGITAL ATLAS OF SOUTHERN GUAM




BACKGROUND	Southern Guam geospatial information server	MAPS
<ul style="list-style-type: none"> Key concepts Glossary of terms 	<p>Welcome to the Digital Atlas of Southern Guam</p> <p>This website is a digital resource center for data related to the physical and environmental characteristics of Southern Guam. Its purpose is to provide accurate and easily accessible baseline information to government agencies, environmental specialists, educators, students, and all interested parties. The geographic scope of the atlas is Southern Guam, which is defined as all land area south of the Pago-Adelup geologic fault (see map below.)</p>	<ul style="list-style-type: none"> Topography Geology Climate Soil Surface Water Groundwater Land Cover Coast and Marine Population Infrastructure
<ul style="list-style-type: none"> Overview General geology General hydrology Climate Soil Vegetation 		<ul style="list-style-type: none"> ON-LINE MAP VIEWER Data files for GIS Data files for Google Earth Downloaded software
<ul style="list-style-type: none"> Overview Stream toponymy Stream profiles Stream flow 		<ul style="list-style-type: none"> Landscapes Features Aerials Photo gallery
<ul style="list-style-type: none"> Overview Individual watersheds 		<ul style="list-style-type: none"> Publications Project documentation Summaries and handouts Field trip guides WERI, USGS, and EPA reports
<ul style="list-style-type: none"> Overview Forests Shrub Savanna Backlands Wetlands Beaches Reefs 	<p>The information provided by this website comprises a geo-database that includes physical, environmental, and socio-economic information about the Southern Guam and its watersheds. We encourage the use of such information provided by this website in any environmental study involving southern Guam, particularly in water resources studies such as watershed planning and management, estimation of upland erosion, and impact of anthropogenic activities on the quality and quantity of water in streams and lakes.</p>	<ul style="list-style-type: none"> OUTSIDE LINKS WERI IREI GovGuam GovGuam BIP USGS NGLA NGLA DCRM
<ul style="list-style-type: none"> Overview Municipalities Military lands Protected areas Infrastructure 		

Figure 2. b. Digital Atlas of Southern Guam

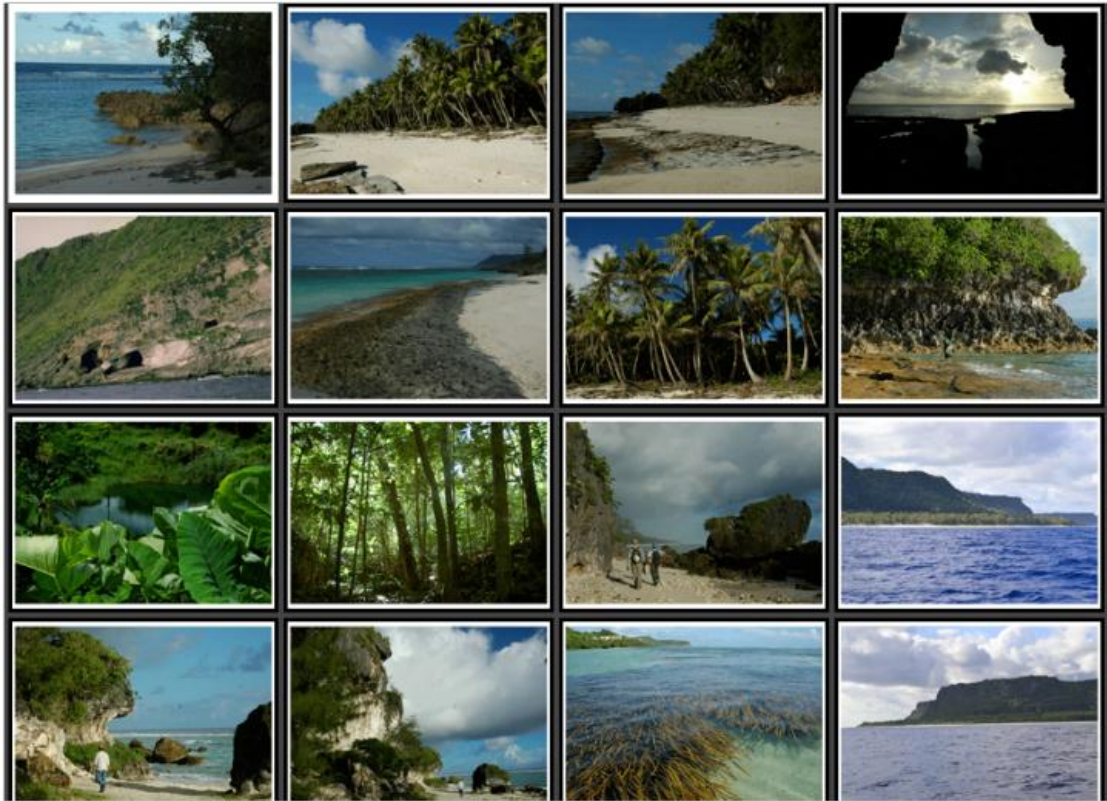


Figure 3. Selected photo gallery page (landscapes and natural features of Northern Guam)

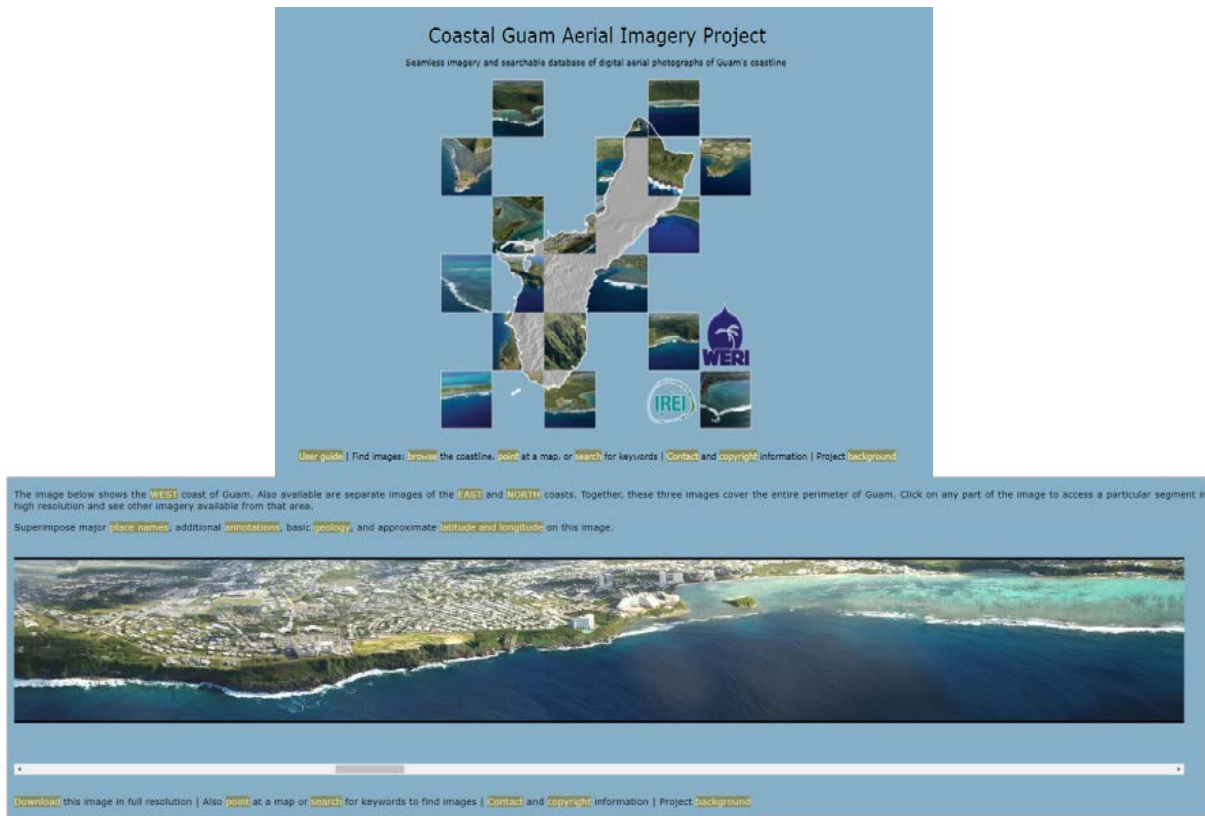


Figure 4. Imagery and searchable database of digital aerial photographs of Guam's coastline