Mapping Downtown Honolulu's Urban Past: Exploring the Potential of Geographic Information Systems (GIS) and Sanborn Fire Insurance Maps for Historic Preservation

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We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in fulfillment as a Doctorate Project for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.

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Abstract

Historic maps are a valuable resource for understanding our past. Historic preservationists, in their endeavor to conserve, protect, and preserve historic buildings and neighborhoods, use historic maps to gain a richer understanding of the places where we lived, worked, and played. This research explored the synergy of using Geographic Information Systems (GIS) with historic maps to achieve a greater appreciation and understanding of the past.

The Sanborn Fire Insurance Maps are a set of maps that traced the growth and development of major cities and neighborhoods from 1867 to 2007. Developed as an aid for insurance companies in estimating fire insurance liabilities in urban areas, the maps not only provide parcel information such as property sizes, block numbers, street names and addresses, they also depict a wealth of building information, such as shape and height, construction materials, locations of windows and doors, uses and occupants. When viewed over an extended time period, these maps accurately document the growth, decline and changes in cities and communities over time.

ArcGIS software was used to digitize and map the rich source of data inherent in the Sanborn Fire Insurance Maps for a 25-block area surrounding Fort Street Mall in downtown Honolulu, Hawaii. Seven time periods of Sanborn Fire Insurance Maps from 1914 through 1993 were digitized and mapped using GIS to demonstrate how urban areas could be studied and interpreted through this particular mapping method. The resulting methodology showed that by using GIS with historic maps to track and analyze urban changes over time, a wealth of information and insight about a community’s past is revealed, something that is not apparent when simply studying individual paper maps.

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Chapter 1. Introduction

1.1 Maps

Maps have been used throughout history to help us explore, inform, and find our way. From the earliest days, man has used maps as a tool to better understand the world. Whether as a painting on cave walls or carved into clay tablets, maps were used to abstractly convey a part of our environment. We create maps to provide information; the information provided is dependent on our goals as a map maker. Today, maps in all forms are everywhere—on phones, car navigation systems, route maps at bus stops, or inside local papers. Maps are a ubiquitous and essential part of our lives.

But what constitutes a map? All maps are estimations, generalizations and interpretations of true geographic conditions.[1] Because it is impossible to completely translate the real world onto a map, we pick and choose what to depict. No map can show all the physical, biological and cultural features for even the smallest area. For a long time, the most well-known maps were the ones painstakingly produced on paper by cartographers who took years to accurately complete them. Those maps were open to interpretation and criticism by people who did not agree with perhaps the borders drawn, or the depiction of the area of the land mass. Maps today are still subject to criticism or praise, based on the information provided and the audience reading them.

In his book, "Artifacts and the American Past," Thomas J. Schlereth states that "since historical scholarship began in the European Renaissance, maps have been considered a crucial interpretive tool in deciphering the major economic, political,

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[1] James S. Aber, "Brief History of Maps and Cartography," http://academic.emporia.edu/aberjame/map/h_map/h_map.htm.

diplomatic, and military events of the past five centuries."[2] Historic maps offer a glimpse into showing what life was like in days past and pinpoint events to geographic locations. Historic maps convey spatial information more efficiently than words and are indispensable to recreating the story of our past.

1.2 Historic Preservation through Mapping

Historic maps are an abundant source of information about the past. Historic maps reveal much about the history of an area, how it developed and where historic events took place. They enable preservationists to understand and interpret the past. Preservationists use historic maps to research and plan for the preservation of important historic and archaeological resources.

Historic Preservation is the process of identifying, protecting, and enhancing buildings, places, and objects of historical and cultural significance. The National Historic Preservation Act of 1966 defines Historic Preservation as:

> *Identification, evaluation, recordation, documentation, curation, acquisition, protection, management, rehabilitation, restoration, stabilization, maintenance, research, interpretation, conservation, and education and training regarding the foregoing activities, or any combination of the foregoing activities.*[3]

Historic preservation includes performing specific activities related to preserving a building for its architectural or educational value, or because it links us to characters or events from the past. One key historic preservation activity is the research and

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[2] Thomas J. Schlereth, *Artifacts and the American Past* (Nashville, Tenn.: American Association for State and Local History, 1980). 66.

[3] "National Historic Preservation Act of 1966, as amended through 1992," in *16 U.S.C. 470* (Washington, D.C.: US Congress, 1992), 32.

interpretation of past structures, neighborhoods or landscapes. When done thoroughly and thoughtfully, the documented history becomes an honest interpretation of the past, not clouded by historical bias or prejudice. Historic preservation also includes looking at our surroundings today and comparing it to the past to figure out the evolution of our environment. Schlereth states that we should consider the American environment as a historical museum. In particular, seeing landscapes as artifacts and using those artifacts to aid us in "understanding the uncommon history of common things."[4] According to Schlereth, artifacts are the physical evidence that link us to the past. Examples of artifacts include such items as photographs, mail-order catalogues, cartography, historic sites, and landscape and vegetation. Historic research and interpretation involves synthesizing many such artifacts in order to get a true representation of the past. A visual way to combine such artifacts is through mapping. Maps provide an excellent method of visualizing the layers of data within a spatial framework. However, this type of comparative work is extremely time-consuming. It is very difficult to manually integrate an array of artifacts and filter it down into digestible data onto a map. Fortunately, computers have drastically changed how we visualize and use maps. Over the last 10 years, computer mapping tools have made it possible to combine and compare huge and diverse datasets, including satellite imagery, aerial photographs and digital mapping. This allows data from both historical and other sources to be easily integrated and examined at multiple scales. Using computer mapping tools, a time series of digitized historical maps can yield a wealth of data that may not have been readily apparent by just viewing two-dimensional, paper maps.

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[4] Schlereth, *Artifacts and the American Past*. 4

The Sanborn Fire Insurance maps, drawn for the same areas over a number of decades, provide valuable temporal information such as settlement patterns, urban planning, businesses industrial building locations, street patterns, block size, and construction materials. For Historic Preservation research, the Sanborn maps are the ideal artifacts to help interpret the past.

1.3 Sanborn Fire Insurance Maps

1.3.1 History

Founded in 1867 by Daniel Alfred Sanborn, a surveyor from Somerville, Mass, the Sanborn Map Company was the primary American publisher of fire insurance maps for nearly 100 years. D. A. Sanborn began his career in 1866 by doing commissions for the Aetna Insurance Company, producing fire insurance maps of Boston and Tennessee. A year later, he founded the D.A. Sanborn National Insurance Diagram Bureau, which was later called the Sanborn Map and Publishing Company. His new firm mapped 50 towns in its first year and more than 600 within the next seven.[5] The Sanborn map collection consists of a uniform series of large-scale maps, dating from 1867 to 2007, depicting the commercial, industrial, and residential sections of some twelve thousand cities and towns in the United States, Canada, and Mexico.[6]

Why was there such a market to produce these maps? The Industrial Revolution in the nineteenth century caused rapid urban growth. As the density of urban areas increased, fires became a growing threat to the life and property of city dwellers. During this time period, fire-fighting services, still in their infancy were usually ineffective, and

[5] "A Visit to the Sanborn Library," (Milford: EDR (Environmental Data Resources Inc), 2007).

[6] "Introduction to the Sanborn Map Collection," http://www.loc.gov/rr/geogmap/sanborn/san4a1.html.

very few buildings were actually fire-resistant.[7] When a fire struck, it often destroyed multiple buildings and threatened entire districts. Following the Great Chicago Fire of 1871, which destroyed a third of the city, fire insurance companies increased their efforts to manage their risk of catastrophic loss by limiting or refusing to insure fire-prone structures and by avoiding insuring too many properties within a single neighborhood.[8] Because insurance underwriters were too busy to personally assess every building they insured, they began hiring surveyors like D.A. Sanborn to create fire insurance maps of cities and towns, containing every detail needed to assess each commercial, residential, or industrial building for the risk of fire. The maps were designed to assist fire insurance agents in determining the degree of hazard associated with a particular property and therefore showed the size, shape, and construction of dwellings, commercial buildings, and factories, as well as fire walls, locations of windows and doors, sprinkler systems, and types of roofs. The maps also indicate the widths and names of streets, property boundaries, building use, house and block numbers, the locations of water mains and their dimensions, fire alarm boxes, and fire hydrants. Sanborn maps are thus an unrivaled source of information about the structure and use of buildings in American cities.

Although there were other smaller mapping companies who specialized in producing fire insurance maps, by 1920, virtually every underwriter in the country were buying maps from the Sanborn Company.[9] Sanborn Maps were an essential tool for fire

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[7] "A Visit to the Sanborn Library."

[8] Ibid.

[9] Diane L. Oswald, *Fire Insurance Maps: Their History and Applications* (College Station, Tex.: Lacewing Press, 1997). 31.

insurance companies, allowing underwriters to recognize possible risks based on clear evidence of the building's characteristics in particular areas.[10]

Sanborn maps cover both major urban areas and many smaller cities and towns. The surveyors documented very specific and in-depth detail of the built environment of that time. The maps D.A. Sanborn produced provided a wealth of information, such as building outline, size and shape, windows and doors, street and sidewalk widths, boundaries, and property numbers. The maps often included details on construction materials and building use; they also depicted pipelines, railroads, wells, water mains, dumps, and other features likely to affect the property's vulnerability to earthquake, fire, and flood.[11] These maps are drawn to scale and color coded to distinguish each building's construction material--olive for adobe, blue for stone, pink for brick, yellow for wood and gray for metal. Additionally, there are symbols to record specific details such as sprinkler systems, fire alarms, steam boilers, elevator details as well as window and door openings.

The Sanborn Maps were updated frequently, usually once a year, sometimes as often as every six months in rapidly changing large urban areas. The frequent updates were necessary because the fire-insurance underwriters needed to issue policies based on the most current facts. For their updates, the surveyors sometimes created completely new maps. Other times, they pasted their updated information directly onto their existing maps.[12] This updating process, which was necessary at the time for the fire-insurance companies, proved to be invaluable for modern historians and other professions who use

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[10] Kim Keister, "Charts of Change," *Historic Preservation: Quarterly of the National Council for Historic Sites and Buildings* 45, no. 3 (1993): 47.

[11] "Digital Sanborn Maps 1867-1970," http://www.proquest.com/en-US/catalogs/databases/detail/sanborn.shtml.

[12] "A Visit to the Sanborn Library."

the Sanborn maps to chart and analyze the change of urban areas over time. The evolution of cities and towns can be researched through successive surveys with buildings being built and demolished, with land being used for differing purposes, with new and necessary businesses growing or diminishing.

Over the years, the Sanborn Company and other institutions with Sanborn map collections have digitized their map collection. The digitization of the maps increased their accessibility and thus their popularity. They have become an important reference source for professionals outside of the insurance business, such as genealogists, demographers, environmentalists, urban planners, and laypersons.[13] The Sanborn Library contains more than 1.2 million Sanborn fire insurance maps, comprising a detailed visual and textual record of the structural and industrial history of more than 12,000 American cities and towns.[14] The Library of Congress has the largest public collection of Sanborn Maps and state, local, and university libraries as well as historical societies, have their own smaller collections.[15]

1.3.2 Other uses for the Sanborn maps

Sanborn maps are frequently consulted by historians, urban planners, genealogists, demographers, preservationist and environmentalists. The Sanborn maps are used by such a variety of professionals because of the extensive detail they provide and they are an ideal source to observe change over time in urban areas. The maps can be used to date historic buildings and structures, to document development patterns in

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[13] Kenning Arlitsch, "Digitizing Sanborn Fire Insurance Maps for a Full Color Publicly Accessible Collection," *D-Lib Magazine* 8, no. 7/8 (2002).

[14] "A Visit to the Sanborn Library."

[15] Keister, "Charts of Change," 45.

districts, and to determine the characteristic of a neighborhood. Other communities or organizations used Sanborn Maps for their historical preservation efforts.

Today, the largest users of the Sanborn maps are environmental professionals who access the maps to identify historical environmental conditions that potentially impact the sites they are investigating.[16] Interestingly, the Sanborn maps were not intended to chart environmental risks but to assist insurance underwriters who needed to know about the uses and physical attributes of buildings in order to estimate the risk of a fire destroying an insured property. Environmentalists find value in the Sanborn maps because the property features which the cartographers mapped because of their fire risk, such as storage facilities for fuels and chemicals, are clues that can pinpoint the exact locations of possible environmental issues. The Sanborn Maps also show the historic uses of properties (a paint supply store, for example), and environmentalists can infer from this information about potential environmental concerns. By carefully reviewing relevant Sanborn Maps, environmental professionals conducting a site assessment can track the historical presence of operations such as gas stations, auto repair shops, underground storage tanks and industrial sites that may have caused contamination, as well as the specific operational processes associated with industrial locations.

Genealogists researching old addresses use the Sanborn Fire Insurance Maps to determine which new house number corresponds to particular old dwellings when a community or city renumbers. Historians use the Sanborn Maps to locate and identify neighborhoods and buildings to track changes over time. Urban planners use Sanborn

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[16] "A Visit to the Sanborn Library."

Maps to study the layouts of cities and view the effects of urban expansion and industry, while demographers study population shifts.[17]

1.4 Geographic Information Systems

A complete appreciation of historic buildings requires not only a comprehensive understanding of the building and its history; but also a comprehension of its relationship to the site and the surrounding communities. These relationships are often defined by their spatial proximity to each other. Geographic Information System (GIS) is the perfect tool to highlight the spatial relationships between historical buildings to other historical buildings and sites, and to the surrounding neighborhoods.

GIS is a computer based system which aids in the collection, maintenance, storage, analysis, output, and distribution of spatial data and information.[18] GIS allows information that we have always had at our fingertips to be viewed in a different way. GIS can be considered the merging of cartography, statistical analysis, and database technology, visualized as a layered map. GIS is currently used in numerous and varied professions such as operations and maintenance engineers, regional planners, road engineers, forest managers, oil tank captains, and bank officials.[19] GIS allows one to combine, organize, and layer many different types of data, such as streets, buildings, and landmarks, in a spatial format to help one gain a better appreciation of a place. GIS can

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[17] "Using Maps in Genealogical Research," http://www.ancestry.com.

[18] Paul Bolstad, *GIS Fundamentals : A First Text on Geographic Information Systems*, 3rd ed. (White Bear Lake, Minn.: Eider Press, 2008). 1.

[19] Tor Bernhardsen, *Geographic Information Systems : An Introduction*, 3rd ed. (New York: Wiley, 2002). 26.

make very complicated statistical data clearer because it can show the data spatially, making it much easier to understand.

What makes GIS unique is that it is able to integrate spatial data in the form of points, lines, polygons, or grid cells, with data about each of these spatial units stored in a relational database. One of the most fundamental principles of GIS is the layering of many different datasets for analysis. For instance, a data layer containing road data can store the individual road names, road widths, and the number of people who drive on that road daily. GIS is able to make connections between road activities based on spatial proximity. This information could be used by transportation officials to track traffic patterns in high density cities. A tree data layer which maps the location of all the trees in a neighborhood could be used by city landscapers to determine how many trees are within a 5 mile radius of a development area, how many trees within a 5 mile radius exceed 20 feet height limit, or how many trees within a 3-mile radius are Red Oaks. An infinite amount of statistical and relational data can be easily derived using GIS. GIS can be used to manage forests by finding the bests soils for a specific tree species to grow, or to analyze the types of vegetation growing in a particular forest and to keep track of areas that have been cut, burned, or otherwise managed at some point.

GIS plays a significant role in historical preservation. Accurate locational information is a key factor in the interpretation of cultural resources. The National Park Service recognizes the significance of spatial data and cultural resource management. Examining cultural resources within their geographical context provides us with an alternative perspective, allowing one to see the interaction of resources and larger trends across regions.[20] Although historic sites can be considered a single entity, it can be viewed from a variety of perspectives: as built features, as part of an archaeological site, as a cultural landscape, or as a part of an existing thriving neighborhood. GIS allows us to overlap or merge these perspectives to see history from a different vantage point. GIS technology to map and analyze historical building data is important not only to preservationists, but to government policy makers and regulators because it provides a powerful visual tool to assist with decision making and management. The potential of GIS to visualize historic preservation in a spatial context is exciting and GIS software can create maps that can enrich the context understanding of a historic building and site.

1.4.1 The Essential Elements of GIS

GIS software provides the tools to manage, analyze, and effectively display and disseminate spatial data and spatial information.[21] GIS allows us to take any real world object and geographically represent it with these three components: location, shape and description. The location is the geographic location of the object. The shape is the geometric representation (polygon, point or line) of the object drawn on the map. The description is data about object, provided in a database format. The resulting spatial data is used in GIS to represent any type of real world objects, such as buildings, city blocks, rivers, and city streets.

Spatial data is a graphic representation of a landscape or of objects that are around us. There are two types of spatial data: Vector Data and Raster Data. Vector data consists of points, lines, or polygons. Vector data represent different objects in the landscape. For

[20] "Critical Nature of Spatial Data in Cultural Resource Management," http://www.nps.gov/history/hdp/standards/CRGIS/spatial.htm.

[21] Bolstad, *GIS Fundamentals : A First Text on Geographic Information Systems*: 14.

example, roads on a map can be represented by lines. Buildings can be represented by polygons of various sizes depending on the size of the building. Trees can be represented by points or circles. Points would be used if only the location of the tree needed to be known, not the exact shape.

Raster data is composed of a series of flat squares known as pixels. These pixels in turn represent a certain property or characteristic of the landscape. Many pixels next to each other create a raster graphic. A digital image such as an aerial photograph is an example of one type of raster graphic. Both raster and vector data types are georeferenced, meaning that the vector or raster exist at a certain location atop the earth's surface. The advantage of GIS is its ability to overlay spatial data to produce an accurate representation of the physical environment at the site.

Attribute data consists of numeric values and text that describe the characteristics of the *spatial data*. Attribute data is a database of information about corresponding spatial data.

Attribute data for a map of roads may include road names, the length or area of the roads, or even information about the number of cars that travel the road daily or when it was last paved. If the information can be put into a table, then it can be stored in a GIS attribute table.

1.4.2 Users of Geographic Information Systems

GIS is an essential tool use by many businesses and government, educational, and non-profit organizations to help plan, design, engineer, build and maintain information infrastructures that affects our everyday lives. Many government agencies use GIS to help in planning and organizing their geographic data.

Local and state governments use GIS to keep track of the properties, public works, roads, and more within their jurisdiction. They use them in environmental applications, statistical applications and to disseminate information to the public. Police departments, fire departments and other emergency services use GIS to help in their daily operations. GIS software can help officials track crime, find the shortest route to emergencies and more.

Real estate agents and bankers use GIS to track properties, property values, and tax information. Health care professionals are using GIS to track the spread of disease and provide wellness information. Communication technology companies use GIS in planning of their utility expansions. Weather forecasting also uses GIS technologies and a host of other businesses use it for marketing purposes.

Table 1-1 shows how GIS is used by business, government, education and science, environment and conservation, natural science, and utilities sectors. This list reveals just how extensively GIS applications have permeated into our day-to-day lives.

Table 1-1. GIS Users[22]

Business	How they Use GIS
Banking	Financial analysts employ GIS for targeting their markets by visualizing service needs
Insurance	To visualize, analyze, and distribute risk
Logistics	Planning the distribution fleet's activities, route locations, and schedules
Media	Analyzing circulation and attracting advertisers, and creating maps used in the advertisements
Real Estate	Map-based contact management, investment analysis in large real estate investment trusts
Retail	Maintain information about sales, customers, inventory, demographic profiles and mailing lists
Government	How they Use GIS
National Government	Method to provide public information, to evaluate the results of the U.S. Census, link documents and image files to map features for an integrated view of information
Local Government	Revenue collection, economic development, and public information
Homeland Security	Emergency response in the areas of detection, risk assessment, mitigation and prevention, preparedness, response, and recovery
Military Defense	Intelligence, terrain analysis, mission planning, and facilities management
Fire/Emergency Medical Services/Disaster	Plan for emergency response, determine mitigation priorities, analyze historical events, and predict future events
Law Enforcement	Planning and event modeling, tactical and strategic planning, and incident mapping
Health	Epidemiological and public health monitoring, geographically track public health indicators, identify disease clusters, and explore sites of environmental risk.
Transportation	Insight for networking planning and analysis, vehicle tracking and routing, inventory tracking, and route planning analysis
Education and Sciences	How they Use GIS
Research	Helps researchers model real world, classify & observe phenomena, and predict changes over time
Libraries and Museums	Creates interactive maps for museum exhibits that help visitors explore people, places, and events
K-12 Education	Helps learners of all ages grasp the ways in which geography matters
Higher Education	Opened up employment opportunities. More than 3,000 colleges and universities have developed course and certificate and degree programs in GIS
Environment & Conservation	How they Use GIS
Water	Habitat, wetland, and water quality mapping and planning
Oceans	Data from oceans and seas to represent near-shore and deepwater phenomena such as current, salinity, temperature, biological and ecological mass, and density
Land	Digital maps of sites linked to a relational database that stores topography, baseline data, site documentation, and aerial digital photography
Wildlife	Enables the study of animal populations at a variety of scales as well as analysis tools to study habitat corridors, migration patterns
Vegetation	Mapping and inventorying vegetation across landscapes to better understand threatened and endangered species inventories for scientific and managerial applications
Natural Resources	How they Use GIS
Agriculture	Site-specific spatial analyses of agronomic data, forecast crop yields and determine fertilizer spreads for farmers
Forestry	Managing timber resources and maintaining sustainable forest management
Mining	Terrain and ore body modeling, exploration, drilling, mine planning, reclamation, and rehabilitation mapping
Oil and Gas	Resource analysis for determining where to drill, route a pipeline, or build a refinery
Utilities	How they Use GIS
Power Management	Routing of energy is highly dependent on geographic information, used for network design and outage management
Electricity	Leverage facilities management to respond to storm-caused outages
Gas	Gas source and physical pipeline management depend on GIS for every detail from stations and pipe pressures to valves and pipe diameter.
Telecommunications	Analyzing relationships among signal coverage, test results, trouble tickets, customer inquiries, revenues, and gap analysis
Water and Wastewater	Use high resolution maps to detail the location of its underground pipelines, watersheds, reservoirs, and hydroelectric facilities

[22] "Who Uses GIS?," http://www.gis.com/content/who-uses-gis.

1.4.3 ArcGIS Software

The GIS software utilized for this study was ArcGIS Version 10.1. ArcGIS is a software suite consisting of a group of geographic information system (GIS) products produced by Environmental Systems Research Institute, Inc. (Esri), a company based in Redlands, California. Esri is a privately held global company founded in 1969 by Jack and Laura Dangermond.

ArcGIS is a system for working with maps and geographic information. It is used for creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web.

ArcMap is the main component of Esri's ArcGIS suite of geospatial processing programs and is used primarily to view, edit, create, and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps. ArcMap users can create and manipulate data sets to include a variety of information. For example, the maps produced in ArcMap generally include features such as north arrows, scale bars, titles, legends, etc. The software package includes a style-set of these features.

The ArcGIS suite is available at three license levels: Arc View, ArcEditor, and ArcInfo. Each step up in the license provides the user with more extensions that allow a variety of querying to be performed on a data set. ArcInfo is the highest level of licensing, and allows the user to use such extensions as 3D Analyst, Spatial Analyst, and the Geostatistical Analyst.

Maps created and saved within ArcMap will create a file on the hard drive with an .mxd extension. Once an .mxd file is opened in ArcMap, the user can display a variety of information, as long as it exists within the data set. At this time the user can create an entirely new map output and use the customization and design features to create a unique product. Upon completion of the map, ArcMap has the ability to save, print, and export files to PDF.

The geographic information that is loaded into ArcMap can be viewed in two ways: data view and layout view. In data view, the user can interact with the geographic information presented, and the map elements are hidden from view. Most projects begin in this view, and continue to the layout view for final editing and production. While in the layout view, the user can incorporate a number of useful features such as scale bars and north arrows. These elements are crucial to map-making, and provide clients with appropriate reference information.

ArcGIS also offers two 3D visualization applications in which to work—ArcGlobe and ArcScene, which allows display, analyze and animation of 3D or 2D data in a 3D space.

1.4.4 GIS vs Google Earth

Google Earth is sometimes confused with GIS. Geographic Information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS also allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

Google Earth is an online virtual globe, map and geographical information program called Earth Viewer 3D, and was created by Keyhole, Inc, a company acquired by Google in 2004. It maps the earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS 3D globe.[23] The main difference between the two is that GIS is primarily a platform to analyze data and Google Earth is a platform to display data.

[23] "Google Earth," http://en.wikipedia.org/wiki/Google_earth.

Chapter 2. Historic Preservation - Sanborn Maps and GIS

Utilizing the functionality of GIS, historical data from the Sanborn maps can produce detailed histories of past neighborhoods. A time series of Sanborn maps gives a clear visual timeline of changes in a community. More difficult to see are answers to questions such as the underlying reasons as to how and why a community has changed, or during what time periods were the changes most significant. GIS can provide this type of analysis by carefully scrutinizing all the bits of information on the maps and correlating it with other data in order to glean out new information for interpreting the historical spatial patterns.

Geographic Information Systems basically take data and plot it on maps. By mapping the data it is often much easier to spot patterns or trends. GIS is an important tool to uncover information buried within the Sanborn Fire Insurance maps. Different variables can be considered, such as land use, construction materials, building heights, etc., and changes charted over time.

Cultural resources are separated organizationally depending on the type of resource: archeological, building, ritual, etc.[24] This results in a fragmentary look at cultural resources where each group is cared for by different disciplines and managers. For resource managers, planners and decision-makers, the current challenge is trying to make sense of a battery of information from multiple sources because there is no umbrella organization of methodology for linking all the various cultural resource databases together. In this case, geography itself must be the underlying key that

[24] "Critical Nature of Spatial Data in Cultural Resource Management".

integrates these various databases – a single location becomes the key between different disciplines.[25]

2.1 Use of Sanborn Maps for Historic Preservation

The Sanborn Fire Insurance maps have a great deal to offer the field of Historic Preservation because they are a rich and detailed source of historical data and contain information that is fundamental to reconstructing past buildings and places. The Sanborn maps provide abundant information about buildings and neighborhoods and their relationship to the surrounding area. Although the maps were initially intended to assist fire insurance assessors, they have transcended their original purpose and are now regularly used by anyone interested in seeing urban history unfold in the Sanborn map's rich wealth of detail. The types of information included in the maps were designed to specifically assist Fire Insurance companies to properly insure buildings without actually visiting the sites. It was fortunate this was done because this same type of information has proven invaluable to historians and preservationists.

The Sanborn Fire Insurance maps are particularly valuable because they provide not only contextual information, but very specific information about the building that is typically not available anywhere else (such as the footprint of each building, the size, shape and construction materials, heights, and function of structures, location of windows and doors). The maps often indicate construction details (for example, steel beams or reinforced walls) and differentiate building materials (wood, brick, metal or stone) using a color-coded shading system. The maps also show street names, street and sidewalk widths, property boundaries, building uses, and house and block numbers.

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[25] Ibid.

A Sanborn survey of an area includes the overall town map (index sheet), legend, street listings, and scaled neighborhood drawings which typically consisted of four to six city blocks drawn on one map sheet. A typical index sheet includes an overview of the entire area mapped in the set, an index of streets and prominent local sites, a legend and a short report of subjects which would be of interest to Fire Insurance Companies, such as the location and construction status of water towers, pumping stations and Fire stations, and population statistics and economy data.

The original Sanborn Maps were hand-drawn and colored. The building's construction materials were distinguished by its color—olive for adobe, blue for stone, pink for brick, yellow for wood, and gray for metal.[26] Figure 1 shows a color-coded index map of the Honolulu area in 1914. The color map provides a striking image of the fabric of the neighborhood, visibly highlighting the concentration of businesses and residential areas on the map. The pink shading indicates brick buildings and the yellow shading indicates framed (wood) buildings. Commercial buildings were typically larger and built with brick, and residential buildings were smaller and built with wood. Figure 2 is an example of a legend for the Sanborn Maps produced in 1940. The Sanborn legends explained the color coding system and the various symbols used on the maps. The symbols allowed the map surveyors to clearly convey complex information about a building's risk for fire.

[26] Keister, "Charts of Change," 45.

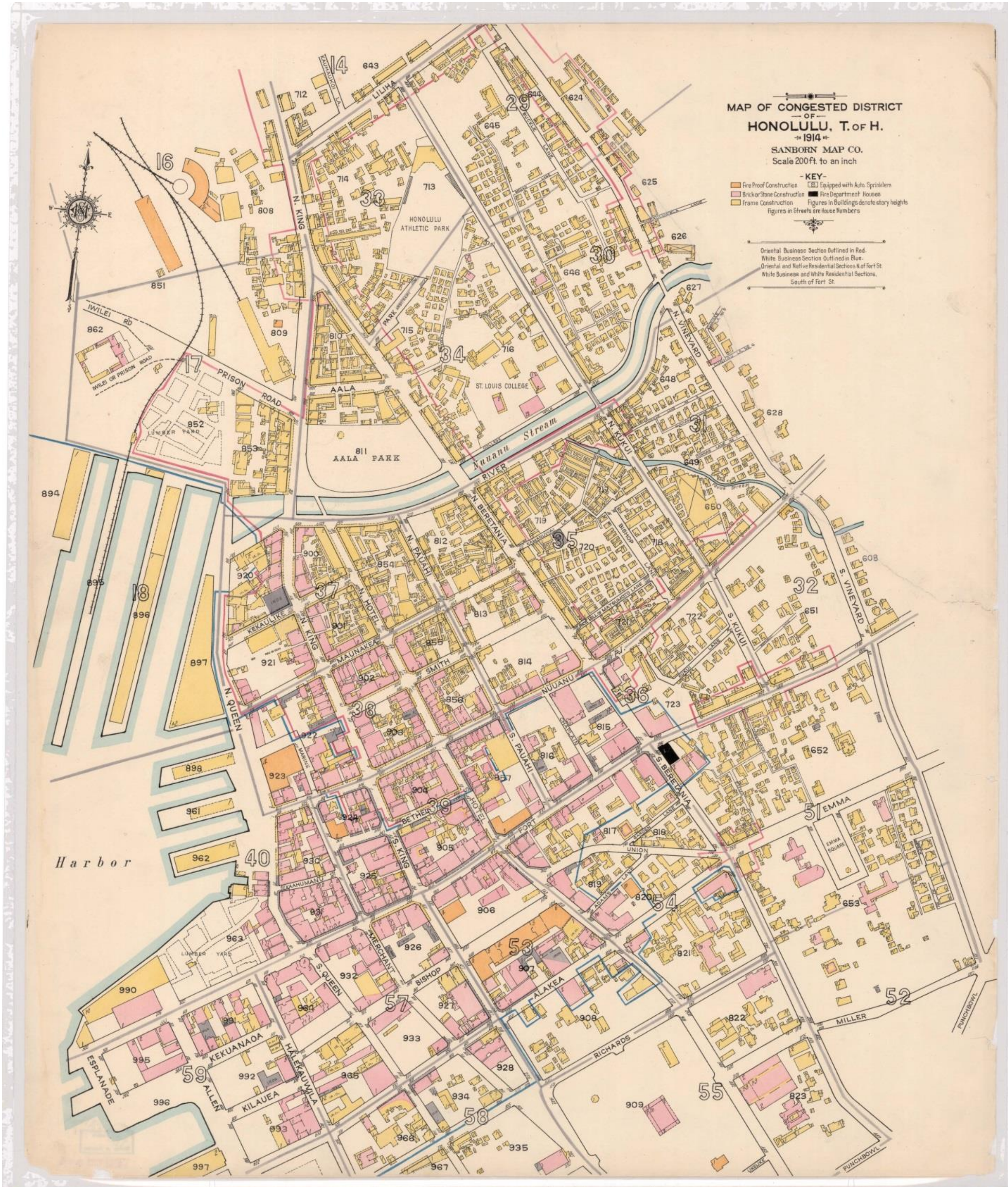

Figure 1. Color Sanborn Fire Insurance Index Map of Honolulu, 1914[27]

[27] "Congested District of Honolulu," in *Sanborn Fire Insurance Maps, 1914* (University of Hawaii at Manoa Digital Map Collection).

THE KEY TO SYMBOLS

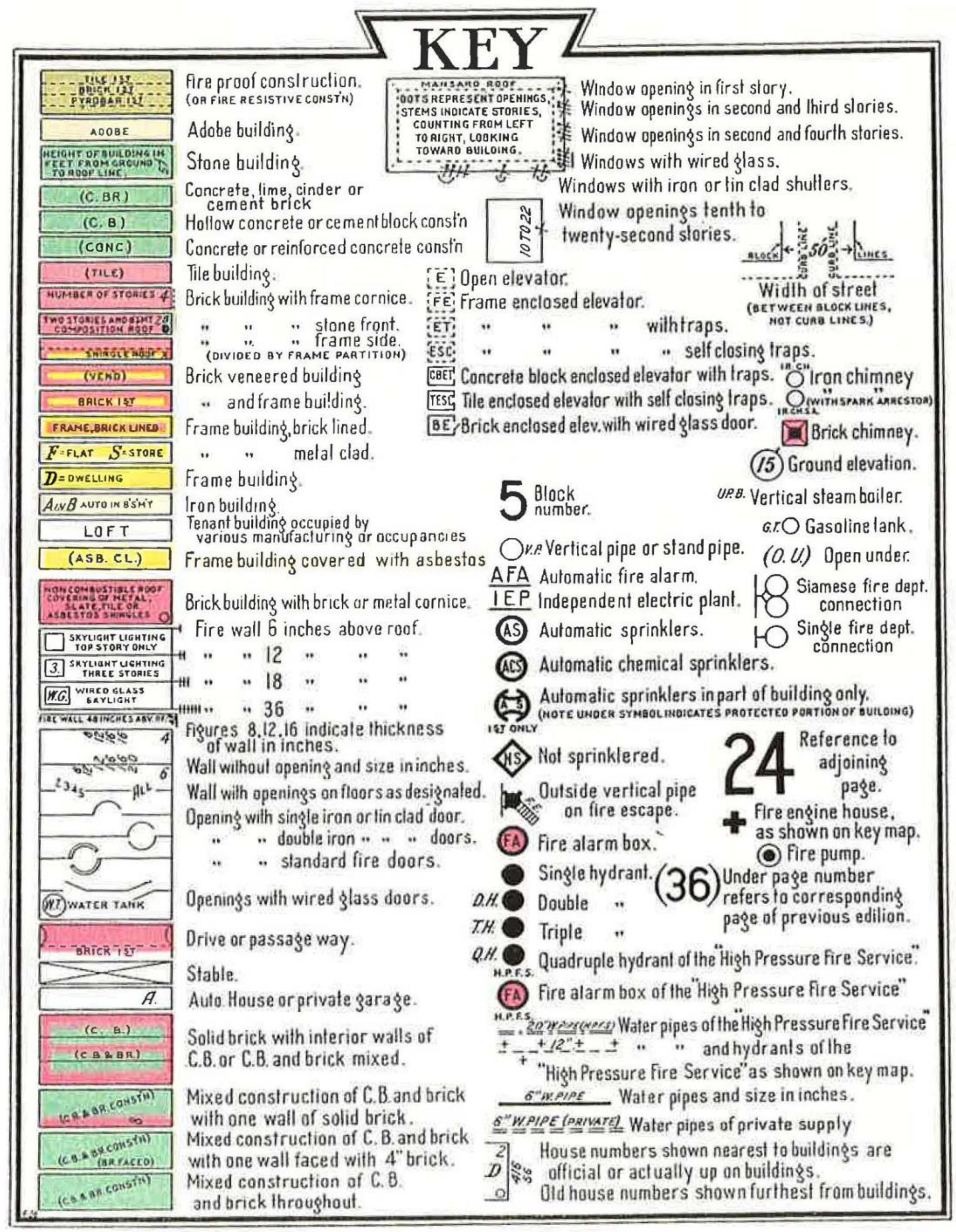

Figure 2. Sanborn Fire Insurance Company Color-Coded Legend[28]

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[28] "The Key to Symbols," in *Description and Utilization of the Sanborn Map* (New York: Sanborn Map Company, 1942), 2.

Depending on the date the Sanborn maps were issued it is possible it could show a building's original size and construction details, before subsequent alterations and additions that are almost inevitable for an old building. Other drawings on the same map can be studied to learn about the neighborhood, and thus place the building into a context that probably would not be gained from a city directory or even from tax records. The Sanborn Map Company updated their maps every few years. In some cases, seven or eight different editions of the maps are available, showing both urban growth and even a limited amount of migration trend information.

The Sanborn maps are a valuable historical tool for a wide range of professionals, such as urban specialists, social historians, architects, geographers and planners, with each profession gleaning their own specific data from the Sanborn maps. Genealogists, for example, use the maps to pinpoint the houses and neighborhoods of their ancestors. Planners use the maps to decipher the layouts of urban living. Environmentalists look for indications of natural features erased long ago and of businesses that might have produced toxic waste. Urban geographers use the maps to re-create the growth and evolution of cities and demographers use the maps to examine population shifts.

But perhaps no one has found more vital, varied, and constant usefulness of Sanborn maps than preservationists. Historic preservation and the fire-insurance industry both focus on characteristics of individual buildings. Sanborn maps were designed to efficiently provide information, and they often prove to be the fastest, simplest, and most graphic way to learn details about a building.

In one city, for example, a number of Sanborn maps may have been drawn over a span of time covering the last part of the nineteenth and early twentieth centuries, a period of tremendous urban growth. The Sanborn maps together with other historical records such as old photographs and property records can be a critical tool for studying the growth of an area. By comparing the different sets of maps, a researcher could tell when brick structures began to replace frame shops, when specialty stores appeared and general stores declined, and when the commercial area started to expand in what had previously been a residential area. For preservationists, the wealth of information gleaned from these maps can help in the study of urban growth and change in American cities and in the identification and justification of historic districts.

2.2 Case Studies - Sanborn Fire Insurance Maps

The following three case studies all utilized the Sanborn Fire Insurance maps for their research but in different ways. The first case study parallels the methodology of this research document the most. The other two case studies used the Sanborn maps in another way--one focused on a small area and the other only extracted specific data from the maps. All three show how different researchers were able to extract what they needed from the Sanborn maps.

2.2.1 Vieux Carré Commission, New Orleans, LA

In 1999, the Vieux Carré Commission, a state agency in New Orleans which oversees the historic French Quarter district, purchased historic Sanborn maps of the French Quarter for the year 1885. The Commission’s goal was to expand its collection of historic information on the French Quarter. The digital versions of the maps could allow the commission to study changes in the area and identify patterns in urban development. They commissioned a study with the Sanborn Map Company to digitize the historic Sanborn map building footprints for this year.

In a paper published in the Journal of GIS Archaeology, Volume 1, Joseph W. Berry, a Senior Proposal Coordinator for the Sanborn Map Company, discussed the methodology for this effort. The first step was to determine a base map to use as the base layer to overlay the Sanborn map upon. A proper base map is important because the Sanborn map would be georeferenced or aligned with this reference map. If the base map had errors, then all subsequent georeferenced data would be incorrect. In this study, they used the base map provided by the GIS department within their City Planning Office. Most cities or states have a department dedicated to GIS data and is the repository for all the official GIS layers for their area. For the state of Hawaii, this department is the GIS Program under the Office of Planning. For the City and County of Honolulu, the GIS department is the Honolulu Land Information System (HoLIS), under the Department of Planning & Permitting.

According to Berry, the most difficult part of this task was the complexity of the georeferencing because spatial accuracy is difficult to ensure.[29] Once the scanned maps were georeferenced to the base map, the building footprints were digitized on the computer screens using a “heads-up” digitizing technique and the associated attributes for each building were entered into the GIS database. Heads-up digitizing is the process of creating the digital building footprints manually, straight off a computer screen, using a mouse or digitized cursor. The digitization of the building footprints essentially means tracing the outline of the building using GIS software. This is an extremely tedious process but must be accomplished as accurately as possible. There are a number of

[29] Joseph W. III Berry, "Historic Sanborn Maps in the Digital Age: City of New Orleans," *Journal of GIS Archaeology, Volume I*(2003), http://www.esri.com/library/journals/archaeology/volume_1/historic_maps.pdf.

common errors which can occur when using this technique. Although the report of this case study did not address data entry errors, this should not be overlooked. A more detailed discussion of the common errors is addressed in the Lessons Learned section.

Figure 3 and Figure 4 shows the resulting digital building footprints of the French Quarter from the Sanborn Maps published in 1885.

Figure 3. Digital Building Footprints Shapefile, From Sanborn Maps Published in 1885, French Quarter, New Orleans, Louisiana[30]

[30] Ibid.

Figure 4. Digital Sanborn Building Footprints, French Opera House circa 1885, French Quarter, New Orleans, Louisiana[31]

Each building footprint, called a polygon, contains specific building information called attributes. The types of attribute information captured from the original map include: number of stories above ground, building height, building use, construction material, address and floor construction information.

Many historic districts could be mapped in this same way to provide a window into the conditions of an area from a past time period. This report did not show any discussion of the attribute data or whether they were analyzed in any way. Research to determine the current status of this digitization project in New Orleans proved fruitless. Other than the initial proof-of-concept study, the commission has not done any further analysis studies on these Sanborn maps. In a telephone interview, the Vieux Carré Commission staff Historian could not recall the study and was not aware of any past, present or future Sanborn map georeferencing projects. The Historian confessed that in the wake of the Katrina disaster and recent budget cuts and reorganizations, their

[31] Ibid.

priorities are on other issues. Email contact with the author of the paper yielded similar results. Although the Vieux Carré Commission did not continue this project past a proof-of-concept study, the methodology on how they accomplished this digitization process was very valid and can be used for future digitization projects.

2.2.2 Blandwood Mansion, Greensboro, NC

Blandwood, the home of former North Carolina Governor John Motley Morehead, was constructed in 1844 by the nationally renowned architect Alexander Jackson Davis and is considered the oldest standing example of Italianate architecture in the United States. This home was nominated to the National Register of Historic Places in 1970 and also named a National Historic Landmark in 1988. [32] William Robinson's Master's Thesis, "Archaeological Data Management and Analysis at Blandwood Mansion" discusses data resulting from an archaeological excavation held within the Blandwood property in 2008.[33] Robinson's thesis involved the creation, organization, and analysis of digital archaeological data within a GIS and Microsoft Access relational database for the results of excavations at the Blandwood Mansion. A major goal of his study was to gain further understanding about the periods of buildings within the property and to find evidence which explains the functions of each building. Robinson used old photographs, maps and schematics to gain a clearer picture of Blandwood's historical landscape. To show the change of the site over time, Robinson used four Sanborn Fire Insurance maps from years 1907, 1919 and two from 1925. The Sanborn maps provided a

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[32] Preservation Greensboro Incorporated, "Blandwood: Where the Old South and New South Meet," http://www.blandwood.org/blandwood.html.

[33] William R. Robinson, "Archaeological Data Management and Analysis at Blandwood Mansion" (University of North Carolina at Greensboro, 2010).

detailed look into the structural makeup of the buildings and surrounding Blandwood estate.

As this study encompasses a relatively small area, georeference accuracy is not as important. Robinson used the four corners of the existing main house structure as the main anchor points of reference. Normally, this would not be a good idea because reference points should be widely spaced out, but since the area of interest did not extend beyond the boundaries of the Blandwood property, the house served as the best historical reference point. Robinson also pointed out that having the maps scale to the known corners of the house served to test the accuracy of the overall map scale and helped with the comparison of the building footprints presented by each map.[34]

Robinson found discrepancies between the 1907 and 1919 maps relative to the distances between buildings. He attributed the errors due to the map creation process rather than the georeferencing process. Errors on such a scale is not surprising since the maps were not designed to act as detailed building blueprints, but were used to approximate size, relative relationship to surrounding structures and other pertinent attributes of each structure for fire insurance assessment.[35] When conducting an archaeological study, discrepancies in the building footprints can reveal a hidden foundation or possibly a heretofore unknown building.

Robinson utilized other Sanborn maps to show the urbanization that eventually surrounded the farmstead. The maps illustrate how the land surrounding the Blandwood property changed from large tracts to the smaller urban lot present today. Aerial images

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[34] Ibid., 17.

[35] Ibid., 19.

covering different time periods were also used, which aided in the interpretation and identification of many of the features identified throughout the duration of the excavation.

Figure 5 illustrates the spatial differences of the footprints from three time periods. There were discrepancies in location between the building footprint and the excavated features, but despite these errors, the maps were able to date the construction of features which could later serve as a helpful benchmark for interpreting artifact remains associated with the features and their role in the overall site.

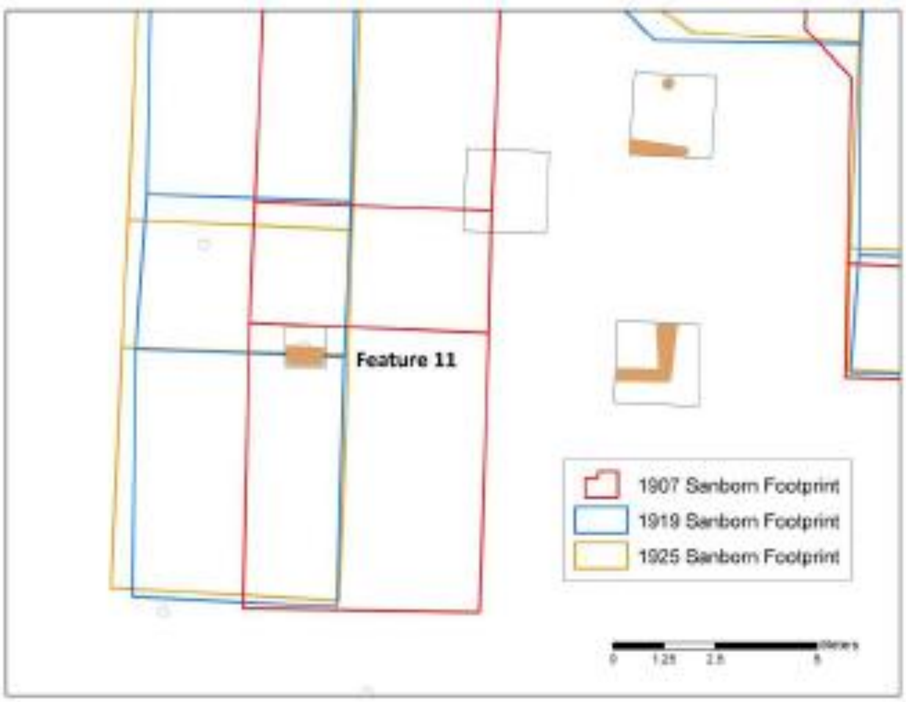

Figure 5. 1907, 1919, and 1925 Footprints determined from Sanborn Fire Insurance Maps[36]

[36] Ibid., 66.

2.2.3 Mapping the Industrial Archeology of Boston

In a pilot project initiated in September of 2001, the Boston Public Health Commission, in collaboration with the Department of Urban Studies and Planning at the Massachusetts Institute of Technology, developed a methodology for superimposing historical and present-day industrial land use data layers with demographic information and public health data. The goal was to identify and to possibly define a historical relationship between present-day public health concerns and past practices of land use within an urban environment. Historical data layers showing location and type of industries known to emit hazardous substances were interpreted from Sanborn Fire Insurance maps in the years 1888, 1962 and 1968.[37]

This study used the Sanborn Fire Insurance maps as their primary source of historical data as they provided detailed and comprehensive information about the type of industry present at the time and its inferred land use, building typology, building footprint, and limited physiographical details about the landscape such as the presence of bluffs and streams.[38] This study used a heads-up digitizing process but did not trace building footprints because this study was more focused on the nature and scale of industrial activities at specific sites rather than information about building sizes and types. Each building was translated into point data, which included attribute data of the name of the building and the type of facility, along with a hazard ranking. They utilized a GIS tool to perform a "spatial filtering" to add up the hazard rankings of facilities within

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[37] Kris Kolodziej, Raul P. Lejano, Chikako Sassa, and Jalal Ghaemghami Sushila Maharjan, and Thomas Plant, "Mapping the Industrial Archeology of Boston," *URISA Journal* 16, no. 1 (2004).

[38] Ibid., 6.

a Census tract and displayed the results on thematic maps, identifying areas of potential risks to public health.

This research study developed a systematic methodology for documenting and analyzing the industrial ecology of past industrial activities, in an effort to better comprehend present-day environmental risk. The investigators of this project explored various uses of such a tool to conduct research and design health intervention programs in a way that enables them to target the zones of the greatest concern. The most significant outcome of this study is that communities can utilize this mapping tool as a community information system in an attempt to mobilize around issues of health and potential risk. Developers and communities, in partnership, can use the mapping to make better investment decisions and to allocate funds more aggressively for cleanup. In many ways this methodology can be applied to documenting and analyzing historical building patterns and using that knowledge to predict future building patterns. This study showed the value of digital cartography when combined with a spatial database at enhancing our interpretation of the past and of improving the possibility of changing the future.

2.3 Use of GIS for historic preservation

In the context of historical districts, GIS clearly can play an important role in the research and understanding of a historical area. Anne Knowles, in her book, "*Placing History: How Haps, Spatial Sata, and GIS are Changing Historical Scholarship*," notes that archaeologists were among the first scholars in the humanities to use GIS and global positioning system (GPS) methods, beginning in the early 1980s.[39] Their familiarity with

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[39] Anne Kelly Knowles and Amy Hillier, *Placing History: How Maps, Spatial Data, and GIS are Changing Historical Scholarship*, 1st ed. (Redlands, Calif.: ESRI Press, 2008). 7.

field methods and long-standing interest in the relationship between terrain and human settlement drew archaeologists to digital tools that could improve the accuracy of site measurements and locate artifacts more precisely.

GIS can also be a tool of analytical thinking and visualization by using it as an educational aid to engage history students. GIS can add value to education because it can teach valuable analytical and problem-solving strategies and emphasize visualization as an approach to process large amounts of information. Through GIS, students also learn to develop skills for collecting, assessing and comprehending a wide range of information.

GIS can uncover the truth about certain historical events that are taken for granted, like the Dust Bowl. Many consider the 'Dust Bowl' a unique period in history, largely due to the breaking of the surface of agricultural land. Yet, historical records and GIS analyses show several periods previous to the 1930s where dust and winds were blowing across the US mid-west in equal or greater amounts. Getting to the ground truth allows us to make reasonable assumptions about the past. As to the reason why the Dust Bowl seems to have such a prominent exposure, research suggests it had a lot to do with the media of the day, often wanting to get people into the west and not frightening them off. [40]

GIS proves to be a valuable tool for revealing the "truth" and addresses the relevant issues between GIS as a technology and historical endeavor as a discipline. History was documented quite differently before geographic science. Geographic science tools bring to the table a lot of fascinating new technology to help make historical studies clearer or more understandable.

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[40] Ibid., 96.

2.4 Case Studies - GIS

The following case studies are examples of how GIS is used for historical mapping. The common theme among the case studies here is how GIS can used as a base to connect disparate pieces of information for a historic area in addition to being the spatial and analytical powerhouse of maps.

2.4.1 Mapping the Medieval Urban Landscape

“Mapping the Medieval Urban Landscape” was a two-year project funded by the Arts and Humanities Research Council (AHRC).[41] The project was completed at the end of May 2005. This project was concerned with new ways of analyzing medieval urban landscapes. This project explored the design and planning of towns in the Middle Ages. This required the careful study of the surviving layouts of medieval towns, looking in particular at their shape and form. They combined survey data using Global Positioning Systems and the analysis of these data in a GIS. They used GIS to amalgamate different sources of spatial data for each of their twelve study towns. GIS thus provided an analytical tool which enabled them to examine the morphological make-up of a town, the shape of its component features. GIS also provided a means of visualizing the data and representing the urban landscape cartographically, in three dimensions. This project resulted in an interactive online atlas of medieval towns--a digital resource for a wide public audience. GIS provides a means of visualizing these data and representing the urban landscape cartographically, in three dimensions.

[41] "Mapping the Medieval Urban Landscape," http://www.qub.ac.uk/urban_mapping/.

A georectified plan, digitized from historical Ordnance Survey mapping, shows the layout of each of the twelve study towns. The features selected are the towns' streets and plots, as well as key medieval buildings such as castles and churches.

2.4.2 Mapping Medieval Chester

"Mapping Medieval Chester" is a project that brings together scholars working in different disciplines such as geography, archaeology and history to explore how material and imagined urban landscapes construct and convey a sense of place-identity.[42] The focus of the project is the city of Chester in Cheshire, England and the identities that its inhabitants formed between 1200 and 1500. A key aspect of the project is to integrate geographical and literary mappings of the medieval city using cartographic and textual sources and using these to recognize how urban landscapes in the Middle Ages were interpreted and navigated by local inhabitants. A key goal of the project was to develop and use technology in innovative ways.

This project used GIS to create a map of Chester as it was in 1500 and as a means of widening access and public interest in Chester's medieval past and in medieval urban studies generally by linking literary and cartographic sources in digital media.

2.4.3 Historical GIS: Boston 1775

This project, created by Charlie Frye, Chief Cartographer and manager of the Mapping Center and Cartographic Projects Group at ESRI, is a GIS map of colonial Boston at the time of the American Revolution in 1775 using only maps published from that period. The goal was to create as a complete picture as possible of Boston's environment in 1775. Another goal was to cite every feature to a source document. To

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[42] "Mapping Medieval Chester," http://www.medievalchester.ac.uk/index.html.

that end, information included notes about which sources were used to determine whether that feature existed in 1775, the name of the feature, and anything else interesting about that feature.

The map began as a research project about the Battle of Bunker Hill. The database was then expanded to include all of Boston, and the surrounding coastline. Between 400-500 hours of GIS work was expended researching, drawing and creating data over a four-year period. Nearly every place and name on the map is shown based on it appearing in a document published prior to 1784.

The most interesting facet of this study is the use of a citation methodology to connect the GIS data to the bibliographic information. The information in the GIS database was cited in much the same way that facts and ideas are cited in academic literature. The result is accountability in mapping. In this case study, a Citation Data Model (CDM), an ArcGIS proprietary data base schema designed to manage spatial data in ESRI's ArcGIS software was utilized to manage the reference data. A CDM stores and relates bibliographic information to the GIS features on the map. These bibliographic sources range from traditional scholarly texts and journal articles to primary documents such as maps, field notes, and manuscripts. Once these sources are linked to the feature in GIS, those features can be queried or shown based on their bibliographic characteristics. For instance it is possible, with CDM, to derive a list of all the features in the GIS that a particular source was used as a basis for citation.

A side-benefit of implementing the CDM is that it enforces rigorous organization of data in order to ensure fidelity between features and sources. That in turn results in the formation of logical connections between features or places in time. Once historical data is entered into a geodatabase, it can easily be sorted and cross indexed to quickly find connections and inconsistencies.

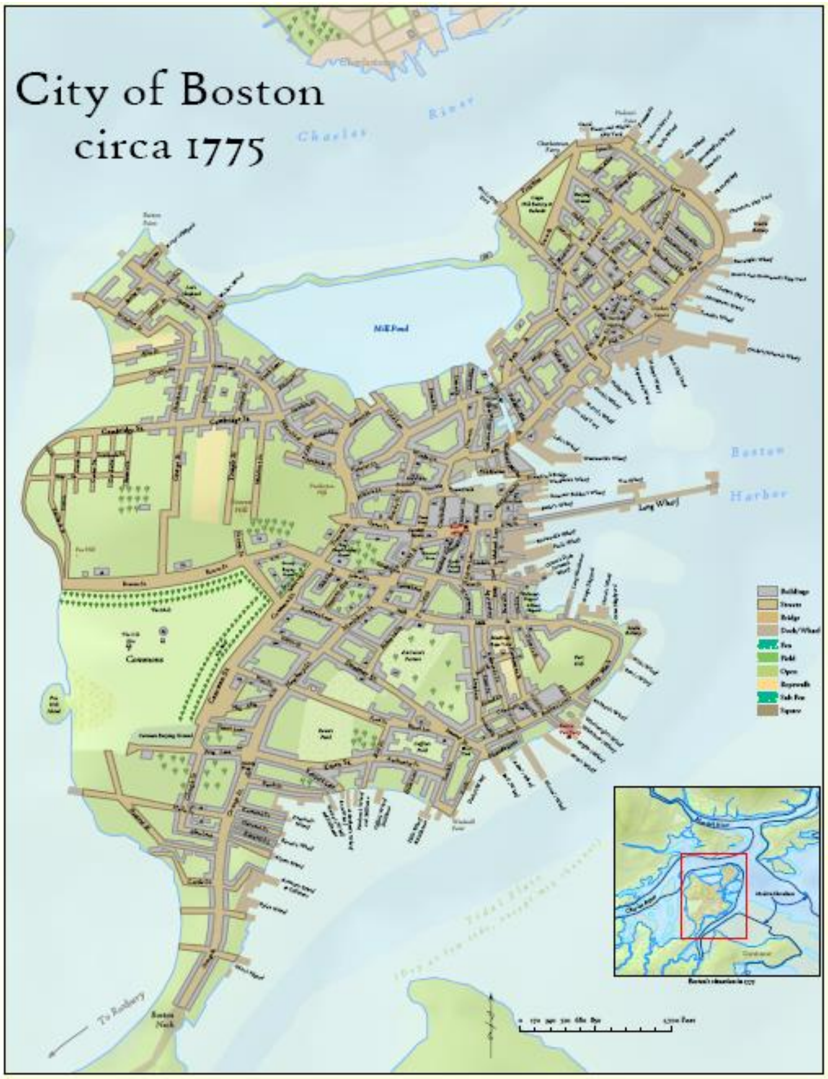

Figure 6. City of Boston, c. 1775[43]

[43] Charlie Frye, "Historical GIS Template: Boston 1775," http://blogs.esri.com/support/blogs/mappingcenter/archive/2009/05/28/historical-gis-template-boston-1775.aspx.

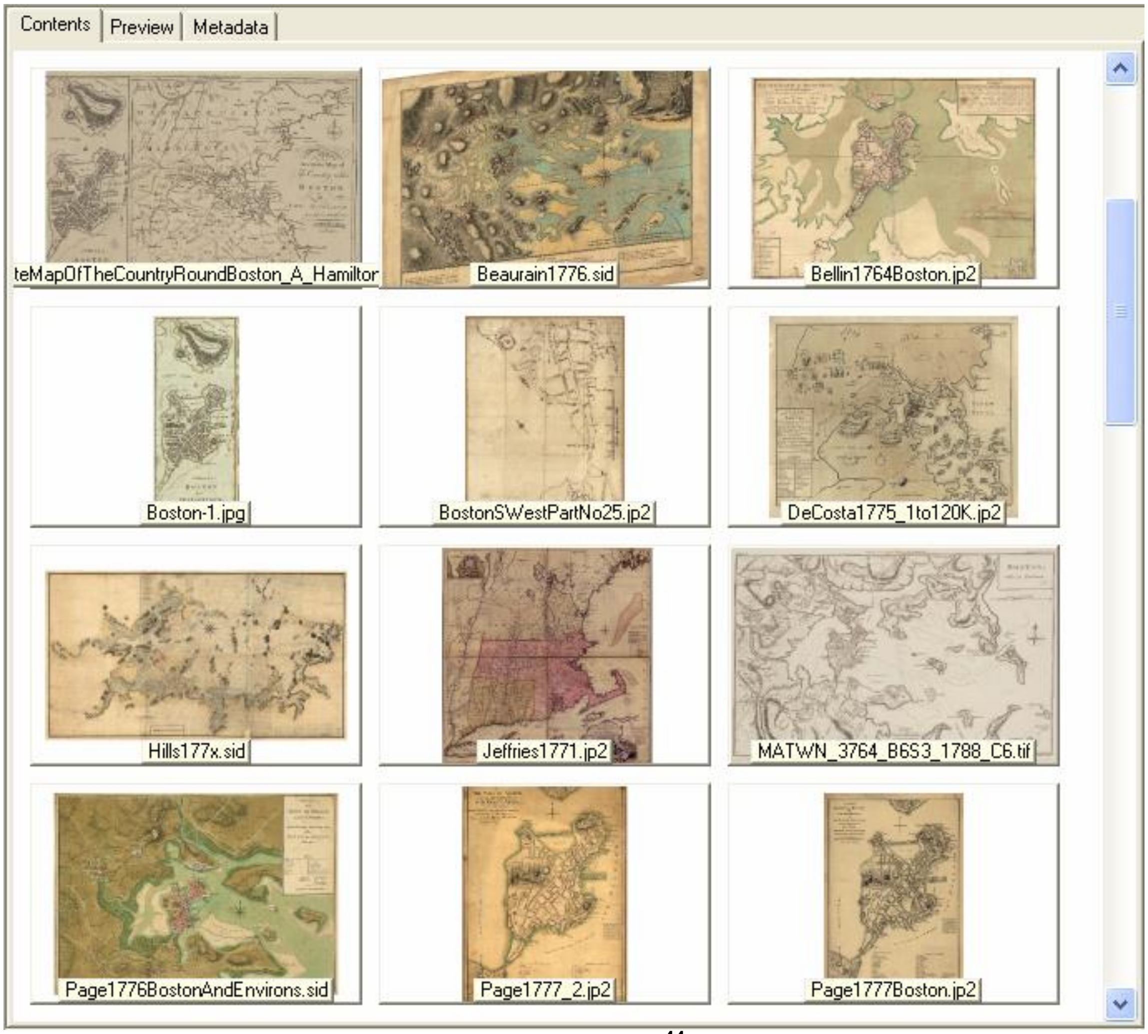

Figure 7. Samples of Historic Boston Maps Used[44]

[44] Ibid.

Chapter 3. Applied Research

The goal of this research was to incorporate GIS with historical map data to achieve a more nuanced picture of the past than from just examining maps alone. The historical maps used were the Sanborn Fire Insurance Maps. Fort Street, in downtown Honolulu, was chosen as the central point for the study area because it is well documented by maps and photographs. Sanborn Fire Insurance maps of the study area from 1914, 1927, 1950, 1956, 1975, 1986, and 1993 were digitized and analyzed within ArcGIS.

3.1 Fort Street and Downtown Honolulu

Downtown Honolulu contains many modern and historic buildings and complexes, many listed on the National Register of Historic Places. Fort Street in the heart of downtown Honolulu is one of the oldest streets in Hawaii and for much of its history was the primary shopping destination in the city. Fort Street reigned as the shopping center of Honolulu from the 1800s through the 1950s. Fort Street hosted several of the largest department stores of its time in Hawaii, including Kress, Liberty House and Woolworth's.

After World War II, land values plummeted, and downtown Honolulu declined considerably as suburban shopping centers took over much of the retail trade and as urban expansion, traffic congestion, and lack of parking made the trip downtown less and less attractive to shoppers. The Downtown Improvement Association, formed in 1958 to combat further decline, recommended changes such as closing Hotel Street to all but bus traffic and turning Fort Street into a pedestrian promenade.[45] The opening of the Ala Moana Shopping Center in 1959 led to an exodus of Fort Street's retail businesses, even as high rise office buildings began sprouting up around Fort Street. In 1968, the City & County of Honolulu converted Fort Street into a pedestrian mall as a part of a long range effort to improve the downtown experience for pedestrians and to compete with Ala Moana Center.[46]

During the business week, Fort Street Mall is bustling and teeming with office workers and shoppers. After business hours and on the weekends, the Mall becomes underutilized and transforms into a deserted place like most of the downtown business area. Recently Macy's, the last major department store in downtown, closed down. Fort Street may undergo yet another change as it tries to recover from the loss of this anchor store.

3.1.1 Fort Street Area Description

Fort Street Mall is eight city blocks long and runs in a Mauka-Makai direction beginning at S. Kukui St. near Central Intermediate School and ends at Aloha Tower Marketplace. Figure 8 is an aerial photo of the downtown area, with Fort Street Mall highlighted in yellow and the study area boundaries bordered in red. Fort Street Mall has a mix of high rise office buildings and historical structures. Figure 9 depicts the current building footprints of the structures in the downtown area.

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[45] Edward Greaney, "Crossroads," *Honolulu Advertiser*, March 20, 1958.

[46] "Fort Street Mall," http://www.fortstreetmall.org/.

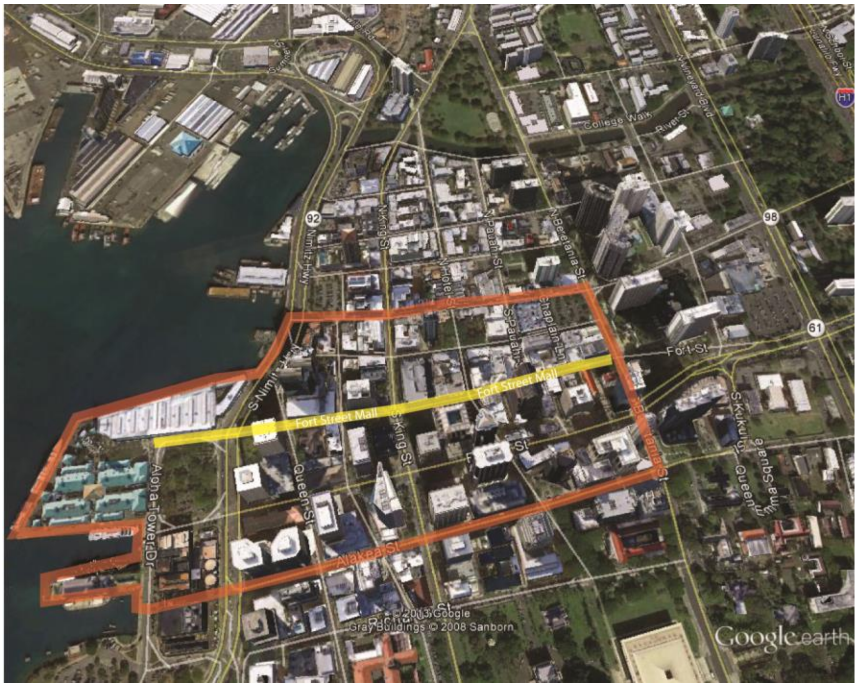

Figure 8. Downtown Honolulu, Aerial Map[47]

Figure 9. Building Footprints, Downtown Honolulu[48]

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[47] "Downtown, Honolulu," (21 18'37.52"N and 157 51'44.56W. Google Earth. January 29, 2013., April 22, 2013), Edited by author.

[48] "Department of Planning and Permitting Honolulu Land and Information System (HOLIS)," http://gis.hicentral.com/data.html. Edited by author.

3.1.2 Historical Buildings on Fort Street Mall

Many historical buildings are located on Ft. Street Mall.

Table 3-1 summaries a few of the historical buildings located on Fort Street and Figure 10 shows the locations of these buildings. These buildings contribute to the "sense of place" of downtown Honolulu.

	Historic Buildings	**Year Built**	**Address**
1	Central Fire Station	1934-5	104 Beretania Street
2	The Cathedral of Our Lady of Peace	1843	1183 Fort Street
3	Sacred Hearts Convent School	1901	1159 Fort Street
4	Pantheon Block (Altered c. 1955 and c. 1968)	1911	1102-1122 Fort Street
5	The McCorriston Building	1914	1107 Fort Street
6	Judd Building	1899	111 Merchant Street
7	Stangenwald Building	1901	119 Merchant Street
8	C. Brewer & Co.	1930	827 Fort Street

Table 3-1. Historic Buildings on Fort Street in Downtown Honolulu

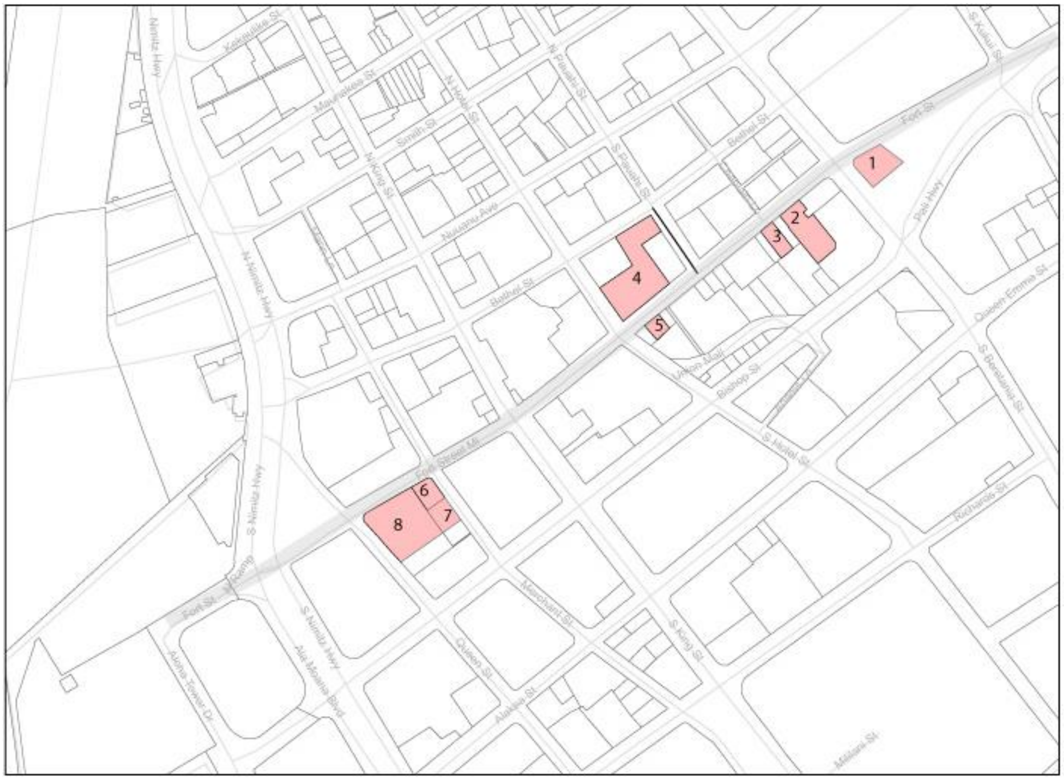

Figure 10. Location of Historical Buildings on Fort Street[49]

3.2 Creation of GIS Maps

The digital maps for the downtown Honolulu Sanborn Map study were created using ArcMap 10.01. The process for creating the GIS maps area involved first obtaining the correct Sanborn Fire Insurance maps for the study area, preparing the maps for georeferencing, executing the georeferencing process, creating map mosaics, digitizing the data and populating the database with the information from the maps. Each process is explained further in this section.

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[49] Ibid. Edited by the author

3.2.1 Gathering the Maps

From its original paper sheet form, many Sanborn Fire Insurance Maps have either been digitally scanned or put on microfilm. In Hawaii, paper, microfilm and digital copies of Sanborn Fire Insurance Maps are held at the University of Hawaii Manoa Library, the Hawaii State Archives, the Hawaii State Library and the Bishop Museum. Each location differs as to the extent of their map collection. The most complete digital collection is available through the ProQuest Information and Learning microfilm collection, which can be accessed through the University of Hawaii Hamilton Library website. ProQuest's Digital Sanborn Map collections were created from the Chadwyck-Healey microfilm collection, which had, in the early 1990s microfilmed the maps from the Library of Congress collection.[50] Those microfilm copies, including the ones for Hawaii, are in black and white. A few color maps in their original hardcopy form are located at the University of Hawaii Hamilton Library Map Collection, the Hawaii State Archives and the Bishop Museum. The color maps are obviously preferable to the black and white versions. Unfortunately, they are not all widely available in digital form. The University of Hawaii has scanned color copies of their 1914 Sanborn maps available by request.

The first step for determining which maps to use is to refer to the Sanborn Index Map for the specific year. Figure 11 is the 1927 Sanborn Fire Insurance Index Map for Honolulu. The 1927 series of Sanborn Fire Insurance Maps for Honolulu were divided into three volumes. The Central Honolulu area is part of Volume 2. The map numbers for a specific area are indicated on the index maps. Figure 12 is a zoomed in detail of the

[50] "Introduction to the Sanborn Map Collection".

Sanborn index map; map numbers 223 and 225 are highlighted, with their respective maps shown below.

Figure 11. 1927 Sanborn Fire Insurance Index Map of Honolulu[51]

[51] "Sanborn Fire Insurance Map," in *Proquest LLC* (1927). Edited by author.

Figure 12. Detail of 1927 Sanborn Map Index and Map Nos. 223 and 225[52]

52 Ibid. Edited by author

Table 3-2 lists the sheet numbers and summarizes the number of Sanborn Fire Insurance Maps downloaded for each year. A total of 44 maps were downloaded as PDFs from the ProQuest Digital Map Collection. The web page was accessed via the University of Hawaii at Manoa Library on-line portal.

Name	Date	Sheet Numbers	Number of Maps
Sanborn Maps of Honolulu, Volume 2	1914	32, 36, 39, 40, 51, 53, 54, 57 & 59	9
Sanborn Maps of Honolulu, Volume 2	1927	217, 223, 224, 225, 226, 231, 243, and 244	8
Sanborn Maps of Honolulu, Volume 2	1950	217, 223, 224, 225, 226, 231, 243, and 244	8
Sanborn Maps of Honolulu, Volume 2	1956	201, 202, 203, 204, 205, 206, 207, 208, 209, 211, 212, 223, 224, 225, 226, 231, 231A, 243, and 244	19

Table 3-2. Sanborn Fire Insurance Maps Downloaded from Proquest

Table 3-3 lists the Sanborn Fire Insurance Maps which were retrieved from the University of Hawaii at Manoa Library Microfilm Collection and digitally scanned. A total of 56 maps were retrieved from this collection.

Name	Date	Sheet Numbers	Number of Maps
Sanborn Maps of Honolulu, Volume 2	1975	201, 202, 203, 204, 205, 206, 207, 208, 209, 211, 212, 223, 224, 225, 226, 231, 231A, 243, and 244	19
Sanborn Maps of Honolulu, Volume 2	1986	202, 203, 204, 205, 206, 207, 208, 209, 211, 212, 223, 224, 225, 226, 231, 231A, 243, and 244 (note: sheet 201 missing from microfilm file)	18
Sanborn Maps of Honolulu, Volume 2	1993	201, 202, 203, 204, 205, 206, 207, 208, 209, 211, 212, 223, 224, 225, 226, 231, 231A, 243, and 244	19

Table 3-3. Sanborn Fire Insurance Maps from the Univ of Hawaii Hamilton Library Microfilm collection

The maps selected covered the area two blocks east and west of Fort Street, South of Beretania Street to the ocean as shown in Figure 13.

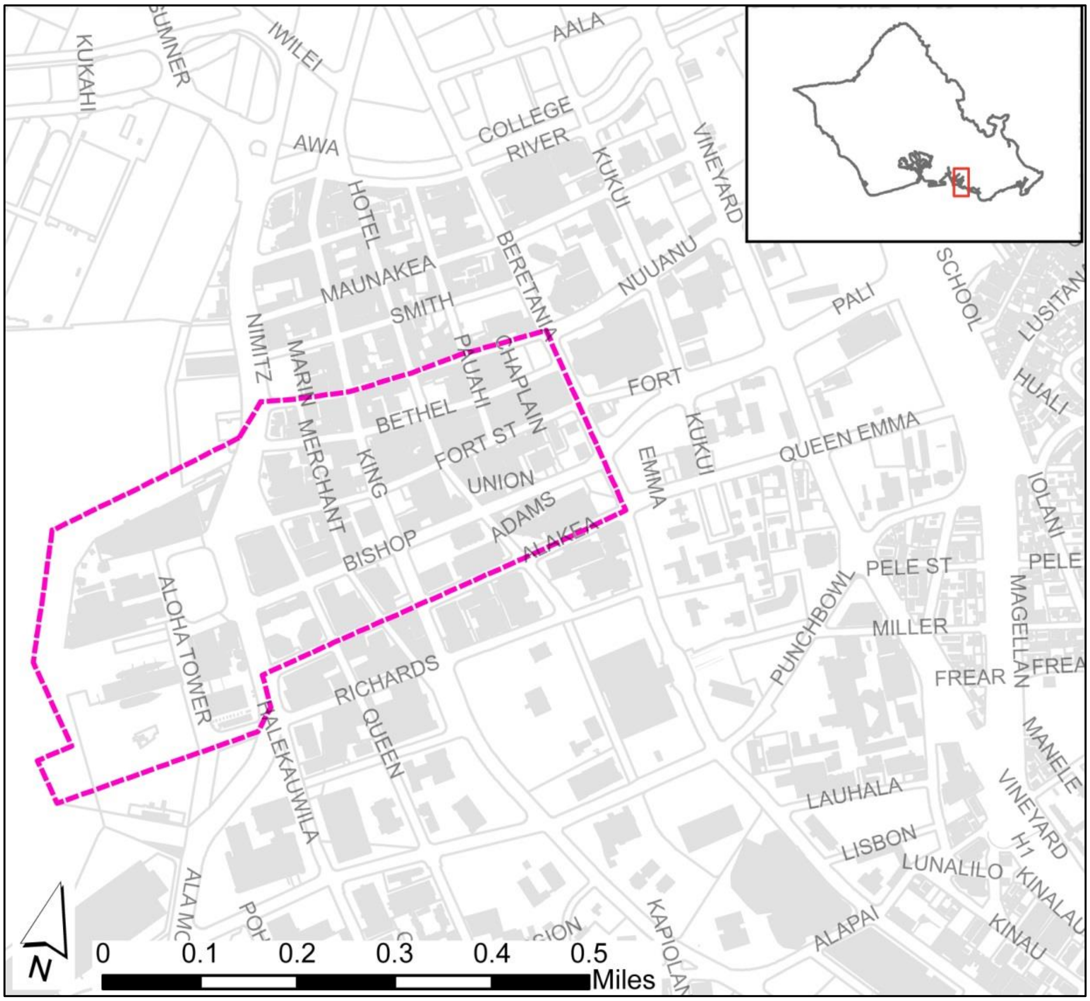

Figure 13. Downtown Honolulu Mapping Coverage Area[53]

3.2.2 Preparing the Maps

The original Sanborn Fire Insurance Maps were drawn at a scale of 1 inch = 50 feet on sheets measuring 21 by 25 inches.[54] Depending on the size of the block, a single sheet

[53] "Department of Planning and Permitting Honolulu Land and Information System (HOLIS)". Edited by author

may depict between two to four city blocks. Often the distances between the blocks are not drawn to scale so that the blocks can be drawn more neatly on a single sheet.

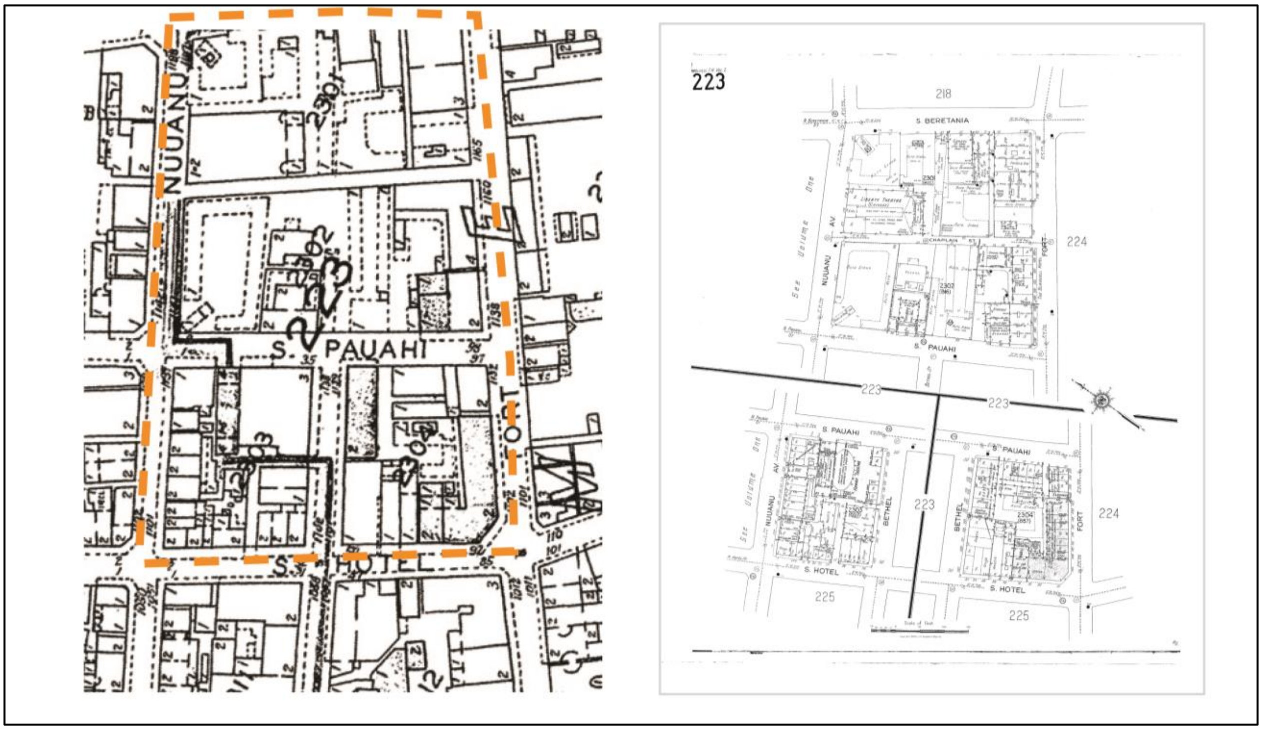

Figure 14. Sanborn Fire Insurance Map dated 1927 –3 City blocks on one sheet

An example is shown in Figure 14. On the left is a detail of the 1927 Sanborn map index, highlighting the coverage area for map number 223 which is shown on right. Map 223 depicts three adjoining blocks, even though at first glance the map appears as if blocks are not adjoining. Georeferencing the entire sheet as one map would be problematic because the distance between the blocks is not to scale. To resolve this problem, each block must be cropped out and saved as a separate digital file and georeferenced as illustrated by Figure 15. Table 3-4 summarizes the total number of individual maps required for georeferencing after cropping to separate out the city blocks.

[54] "A Visit to the Sanborn Library."

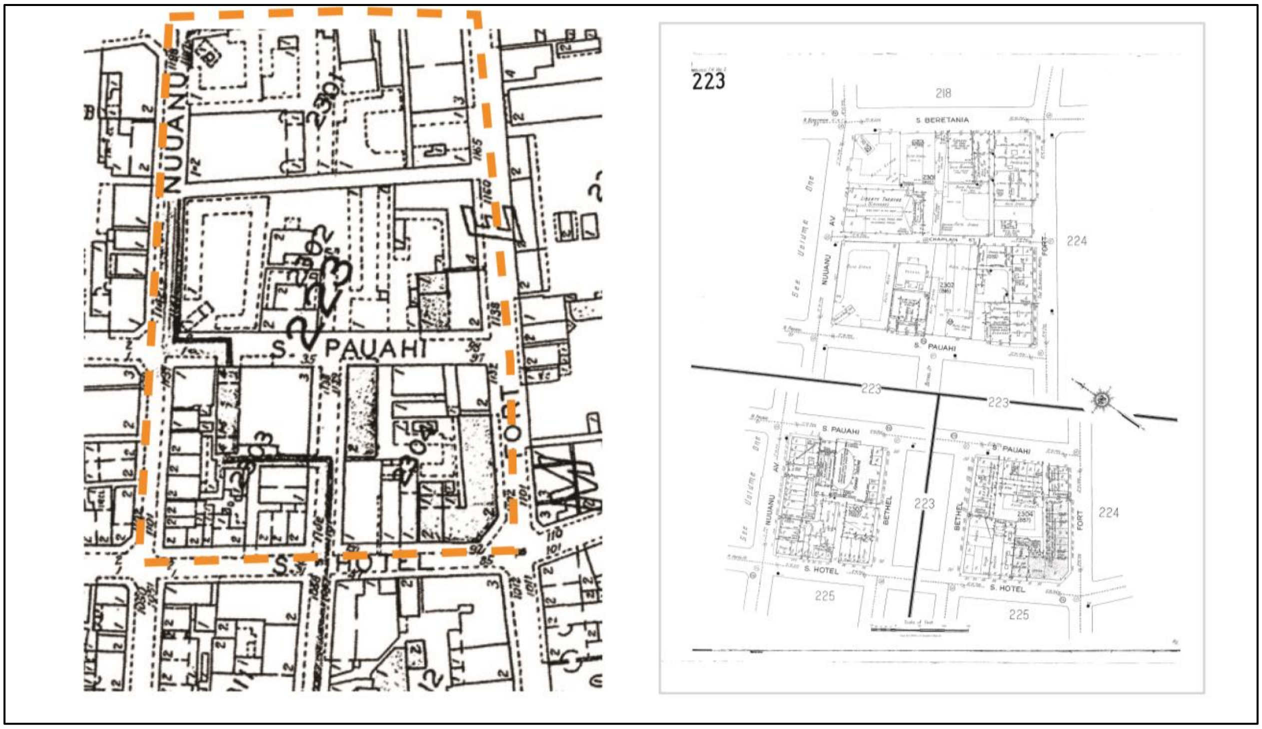

Figure 14. Sanborn Fire Insurance Map dated 1927 –3 City blocks on one sheet[55]

[55] "Sanborn Fire Insurance Map." Edited by author.

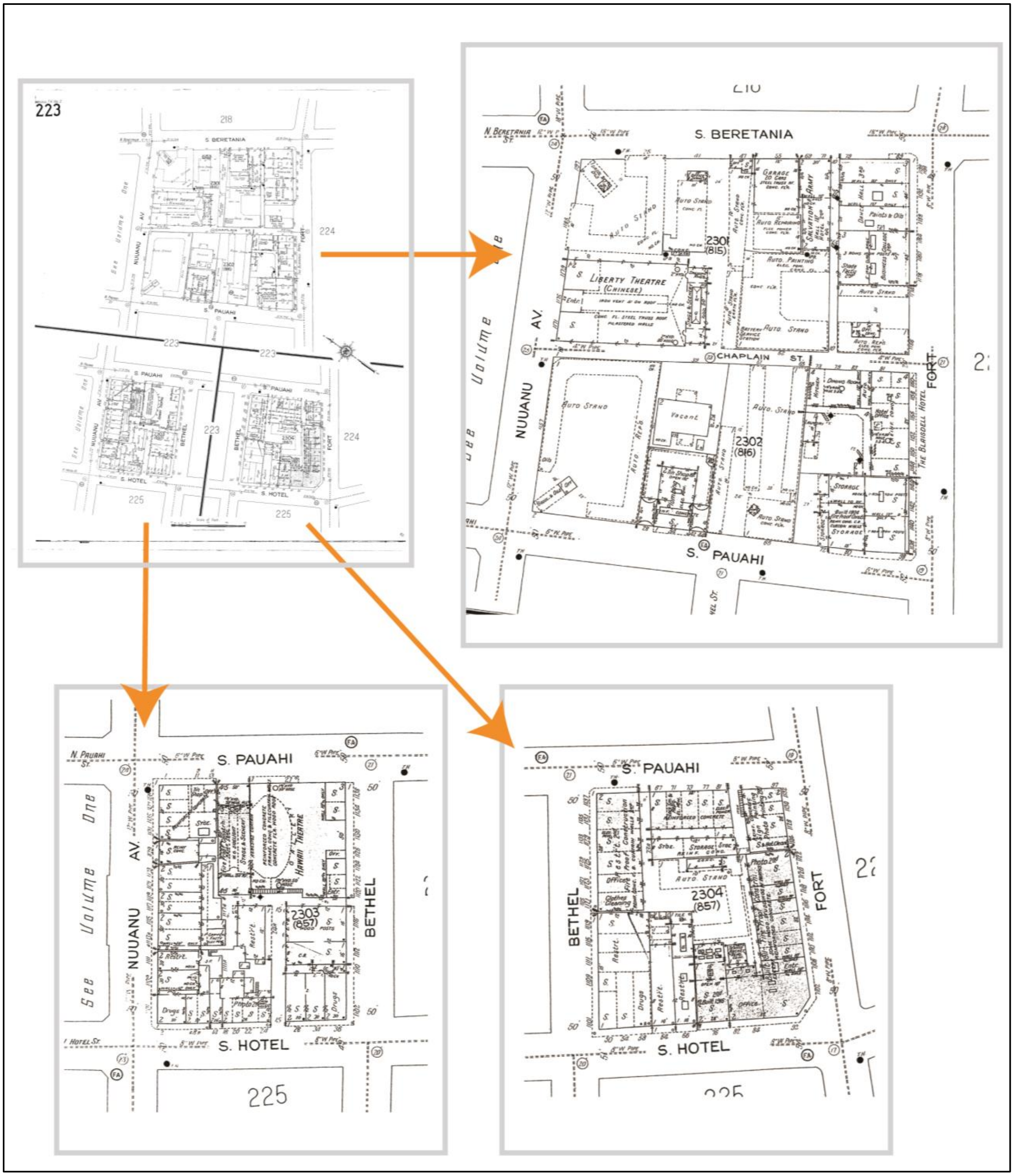

Figure 15. Sanborn Fire Insurance Map 223, Cropped into three map files[56]

[56] Ibid. Edited by author.

Map Year	Original Number of Maps in Study Area	Final Number of Maps after Separating out the City Blocks
1914	9	15
1927	8	21
1950	8	21
1956	19	21
1975	19	21
1986	19	20
1993	19	21
Total	**101**	**140**

Table 3-4. Summary of Number of Maps Required for Georeferencing

3.2.3 Georeferencing Process

Georeferencing is the process of aligning an image, a map for example, to a known coordinate system. Prior to georeferencing, a digitized map has no spatial reference to the earth's surface—meaning that it is not correlated to real-world coordinates. Georeferencing places the map on the correct "place" on the earth's surface. Georeferencing may involve shifting, rotating, scaling, skewing, and in some areas warping, rubber sheeting, or orthorectifying the data.[57] These terms are used to describe how a map is made larger or smaller, turned or rotated, or stretched to best fit a geographic area. Once georeferenced, a map can be viewed, queried, and analyzed with other geographic data.

The mechanics of georeferencing the Sanborn Fire Insurance maps in ArcGIS is essentially the process of overlaying a map or image on a "base map" and adjusting the Sanborn map until the landmarks present in both maps are aligned. To make the Sanborn

[57] Tasha Wade and Shelly Sommer, *A to Z GIS : An Illustrated Dictionary of Geographic Information Systems*, 2nd ed. (Redlands, Calif.: ESRI Press : Independent Publishers Group [distributor], 2006). 89.

map match with the base map, the ArcGIS software is used to increase or decrease, rotate, stretch or compress parts of the map to make the best fit. Control points are added to anchor the Sanborn map to similar features on the base map.

The City and County of Honolulu GIS tax parcels, building footprints, and street line shape files were used as the “base map” for the georeferencing. These shape files were obtained from the City and County of Honolulu Department of Planning & Permitting Honolulu Land Information System (HOLIS) website located at http:gis.hicentral.com. The projected coordinate system in use at the City and County of Honolulu is *NAD_1983_HARN_StatePlane_Hawaii_3_FIPS_5103_Feet*.

The Sanborn maps were georeferenced in the order of the most current to the oldest. The latest Sanborn maps were the first set to be georeferenced because they had a larger number of similar landmarks with the base map, making them easier to match up. As each map was georeferenced, they in turn were used as reference points to georeference the earlier maps. The street centerlines or city block corner points were typically reliable reference points for georeferencing, as shown in Figure 16**Error! Reference source not found.**. There are many factors that affect the quality of the georeferencing such as if the original map was not drawn to a consistent scale or if it was of a poor quality. Georeferencing is not an exact science, but the goal is to achieve the best “fit.” Figure 17**Error! Reference source not found.** displays a portion of the study area with a number of georeferenced maps.

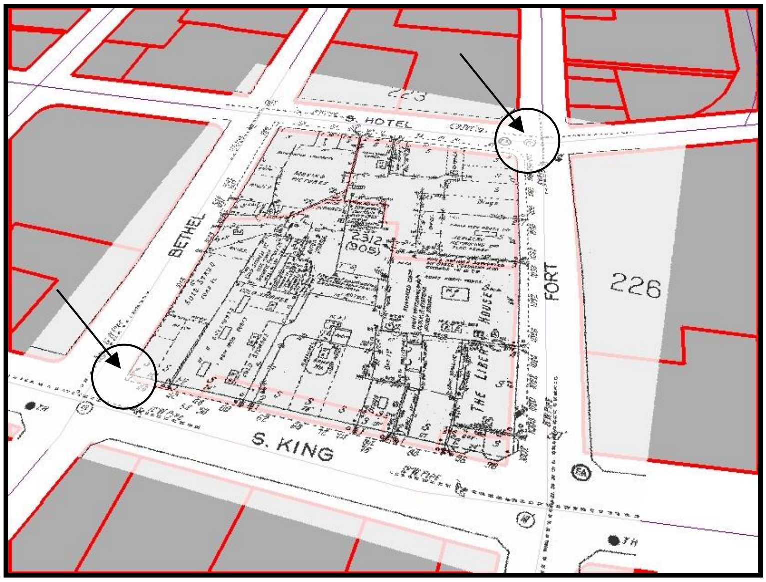

Figure 16. Sanborn Fire Insurance Map - Reference Points

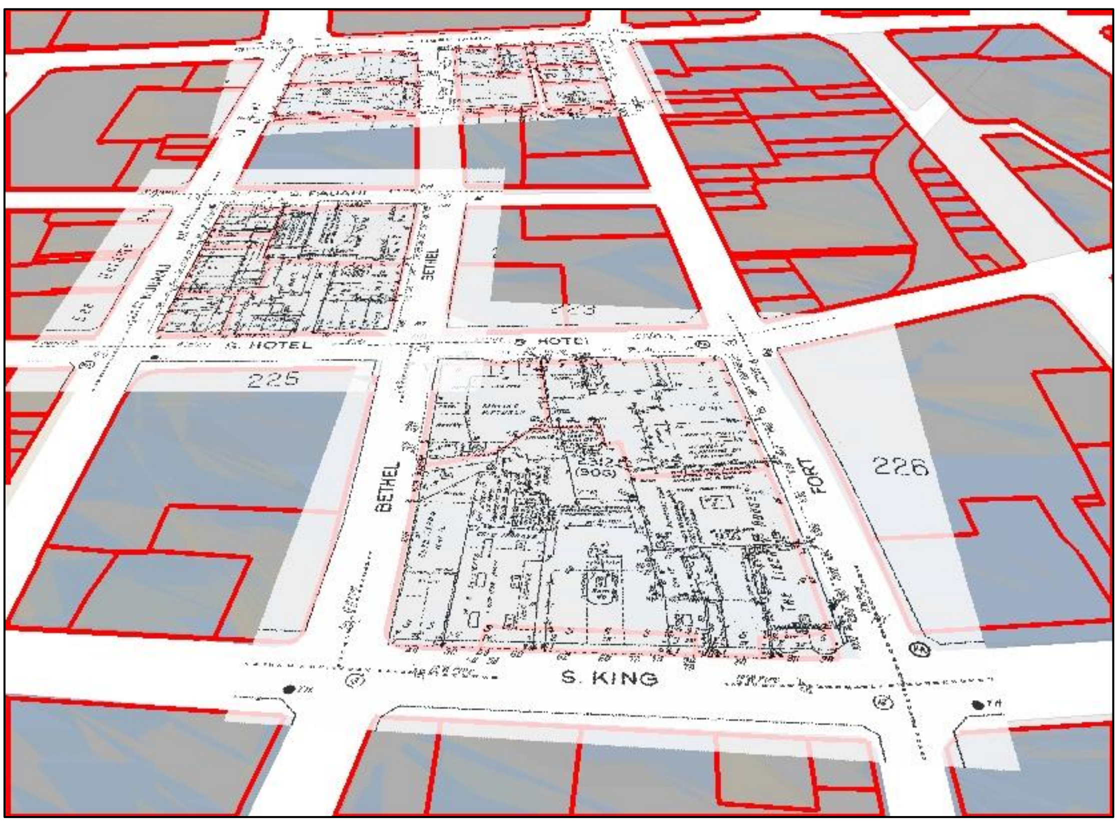

Figure 17. Sanborn Fire Insurance Map Tiles Georeferenced to a Base Map

3.2.4 Creating Map Mosaics

Map Mosaics in ArcGIS are a collection of georeferenced images which are joined together in the software to allow them to be displayed simultaneously. The mosaic feature makes it appear as if the individual map files are part of one large map mosaic. The images are arranged based on the georeferencing information given on the reference image. The advantage of mosaics map is that all the blocks in the study area can be viewed at once instead of opening each map individually. The extraneous data on the edges of each map can also be blocked out to make the entire mosaic seem like one large seamless map. The mosaics are also helpful for researching multiple years at once. The entire area can be displayed as one map, making it easier to go from one year to the next to study the maps.

Without a map mosaic, all the maps for the area would need to be opened individually, a time consuming process, particularly if studying a large area encompassing many maps. Mosaics were created for years 1914, 1927, 1950, 1950, 1975, 1986, and 1993. An example is shown in Figure 19, which shows the 1927 Sanborn map mosaic for the study area created from tiling 22 Sanborn map tiles. In this figure, the footprints for each map sheet is highlighted. Figure 19 shows the final version of the mosaic. Notice that there do not appear to be any seamlines between the map sheets in the final mosaic.

Figure 18. Sanborn Fire Insurance Map Mosaic - Showing Footprint of Map Sheets

Figure 19. Sanborn Fire Insurance Map Mosaic - Final

3.2.5 Digitizing

Digitizing is the process by which landmarks from a map, image, or other sources are converted into a digital format in a GIS.[58] The digitization process was the most time-consuming and tedious part of this project due to the large number of footprints. The poor reproduction quality of some of the maps also made it difficult to decipher the information on the maps.

3.2.5.1 Building Footprints and City Blocks

Once the Sanborn maps were georeferenced to the basemap, the building footprints and city block shapes were created by tracing the outlines from the georeferenced maps. Each shape is associated with a unique record in the database. As each shape is created, descriptive information is such as height, year built, land use and address was added to the database. Figure 20 shows the digital building footprints for the 1914 Sanborn Fire Insurance Maps. A total of 2,431 buildings were digitized for all 7 years. A summary of the number of buildings digitized for each year is shown in Table 3-5.

[58] "Sanborn Fire Insurance Map."

Figure 20. Digital Building Footprints – 1914 Sanborn Fire Insurance Maps (viewed using ArcScene)

Map Year	Number of Buildings Digitized
1914	573
1927	504
1950	400
1956	379
1975	223
1986	179
1993	173
Total buildings digitized	2,431

Table 3-5. Summary of Buildings Digitized

In addition to digitizing the building footprints, the city blocks were traced using the mosaic maps for each year. An example of the city block shape file is shown on the right in Figure 21. On the left side is the 1914 Sanborn mosaic map. City block shape files were created from the Sanborn mosaics for the 1914, 1927, 1950, 1956, 1975, 1986 and 1993 map years.

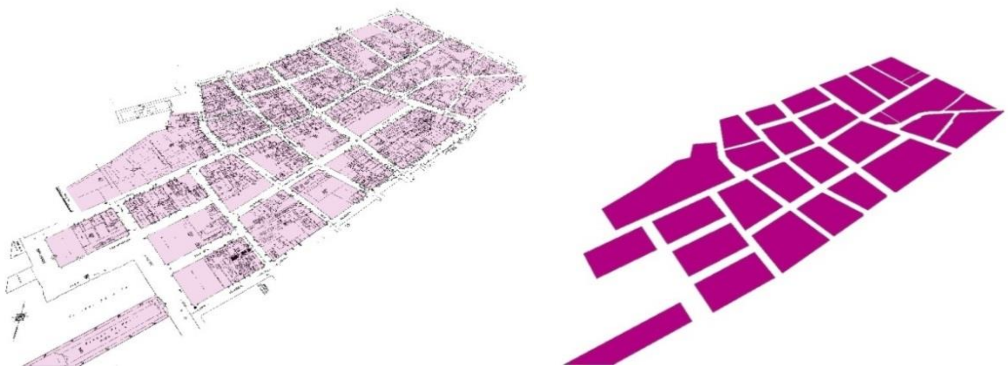

Figure 21. City Block Digitization - 1914 Sanborn Maps

3.2.5.2 Digitization Workflow

As in the georeferencing process, the digitization process began with the most current Sanborn map. The latest Sanborn maps would have the most commonality between the present day buildings and city blocks. The digitization for all the years of one block would be completed before moving on to the next block. Starting with a block from the 1993 Sanborn year, the buildings were digitized and the database populated for each building. Once all the buildings were completed for the block, the next earlier Sanborn Map year was digitized. Once the earliest year was completed, then another block was started. If most of the buildings on one block were the same as the prior years', the data was simply cut and pasted and corrected for any discrepancies. This method made it easier to check for outliers and perform data quality checks.

3.2.6 Database Development

Building information is critical to the field of historic preservation. The more information we know about a building, the better we are at interpreting its history and how to best preserve it. Culling the data from the Sanborn Fire Insurance maps and organizing it in a database will assist with the preservation of spatial and historical information and follow on research and analysis.

The building database was developed using Microsoft Access, a relational database which allows related data stored in different tables to be joined together to summarize and calculate data. Microsoft Access databases are compatible with ArcGIS, as tables within Access databases can be directly accessed by ArcGIS and added to the ArcGIS map. Databases are joined to shape files based on a common field, and the data within the tables can be mapped. Table 3-6 describes the information included in the database for each building footprint along with the data type (text or numeric).

Field Name	Description	Type
Building Id	Building Identifier	Text
Map Year	Date of the Sanborn Map	Text
Map No	Map reference number	Text
Block No	Block Number	Text
House No	House Number	Text
Street Name	Street Name	Text
House No (2)	Alternate House Number	Text
Street Name (2)	Alternate Street Name	Text
Height	Height of Building in Feet	Numeric
Stories	Number of floors	Text
YB	Year Built	Text
LU	Building Use Code (commercial, warehouse, store, etc.)	Text
FP	Fire Proof Construction	Text
Desc	Building Data1 (Name of Building or Use)	Text
Desc	Building Data2 (construction or other bldg. data)	Text
Desc	Building Data3 (construction or other bldg. data)	Text

Table 3-6. Sanborn Fire Insurance Map Database Fields Summary

3.2.7 Time Estimates

This project to map the Fort Street downtown area involved digitizing maps and creating a database describing the area from 7 different time periods, beginning in 1914 through 1993. The area covered an area of approximately 22 blocks--20 maps per year, 140 maps total. The following are the time estimates for each step in the mapping process.

Task	Time per map (mins)	Number of Maps	Total Time (Hrs)
Georeferencing Sanborn Maps	15 minutes	140	35
Digitizing the Building Footprints	60 minutes	140	140
Entering data into the database	120 min	140	280
Reviewing the data	30 minutes	140	70
Total time (hrs)			**525**

Table 3-7. Time Required to Complete Mapping

3.3 Historical Building Photographs

Historical building photographs are a rich source of information essential for interpreting the past and serve as compelling records of people, events, and places. Old photographs remind people of a past time and evoke ideas and emotions in ways that maps, words or statistics alone cannot. In addition to displaying a clear visual record of a structure, historical building photographs can reveal much about people and how and where they lived and worked and bring to life what was once forgotten. The photographs reveal the building styles of the period, the uses for the buildings and many other clues about that time period.

When historic photos are displayed with their location on a map, the resultant combination of the two can intensify and enliven the history of a particular place and provide an innovative way to interpret history. Historic building photographs achieve greater historical value if information is known about where and when they were taken and about people, building or objects in the photograph. GIS is an effective tool to integrate the photograph and the information about the photograph to locations on maps and to historical databases.

3.3.1 Data Sources

Archival photographs are publically available at many locations, such as the state and university libraries, state archives, and museums. Historic building photographs can also be gleaned from books, microfiche collections, and on-line searches. There is a large archive of historic photographs of the Downtown Honolulu area. For this study, historic building photographs were obtained from the Hawaii State Archives. The majority of the

Archives' photographic collections are hard copy images although they have a limited number of images available on-line.

3.3.2 Data Collection

The Hawaii State Archive does not allow scanning of their images so the only way to obtain a digital copy is to photograph the pictures. To ensure an optimal image, special care must be taken when using a camera to document historical photographs. The photograph should be taken in an area with no strong directional lighting that will cause hotspots or glare to appear on the image. To keep perspective distortion at a minimum, a tripod should be used and the camera lens must not be tilted on an angle compared with the plane of the photograph.

Most of the archival photographs were grouped in manila folders or photo albums. The workflow involved working with a batch of 30-40 images at a time. After one batch is photographed, the images are downloaded to a computer and information about the photograph—the date, the location, building name, collection name and any other available information about the photograph are logged onto a database. All the processing is completed for a batch before moving on to the next batch of photographs. It is much easier to work with a small number of photographs at a time in case a problem occurs which requires double checking the data. If an image did have a problem with it, for example if it was blurry, it was much easier to backtrack to locate the image and take another photograph of the picture.

3.3.3 Database Development

Similar to the workflow for the building footprints, the database was kept as a table separate from the geographic shape files because the data entry process within

Microsoft Access is much simpler than within ArcGIS. The type of information recorded for each photograph is detailed in Table 3-8.

Field Name	Description	Type
Desc	Description of Photograph	Text
Addr1	Location by Street	Text
Addr2	Location by Street - 2	Text
Photo_Yr	Year photo taken	Text
Source	Photo Source	Text
Coll_Na	Name of Collection	Text
Call_Num	Call Number	Text
Author	Photographer	Text
File_na	Internal File name	Text
Link	Hyperlink to Photograph	Text

Table 3-8. Building Photograph Database Fields Summary

3.3.4 Displaying the Photographs

The photographs were pinned to a geographic location on the map as point shape files based on the information known about the photograph's building location. Figure 22 shows the locations of where the images are pinned to on the map. Access to the individual photograph files is through a hyperlink to a local drive or a cloud-based storage site. Although a total of 362 images were retrieved from State Archives collection and catalogued into the database, only 121 images were pinned to geographic locations on the map because the remaining images did not have enough information in its label or in the image to confirm its location.

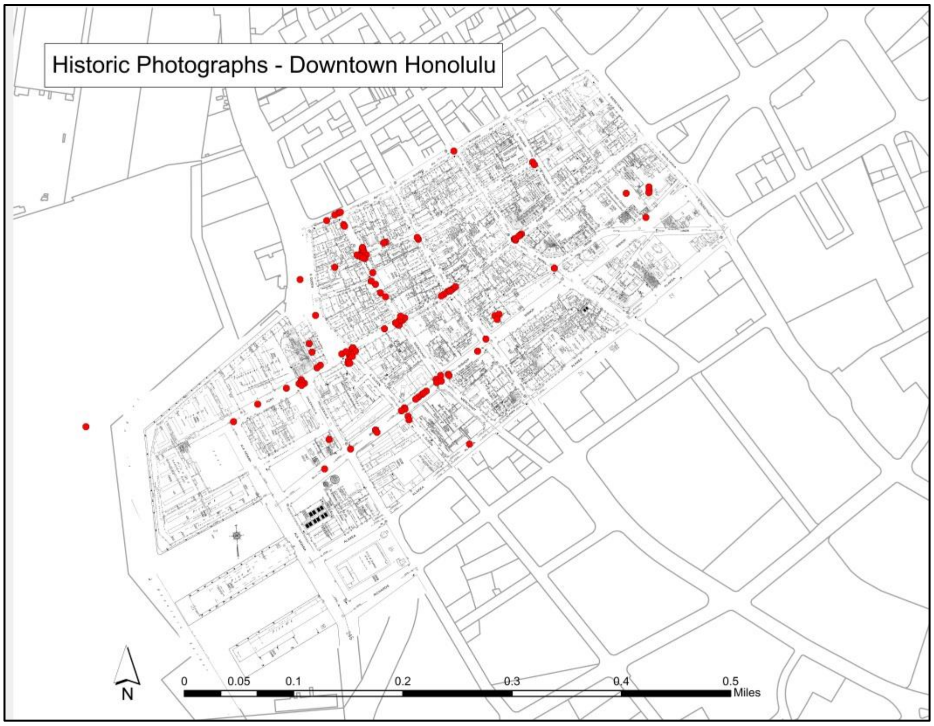

Figure 22. Historic Photographs in Mapping Area

As shown in Figure 23, the photographs are represented as points on a map. Clicking on a point will bring up a pop-up window displaying the building images for the area. The pop-up window may be customized to include additional information about the building, such as street address, or date photograph taken.

Figure 23. Building Photograph Pop Up Window

By first spatially connecting the photograph to a location on the map, more detailed data is obtained when zooming in on the Sanborn Map and comparing the photograph with the information from the map. This is illustrated in Figure 24, which shows a photograph taken from the King Street and Fort Street intersection and depicts the buildings on Fort Street. The Sanborn map shows that the two-story corner building on the left is 24 feet in height, functions as a store and has office space on the south west corner. The adjacent structure is a four-story 63-foot height rectangular building. The ground floor includes a store and a drug store and the upper floors are halls. Across the street, a two-story, 30-foot height building is occupied by a bank. The Sanborn map also shows addresses which can also be correlated to the buildings in the photographs.

Figure 24. Corner of King Street looking up Fort Street. First National Bank on the right. M.A. Gunst building on left[59]

[59] "Hawaii State Archives Digital Collection," http://archives1.dags.hawaii.gov/gallery2/main.php.

Chapter 4. Results

The advantage to using GIS in the study of historical maps is that it allows visualization of how an area has changed over time, where patterns exist, and where they vary across the study areas. By using the spatial component in the analysis a more sophisticated understanding of the information on the maps can be developed.

Digitization of the Sanborn Fire Insurance Maps of the downtown Honolulu area from 1914 to 1993 reveals how dramatically the urban space changed during this 79-year time period. Figure 25 shows the mapping area for this study. Practically every city block has gone through a transformation to accommodate the emergence of large office buildings and complexes throughout the city. Only a handful of the buildings from the early 1900s still exist today.

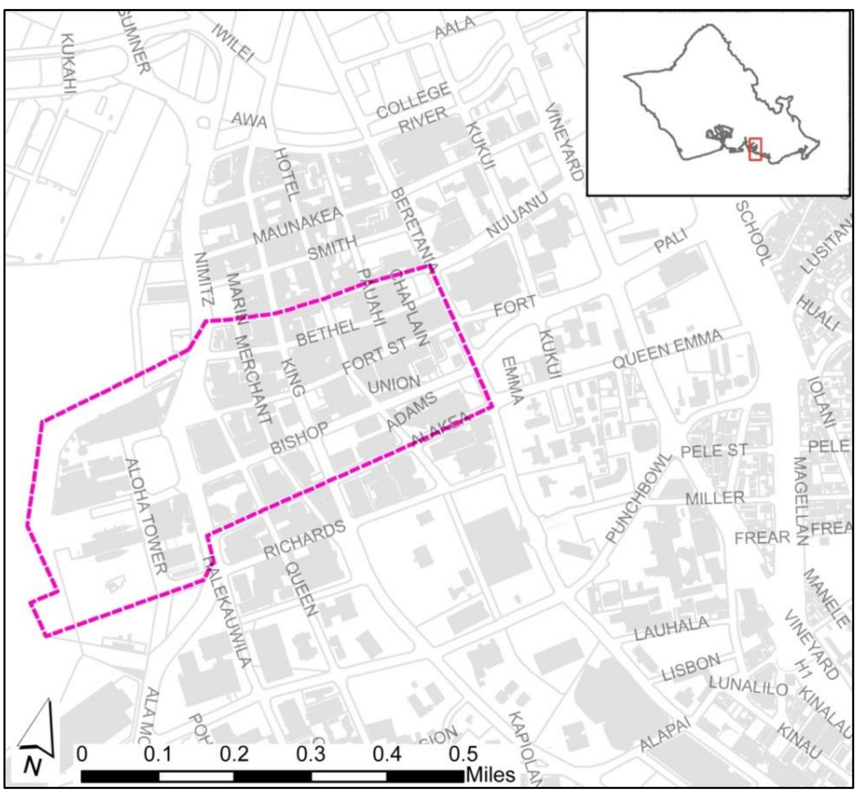

Figure 25. Mapping Area - Downtown Honolulu

4.1 City Blocks

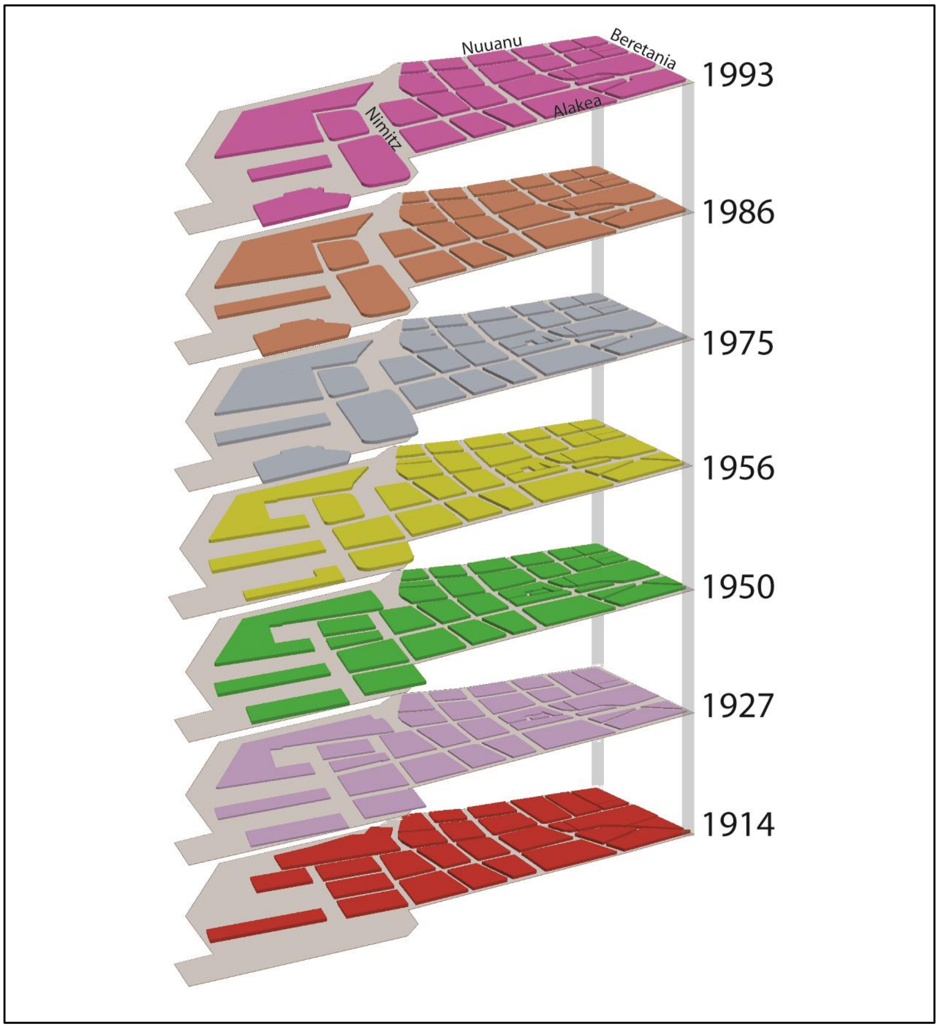

Figure 26. City Blocks in Mapping Area from 1914 to 1993

The growth and changes of a city can be seen by examining the street and block changes over time. As discussed in Section 3.2.5, the city blocks were digitally traced using the mosaic maps created for each year. Figure 26 shows the outline of the city blocks for the study area for each year mapped, and depicts at a glance how the city blocks changed from 1914 to 1993. GIS can be used to analyze and study the streets and blocks in a number of ways. For example, the number of blocks and the total square footage at different time periods can be easily computed. The street and block patterns can also be examined to help determine the time frame of undated historic maps. Tracking this type of change in addition to providing quantitative data would be difficult without GIS.

4.1.1 Street Analysis Example

Examining the GIS map mosaics sheets for the study area over different time periods makes it easy to visualize and compare the street and block changes. Figure 27 shows the 1914 Sanborn mosaic maps for the study area. The outline of the digitized blocks and the modern street names are layered over the map mosaic to further visually highlight the blocks and provide a present-day point of reference, respectively. Using Bethel Street as an example, the 1914 maps shows Bethel Street extended just through two blocks from Merchant Street to Hotel Street, as indicated by the yellow highlight on the map. The change to Bethel Street over time can be seen in the 1927 Sanborn map mosaic at Figure 28 which shows Bethel Street extended north one block up to Pauahi Street. By 1950, Bethel Street had extended up two more blocks to Beretania Street on the north and on the South, down through one block through to Queen Street, as shown in the 1950 Sanborn map mosaic at Figure 29.

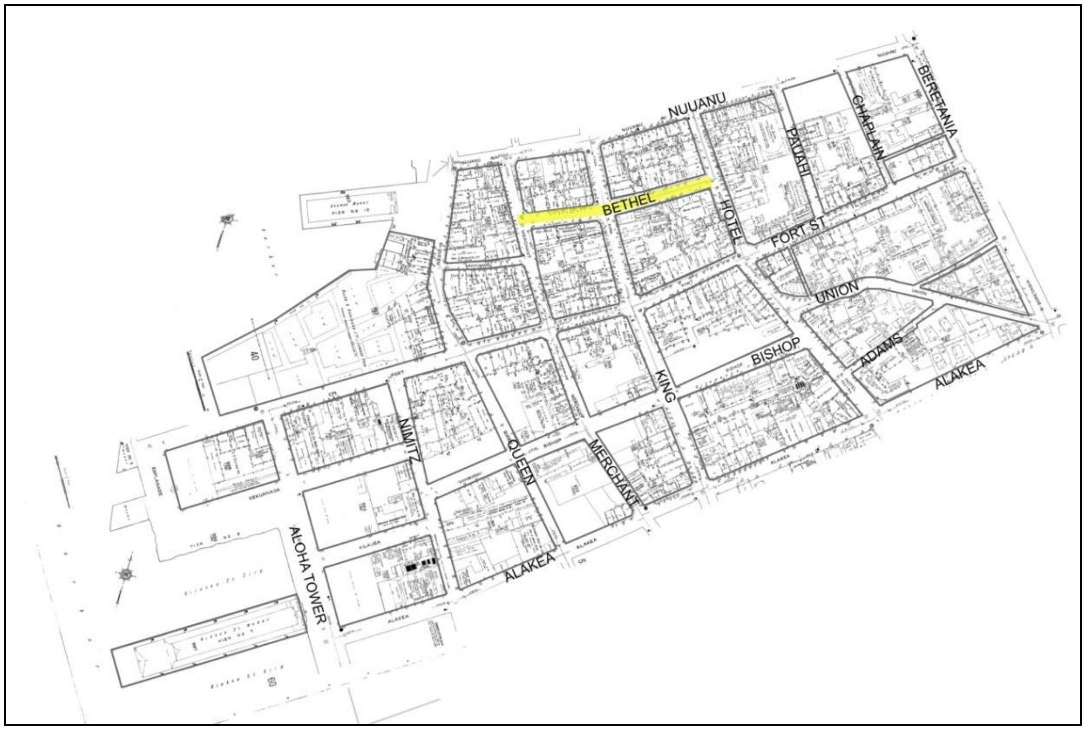

Figure 27. 1914 Sanborn Map Mosaic – Bethel St.

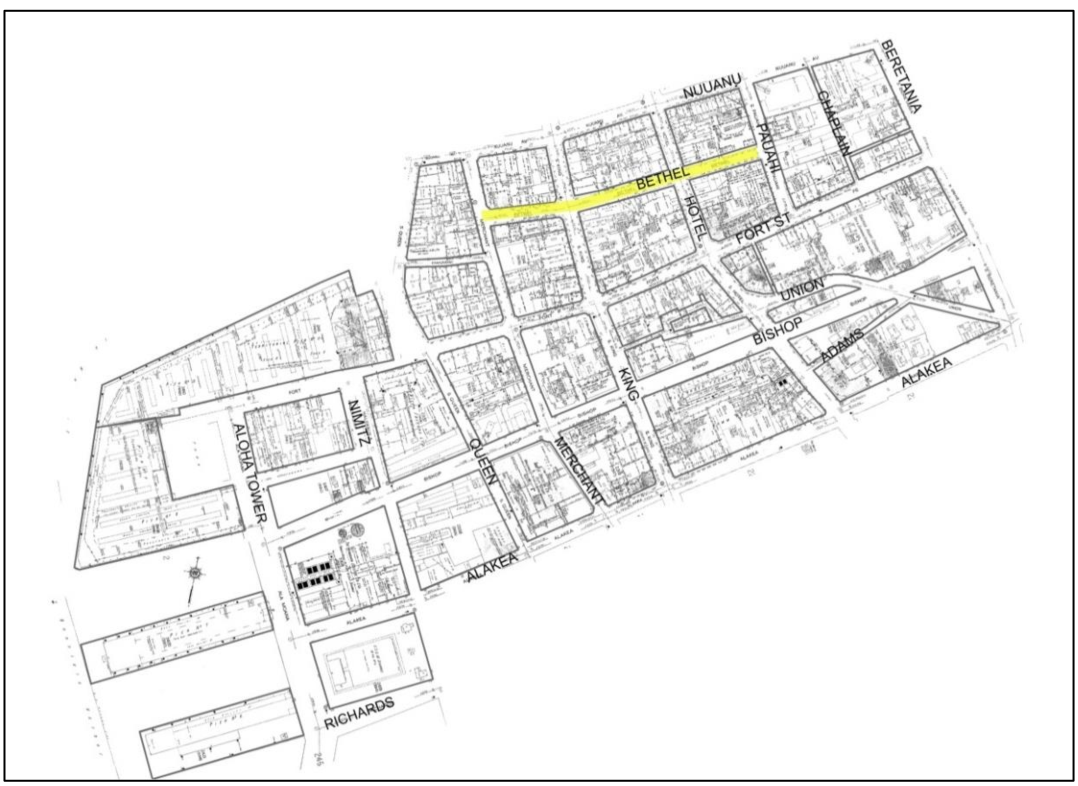

Figure 28. 1927 Sanborn Map Mosaic – Bethel St.

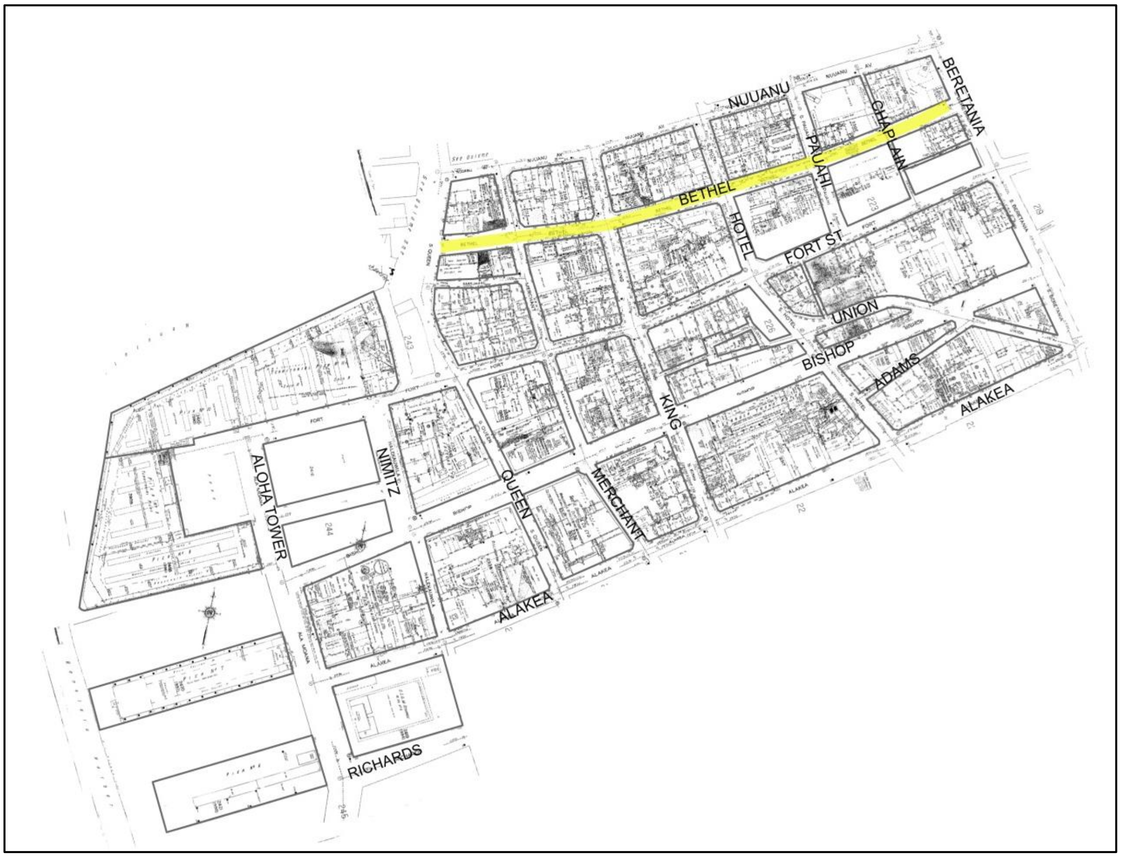

Figure 29. 1950 Sanborn Map Mosaic – Bethel St.

Bishop Street is another example of a street that was extended over the years. As shown in Figure 30, in 1914 Bishop Street transverses four city blocks, starting at Hotel Street going south to Nimitz. By 1927, blocks north of Hotel Street and south of Nimitz were cleared to continue Bishop Street from Ala Moana Blvd through to Beretania as shown in Figure 31.

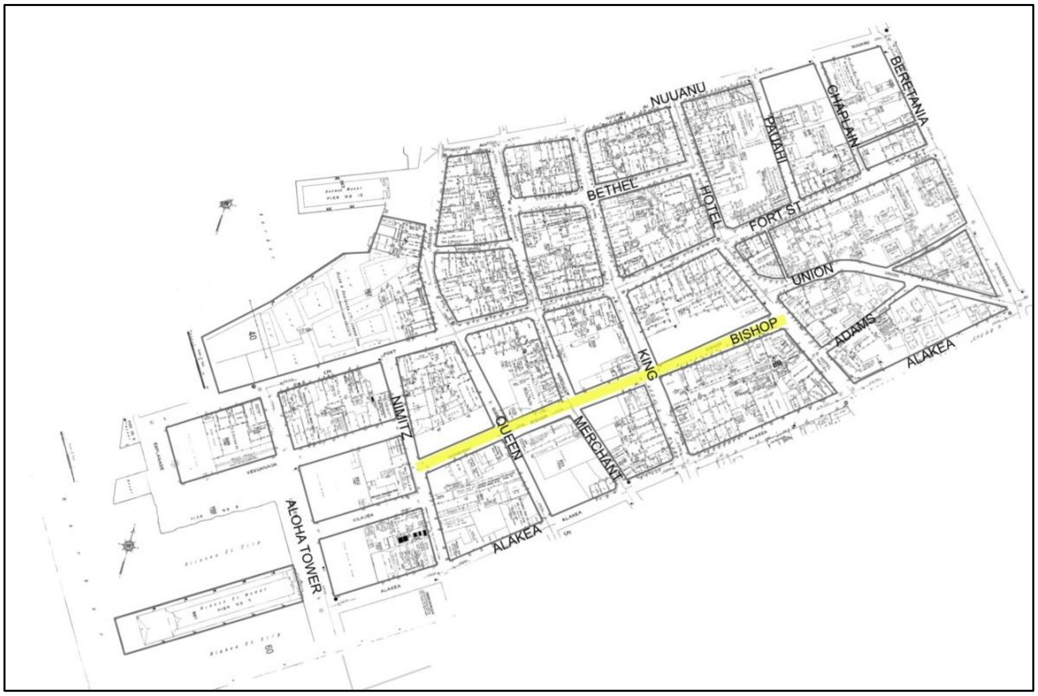

Figure 30. 1914 Sanborn Map Mosaic - Bishop St.

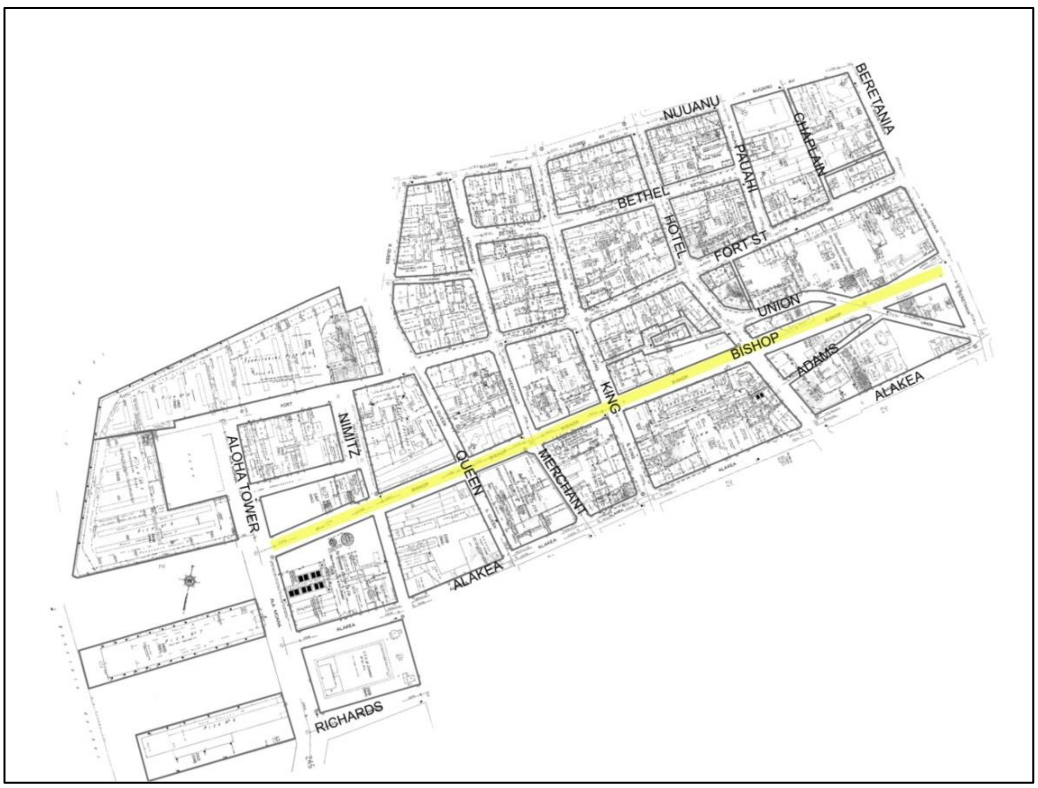

Figure 31. 1927 Sanborn Map Mosaic - Bishop St.

4.1.2 City Block Analysis Example

In conjunction with the street extensions were the alterations to the blocks to accommodate the modifications to the streets. To illustrate how GIS can be used to analyze street and block changes, the blocks for the study area for 1914 and 1950 were compared to see the effect from the two street extensions. Figure 32 shows the blocks in the study area for 1914 and 1950 and illustrates which downtown blocks were cleared to accommodate the road extensions for both the Bethel and Bishop Street extensions. The blocks affected by the Bishop and Bethel Street extensions are shown with dashed lines in the 1914 map. The 1950 map shows the resulting effects of the street extensions.

Figure 32. Block Changes Due to Bethel and Bishop Street Extension - 1914 to 1950

By adding more digital information to the GIS map, urban street information such as roads that have been widened, made narrower, closed, made longer or shorter or changed direction over time can give more information to help researchers learn more about a historical place.

4.1.3 Urban Change Analysis Example

Various data about the buildings affected due to the street expansions can be analyzed using GIS's analysis toolset. Information such as quantity of buildings, total square footage, and types of buildings affected can be computed to aid in the analysis of a city's past.

To determine the buildings impacted by the Bethel Street expansion, a 20-ft buffer was created on both sides of the centerline of the Bethel Street, as shown in Figure 33. Using the *Spatial Join* analysis tool in GIS, buildings that fell in the path of the buffer are selected. The resulting building data shown in Figure 34 can be further analyzed to determine the total square footage affected, in addition to the types of and age of the buildings affected.

Figure 33. 20-Foot Buffer - Bethel St

Figure 34. Buildings affected by Bethel St. Extension

4.2 Urban Density Analysis

The building fabric of downtown Honolulu, once the center of city life, has seen much change over the years. From 1914 thru 1993, the total number of structures in the downtown study area decreased from 573 to 173. During the same time period, the average square foot of the building increased from 4,161 SF to 82,665 SF. The digitized building footprint maps for each year provides a visual impact to the story of how much downtown has changed. GIS allows the data to be visualized in multiple ways. Figure 35 shows the 3D view of the buildings from1914 to 1993. Figure 36 thru Figure 39 depicts the same information for each year from an overhead view. Both the 3D and overhead views illustrate how dramatically downtown Honolulu has changed over time.

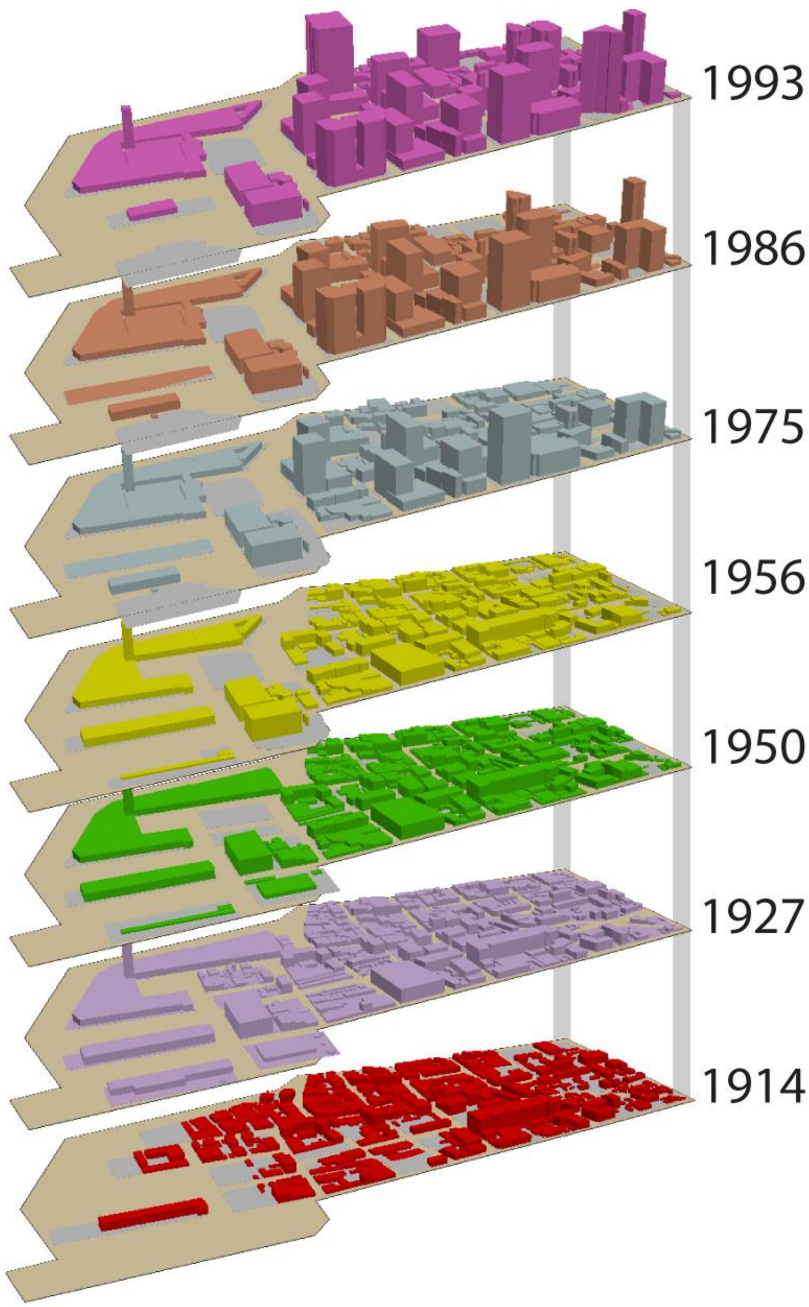

Figure 35. 3D Building Footprints - 1914 to 1993

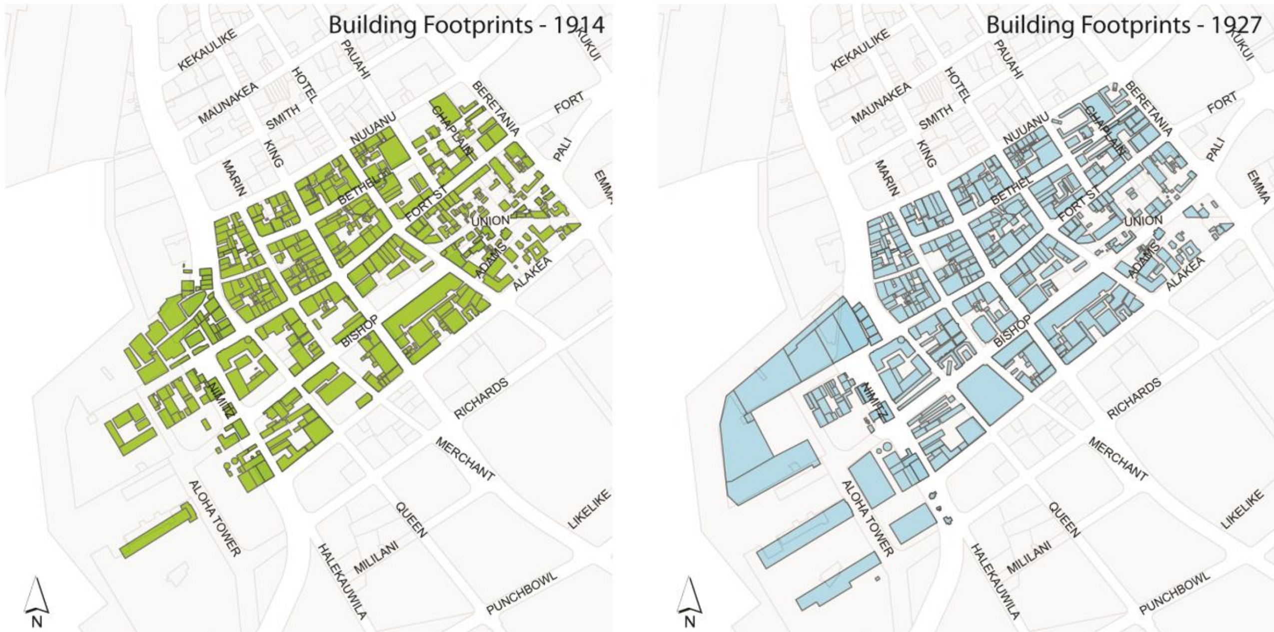

Figure 36. Building Footprints - 1914 &1927

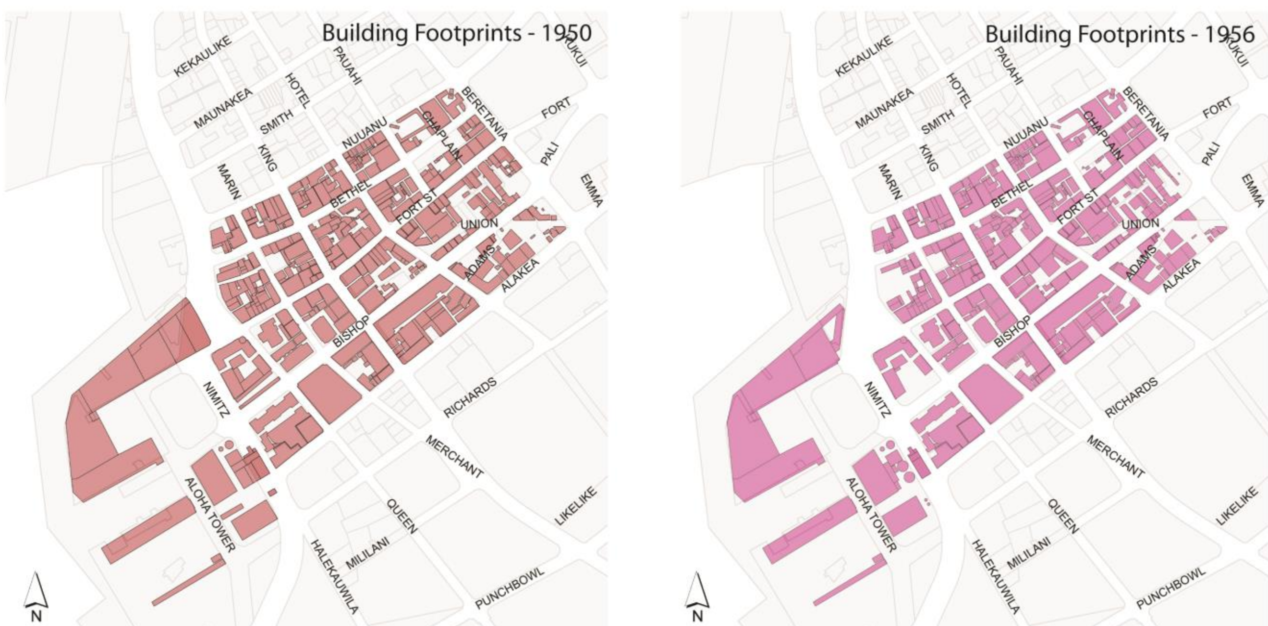

Figure 37. Building Footprints - 1950 & 1956

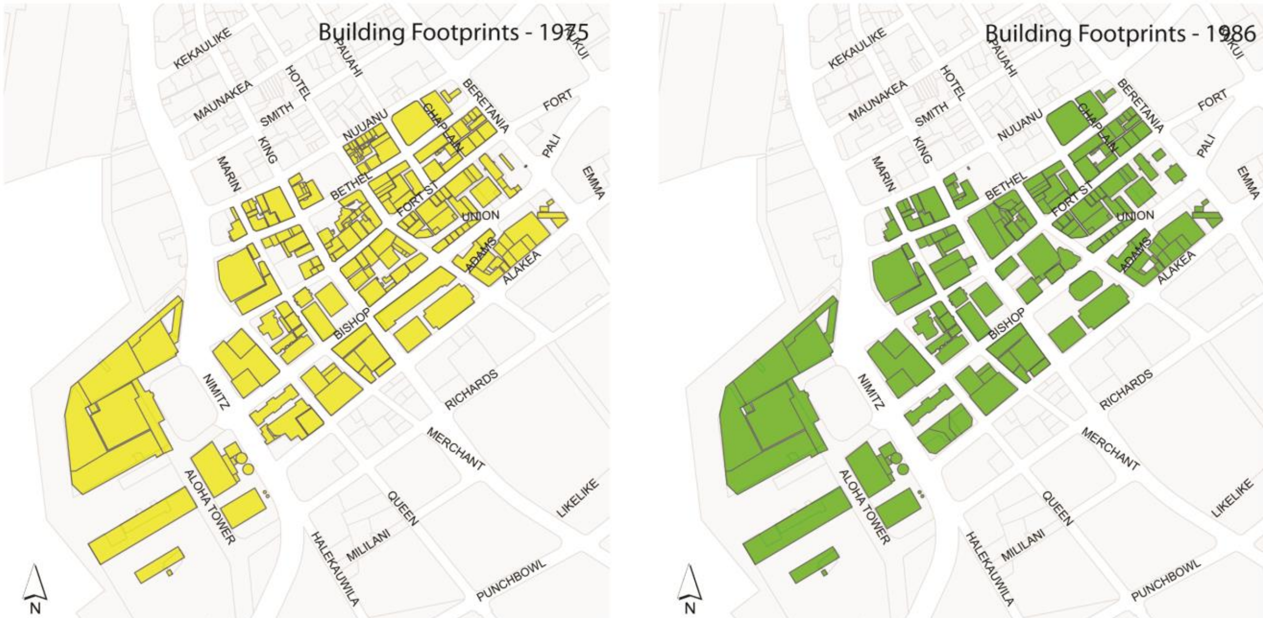

Figure 38. Building Footprints - 1975 & 1986

Figure 39. Building Footprints – 1993

Using GIS, the mapping database created with the digital footprints provides the source to conduct a number of statistical analyses of the change in urban density over time. Figure 40 charts the change in the number of buildings in the study area from 1914 to 1993. As indicated in the chart, the number of buildings declined steadily from a high of 573 buildings in 1914 to 173 buildings in 1993.

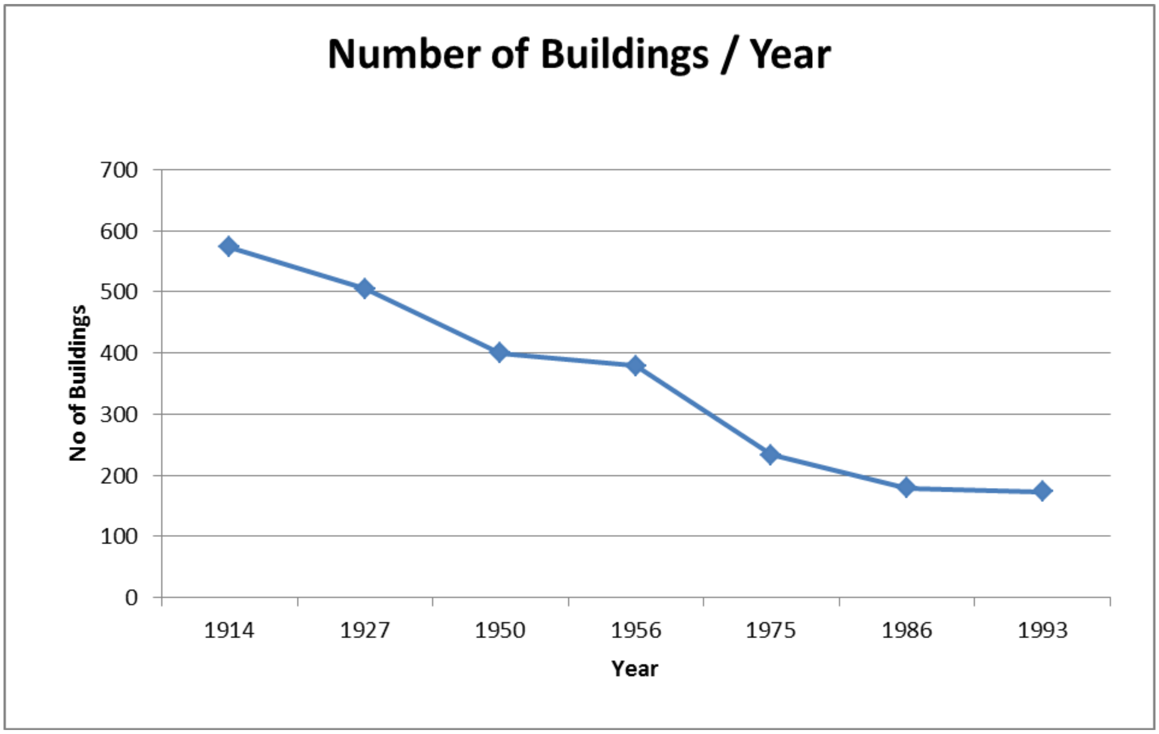

Figure 40. Change in Number of Buildings - 1914 to 1993

The size of the buildings in the study area also changed dramatically during this time period. As shown in Figure 41, the average square footage changed from 4,000 SF to 82,000 SF from 1914 to 1993, indicating the steady change in the overall charateristic and feel in the study area over this time period.

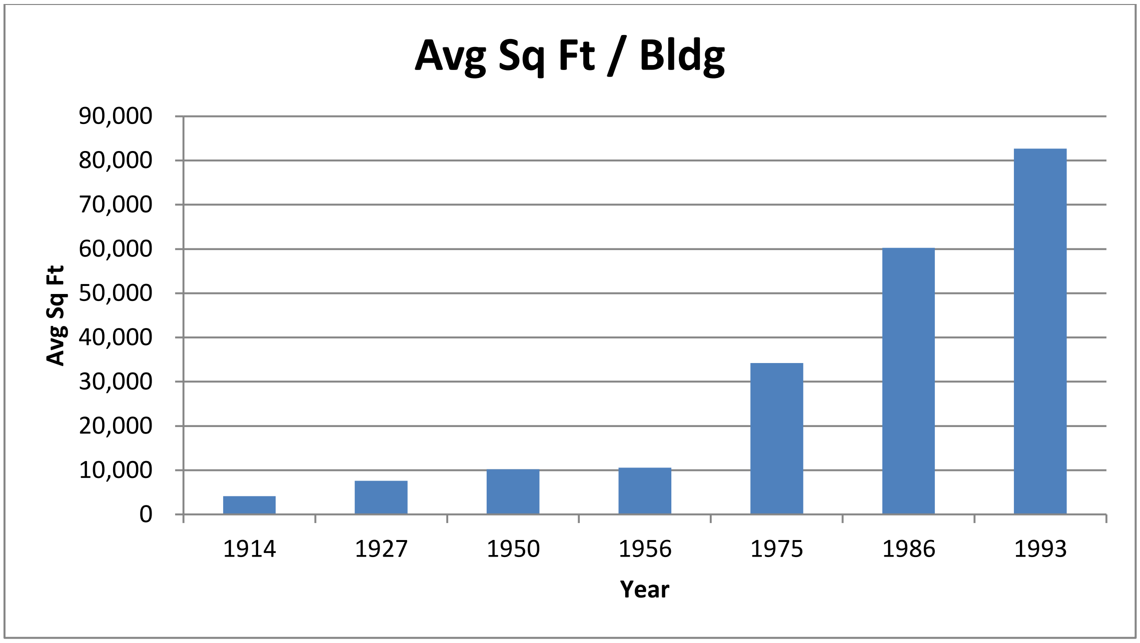

Figure 41. Average Square Foot Per Building - 1914 to 1993

Overlaying the Number of Buildings and Square Footage Charts (Figure 40 and Figure 41), the chart at Figure 42 shows that as the number of buildings decreased, the average square footage increased implying that buildings were demolished to make way for larger buildings.

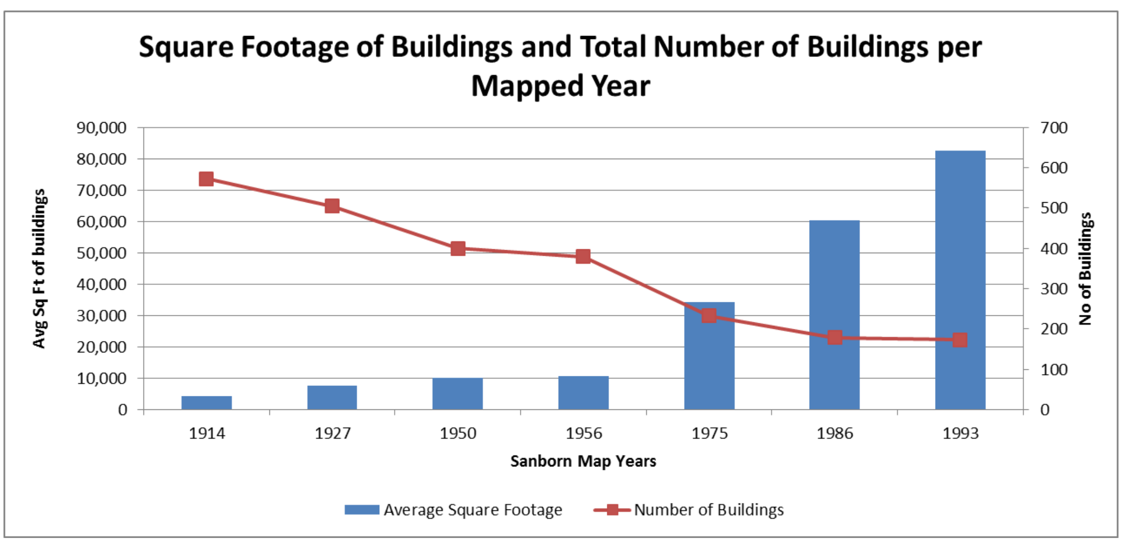

Figure 42. Square Footage of Buildings and Total Number of Buildings - 1914 to 1993

Data about how building heights changed over the years is another urban evolution change that can be analyzed. Figure 43 depicts the average building height during the study period overlayed with the number of buildings per year during the same period. As can be clearly seen below, as the number of buildings decreased, the overall building heights increased.

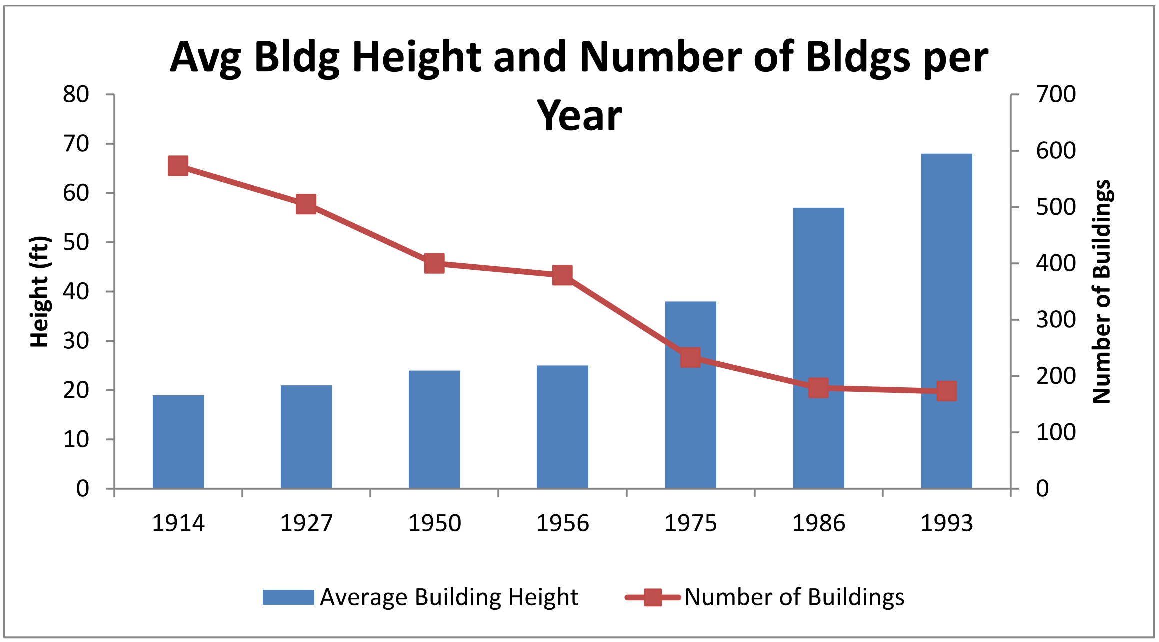

Figure 43. Average Building Height and Number of Buildings per Year

4.3 Land Use

Past land use data provides a rich history to how and where residents used to live, work and play. The land use history in the Sanborn maps can be systematically tracked over time in GIS to show the land use change over time. Other factors, such as building height, square footage and materials can be correlated to show how those items changed as land use changed.

4.3.1 Downtown Honolulu Land Use Statistics

Figure 44 to Figure 50 depict the land use for each year as a percentage of the number of buildings in the study area. Figure 51 graphs the change in land use over the seven time periods. The most significant changes during this time period are the increase in office buildings and the decrease in stores.

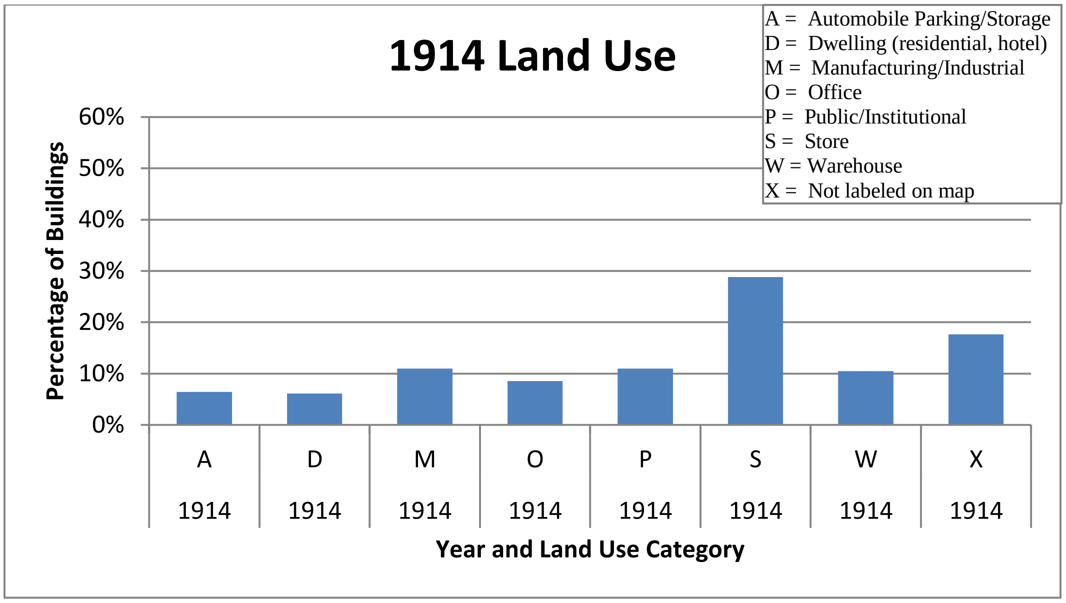

Figure 44. Land Use Percentages in Study Area – 1914

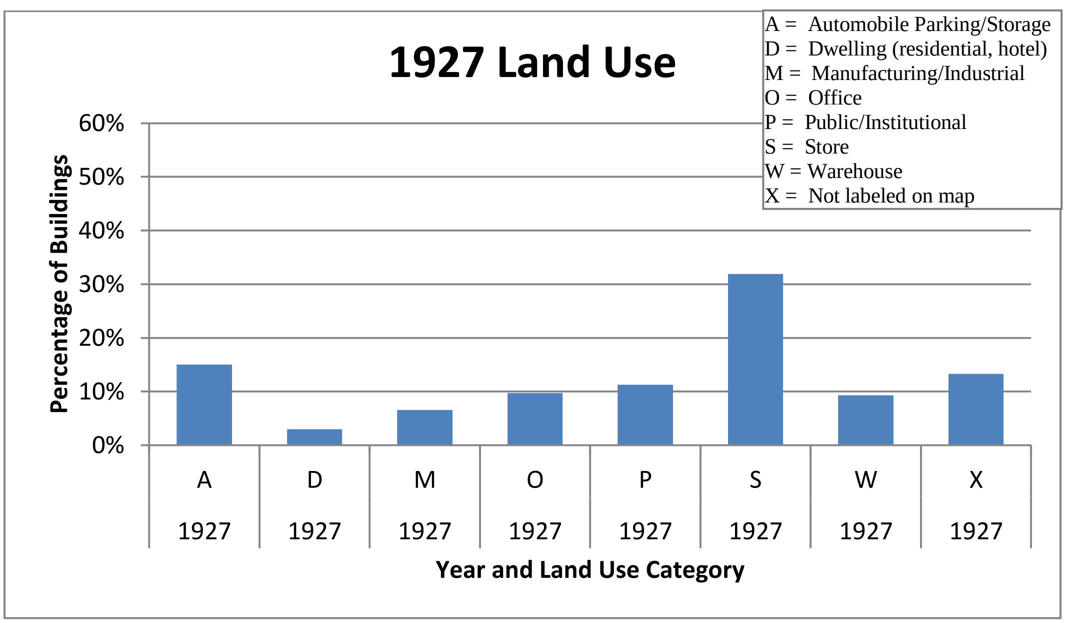

Figure 45. Land Use Percentages in Study Area - 1927

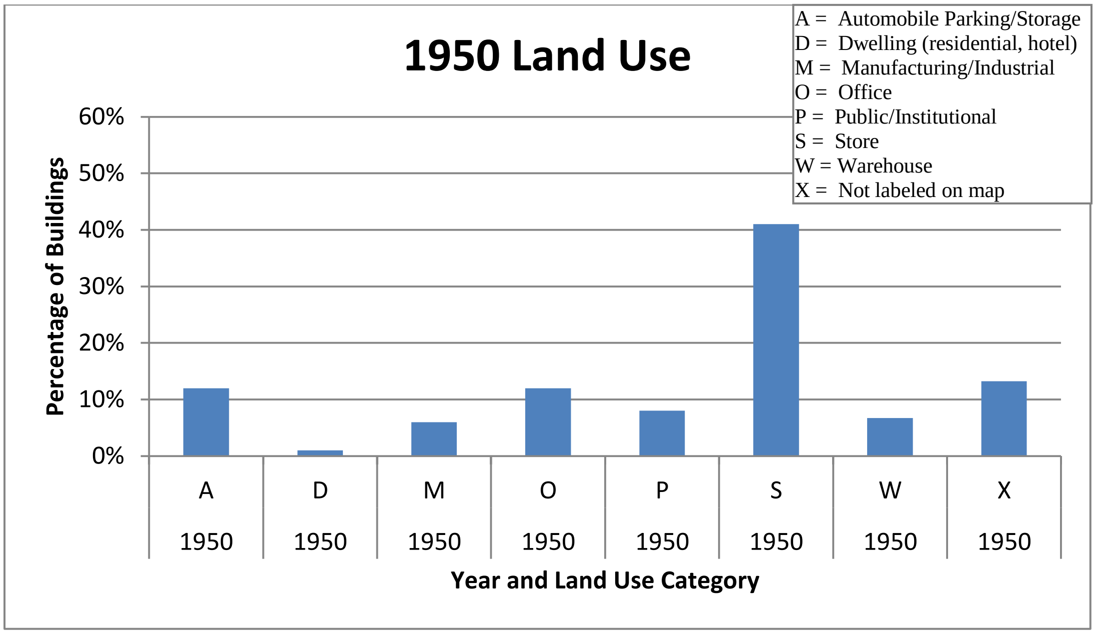

Figure 46. Land Use Percentages in Study Area - 1950

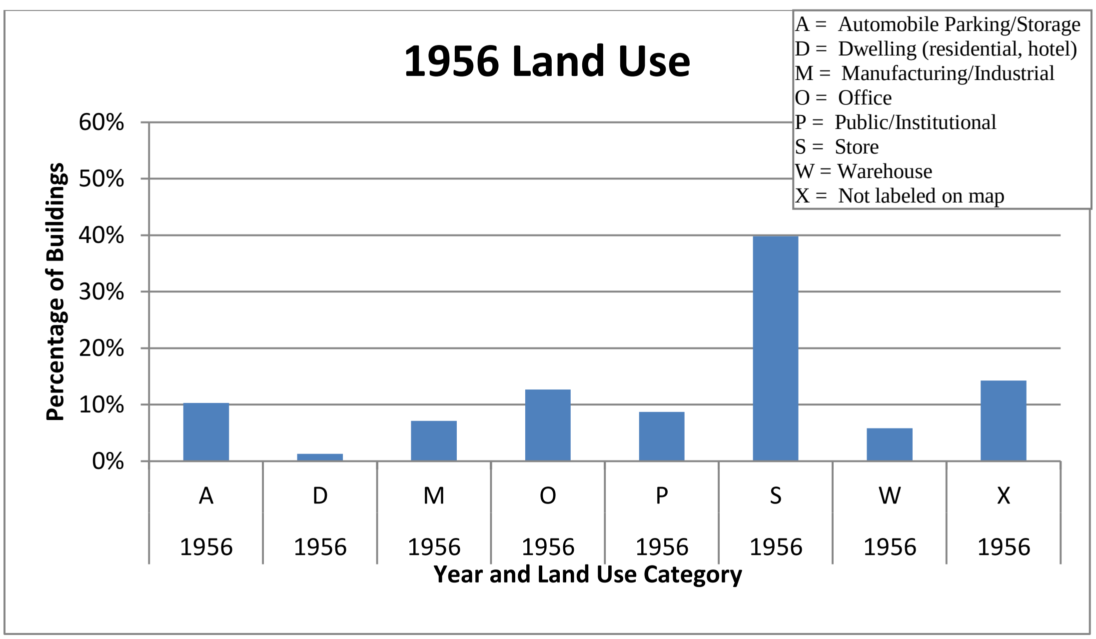

Figure 47. Land Use Percentages in Study Area - 1956

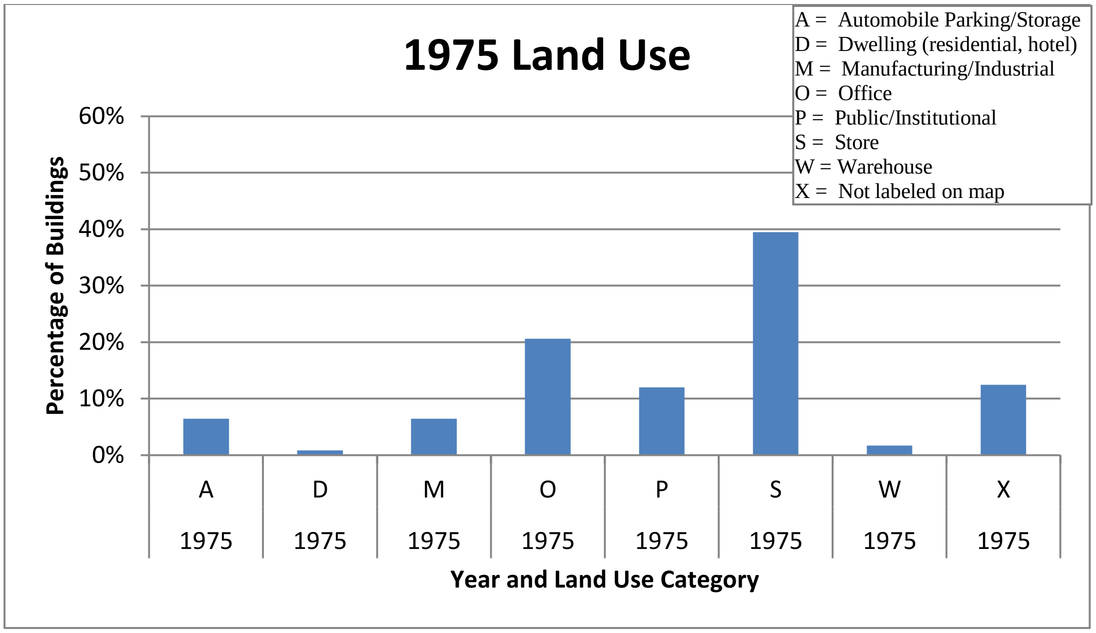

Figure 48. Land Use Percentages in Study Area – 1975

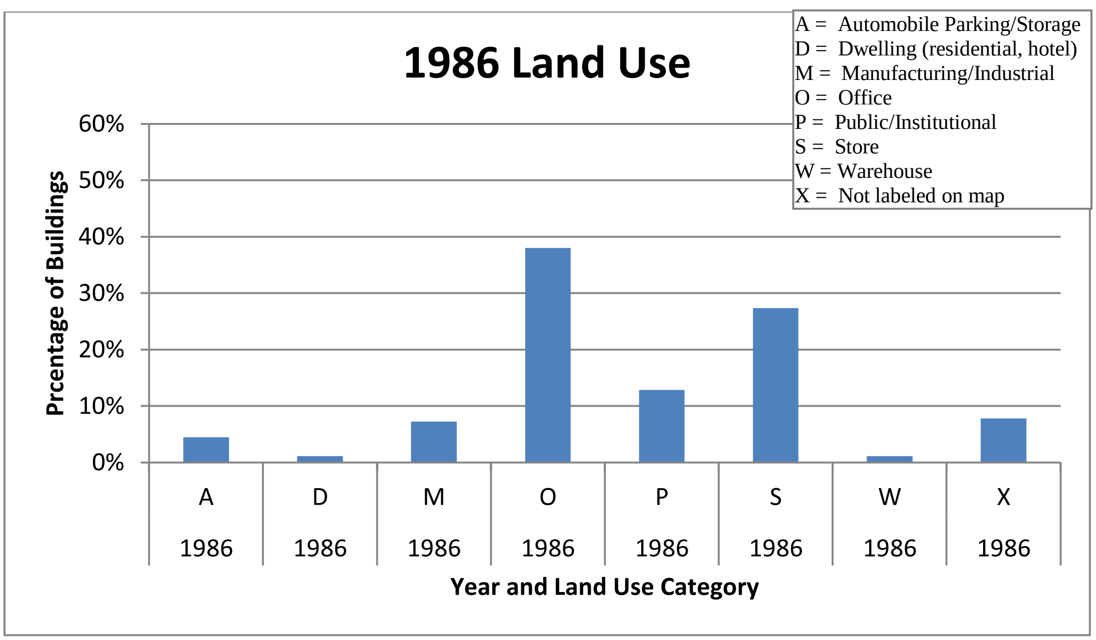

Figure 49. Land Use Percentages in Study Area - 1986

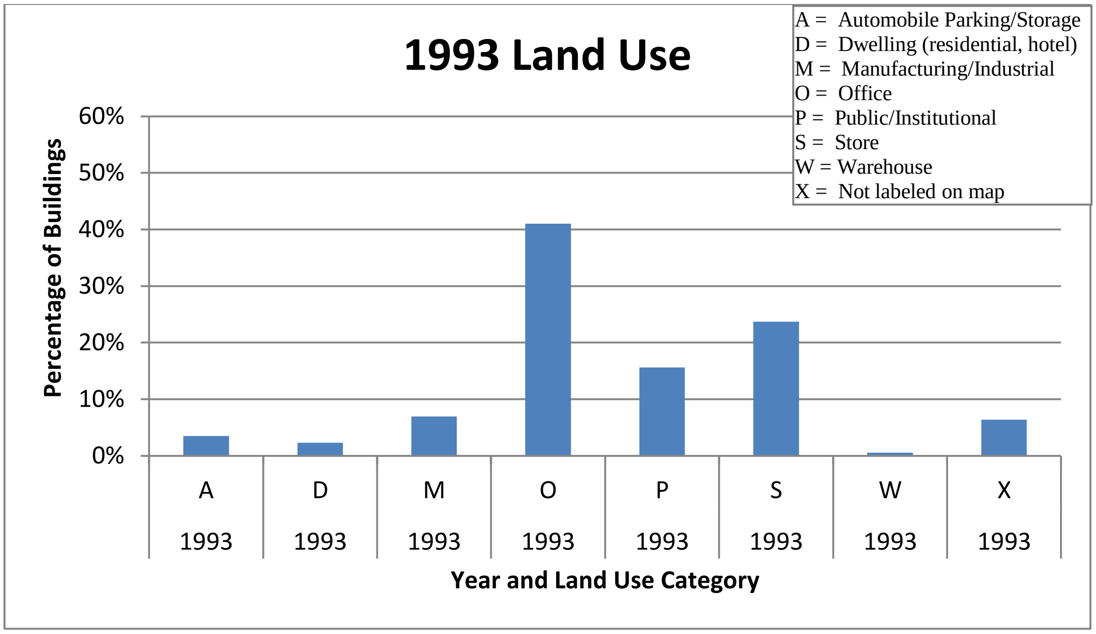

Figure 50. Land Use Percentages in Study Area - 1993

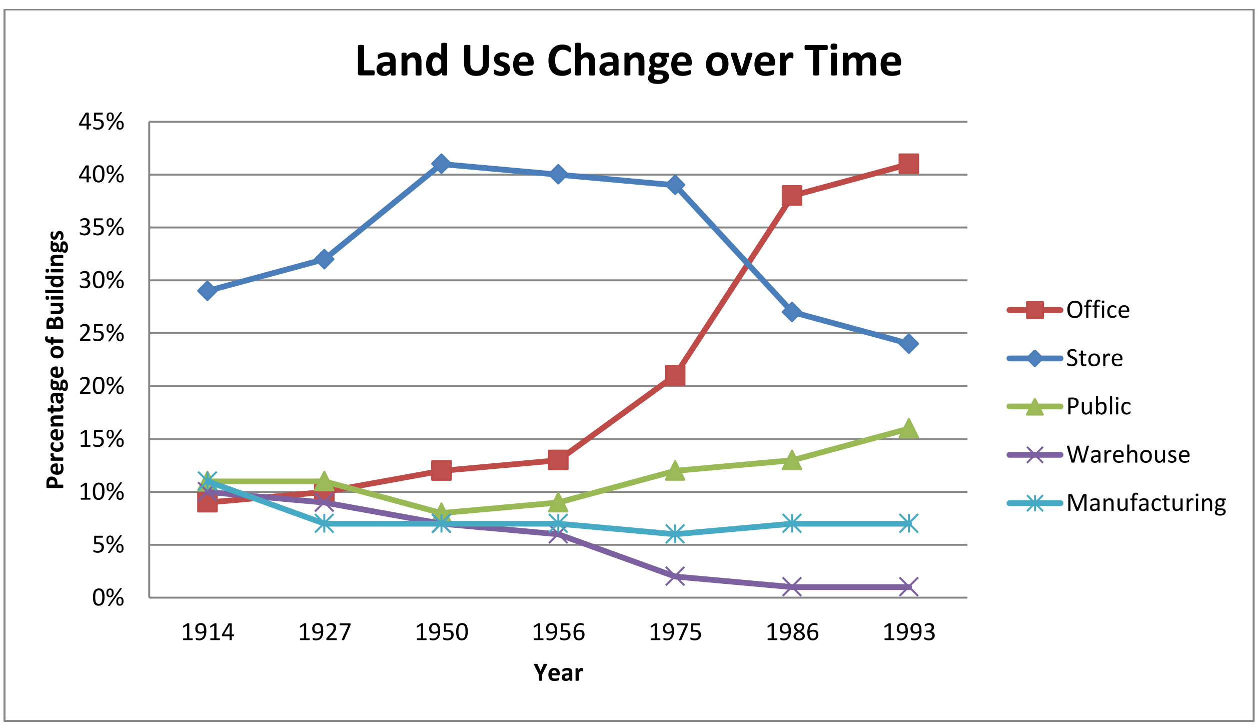

Figure 51. Land Use Change Over Time

The land use data shown in the previous charts and graphs can also be displayed on a map. In Figure 52 the land use data for the 1927 Sanborn Maps are color-coded and displayed spatially. The same data is displayed in a 3-dimensional view in Figure 53. This method of displaying the data provides another viewpoint for interpreting the past.

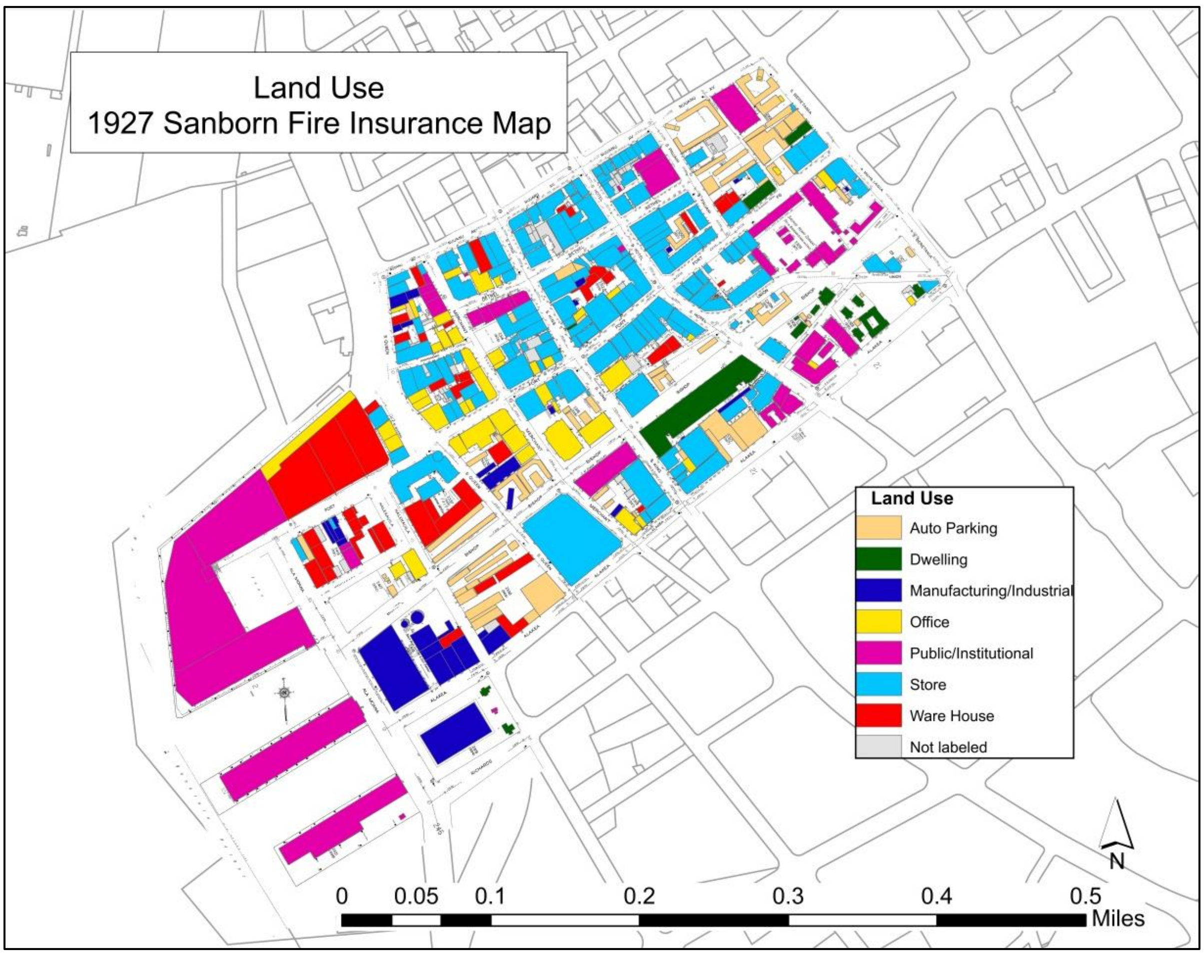

Figure 52. Land Use - 1927 Sanborn Fire Insurance Map

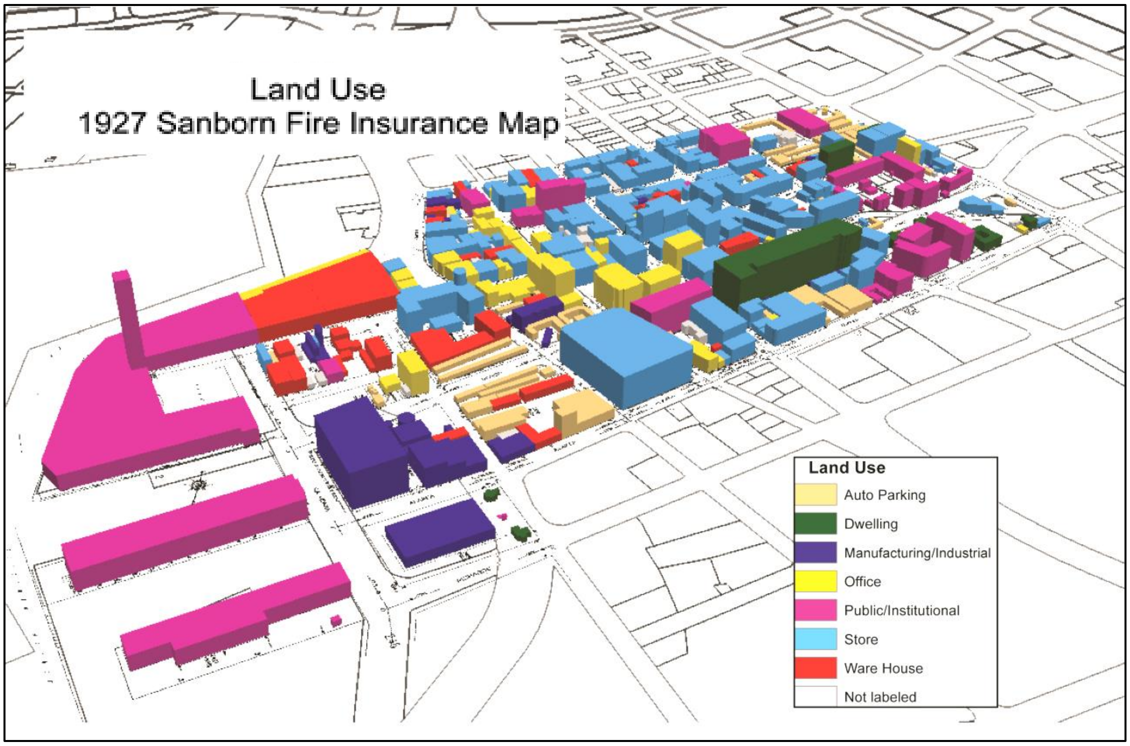

Figure 53. Land Use - 1927 Sanborn Fire Insurance Map - 3D View

4.4 Relational Database

The final database consisted of 2571 records. As mentioned in Section 3.2.6, the building database was developed using Microsoft Access, a relational database which allows related data stored in different tables to be joined together to summarize and calculate data. The database was kept as a table separate from the geographic shape files because the data entry process within Microsoft Access is much more user friendly than within ArcGIS. In addition, the data can be sorted in multiple ways, making error-checking and locating records much easier. The database can be joined with the shape file as needed. An extract of the database is shown at Figure 54.

ID	MAPYR	MAPNO	BLKNO	HOUSE_NO	ST_NA	HT	STY	YR_BLT	FP_CONS	LU	DESC_	MISC	MISC2	MISC3
40	1927	226_BL	2318	935-943	FORT ST	52	3	1929	Y	S	E. O. HALL & SON LTD	REINF CONC FR FLS & RF	8" TILE CURT WALL	CONC COLS ALL
80	1927	226_TL	2316	140	S KING ST	41	3	1926	X	S	BANK OF HAWAII	EXCEPT EXPOSED STEEL IN RF	REINF CONC WALL	WG-2, E-2
133	1927	224_L	2305	1136	UNION ST	25	2	1926	Y	P	HALL 1ST, CLASS RMS 2ND	REINF CONC		
480	1927	223_BR	2304	1121-1137	BETHEL ST	28	2	1926		S	STORE-4, OFFICE, CLOTHES CLEANING, RESTAU	REINF CONC	C.B. CURTAIN WAL	ELEC POWER
601	1927	243	2409		FORT ST	216	21	1926	Y	P	ALOHA TOWER	REINF CONC	CURT WALL	
853	1927	226_TR	2317	182-184	S KING ST	14	1	1926	Y	S	OFFICE, STORE	SKYLIGHTS-3, TILE & CONC		
151	1927	224_L	2305	1160	BISHOP ST	42	3B	1925	Y	P	DINING ROOM, KITCHEN B	REINF CONC		
190	1927	224_L	2309	1131	UNION ST	10	1	1925	Y	S	GAS & OILS	CB CONS RF		
441	1927	225_TR	2312	1023	BETHEL ST	14	1	1925	Y	W	AUTO & STORAGE	REINF CONCRETE FR, CURTAIN WALLS		
42	1927	226_BL	2318	141	S KING ST	50	4	1924	Y	O	1ST NATIONAL BANK	REINF CONC	WATCHMAN WITH	WG
520	1927	223_TB	2302	80	S PAUAHI S	15	1	1924	Y	W	STORAGE	REINF CONC C.B.	CURTAIN WALLS	NO CH
812	1927	226_BR	2319	901-937	BISHOP ST	65	4	1924	Y	P	S.M. DAMON BLDG - THE BANK OF BISHOP & (	THE BISHOP TRUST CO. LTD	REINF CONC	
44	1927	226_BL	2318	130	MERCHANT	58	4	1923	Y	O	CASTLE AND COOKE LTD OFFICES	AIR COND		REINF CONC, W
914	1927	224R	2307	1188	UNION ST	22	2	1923	Y	S	PAPER WARE HO, PATTEN COL. LTD	CURT WALLS, REINF CONC FR		
765	1927	231_TR	2336	841	BISHOP ST	70	4	1921	Y	S	THEO H DAVIES & CO., LTD DEPT STORE	WHOLESALE & RETAIL GENER	SHIPPING ROOMS	E-5, REINF CON
879	1927	224R	2308	1130	ALAKEA	62	4B	1920		P	MUTUAL TELEPHONE CO.	DINING RM 4TH		
838	1927	226_TR	2317	179	S HOTEL ST	50	3	1917	Y	S	AUTO SALES RM, HOTEL R'MS 2ND & 3RD	REINF CONC STEEL FR, FR. RF	WG-2, H	VAN HAMM YO
473	1927	223_BR	2304	76	S HOTEL ST	28	2	1916		S	STORE, STORE 2ND	16' HEIGHT IN MIDDLE	WG, SKYLIGHT-6	
78	1927	226_TL	2316	120	KING ST	55	5	1914	Y	O	HAWAIIAN TRUST CO. OFFICE	REINF CONC WALLS, FL'S & RF	FALSEWOOD RF	WG
474	1927	223_BR	2304	82-92	S HOTEL ST	32	2	1911		S	STORE			
476	1927	223_BR	2304	1108-1122	FORT ST	32	2	1911	X	S	STORE-6, PHOTO 2ND	FP CONSTR EXCEPT SOME WO	REINF CONC	
740	1927	225_BL	2313	24-32	MERCHANT	40	2B	1911	Y	S	BANK	STONE & STEEL FR		
880	1927	224R	2308	1141	ADAMS LA	62	2B	1910		P	MUTUAL TELCOM CO & OPERATING RMS	OFFICES		
837	1927	226_TR	2317	1001-1091	BISHOP ST	88	5B	1901	Y	D	ALEXANDER YOUNG HOTEL	NONCOMB PROTECTED STEEL	OFFS ALL ABOVE 1	LOBBY 5&6 BU
17	1927	231_TL	2335	115-123	MERCHANT	74	6	1900		O	STANGENWALD BLDG, OFFICES	NOMCOM, CONC FLS & RF ON	STEEL POSTS & BE	M.L. & P. PART

Figure 54. Extract of Database Table for Honolulu Downtown Buildings

4.5 Web-based Representation of the Data for Public Access

An important benefit of digitizing the Sanborn Maps with GIS is to make the map and database accessible to the public to further historic preservation research. ESRI provides an on-line service called ArcGIS Online which allows GIS users to publish their on-line maps and other layers of data. The owners of the maps can choose to make the maps available to the public as a whole or make it available only to a select community. Many types of map templates are available through ArcGIS Online; two examples are shown below. The web map shown at Figure 55 has the capability to display the digital footprints for all the Sanborn years surveyed as separate layers. As shown on the map, the layer for the 1914 Sanborn year is turned on and the footprints are displayed. This map has the capability to provide a pop-up window feature to provide additional information when the user clicks on a building footprint. Another type of web map is shown at Figure 56. Two different years of Sanborn Map Mosaics are displayed side by side. The red line in the center is a swipe feature, which allows the user to slide back and forth over either image for comparison purposes.

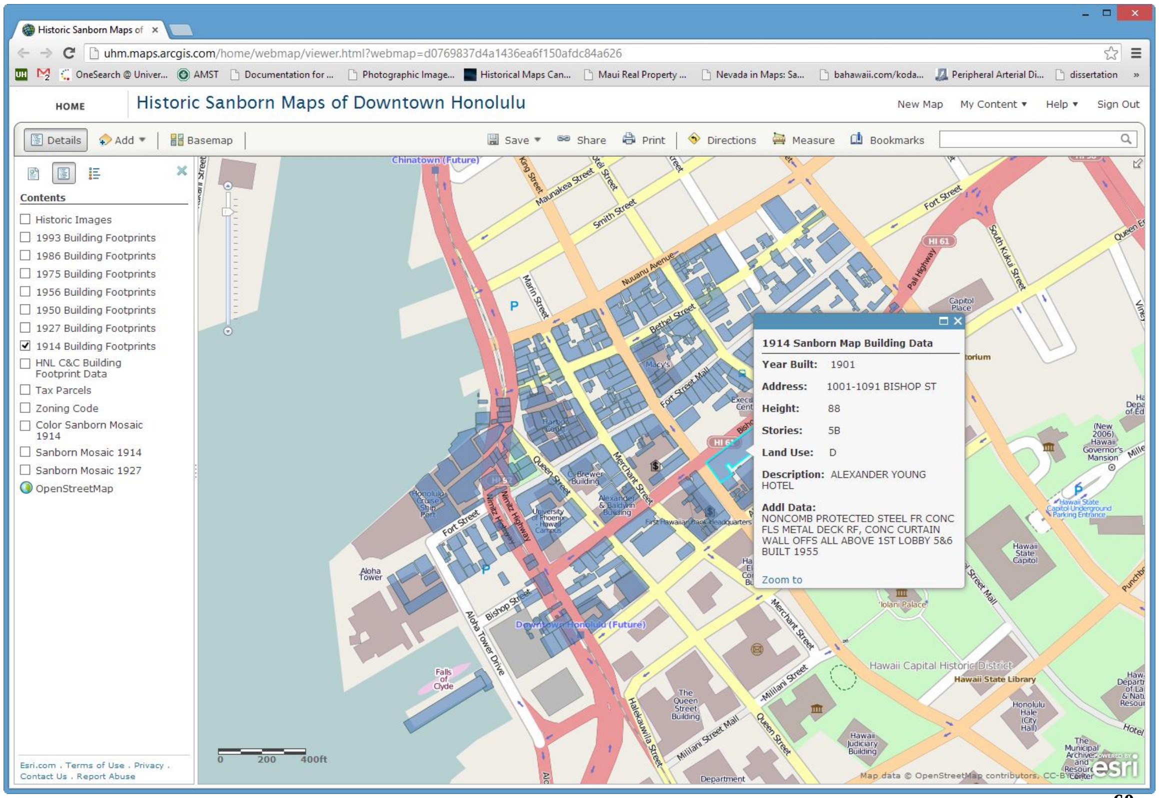

Figure 55. ArcGIS On-line Map - Historic Sanborn Maps of Downtown Honolulu[60]

[60] "Historic Sanborn Maps of Downtown Honolulu," (generated by Mary Kodama using ArcGIS On-Line http://uhm.maps.arcgis.com/home/webmap/viewer.html?webmap=d0769837d4a1436ea6f150afdc84a626, May 2, 2013).

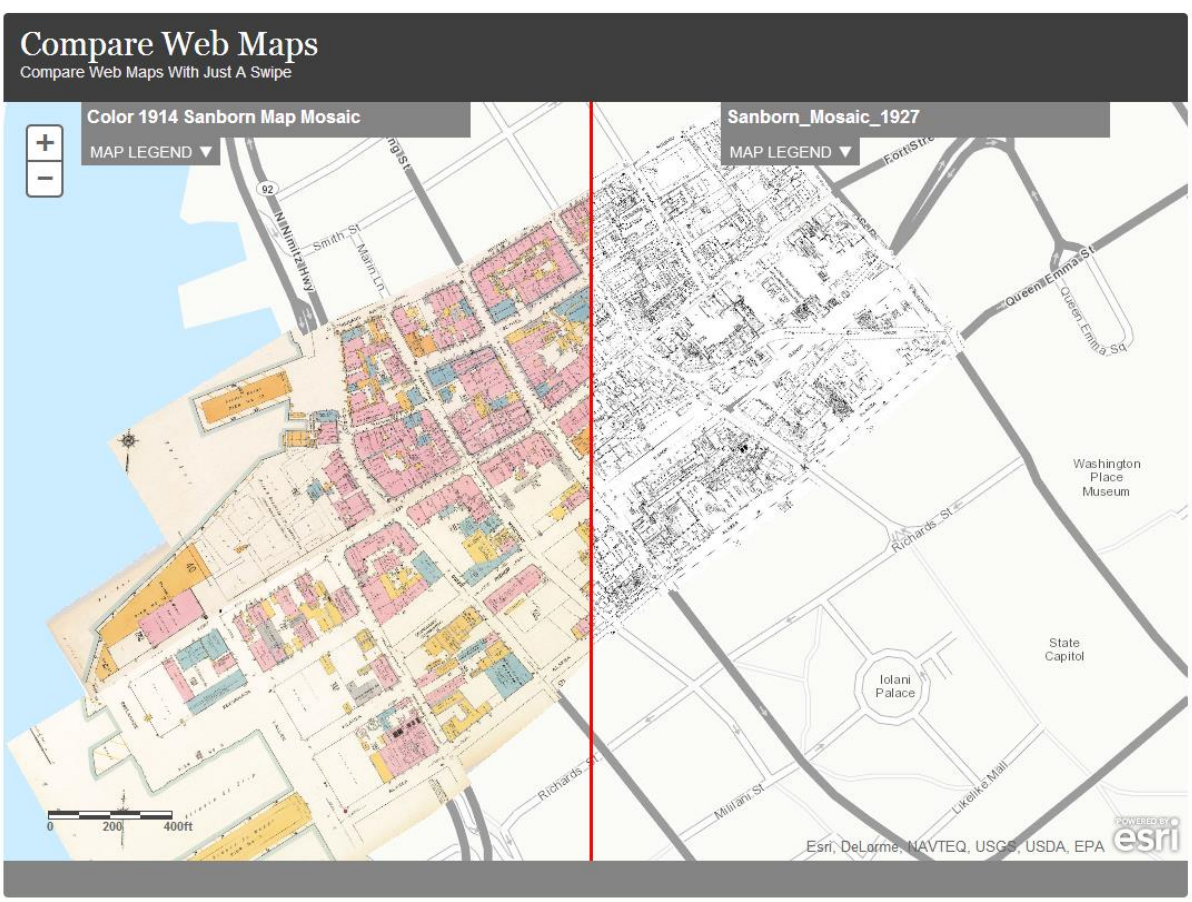

Figure 56. ArcGIS On-Line Map - Compare Web Maps[61]

[61] "Compare Web Maps," (generated by Mary Kodama using ArcGIS On-Line http://uhm.maps.arcgis.com/apps/OnePane/swipe/index.html?appid=f8dd54bf3afa4897a4e6b0040c861e38, May 2, 2013).

Chapter 5. Next Steps

5.1 Expand Mapping Area

The Sanborn Fire Insurance Company mapped many urban areas on Oahu in addition to the outer islands. The next steps for this research could be to expand the mapping area to include the entire downtown area or start anew with another urban location on Hawaii. The data already recorded should be reviewed for consistency throughout. As color maps become available, those should be georeferenced and correlated with the existing database to add data not included initially. The framework has been established now for the inclusion of other maps and records into the area of study. GIS can be used to integrate data from different sources and added to the map as another layer of information.

5.2 Brainstorming Database Queries

The database and visual nature of the data naturally opens the door to exploring many different queries, which takes only a few seconds to compute but would be quite time and labor intensive if using just paper maps. For example, if we wanted to answer the question, "How many buildings were labeled by their building or company names and what were they?" A quick query of the database shows 65 buildings meeting this criterion. The full results are shown in Figure 57. The names are listed according to the year the name first appears on the maps.

Another query could be, "How many buildings listed "coral" as a construction material?" The answer according to the database is: 14. Many queries, simple or complex are possible

1914

Theo. H. Davies & Co., Ltd
The Bijou
Yokohama Specie Bank
Schuman Carriage Co Ware House
H. Hackfeld & Co. Ltd Ware House
Hawaiian Electric Co., Ltd., Power Plant
Allen & Robinson Ltd, Lumber Yard
Lewers & Cook Ltd
Stangenwald Bldg
E. O. Hall & Son Ltd
Mutual Telcom Co & Operating Rms
Boston Bldg
Kauikeoulani Bldg
Liberty Theatre
Our Lady Of Peace Cathedral
The Blaisdell Hotel

1927

1st National Bank
Armand Well & Co. Ltd,
S.M. Damon Bldg - Bishop First Natl Bank
Castle And Cooke Ltd Offices
Young Steam Laundry
Bank Of Hawaii
The Liberty House
Hawaii Theatre Performing Center

1950

Home Ins Co Of Hawaii Ltd Bldg
Bishop Trust Bldg
McCandless Bldg
Pythian Bldg
James Campbell Bldg
S.H. Kress & Co
King Theatre
Oregon Bldg
Empire Bldg
The Dillingham Transportation Bldg
C. Brewer & Co. Ltd
Alexander & Baldwin Ltd

1956

Inter-Island Building
Woolworth Co.
Gasco Bldg
Watumell Bldg

1975

First Hawaiian Bank Bldg
Alexander Young Bldg
Davies Pacific Center
Honolulu Savings & Loan Co. Ltd
Dean Witter Bldg
Jade Bldg
Federal Savings Building
Hawaii Bldg
Amfac Bldg
Bank Of Hawaii Bldg
1164 Bishop St Bldg
James Campbell Bldg
Hawaiian Savings Bldg
Bethel Pauahi Bldg
Bishop Insurance Bldg
First Hawaiian Bank Bldg
Pacific Trade Center Bldg
Hawaiian Telcom Co & Operating Rms

1986

Bishop Trust Bldg
Executive Centre Bldg
Century Square Office Bldg
Pioneer Plaza Bldg
The Grosevnor Center

1993

Kea Plaza Office Bldg
Pan Pacific Plaza

Figure 57. Building or Company Names

5.3 Dakin Maps

Utilizing established georeferencing techniques, maps from different sources can be overlayed and integrated to evaluate historical development over time. Ancillary data such as city planning maps, city directory databases and census data can enhance the information. The Dakin Publishing Company of San Francisco also produced fire insurance maps. The company published maps from about 1885 until the early 1960's, and actively produced insurance maps from its beginning until the second decade of the 20th Century.[62] These maps are dated earlier than the Sanborn maps of the same area, and as a result are suitable to be added to the database to provide continuity of urban development prior to 1914. The University of Hawaii Hamilton Library have colored scanned copies of the maps for the years 1891, 1899 and 1906 which are available through the University of Hawaii at Manoa Hamilton Library website.

Figure 58 displays how the map looks with a Dakin Fire Insurance map sheet added as another layer to the GIS map of the research area. Zooming in to get a closer look at the city blocks circled in red, the Dakin or Sanborn layer can be turned on or off as in Figure 59. Transparency levels are also available to view both maps over each other. This is especially helpful when researching the chronological history of a building or area.

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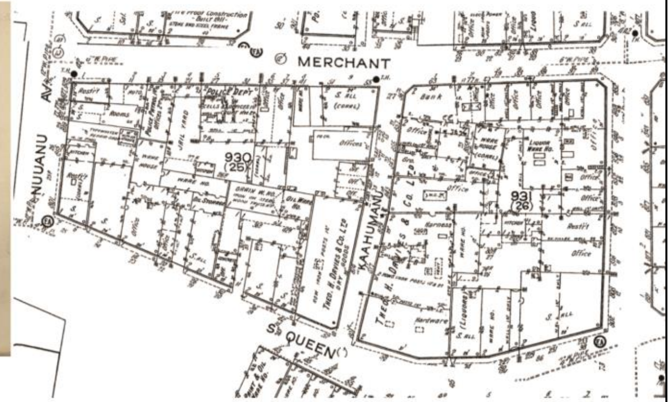
[62] Philip R. Hoen, "Dakin Publishing Company and its Fire Insurance Maps," (Information Bulletin Western Association of Map Libraries, 1976), 47.

Figure 58. 1904 Dakin Fire Insurance Map overlayed on 1914 Sanborn Map Mosaic

1904 Dakin Fire Insurance Map



1914 Sanborn Fire Insurance Map

1914 Sanborn Fire Insurance Map Overlayed over 1904 Dakin Fire Insurance Map

Figure 59. Detail of Dakin Fire Insurance Map

5.4 City Planning Maps

Old city planning maps provides insight to how the local government viewed past urban environments. Building information annotations and planned street improvements are often shown on these maps. These old city planning maps can be overlayed to the existing maps to compare or supplement the data from the Sanborn maps.

5.5 Business or Residential Directories

Since the address information in the Sanborn Maps have been included in the database, researchers using historical directories will be able to locate businesses or people associated with the address. Conversely, old business directories can be used to fill in the gaps of the main database.

5.6 Creating Historic 3D Building Models from Footprint Information and Historic Photographs

3-D Reconstruction of a historic city or area is an effective means of visualizing the landscape at different points in time and communicating development patterns. 3-D reconstruction models faithful to the original historical urban space are difficult to achieve using just photographs because of the labor intensive process to decipher the height and scale of the buildings and the relationship of the buildings with other structures. With the GIS Sanborn maps the digital footprints and building height data provide an accurate foundation for 3-D building reconstruction over multiple time periods. Combining the data with the historical building photographs provides more detailed information to accurately build 3-D models.

Chapter 6. Lessons Learned

6.1 Quality of the maps

The majority of the maps obtained for this research were in a digital format, downloaded from the ProQuest Sanborn Map collection. As mentioned in Section 3.2.1, the entire collection was scanned from the black and white microfilm masters. An important part of the Sanborn system was its color coding of building construction materials. The lack of color undercuts the informational value of these maps because it becomes more difficult to readily recognize building and land-use trends. Despite the inclusion of a key developed by the Sanborn Map Company for use on black-and-white versions of its maps the lack of color added a layer of difficulty to the digitization process. The maps obtained from the University of Hawaii at Manoa Library Microfilm catalog were of poor quality, making it difficult to accurately digitize the building footprints and decipher the building information on the maps.

6.2 Mapping Fatigue

The digitizing and data entry process was the most tedious and time consuming part of the research. Each building had to be individually digitized and the attributes for each building entered into a database and verified. It was often difficult to decipher the information on the maps, so the next or previous year had to be examined to determine if the same building data was present and more legible. As described in Section 3.2.7, each block took about 3 hours to complete. Taking breaks periodically helped to break up the monotony of mapping.

6.3 Interpreting the Building Data

The building height of some buildings, in particular the outlying buildings, only indicated the number of stories, not the building height. For those buildings, a special data entry method for the building height was used. For example, a one story building's height would be inputted as 10.01 feet in the database, a 2 story building as 20.02 feet and so forth. The fraction was used as an indicator in the database to signify the number was interpreted from the map.

Many structures were not a consistent height throughout and many structures also indicated multiple stories but did not indicate a division line. Not all buildings had addresses listed. On commercial buildings, individual structures often had a range of addresses, with no clear internal divisions. The addresses recorded for buildings that did not have an address listed were close to or the same as the address of the nearest building. Buildings located on the corners were recorded with both street names. There were many small structures which were unknown as to what main buildings they were associated with. Many buildings did not indicate their use (store, office, dwelling, etc.) and so were listed as unknown in the database.

Some of the blocks and roads on some of the earlier Sanborn maps no longer existed which made georeferencing difficult. The street center lines were used as a control point in georeferencing in most cases, but sometimes this did not result in a proper alignment with previous maps, so readjustments were made. Some buildings did not correctly line up, even though the buildings were the same buildings.

6.4 Level of Knowledge Required

The care and precision in performing the building digitization can make a big difference to the final quality of the maps. When digitizing, the cursor must be placed on the correct spot to capture the exact location accurately. When drawing building corners, it is important to capture the precise point at which the line changes direction. The data entry process was also an area where mistakes were likely to occur. Firmly established procedures and guidelines for this process can minimize errors and ensure consistency in the data entry and digitization process. Besides the necessary GIS software training, it is important to have a thorough understanding of the Sanborn map symbols used and familiarity with where the building heights were drawn on the building, where addresses were indicated, and special symbols. There are different versions of legends developed for the maps depending on the date of and whether the maps were in color or black and white, so it is important to ensure the correct legend is used.

Chapter 7. Conclusion

This study explored the use of geographic information systems as a framework for analyzing digitized Sanborn Fire Insurance Maps and effectively demonstrated the benefits of digital mapping with GIS for historic preservation research. Geographic Information Systems are a powerful tool for the rapid analysis and visualization of historic neighborhoods. GIS can infuse new life into historic maps and aid planners, historians, and other researchers by looking at a particular area from a different perspective. Although the creation of a GIS historical database covering a large area is a major undertaking, the resulting database and spatial data which displays the change over time offers much potential. The documentation of the spatial and historical information through GIS helps to expand our knowledge base and promote a wider appreciation of the past landscape.

The Sanborn Fire Insurance Maps are unquestionably an invaluable data source for historic preservationists. The challenge with these maps has always been the cumbersome size of the maps making it difficult to browse, reproduce and analyze. The Sanborn Fire Insurance Maps have publically been available to researchers for years, but the bulk of the data was spread out over many books of maps, or if on a digital collection, over a confusing system of sheets, making the process of using the maps in a systematic fashion to glean a comprehensive database almost impossible. Locating the Sanborn Maps for one area over a span of years is challenging because the Sanborn Map Company often completely redrew and renumbered their sheets from one edition to the next. An area covered by one sheet may be divided among two or three sheets in a later edition. With GIS, the digital maps are catalogued geospatially allowing the analysis of data to be displayed as an aggregate instead of small snapshots in time.

GIS allows the use of layers of data to easily display a neighborhood during different time periods, making it possible to analyze changes in the landscape through time. Both time and space can now be explored allowing researchers to reconstruct past neighborhoods and show the relationship with the present. When photographs are tied to locations on the map, there is a better appreciation for understanding each building in relationship to the surrounding buildings.

In conducting historical urban research over a broad area, it is difficult to see patterns of change without comparing the differences over time. This study has shown how using GIS allows multiple data sources to be spatially integrated and examined to uncover unexplored insights into the past. The GIS approach opens new possibilities for research in the integrated study of historical areas.

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