THE ROLE OF GIS IN ASSET MANAGEMENT: COUNTY OF KAUAI DEPARTMENT OF PARKS AND RECREATION A NEED FOR AN ASSET MANAGEMENT PROGRAM

by

Nancy Ann McMahon

A Thesis Presented to the
Faculty of the USC Graduate School
University of Southern California
In Partial Fulfillment of the Requirements for the Degree
Master of Science
(Geographic Information Science and Technology)

May 2016

I thank all the souls who helped me in this herculean task.

Table of Contents

Acknowledgements

During the development and writing of this thesis study, it became apparent to me that it could not be accomplished alone and I needed the help of others. This project could not have been completed if it were not for the access to data, people, software, and other resources granted to me as an employee of the County of Kauai. I would like to thank our summer interns, for their help in the development of the asset database structure. I would thank my thesis advisor Dr. Yao-Yi Chiang for his countless hours of assistance and support, guiding me in various geodatabase topics and ideas. I would also like to thank the other thesis committee members, Dr. Jordan Hastings for his added input to my thesis study. Dr. Hasting suggested I really look into databases in GIS for a thesis topic. I appreciate Dr. Darren Ruddell, Dr. Jennifer Swift and Dr. Wei Yang for agreeing to be on my committee and their insightful help, guidance and suggestions. Dr. Swift spend considerable time editing my final manuscript which was very appreciated.

List of Tables

List of Figures

List of Acronyms

ASCE	American Society of Civil Engineers
ADA	American Disabilities Act
AMWA	Association of Metropolitan Water Agencies
APWA	American Public Works Association
AWWA	American Water Works Association
AM	Asset Management
AMP	Asset Management Plan
AMS	Asset Management Server
CAPEX	Capital Expenditures
CIP	Capital Improvement Project
CMMS	Computerized Maintenance Management Systems
COK	County of Kauai
DOPR	Department of Parks and Recreation
EAM	Enterprise Asset Management
EPA	U.S. Environmental Protection Agency
Esri	Environmental Systems Research Institute
GAO	U.S. General Accounting Office
GFOA	Government Finance Officers Association
GASB	Governmental Accounting Standards Board

GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphic User Interface
IT	Information Technology
IIMM	International Infrastructure Management Manual
M-PET.NET	Maintenance Productivity Enhancement Tool
NACWA	National Association of Clean Water Agencies
NSWC	National Association of Water Companies
O&M	Operations and Maintenance
OPEX	Operational Expenditures
PLL	Permit, Licensing and Land
PW	Public Works
RDMS	Relational Database Management System
ROA	Return on Asset
SCADA	Supervisory Control and Data Acquisition System
SDI	Spatial Data Infrastructure
SQL	Sequential Query Language
US	United States
WEF	Water Environment Federation

Abstract

This study demonstrates the integration of Geographic Information System (GIS) with asset management. Asset management can be explained in many ways – for example, an organized infrastructure management system, an economic approach to help planning and decision-making, a methodology to ensure the future level of service life of a facility. It is a systematic process of maintaining, upgrading and operating physical assets cost effectively. It provides the tools necessary to facilitate a more organized, logical approach to decision-making and implementing. It gives a comprehensive view of resource allocation and utilization. Asset management strategies and systems used by the facilities management, construction, and information technology industries provide a framework – a multidisciplinary approach that enables us to consider whether such systems might be able to organize better the data for GIS applications. The aim of this thesis is to investigate the potential of an asset management and GIS approach to organize and manage the data. This thesis demonstrates that using a Microsoft Excel spreadsheet was not appropriate for holding all the data and running an accurate asset management system. This thesis investigates the requirements for a geographic data-focused asset management system and makes a recommendation to the administration on using the M-Pet.Net system to provide County of Kauai, Department of Parks & Recreation (COK DOPR) with the capability to identify all of the COK DOPR's assets and track all maintenance associated with the assets. This thesis shows that the system will then provide the means to support and determine budgets and future long-term expenditures thru the extensive database of information.

CHAPTER 1 – INTRODUCTION

Most United States (US) government agencies have not developed an asset management system to guide maintenance, repair, rehabilitation and replacement of existing facilities and construction of new facilities (County of Hawaii Limited Scope Performance Audit 2011). Deferred maintenance has led to deteriorating structures and decreased levels of service, and disruption or cancelation activities due to unsafe conditions. The words maintenance and repair are frequently seen as an extension of each other to the extent that they could be considered interchangeable in conversation. In the context of this thesis, maintenance is considered a preventative measure that should be performed on an asset throughout its life but is not required for continued use of the asset. Repair, on the other hand, is herein defined a required, one-time measure necessary to return an asset to service because of some failure.

The value of maintenance over repair becomes evident through the discussion of deferred maintenance. According to Vanier (2001), deferred maintenance is the cost to bring an asset up to its current value, if maintenance has not been completed on a regular basis. This notion is based on the understanding that an organization has not or cannot perform regular maintenance on a given asset. Vanier relates the costs associated with deferred maintenance to De Sitter's Law of Fives, which reads that repairs will cost five times the amount of maintenance if it is not performed on a regular basis and replacement of the asset will cost five times the cost of the repair (De Sitter 1984). Figure 1 provides some insight into the deferred maintenance costs based on an investment in maintenance from year to year by displaying the exponential cost increase to return an asset to its full potential when maintenance investments may or may not be completed.

An asset management program would facilitate leveling of budgets from year to year and permit analysis as to whether the combined costs of building rehabilitation, American Disabilities Act accessibility upgrades, and hazardous material remediation would be greater than the cost to completely replace a structure. Asset management tools are needed not only for agencies with inventories of structures/facilities, but also for historic properties, amusement parks, water and wastewater utilities, etc. The need to manage these resources is widespread.

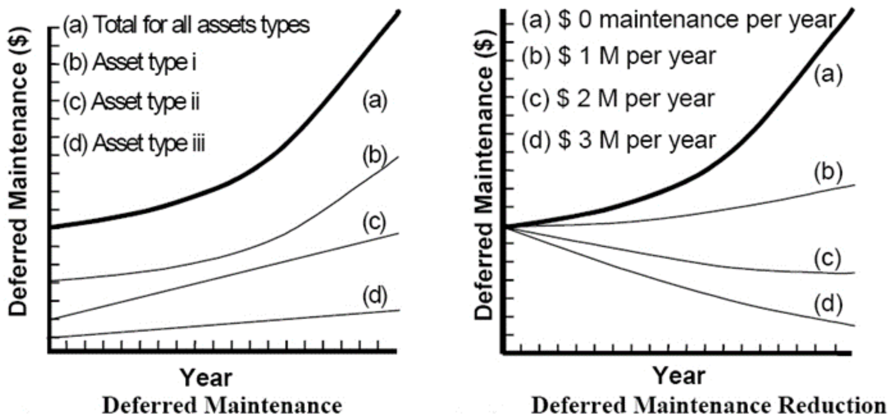


Figure 1 Deferred Maintenance over Time (Vanier, 2001)

Management of resources is needed in vast fields from cultural resources to facilities management. In the context of this study, management of resources should be handled in a database management system. This thesis considers the historical development and current state of database management systems and, more recently, geographic information systems (GISs) in the management of archeological/facilities information. A computerized maintenance management system (CMMS) stores crucial information about a company or municipality's assets and is the primary tool for managing an organization's maintenance and reliability practices (e.g., North Myrtle Beach Parks and Recreation's MainTrac, Kapp 2013). Enterprise Asset Management (EAM) and CMMS implementations have become significantly more complex over the last decade

(Management Resources Group, Inc. 2013).

Today, with larger and more complex enterprises, management needs to have near real-time access to data housed in an accessible database application incorporated with GIS capabilities. That data ranges from facilities and assets types to inventory to features in parks such as a picnic tables, crew makeup, and more. Collectively there is usually a lot of data (e.g., infrastructure assets, work orders, equipment). At its most basic level, data is anything recorded about an object or phenomenon. This simple definition belies a need for further context and identification for the collected data to become useful. Geographic data is somewhat differentiated by involving both a spatial and temporal location, as well as subject-specific data (Lo and Yeung 2002). The complexity inherent in the simple recording of a single data point location on a map becomes apparent through this description, as the person collecting the data must record the spatial location, the time the data was recorded, and potentially numerous other associated data attributes based on the needs of the end user. Lo and Yeung (2002) use this model to break the recording of real-life elements into representations of objects and phenomena. In a GIS, discrete objects are considered as definable locations on the earth's surface, such as a comfort station, picnic table, or a roadway. These definable objects are represented using point, line, and polygon vector graphics in GIS. Phenomena are herein defined as elements that are distributed continuously across a given landscape. These continuous representations are often raster-based, meaning they include a single cell representation of some value, such as temperature, rainfall, or crew make-up [manager, supervisor, and laborer].

At the core, software programs used for asset management (M-Pet.Net, NaviLine, CityWorks, Maximo, etc.,) can all store, categorize, and report on events, but they are only as good as the information collected within them. At some point after the system is in place, there will be a need to evaluate it for viability in regards to usefulness or to re-determine requirements. Effective CMMS relies on high quality, up-to-date data. The value of the system is directly proportional to the accuracy, quality, and detail of the information that the system houses (Belanger, 2013). For example, work orders need to be entered into the system for all new work, and old work orders need to be closed out so the information can be accurately tracked. It is assumed that if an individual knows the data being entered will be used to complete a future task, he or she will take more care to enter accurate, detailed information.

Asset management programs can be defined as managing infrastructure capital assets to minimize the total cost of owning, operating, and maintaining assets at acceptable levels of service. Enterprise Asset Management encompasses the entire organization and recognizes the interdependencies of maintenance, operations, asset performance, personnel productivity, life cycle costs, and capital planning. EAM Systems and CMMS are being implemented by a growing number of water and wastewater utilities and their use in these areas appears to be growing (Management Resources Group, Inc. 2013). A CMMS is a software package which maintains a computer database about maintenance operations. The terms asset management and maintenance management are often used interchangeably. Even though they are related, they are different processes with different objectives. Asset management is focused on reducing the maintenance cost of ownership, while maintenance management is focused on reducing the maintenance cost while extending the useful life of an asset (McKibben and Davis, 2002). An effective asset management system must include an effective maintenance management system and is considered the most important core of an asset management system (Shamsi, 2005).

An EAM is a CMMS focused on maintenance work orders and performance combined with an asset registry or inventory. A CMMS and asset registry are the center of an asset management program. A growing trend is for the GIS geodatabase to be the starting point for an asset management program and the asset inventory. Municipalities need to know the location and condition of their assets. GIS is the best software option for gathering asset data because spatial location is typically an important aspect of the data at a water utility. A GIS geodatabase combined with a CMMS forms a comprehensive customer request, asset inventory and work management system and becomes the foundation for the EAM. This combination captures asset data, work history and condition assessments necessary for cost-effective, condition and predictive maintenance programs (Baird, 2011).

McKibben and Davis (2002) give many reasons for the integration of GIS and CMMS. GIS can significantly enhance a CMMS by providing the ability to access, use, display, and manage spatial data. This is important for utilities with geographically dispersed networks. Also, it can provide access to other spatial data. A GIS combined with a CMMS can provide maps of a utility that can be used in locating facilities included in work orders. It can be used to schedule effectively and assign maintenance work crews to certain work locations, saving time and cost. Baird (2011) points out that using a GIS with full functionality, beyond just map-making, will result in lower maintenance costs and a lower cost EAM.

At the time of their study, McKibben and Davis (2002) found there were only six CMMS vendors that had links to Esri GIS software. Of these, only three, Azteca Systems (CityWorks), GBA Master Series, and Hansen Information Technologies (Hansen's Citizen Relationship Software) had useful CMMS systems. While primarily focused on the tracking and maintenance of hardware assets, a CMMS can provide a strong beginning for the tracking of geographic data. One of the greatest benefits of the CMMS is the elimination of paperwork and manual tracking activities, thus enabling maintenance staff to become more productive. It should be noted that the functionality of a CMMS lies in its ability to collect and store information in an easily retrievable format. A CMMS does not make maintenance decisions; rather it provides the manager with the best information to affect the operational efficiency of a facility.

There are two methods of integrating GIS with CMMS, and these are based on where the asset data is stored – the CMMS or the GIS. GBA and Hansen maintain the asset data in the CMMS database and GIS software is used to access the asset data or provide information stored in the CMMS. GIS features are linked to the CMMS database. Adding a new asset requires the addition of the asset to both the GIS and CMMS databases. The work order and maintenance data are stored in the CMMS (McKibben and Davis, 2002).

An effective asset management system must include an effective maintenance management system, which is focused on reducing the maintenance cost while extending the useful life of the asset (Shamsi, 2005). Many utilities use a react- to-crisis management approach in dealing with infrastructure problems. This is usually not the best approach given the additional costs of emergency crews and property damage. With the use of effective asset management, it is possible to reduce overall infrastructure costs instead of waiting until the assets fail to incur higher than necessary costs (Shamsi, 2005).

A study was conducted in spring 2014 to determine the status of asset management worldwide initiatives.[1] Almost 1,000 companies responded to the study, with 50 percent of the

[1] www.reliabilityweb.com/index.php/articles/asset_management_practices_investments_and_challenges_2014-2019

respondents from the US, the United Kingdom, and multi-national companies. The size of the companies is split evenly, with one-half of the companies having more than 1,000 employees and one-half with less than 1,000 employees. Interestingly, there is also an even distribution of responding companies across industry verticals.

There are three questions that most executives would find interesting. The first is: “Why are you interested in asset management?” The top three responses are all related to the financial impact that asset management could have on their organizations. The first response was to increase system reliability (77%). This response focuses on the need for capital expenditures (CAPEX) for new assets to compensate for poorly performing assets and operational expenditures (OPEX), such as asset maintenance, to compensate for assets that continue to perform poorly. If an organization utilizes proper asset management policies, the asset reliability would have a positive impact on both CAPEX and OPEX expenditures.

The next two responses were to improve financials (66%) and increase service levels at a lower cost (61%). Financials related to assets are typically measured by some type of return on asset (ROA) indicator. If a company is to improve its financials, it has to derive the optimum value from its assets. To achieve this goal, the company must be able to derive the maximum output from its assets, often referred to as design capacity. Additionally, the company would need to carefully manage the maintenance resources utilized to ensure the maximum output from the assets. This would include optimization of maintenance resources through effective planning/scheduling and good materials management policies and processes.

The second question is: “What benefits do you expect from asset management?” The first answer was lifecycle cost reduction. This links to the responses from the aforementioned first question. If an investment is made to develop a formal asset management process, executives expect to see a reduction in the overall lifecycle costs for the asset. Achieving this requires lifecycle tracking of the company's assets (e.g., design, installation, operation/ maintain and decommission/disposal). Then, decisions can be reached that will optimize the investment made in each phase of the lifecycle of the asset.

The next two responses were data to support decisions (58%) and determining optimum maintenance approaches for the assets (57%). These responses show that most executives do not fully trust that the current asset management information is accurate enough to make policy and process decisions. This leads to second-guessing many CAPEX and OPEX decisions that are made based on current asset conditions.

The third question reveals the biggest obstacle faced by companies implementing asset management. The first response was organizational culture (40%). This indicates that many companies have the technical abilities to develop and implement an asset management program, but lack the organizational understanding to do so. This also indicates a need for extensive training to help employees develop a clear understanding of the value proposition for asset management. Additionally, it indicates a need to break down organizational silos so a clear line of sight can be developed. This allows the organization to focus on deriving the maximum value from its assets.

This leads to the second ranked answer, funding/cost (25%). This shows that most executives realize that asset management will not be successful by just throwing money at it. They must have a clear line of sight from the departments/employees to the assets and to the bottom line. It is only through this clear linkage that an organizational culture can be developed that allows for the funding/cost to be controlled and, ultimately, maximizes the value derived from the assets.

A CMMS can be implemented for the more efficient maintenance of a utility because it accurately tracks problems within the utility network. A GIS and CMMS integration can facilitate proactive (preventative) maintenance. Global Positioning System (GPS) is a key technology because it is used to increase the accuracy of existing system maps by verifying and correcting locations of system components.

1.1 Study Objective

The purpose of this thesis is to demonstrate and evaluate the integration of GIS and asset management. The project built as part of this thesis involves the developing an asset inventory for the County of Kauai (COK) Department of Parks and Recreation (DOPR) for a current asset maintenance management system. Currently, the DOPR assets, including parks, playground, pools, ball fields, tennis courts, golf course, neighborhood centers, pavilions, stadiums, convention hall, tables, etc., are represented as a point feature in the GIS. Developing the database for spatial attributes associated with assets is necessary to perform critical analysis and score each facility's asset risk. Specifically, the objective is to develop a critical analysis for DOPR in order to determine proactive maintenance and replacement schedules. Also maps for parks can be created if they do not exist and their attributes can be collected for populating a GIS database.

Even though the majority of the assets are capital expenditures in cost maintenance, repair, or replacement. It is important to develop ways to try to economize with these expensive assets. One of the GIS strategic plan objectives is to develop and implement an asset management program plan to extend the useful life of the capital assets. Another objective of this study is to explore whether spatial factors can assist in determinations regarding which asset need to be replaced, and which assets take precedence above others when failure or replacement occurs at the same time.

1.2 GIS and Asset Management

Because assets occupy a location, maps have always been a desirable method to catalog an organization's assets. As every organization knows, assets are interconnected and in proximity with other assets and features, even if the location is not fixed. Modern "mapping systems" like ArcGIS are able to provide far more than graphical representations of data. The ArcGIS geodatabase is a database system with all the typical data assessment tools to categorize, classify, diagram, index, order, schematize, sort, and tabulate. In addition, it can render data as maps, analyze interconnectivity, proximity, and other complex spatial relationships; and model the physical world. The geodatabase as an advanced database structure is inherently location-aware, providing far more power for managing assets than traditional non-location-aware database systems, including the ability for three-dimensional modeling. The ability to build an asset inventory based on feature locations with multiple levels of related objects assures all of an organization's assets are maintained in one asset data management repository, easily accessible enterprise-wide.

GIS had been proven to be an effective and powerful tool in asset management. An application is an applied use of technology which bridges the gap between pure science and applied use. Overall, effective GIS integrates separate municipal databases (including those stored on obsolete technologies) into a centralized whole. GIS allows users to visualize, question, analyze, and interpret data to understand relationships, patterns, and trends. It can have many functions. For example, it can provide maintenance cost and history along with providing asset inspection data and asset condition assessment. Integrating with a GIS can improve the capabilities of a CMMS by supporting spatial analysis and locating geographically dispersed facilities in the water system. A GIS is a special type of information system in which the database of spatially distributed features and procedures collect, store, retrieve, analyze, and display geographic data. GIS relates database records and associated attribute data to a physical location, creating a "smart map" (Vanier, 2004). A GIS is also a means of effectively analyzing large amounts of spatially related data. Making informed infrastructure maintenance decisions requires large amounts of diverse information on a continuing basis. GIS integrates all kinds of information from disparate sources into one manageable system so better and informed decisions can be based on all relevant factors.

With the integration of information from a variety of sources, it is possible to determine important geospatial relationships and factors on which utility maintenance would be based. For example, failure could be caused not only by age, but also by material, surrounding soil, weather, and vandalism. By analyzing these factors and other related factors, it would be possible to determine which assets are the "hot spot" areas and constitute a priority for maintenance activities.

According to Shamsi (2002), the use of GIS technology can be an ideal solution for the effective management of infrastructure because it offers the power of both geography and information systems. GIS can locate the exact position of facilities or their attributes displaying them on a computerized map. It can also store important data about each asset, including contractor, year of built, repair history, or almost any other type of information. Efficient management must include location information so good decisions can be made relative to the surrounding area and affected assets. With the use of GIS in the area of asset management, it is possible to visualize and understand the geographical context of an asset and improve the efficiency of asset management.

Recent decades, the development of new digital information technologies, particularly GIS, has substantially improved the effectiveness of cultural resource inventories and facilities management. Rapidly growing global access to the Internet has made possible broadly accessible, web-based information systems for the inventory and management of cultural resources/facilities. GIS are designed specifically for the management and analysis of spatial relationships. However, the development of an effective system can be a costly and substantial undertaking well beyond the reach of many cultural resource agencies. Perhaps taking a look at various programs that are designed for facilities management with a GIS component should be looked at for cultural resources, as well as looking at programs designed for specific cultural resources management should be analyzed.

1.3 GIS Implementation at County of Kauai

The COK does not use its GIS to its full potential of GIS. COK has a contract with Esri for ARCGIS. It is available for staff who ask for it and have used it before. It is usually used by many of the planners or engineers for mapping, zoning overlays. Major data needed by the department has been collected in varies formats, including financial spread sheet, excel spreadsheets, files and access database. The data is very significant in size capturing the major attributes of the facility infrastructure. For its operations, the department needed to keep a complete and detailed inventory, including location and condition of all assets. GIS has been shown to be a state-of-the-art technology which can efficiently perform the department's data related processes (Zhao and Stevens, 2003). Obtaining records involved physically going into the record room and manually searching for the needed information. This process was inefficient, error-prone and hindered the productivity (Zhao and Stevens, 2003).

While collecting this data, the department saw the need to integrate a variety of information and applications with a geographic component into one manageable system. The focus of GIS became one of a centralized asset for sharing and managing information rather than a cartographic tool.

Enterprise GIS is an organizational approach that integrates various departmental projects into a centralized GIS which serves as a foundation in integrating other tabular database systems within the district. The core of the integrated systems for the district relates to customers, financial management, work management, and GIS. In 2003, the COK adopted AS400 as its CMMS mainly as the work order management tool. It is still in use.

A key component in the enterprise GIS is the database design. The district used Esri's water utilities data model as the prototype to design the enterprise GIS database. The Structured Query Language (SQL)-based Geodatabase served as the basis for the island-wide enterprise system integration. The open platform of this database structure made it possible for the district's GIS system to integrate with other systems. Between-system integration is essential to make the most of enterprise GIS.

Compared with the GIS technology capability of a decade ago, new GIS technology is enterprise enabled and the district is headed in that direction (Zhao and Stevens, 2009). With the enterprise approach, all operational data should be available and integrated. As part of COK strategic plan, the DOPR wants to leverage its investment with an enterprise integration strategy. This includes a GIS-centric management system. This initiative is the inspiration for this thesis study which was undertaken.

CHAPTER 2 – LITERATURE REVIEW

The first section of this chapter provides an explanation of asset management and a literature review of this topic. Section 2.2 presents an overview of the GIS and Asset Management. Section 2.3 describes various CMMS and EAM software solutions.

Literature in the area of asset management comes from a variety of sources, including government publications, trade magazines, and conference proceedings. The development of asset management approaches with water utilities originated around 2000 (Ward 2005). The techniques involved in asset management have been refined by the international community, particularly in Australia and New Zealand.

Literature relevant to providing background for this study includes both an overview of work done in asset management with water utilities and the narrower topic of the integration of GIS with asset maintenance management, specifically CMMS. This chapter also includes the reviews of the few articles found concerning the use of vertical assets, CMMS, and asset risk, the focus of the thesis study. In most of the software evaluated the geographic data is applied as an attribute for assets.

2.1 Asset Management

The use of asset management in water utilities is a relatively new concept. Until around 2000, it was relatively unknown in North America (Lutchman, 2006). The term originally described the management of financial assets. In the past decade, interest in asset management for water and water utilities has grown mainly due in part to an aging water utility infrastructure. Many professional and government organizations have defined asset management and developed plans for the practice and implementation of asset management in the area of water utilities (Sinha, n.d.). Common definitions of an asset include an implication of ownership or custodianship, with the ability to apply a quantifiable value to the asset (American Heritage Dictionary 2015). Literature from the asset management discipline is focused primarily on cataloging, valuing, tracking and maintaining data through various methodologies and systems.

In 2007, the U.S. Environmental Protection Agency (EPA) and six national water and wastewater associations (Association of Metropolitan Water Agencies (AMWA), American Public Works Association (APWA), American Water Works Association (AWWA), National Association of Clean Water Agencies (NACWA), National Association of Water Companies (NAWC) and Water Environment Federation (WEF)) collaborated on a guide promoting effective utility management (EPA, 2008b). The guide discusses ten attributes of effectively managed water utilities. It concludes that effective asset management can enhance the infrastructure, improve performance in many critical areas, and respond to current and future challenges. The EPA also works with water utilities to provide technical assistance to help utilities implement asset management (EPA, 2008a).

A report by the United States General Accounting Office (GAO) discusses the benefits of comprehensive asset management for drinking water and wastewater utilities. It also addresses the challenges of implementation and the federal government's role in encouraging utilities to use it (GAO, 2004). Utilities reviewed by the GAO reported that collecting accurate data about their assets in areas like maintenance, rehabilitation, and replacement costs can lead to better investment decisions. The challenges include collecting and managing needed data and integrating information and decision making across departments. Also, it is reported that the shorter-term focus of those in charge of utilities can hamper long-term planning efforts. The federal government has invested billions of dollars in drinking water and wastewater infrastructure and wants to protect its investment by having future funds go to those utilities that implement comprehensive asset management plans (GAO, 2004).

One of the goals of asset management is to replace reactive maintenance with planned maintenance with more practices geared toward predictive and condition maintenance (Harlow, 2000, part 1). Good asset management must minimize long-term asset costs and at the same time insure reliable customer service. Effective asset management must be based on practices that are easily implemented, cost effective, and sustainable in the long run (Lutchman, 2006). Lutchman (2006) also believes that good asset management needs to be focused on economic, social and environmental concepts and not just the financial bottom line.

A typical asset management framework consists of the following four parts: 1.) Facilities inventory; 2.) Condition assessment; 3.) Operations, maintenance, repair and replacement management; 4.) Analysis and evaluation (Doyle and Rose, 2001). Facilities inventory is a description of each asset. Condition assessment classifies each asset as to its capability to perform its intended function. That function being operations, maintenance, repair and replacement management tracks and records data about work orders and customer complaints. It also issues and tracks preventative and predictive maintenance schedules, generating crew assignments and work-site maps. This is Computerized Maintenance Management System (CMMS). Analysis and evaluation prioritize work effort, analyzes cost effectiveness and optimizes asset performance. The asset management focus is to maintain a desired level of service at the lowest life cycle cost.

Asset management was first done by the water, wastewater, and public works utilities in New Zealand and Australia. They set the general direction and standards for asset management in these industries. In the mid-1980's and 1990's, the government directed the utilities to become business based, customer focused, more transparent and accountable. Policies and regulations were set and the utilities were mandated to meet them. During a 12-year period, the 24 largest Australian water and wastewater utilities achieved almost a 20 percent savings per customer account. Savings involved capital and operations/maintenance costs with no changes in service levels to the customer. A large regional and wastewater utility (Hunter Water located in New South Wales, Australia) achieved far more savings and is widely viewed as having developed one of the most effective and advanced asset management programs in the world (Sinha, n.d.).

The fuel for the analytical engine is data. Without it, an analysis is at best a hypothesis if not a blind guess. That is not to say that every asset needs exhaustive history, but the level of detail required to generate meaningful data must be considered. The output of the captured data has multiple uses, including financial reporting, budget development, failure analysis, document tracking, etc. It's crucial that data be consistent in its use and that consistency be dictated by the processes in place. It's helpful for those entering the data to understand how others will use the information. If an individual knows the data being entered will be used to complete a future task, he or she will take more care to enter accurate, detailed information. Commit to building and maintaining accurate and consistent foundational data from day one. If the foundation is not built with the proper level of detail, the system will not be able to deliver on its designed value.

Data is the basic building block on which information, and thus nearly any decision support system, is based. As the information age progresses, the ability to examine how data is created, aggregated, managed, and accessed allows organizations to make decisions on how employ the best management strategies to the advantage of their constituents. Current data management practices, in the information technology discipline, are focused on providing efficient storage and access to data; however, these systems rarely provide details to why the data was created or how it can be made more useful. Other industries require this information when focusing on physical assets - particularly in those industries where equipment utilization is a driving factor in revenue production. Industries, like construction and facilities management, have turned to asset management techniques, strategies, and solutions to best understand who, what, where, why and how their assets are being used in order to track its usable life and value.

To start with an inventory of facilities that list their key components is needed as a starting point for effective planning. In its Capital Asset Assessment, Maintenance and Replacement Policy (2007 and 2010), the Government Finance Officers Association (GFOA) recommends: Developing a policy to require a complete inventory and periodic measurement of the physical condition of all existing capital assets". An inventory provides the base asset list for use in assessing conditions; estimate costs; developing routine periodic and backlog remediation plans and schedules; establishing inspections schedules and reporting on actual performance comparisons.

Like the foundation of a building, it is important that the management of assets begins with good foundational data; otherwise, it will become increasingly difficult to obtain useful information from the collected data. Think of foundational data as data that does not often change. Some examples include work order types, catalog items, locations, failure codes, class/subclass combinations, and nameplate templates. In cultural resource management its site numbers/features, site function, site significance, type, location, plan view drawings, artifacts. The purpose of foundational data is to assist in the consistent execution of processes. The goal of a reliability-centered maintenance program is to maintain an asset in its optimal operating condition given the context in which it operates. The task of performing analysis across similar assets in a plant or multiple locations around the world becomes much easier and more meaningful when the foundational data is thoughtfully developed. The differences between data, information and knowledge, should be explained. Data, by itself, is of no use without context or analysis. The interpretation of the data in some form provides a platform for the creation of information that can then be utilized. Through further examination and understanding of the information, one can make the existential leap to knowledge. Oversight groups, such as the Open GIS Consortium, are mandating the creation of data standards and semantic translators, which codify data based on several criteria. However, as knowledge can only be understood on an individual basis, Barr and Masser (1997) focus on information as a format that can be discussed in many forms based on the context in which it is placed. The ability to use this information lies in the representative abilities of geographic information systems. However, GIS is lacking in its ability to maintain information about the context of data.

The development of context is the necessary step to transform geographic data into geographic information. Spatial data infrastructures and metadata are being developed as methods for standardizing and applying this context. These efforts have the potential to describe data as an asset through the inclusion of attributes that are not necessarily relevant to its everyday use. This information becomes useful to the asset manager by providing the context of organizational structure, data quality measurement, and potentially quantifiable value for a piece of stored data.

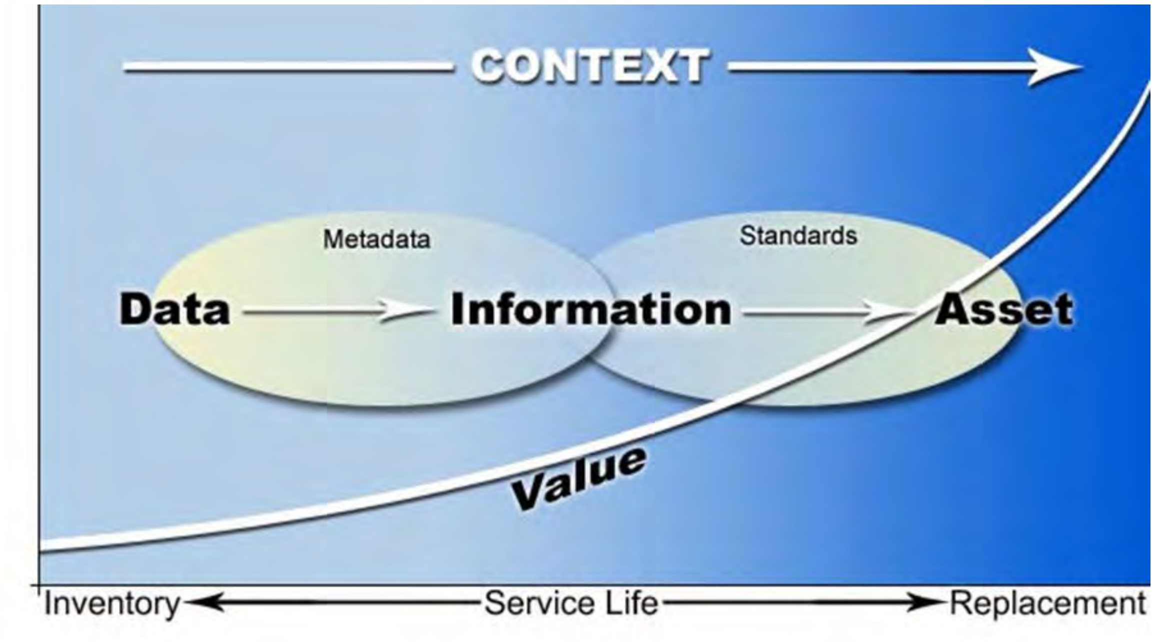


Figure 2 Schema on the development of Data- Information-Asset Context

The significance of the development of data as an asset comes through the creation of context about geographic data. Figure 2 illustrates the transformations that occurs as context increases throughout the useful life of a given asset, from inventory efforts to replacement needs. To become information, data gains context through the metadata, documenting spatial extent, temporal location, and other pertinent details that allow for proper representation. Through the implementation of standards, specifically those from the asset management field, information is provided with context that allows for additional management capabilities. As context is applied, an element of data continually gains value as it is transformed first into information and then into an asset. The process of adding context to the geographic data used in the case study is the focus of the final section of this chapter, describing the various organizational efforts attempted to both track data through its useful life, as well as the increase in the value of the data to the managing organization.

2.2 GIS and Asset Management

Even though GIS technology began in the 1960s. In the early 1990s, the water industry started to use a GIS in mapping, modeling, facilities management and work- order management plans. By the end of 2000, approximately 90% of the water utilities in the United States were using GIS technology in some form (Shamsi, 2005). The use of a GIS as a management tool has grown since the 20th century, and the number of users has increased substantially. Utilities that are using GIS successfully have seen increased productivity and increased efficiency that saves time and money. The Environmental Systems Research Institute (Esri), the leading GIS software company in the world, has been a significant contributor to GIS applications in the water industry.

As an example Figure 3 illustrates a water utility asset management, one of the core business patterns commonly used by infrastructure utilities. Others include planning and analysis, field mobility, operational awareness and stakeholder engagement (Crothers, 2011). The use of a GIS integrated in these systems can be an important part of each of these patterns.

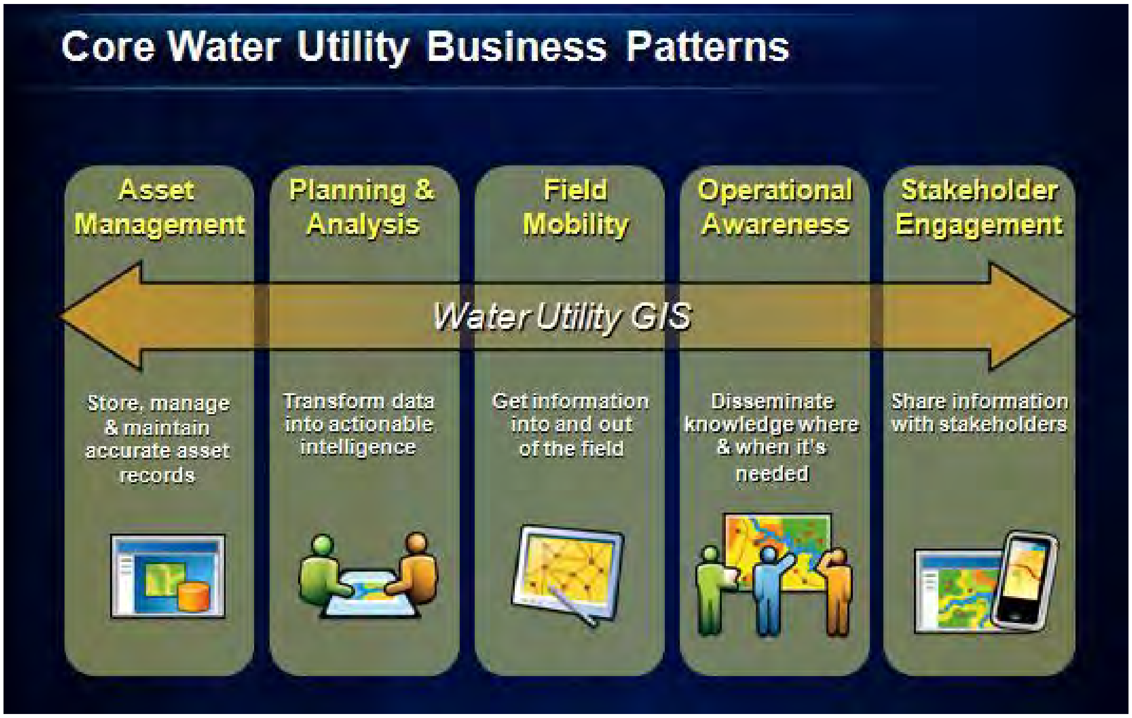


Figure 3 Core Water Utility Business Patterns. Source: Crothers 2011

The basis of effective asset management is high quality asset information. GIS manages asset information by storing, managing, and maintaining accurate asset records that can be shared by the whole utility. Many times, a utility will have complete information about an asset stored in multiple systems. The GIS stores the location, connectivity to other assets and basic attributes. The CMMS stores extended information about the work history for an asset. Other systems could include a financial system and a customer information system.

There should be integration among all of the multiple systems that store information about an asset so data about its location, connectivity, status, history, and description can be easily accessed. A GIS can handle information that can be shared across an entire utility and used to support many of its information needs. Utilities can significantly increase their return in a GIS investment by sharing it around the entire utility and using it to support its many business patterns

(Crothers, 2010).

Asset data in a GIS can also be used to support the planning needs of a utility through spatial analysis. Water utilities are involved in short term planning and long term planning. For short term planning, GIS is used in creating and optimizing reactive and proactive work orders. Long term planning involves the use of asset data, performance data and GIS analysis to understand how an individual asset is performing. This information is used to help determine where to best spend capital funds to maximize the value of an asset (Crothers, 2011).

GIS supports the field mobility business pattern by providing field crews with maps and applications that can be rapidly updated and are easy to use. It also enables field crews to capture GIS data and send it back to the central office. The operational awareness business pattern involves the performance of assets, networks and personnel and how they are affecting each other. Managers can then make decisions based on accurate and up to date information. GIS supports this by enabling assets to have an interactive map of the current state of operations. An interactive map is an easy way to take information from many systems and present it through a common application (Crothers, 2011).

The final business pattern, stakeholder engagement, involves sharing information with stakeholders such as customers, elected officials, regulatory agencies, and other assets in the park area. The trend is for municipalities to engage actively with stakeholders through public outreach programs providing accurate information that minimizes misinterpretation. Utilities use GIS by creating static and interactive maps. Mapping applications for stakeholders include customer self-service, capital project coordination, service interruption management and transparency into maintenance performance (Crothers, 2011).

2.3 Review of Existing CMMS and EAM Software

The COK tasked the author with a search and review of different programs and options for the DOPR's asset management. Described herein are the software programs that were reviewed as part of this thesis work, which the author was able to contact with whom discussed the program's functionalities. Some vendors even provided a webinar so that the author and other staff could review how the software program functioned.

ARCHES

Arches is a new, open-source software system that provides a solution for compiling and managing inventories of immovable cultural heritage at a range of scales (national, regional, city, or site). The Arches project was initiated through a collaboration of the Getty Conservation Institute and World Monuments Fund, with substantial technical assistance from English Heritage and the Flanders Heritage Agency.[2] Arches is purpose-built for the cultural heritage field, using international standards. It is freely available and has a growing international community of Information Technology specialists and heritage professionals.

ESRI AND ASSET MANAGEMENT TOOLS

Environmental Systems Research Institute (Esri) products remain the standard for GIS and spatial data. Esri allows several different file types for spatial data ranging from shapefiles (the most common) to Geodatabases (the most recent). To accommodate the various methods that agencies,

[2] www.getty.edu/conservation/our_projects/field_projects/arches/

firms, and organizations may already be using to create and store cultural resource spatial data, the standards have been organized around individual data layers, rather than a particular file type. These data layers would translate into a single shapefile for instance. Gathered together, they form a Geodatabase. Esri provides standard geographic data sets through its ArcGIS Server technology that is licensed to the users of their software. Esri manages this data by distributing select sets of information and allows users to include finite geographic elements, without ever touching the underlying file structure containing the data. Software solutions such as IBM’s Maximo Asset Management, and Azteca Systems’ CityWorks incorporate readily available hooks that link asset functionality to GIS databases and solutions, and most are Web-enabled.

CITYWORKS

CityWorks is a GIS-centric CMMS focused on the municipal and public works markets. Its GIS user interface allows GIS-centric users to function in the map oriented CMMS environment. It recent cloud solution provides a hosted option. Built inside the Esri GIS environment, it is a great solution for spatially oriented assets. Seamless functionalities between GIS and asset inventories. The GIS focused interface is limiting to non-GIS assets. Non-GIS assets are difficult to manage without the asset hierarchies. Azteca's CityWorks uses the other method that stores the asset data in the GIS database. All assets and the related data are maintained in the GIS database. The addition of new assets in the GIS database does not require an adjustment to the CityWork's database. Work orders and maintenance management functions are maintained in a series of CityWorks tables and all of the maintenance management functions are provided as extensions of Esri's GIS software (McKibben and Davis, 2002). Azteca's CityWorks, with its GIS-centric approach, is considered by many to be one of the best asset and maintenance management systems (Baird, 2011). It has been in use for 15 years and has over 400 clients. According to Baird (2011), a solid CMMS is a necessary part of asset management. Therefore, a CMMS with a GIS-centric approach is considered to be a necessary part of asset management

NAVILINE/SUNGARD

SunGard Public Sector also sells a suite of software for local governments that runs on the older i/OS server, called NaviLine. At one point, SunGard Public Sector had hundreds of customers around the country running on its i/OS-based products, including NaviLine. NaviLine for AS/400. This is currently what the COK has for finance and public works. There are various modules needed for asset management including mobile solutions. It is very menu driven and not very easy to navigate or learn. It is not cloud but server based.

LUCITY

Lucity, formerly GBA Master Series Inc. is a municipal and public works CMMS. Large municipal client base with very specific industry specific functionalities and premade templates. The product is integrated with Esri GIS for spatially oriented assets. Large municipal client base to support user conferences and user groups. Very specific functionalities specifically focused on utilities and public works markets. Not web based solution which makes it more challenging to deploy and maintain. No mobile applications.

M-PET.NET

M-PET.NET (Maintenance Productivity Enhancement Tool) is the next generation of CMMS. Designed for superior performance in every environment from manufacturing to facilities to municipality environments, M-PET.NET has a demonstrated ability to deliver fast, comprehensive results for management of every aspect of an automated maintenance environment. Is also base on GIS mapping for locational information. It can be web based or build on a server. The Four Wind Group Inc. is the developer of this software.

MAXIMO

IBM is the parent company of this leading facility computer maintenance management system. It is the standard computer maintenance management system in many facilities. Maximo is an excellent enterprise solution. Proven facility CMMS that is backed by an army of qualified IBM consultants. Only implemented by qualified IBM consultants so you can be ensured that the product is implemented with the best business processes. Expensive and time consuming to implement with only IBM consultants. The product is only focused on facility and plant facilities but with only limited functionalities for special GIS users.

NEXGEN

NEXGEN Asset Management (AM)is extremely user friendly interfaces on both the web based desktop and mobile application and excellent functionalities in the software. NEXGEN AM a fully integrated and all-inclusive solution which means that one price gets all the modules on the desktop and mobile application. NEXGEN AM is the only software with a robust CMMS integrated with advanced asset management functionalities. This product is designed to be an enterprise solution being able to support both facility and spatially oriented asset inventory. Web based software that can be hosted on the cloud or locally hosted. Its iPad application supports mobile best practices. Excellent value with all-inclusive modules and desktop and mobile solutions. 6-month warranty or money back ensures clients satisfaction. Excellent clients support. Software only implemented by NEXGEN AM experts. The flexibility of the software lends to a diverse market so it is not necessarily focused on one industry. With the vast functionalities of the software, it is vital that it be implemented in phases to prevent overwhelming users.

AS/400

On June 21, 1988, IBM introduced the Application System/400 (AS/400), a new family of easy-to-use computers designed for small and intermediate-sized companies. As part of the worldwide introduction, IBM and IBM Business Partners worldwide rolled out more than 1,000 software packages in the biggest simultaneous applications announcement in computer history. The AS/400 quickly became one of the world's most popular business computing systems. By 1997, IBM had shipped nearly a half-million AS/400s. The 400,000th AS/400 was presented on October 9, 1996, in Rochester, Minn., to Greg LeMond, the three-time winner of the Tour de France bicycle race and a small business entrepreneur. The AS/400 family was succeeded in 2000 by the IBM eServer iSeries – high-performance, integrated business servers for mid-market companies. The AS/400 is a popular family of mid-sized computer systems which can also be used as multiuser computer systems. By this, we mean that a single computer can interact with more than one user at a time.

The AS/400 can be utilized for different business facets. Some models are designed as systems that provide resources to other computers, also known as a "server" in a network of computers, while others are set up for use with terminals or "display stations". OS400 is the operating system for the AS/400. The AS/400 computers offer more compatibility across the product line than the earlier System/3X computers. Hence, the earlier IBM models of the System/36 and System/38 have since been replaced by the AS/400 systems. The AS/400 utilizes a green screen interface, a built in database that resembles DB2, and a vast array of software to provide business solutions for today's business needs.

Much like the case of spatial data analysis, the integration of asset management software with a GIS offers new options for understanding the use of geographic data within a system. The similarities between the two technologies lie in their capacity to provide additional information about the data being used by the system and their ability to improve the GIS user's experience through enhanced results. Acceptance by the marketplace of asset management techniques gives a boost to understanding the potential value the technology may hold when integrated with a GIS.

CHAPTER 3 – METHODS AND DOPR CASE STUDY

This chapter discusses the development process of the web map as part of this thesis project. Section 3.1 details the data sources and how they were used. Section 3.2 presents the database design and how it could be created. Section 3.3 discusses data and how it was prepared. Section 3.4 explains how and asset management system needs to be used for DOPR.

3.1 Scope of the Study

In 2014 the County of Kauai (COK), decided the DOPR needed a more efficient system for managing and disseminating park information to assist staff with the planning, management, and maintenance of the park's assets. This task was given to the Park Planner, the author of this thesis. After investigating several software solutions for facilities maintenance which were discussed in Chapter 2, it was decided by management that the 2015 summer interns would actually inventory the 83 Park Facilities under the DOPR (Figure 4) to help DOPR to better understand the scope of their own assets, including items not in the Finance data e.g., showers, fire pits, etc. It was anticipated that a more efficient system would lead to better maintenance decision-making power, including the creation of maintenance evaluating options for selecting efficient solutions.

The DOPR is charged with operating, maintaining, developing and improving the County's parks, and with administrating and managing recreation facilities and programs. To accomplish this work, the DOPR is organized into seven divisions (Figure 5). The County of Kauai's Parks and Recreation Department contains over 83 parks of various sizes from large regional parks to small neighborhood parks that cover 783 acres and are spread over a distance of 63 miles. In addition to park lands, COK has a 107 acre, an 18-hole public golf course, two cultural preserves, three gymnasiums, two swimming pools, ten staffed neighborhood centers, two clubhouses, and the War Memorial Convention Hall, which has an exhibit hall and an auditorium.

Figure 4. DOPR's Parks Web Map (Beta)[3]

[3] Map by Garret Johnson, County of Kauai GIS Specialist for Access Data Base (2014).

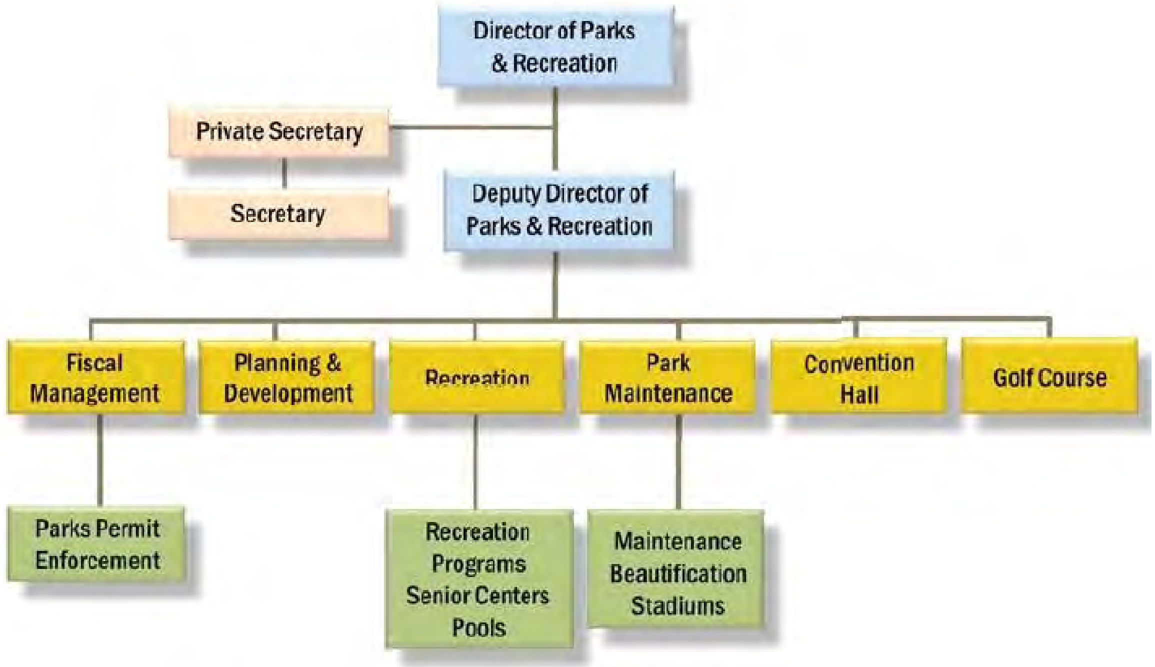


Figure 5 DOPR organizational chart. (Kauai Parks & Recreation Master Plan 2013)

The 1978 Kauai Parks and Recreation Master Plan used a classification system comprised of a four hierarchical levels: Neighborhood Park, Community Park, District Park and Regional Park. A park classification system facilitates efficient park system management by establishing different types of parks, each designed to provide a specific type of recreation experience or opportunity. This classification system was developed by the COK. The classification system was later changed in the 2013 Master Plan. The park classification system includes seven park types:

- Passive Parks
- Neighborhood Parks
- District Parks
- Regional Parks
- Beach Parks

- Linear Parks
- Special Use Parks

Passive Parks may include beautification area, mini parks, pocket parks, scenic overlooks, tot lots, play areas designated primarily for use by small children. Neighborhood Parks are the basic unit of the park system, serving as the recreational and social focus of the neighborhood. These parks provide a combination playground and open space area designed primarily for unstructured recreate activities. District Parks are oriented to the needs of several neighborhoods or large sections of the community. These parks usually have sports fields or similar facilities as a central focus although passive activities for individuals and families may be accommodated as well. Regional parks are recreational areas serving the county as a whole. They consolidate heavily programmed athletic fields and associated facilities. Because of their broad service area, regional parks are strategically located. Beach parks combine the natural environment with recreational use in an Oceanside setting. Linear parks are developed landscaped areas and other lands that follow linear corridors as paths for bicycles and pedestrian that are also known as shared use paths. They serve to connect individual parks or open spaces to form a cohesive system. In addition to the path itself, the linear park may provide rest areas, scenic overlooks, and interpretive or educational markers. Special use areas include public recreation areas or land occupied by special facilities which include a golf course, motocross, track and cultural preserves.

Historically the DOPR has used the Judicial District Boundaries for operations and maintenance and for capital improvement budgeting (Kauai Parks & Recreation Master Plan 2013). Figure 6 shows the Judicial District boundaries for the COK. In fiscal year 2012, the total operating budget was $12,715,081 (Kauai Parks & Recreation Master Plan 2013). The general allocations of the budget by divisions are shown in Figure 7.

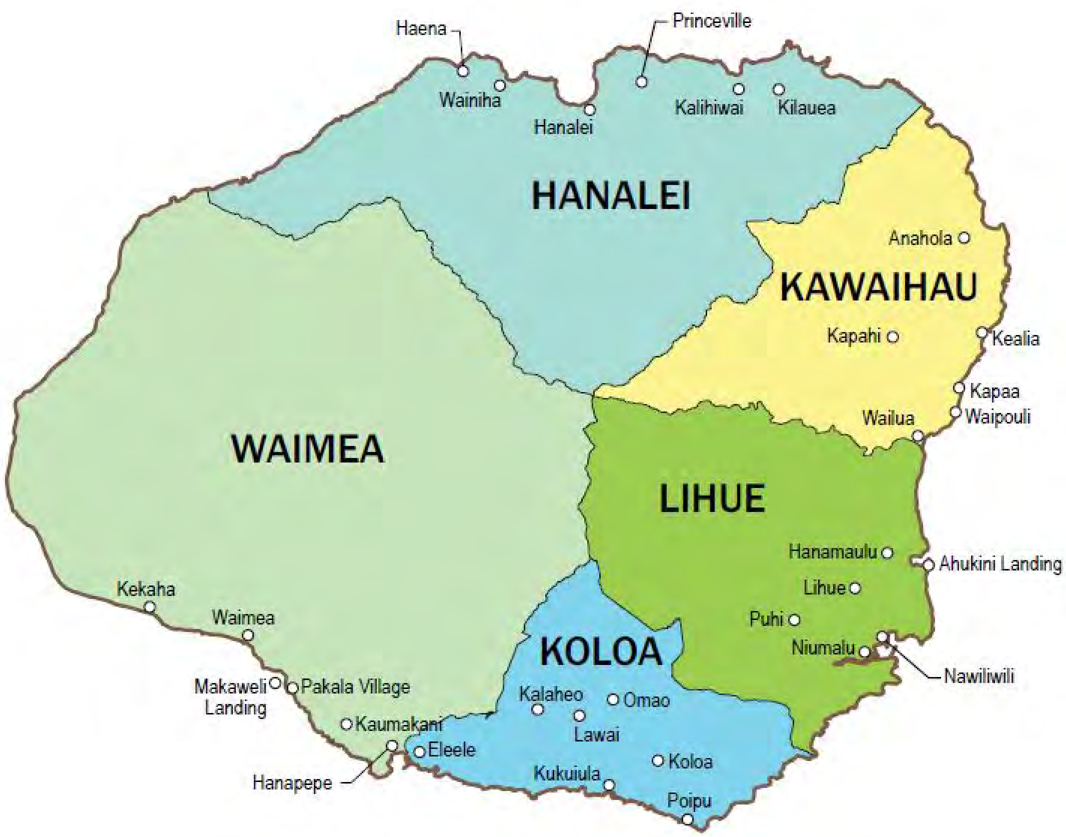


Figure 6 County of Kauai Judicial Districts. (Kauai Parks & Recreation Master Plan 2013)

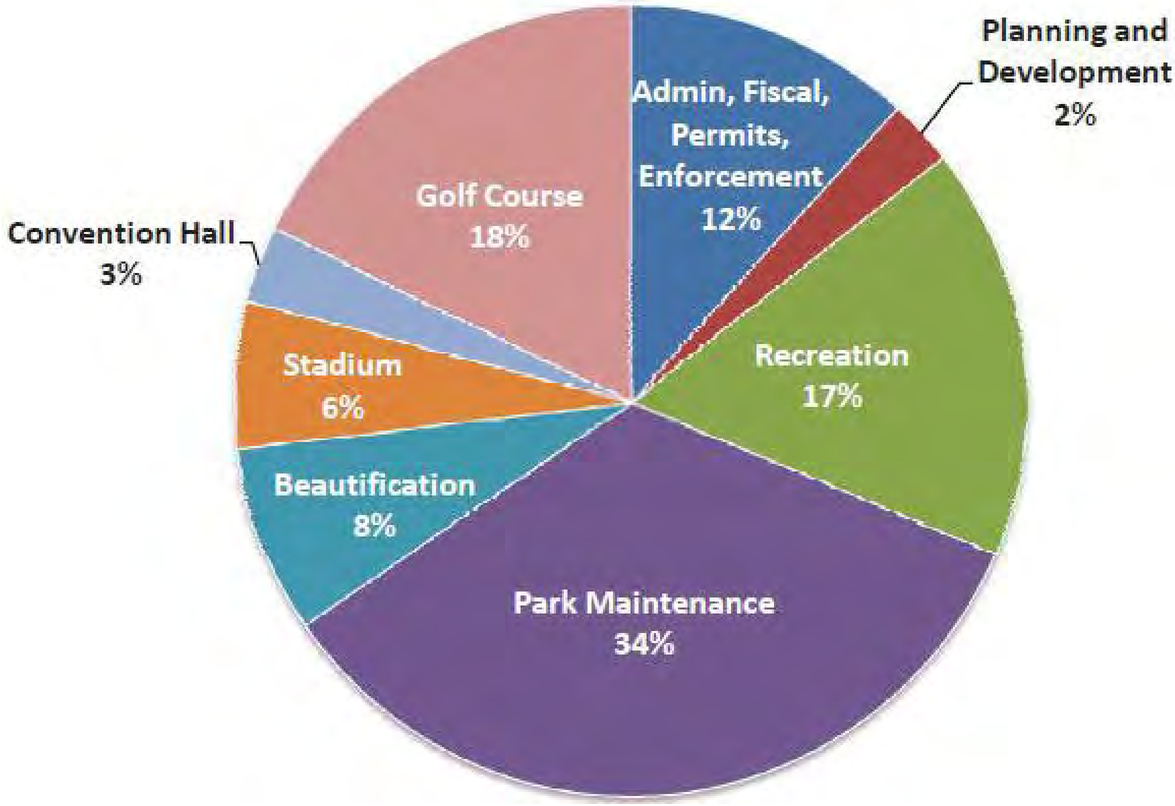


Figure 7 Budget Allocations by DOPR Division. (Kauai Parks & Recreation Master Plan 2013)

Using the classification system, Table 1 shows the number of parks and the recreation facilities by type. Table 2 lists the park types and size.

Table 1 Number of Existing Parks by Judicial District and Recreational Facilities by Park Type

		Hanalei	Kawaihau	Lihue	Koloa	Waimea	Kauai
Passive Park		1	2		1	1	5
Neighborhood Park		2	6	10	6	10	34
District Park			1	1	2	2	6
Regional Park				2			2
Beach Park		5	6	3	3	4	21
Linear Park			1				1
Special Use Area	**Cultural Preserve**	1			1		2
	Other Recreation Facility	1 Kilauea Gym	1 Kapaa Pool	2 Wailua Gold Course, Lihue Tennis Courts	1 Kalaheo Gym	2 Kaumakani Gym, Waimea Pool	7
	Neighborhood Centers*	2	2	2	2	5	13

*** Includes clubhouses and War Memorial Convention Hall.**

Table 2 Kauai Park Acreage by Type

	Hanalei	Kawaihau	Lihue	Koloa	Waimea	Kauai
Developed Park Land						
Passive Park	0.4	0.9		4.4	0.3	6.1
Neighborhood Park	10.1	45.3	32.9	26.3	38.4	152.9
District Park		18.1	2.7	32.4	38.3	91.4
Regional Park			68.6			68.6
Beach Park	33.8	34.8	16.4	12.4	35.5	132.9
Linear Park		11.3				11.3
Special Use Area	1.8	0.8	117.6	14.8	3.0	138.0
Sub-total Developed Acres	46.1	111.2	238.0	90.4	115.4	601.1
Undeveloped Park Land						
Passive Park						
Neighborhood Park		0.9	1.0			1.9
District Park		11.5				11.5
Regional Park			9.9			9.9
Beach Park	23.6		138.1			161.7
Linear Park			7.3			7.3
Sub-total Undeveloped Acres	23.6	12.4	156.3	0.0	0.0	192.2
Total Acres	69.7	123.6	394.3	90.4	115.4	793.3

Before going out into the field, several steps were taken, similar to archeological inventory surveys. DOPR was allotted two summer interns who were college age students attending higher education either on the mainland or local colleges. Having only two interns is advantageous in that the variables of implementation are easier to control and errors are minimum. The two intern's background were both in the medical technology field. The summer interns reviewed the existing information including a hard copy of the DOPR Master Plan. The interns were also given access and hard copies of the Department of Finance’s Asset listings for DOPR (items valued over $1,500), the Department of Public Works (PW) listing of facilities, a listing of facilities under DOPR obtained from the Park Rangers, that can be reserved on temporary basis, and an MS Access database that was created by a consultant as part of the DOPR Master Plan in 2014. DOPR became a separate Department from PW in 2008, but many of the maintenance functions needs specialty labor that is still managed by PW which generates Work Orders in the AS400 system. The MS Access database was created by the consultants of the DOPR Master Plan with the authors help to serve as the primary repository of tabular data detailing infrastructure, asset, and park land information, i.e. executive orders on how the COK got the land, construction plans, and plot plans of the park. The interns were also given a hard copy of the DOPR Master Plan.

The next step was the field inventory of the assets. The interns started their work on June 17th and completed their inventory on July 31st, 2015. The inventory required the physical inspection of each DOPR facility or park in the listing and then the development of a methodology for conducting the survey. The interns were given a DOPR Sony digital camera, a measuring wheel to document size of built facilities, and they used their own smart phone (iPhone 5s) GPS locators on the utilities compass application. The OS versions are not known to the author. One intern primarily did the GPS and photographs task while the other intern did the measurements. To make this systematic, the interns started in the northern portion of each property. GPS points were taken on the northern corners of facilities were possibly. The interns walked the entire park area, taking photographs of all assets (fire pits, water fountains, benches, picnic tables) but only taking GPS points at the facilities. Only GPS point data were taken.

Figure 8 Access Database of DOPR facilities

Figure 9 Example of the Access Database Structure

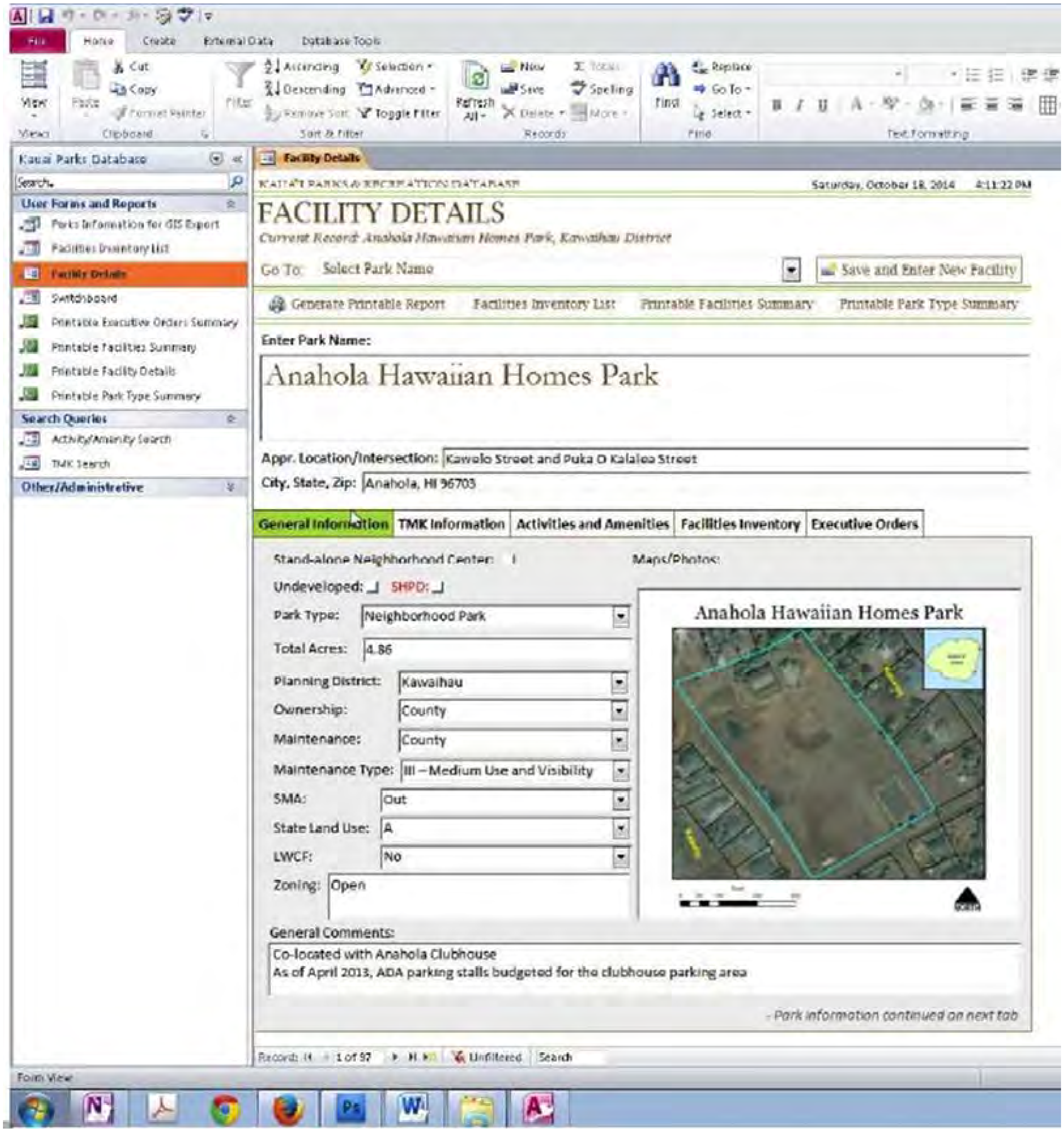


Figure 10 Detail from the Access Database of Information about Anahola Hawaiian Homes Park

The third step was the recording of the findings. The interns recorded their information in an excel spreadsheet, attach photographs of the facilities, signs and anything noteworthy. They were given access to the DOPR shared V drive and organized folders for their work together. The spreadsheet was worked on together via their Dell laptop computer once back in the office and connected to the COK server. GPS locations were taken at the points of the buildings that in the furthest north corner of each facility in order to improve the geo-referencing of each facility on a basemap be consistent. All 83 DOPR facilities were inventoried and mapped by overlaying on Pictometry (Pictometry International Corporation) high resolution ortho-imagery as the basemap used in this project. Pictometry is a provider of oblique geo-referenced aerial imagery and measuring software.[4]

Figure 11 DOPR intern with measuring wheel at a comfort station in Anini Beach Park

[4] https://pol.pictometry.com/en-us/app/login.php

Problems developed with the attachment of photographs to the Excel spreadsheet, as the pixel size and quantity of photos per park became too large and caused the Excel program to shut down. The photos were later downloaded to a separate folder on the COK server (Figure 14). Excel was designed to be an individual productivity tool, not an enterprise system.

Once the inventory of all 83 facilities was completed, the interns' task was to create plot plans (overview maps), correlate the data from the other referenced material and label the facilities. They were not familiar with Esri ArcGIS so they created their plot plans on the COK Pictometry. Pictometry imagery. Using spatial tools supplied by the Pictometry software, users may measure geographic details directly from the photos such as distance, height, and latitude/longitude coordinates. Using the GPS locational information, the interns then visually (manually) searched the Pictometry imagery to identify assets in facilities, labeled these, then printed hardcopies. Interns were also responsible for saving and labeling picture files on the COK server, mentioned above. This inventory assessment was conducted to define DOPR's needs for the asset management program. This included an inventory of existing field inventory, but did not include the correlation or matching of the data from Finance (Figure 16) and Public Works (PW) (Figure 17) to the interns' new inventory of DOPR's assets. At the time this research was conducted, correlation of all of this information was not feasible with the interns limited time.

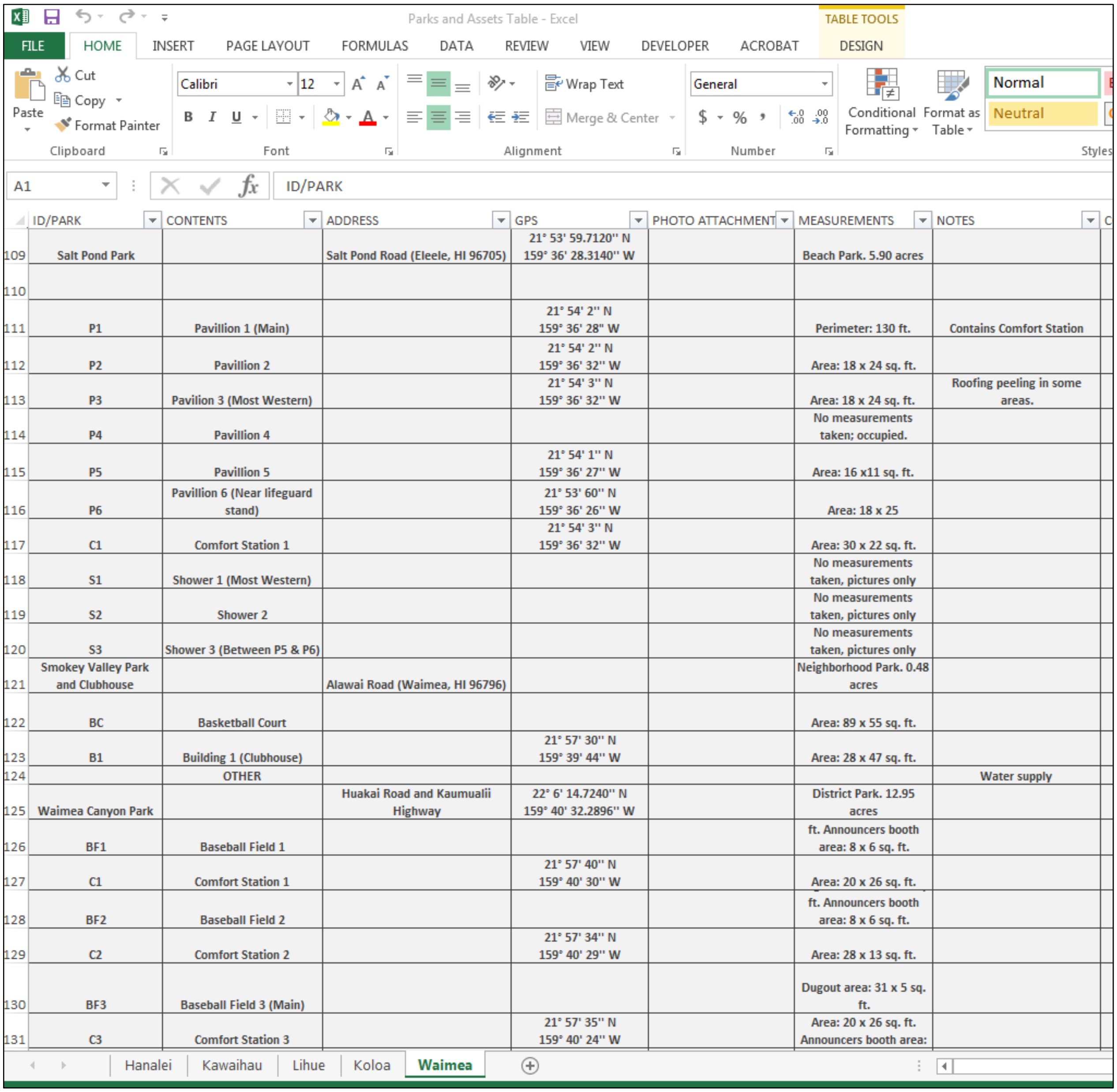
H14

	A	B	C	D	E	F	G	H
1	ID/PARK	CONTENTS	ADDRESS	GPS	PHOTO ATTACHMENT	MEASUREMENTS (ESTIMATES	NOTES	CORRELATI(
2	HANALEI DISTRICT							
3	Anini Beach Park		Anini Road (Kilauea, HI 96754)	22° 13' 23.5560" N 159° 27' 46.7928" W		Beach Park. 12.54 acres		
4	P1	Pavilion 1		22° 13' 21" N 159° 27' 2" W		Area: 27 x 14		
5	P2	Pavilion 2		22° 13'26" N 159° 26' 45" W		Area: 16 x 11		
6	P3	Pavilion 3		22° 13' 27" N 159° 24' 52" W		Area: 24 x 18		
7	C1	Comfort Station 1		22° 13' 26" N 159° 26' 47" W		Area: 27 x 25		
8	C2	Comfort Station 2		22° 13' 29" N 159° 26' 59" W		Area: 24 x 22		
9	C3	Comfort Station 3		22° 13' 29" N 159° 27' 2" W		Area: 24 x 22		
10	S1	Shower 1		22° 13' 23" N 159° 26' 54" W		No measurements taken, pictures only.		
11	S2	Shower 2		22° 13' 26" N 159° 26' 48" W		No measurements taken, pictures only.		
12	S3	Shower 3		22° 13' 27" N 159° 26' 51" W		No measurements taken, pictures only.		
13	S4	Shower 4		22° 13' 29" N 159° 26' 58" W		No measurements taken, pictures only.		
14	S5	Shower 5		22° 13' 29" N 159° 27' 5" W		No measurements taken, pictures only.		
15	S6	Shower 6				No measurements taken, pictures only.		
16		OTHER					Water fountains, sinks, benches, etc.	
17	Haena Beach Park		Kuhio Highway (Hanalei, HI 96714)	22° 13' 11.6724" N 159° 33' 58.0608" W		Beach Park. 8.07 acres		
18	C1	Comfort Station 1		22° 13' 12" N 159° 33' 59" W		Area: 27 x 24 ft.		

Hanalei | Kawaihau | Lihue | Koloa | Waimea

READY

Figure 12 Parks Assets Inventory Complied Summer 2015 by Summer Intern, screenshot of excel spreadsheet Anini Beach Park



	ID/PARK	CONTENTS	ADDRESS	GPS	PHOTO ATTACHMENT	MEASUREMENTS	NOTES
109	Salt Pond Park		Salt Pond Road (Eleele, HI 96705)	21° 53' 59.7120" N 159° 36' 28.3140" W		Beach Park. 5.90 acres	
110							
111	P1	Pavillion 1 (Main)		21° 54' 2" N 159° 36' 28" W		Perimeter: 130 ft.	Contains Comfort Station
112	P2	Pavillion 2		21° 54' 2" N 159° 36' 32" W		Area: 18 x 24 sq. ft.	
113	P3	Pavilion 3 (Most Western)		21° 54' 3" N 159° 36' 32" W		Area: 18 x 24 sq. ft.	Roofing peeling in some areas.
114	P4	Pavillion 4				No measurements taken; occupied.	
115	P5	Pavillion 5		21° 54' 1" N 159° 36' 27" W		Area: 16 x11 sq. ft.	
116	P6	Pavillion 6 (Near lifeguard stand)		21° 53' 60" N 159° 36' 26" W		Area: 18 x 25	
117	C1	Comfort Station 1		21° 54' 3" N 159° 36' 32" W		Area: 30 x 22 sq. ft.	
118	S1	Shower 1 (Most Western)				No measurements taken, pictures only	
119	S2	Shower 2				No measurements taken, pictures only	
120	S3	Shower 3 (Between P5 & P6)				No measurements taken, pictures only	
121	Smokey Valley Park and Clubhouse		Alawai Road (Waimea, HI 96796)			Neighborhood Park. 0.48 acres	
122	BC	Basketball Court				Area: 89 x 55 sq. ft.	
123	B1	Building 1 (Clubhouse)		21° 57' 30" N 159° 39' 44" W		Area: 28 x 47 sq. ft.	
124		OTHER					Water supply
125	Waimea Canyon Park		Huakai Road and Kaumualii Highway	22° 6' 14.7240" N 159° 40' 32.2896" W		District Park. 12.95 acres	
126	BF1	Baseball Field 1				ft. Announcers booth area: 8 x 6 sq. ft.	
127	C1	Comfort Station 1		21° 57' 40" N 159° 40' 30" W		Area: 20 x 26 sq. ft.	
128	BF2	Baseball Field 2				ft. Announcers booth area: 8 x 6 sq. ft.	
129	C2	Comfort Station 2		21° 57' 34" N 159° 40' 29" W		Area: 28 x 13 sq. ft.	
130	BF3	Baseball Field 3 (Main)				Dugout area: 31 x 5 sq. ft.	
131	C3	Comfort Station 3		21° 57' 35" N 159° 40' 24" W		Area: 20 x 26 sq. ft. Announcers booth area:	

Figure 13 Screenshot of Excel Spreadsheet for Salt Pond Park and other Parks in Waimea District

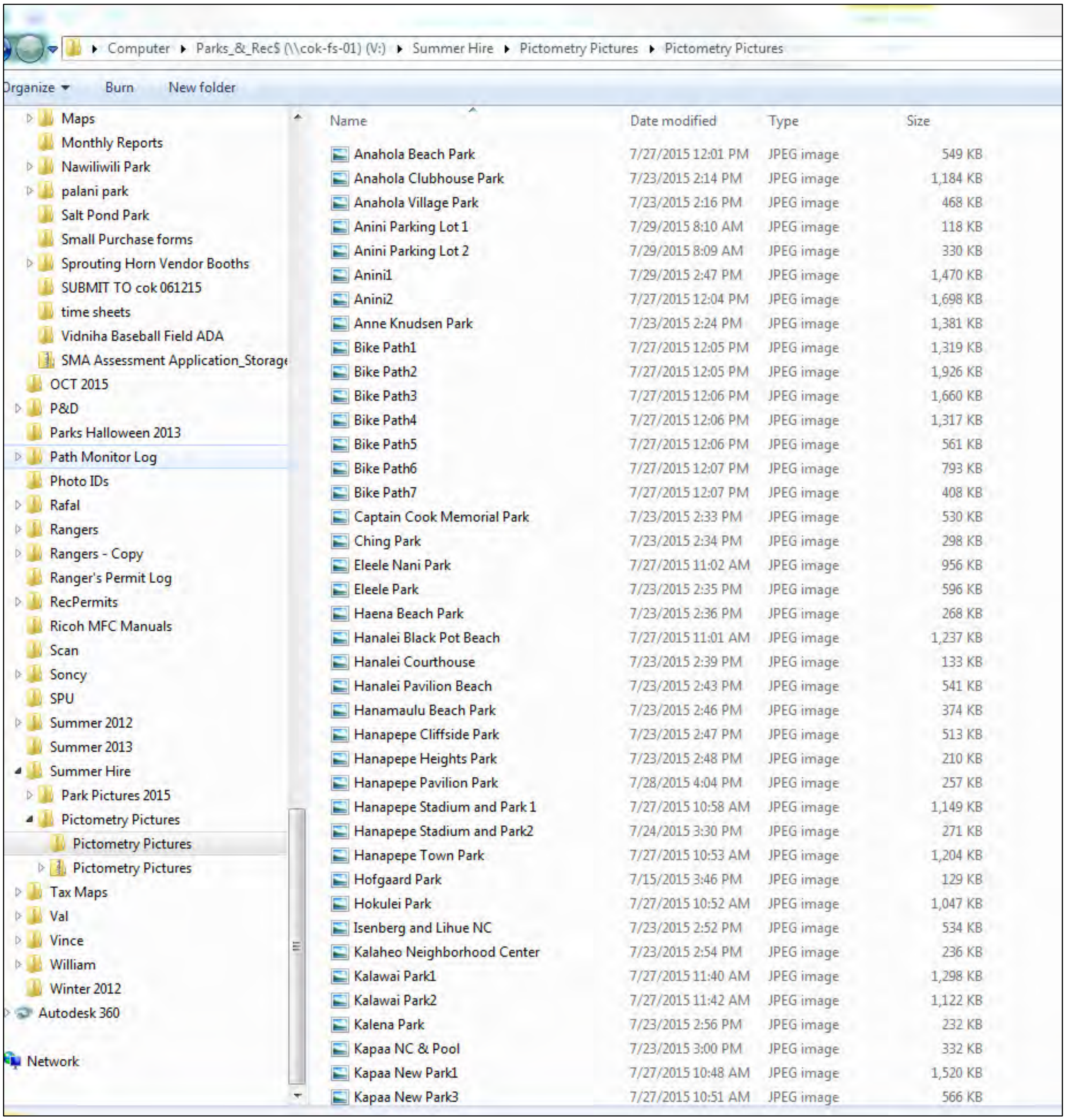


Figure 14 Screenshot of Pictometry maps and photo file on the COK server

3.2 Database Design

The design of the database structure is very important. For a GIS database, it is impossible to record all the detailed features and attributes of the site. Therefore, it is very important to identify the information needed. Infrastructure asset data are typically identified, associated with, or referenced by their geographic locations and spatial relationships. As a result, GIS and spatial data analysis can support asset management processes (Halfway and Figueroa, 2006). Advances in information technology have made GIS powerful and cost-effective tools for land analysis, planning, and management. Arlinghaus (1994), stated the advantages of using GIS tools:

- Ease and speed of map revision and map scale changes
- Inexpensive production of short-run special purpose maps
- Potentially greater mapping accuracy
- Changes in the database are immediately reflected in digital map
- Spatial analysis

There are four main components of GIS application software: geographic processing, RDMS (relational database management system), spatial analysis utilities, and graphic user interface (GUI). The goals and objectives are critical in determining the data that will be recorded in the GIS database. Relationships must be established correctly between spatial feature classes and non-spatial feature classes. When data are plotted correctly, classes of both spatial and non-spatial features will be accessible in GIS. This strategy combines a CMMS with a GIS geodatabase, creating the foundation for an EAM approach. The DOPR's strategic plan emphasizes the enterprise approach to GIS with the interdepartmental sharing of data meeting the needs of many departments. The DOPR's ultimate goal is cost effective business processes in the managing of infrastructure assets (Zhao and Stevens, 2009). It is the purpose of a geographic information system to provide the right information to the right people at the right times.

Figure 15 presents the GIS database structure tree for this project. The GIS database includes eight layers (e.g., Facilities, Land Use, Basemap), and each layer includes a number of feature classes (graphic data), other tables (non-graphic data), and a series of relationships among the tables. Each feature class (point, line or polygon) is managed as a single table. A GIS database includes a large amount of spatial data (graphic) linked with relevant tabular data (non-graphic).

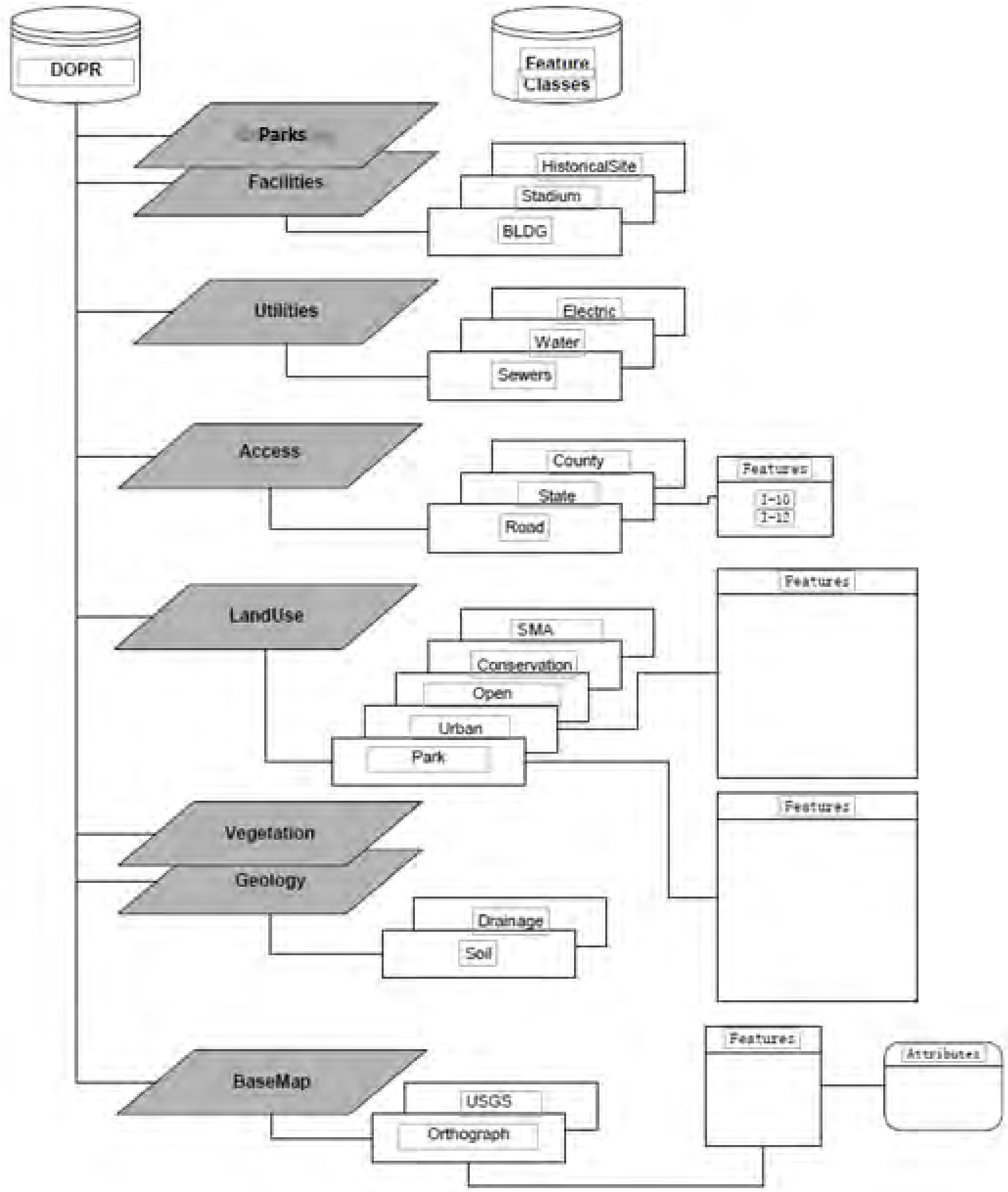


Figure 15 GIS Database Structure Tree Designed for This Project

The SQL-based ArcGIS geodatabase could serve as the basis for COK-wide enterprise system integration. Ideally an open platform database structure makes it possible for the COK's GIS system to integrate with other systems e.g., AS 400. Such integration is essential to make the most of enterprise GIS (Zhao and Stevens, 2009).

With the present state of GIS software and technology, GIS has not been used extensively to capture this information at COK. Some of this information is already in an Access format. As location is an important property of all assets, it has served COK in many projects in the past as the common platform used for data integration. GIS software and related functionalities can alternatively access these databases as external software that enhances the analytical and reporting capabilities of the system.

An important aspect of the database development is the relationship between the abstract classes and the other asset feature classes. Abstract classes are those that cannot be instantiated and cannot be used on their own but must be first inherited by a feature class. When a feature class is linked to the abstract classes that feature class inherits the abstract class attributes. Table 3 shows an example list for DOPR from which spatial feature classes and attributes can be generated. Another aid for the integration and interoperability of databases is the use of commonly accepted data definitions and consistent formats across systems. A standard data dictionary or global standard for data definition, representation, storage and communication is vital to the effort of data integration, regardless of the integration strategy implemented.

Table 3 Asset List Example

Asset Type	Data Attribute	Asset Type	Data Attribute
Park	Location (Longitude, latitude) and type	Convention Hall	Location (Longitude, latitude)
	Elements		Facilities
	Fire Pits		Description
	Picnic Tables		Dimensions
	Camp Sites		Cost
	Benches		Elements
	Walkways		Walkways
	surfaces		surfaces
	Facilities		Maintenance activities
	Description		Condition Measure
	Dimensions		
	Cost	Gyms	Location (Longitude, latitude)
	Maintenance activities		Elements
	Condition Measure		Lockrooms
			Benches
Swimming Pools	Location (Longitude, latitude)		Walkways
	Facilities		surfaces
	Description		Facilities
	Dimensions		Description
	Cost		Dimensions
	Elements		Cost
	Benches		Maintenance activities
	Walkways		Condition Measure
	surfaces		
	Condition Measure	Neighborhood Centers	Location (Longitude, latitude)
	Maintenance activities		Elements
			Benches
Golf Course	Location (Longitude, latitude)		Walkways
	Facilities		surfaces
	Description		Facilities
	Dimensions		Description
	Cost		Dimensions
	Elements		Cost
	Tees		Maintenance activities
	Benches		Condition Measure
	Walkways		
	surfaces		
	Condition Measure		
	Maintenance activities		

In the GIS database design, metadata, or additional data used to describe data, plays a key role reflected in several aspects of data. A significant lesson learned is that at the beginning of the GIS database design, it is necessary to think thoroughly about some aspects of the metadata, which include the spatial reference, data organization information, and entity and attribute information. Gunther and Voisard (1997) speak of the value of metadata by describing methods for collecting data, modeling data, and detailing the collection of international standards available for organizing metadata. Metadata is collected during the processes of data capture, data aggregation, data storage and data analysis, each process the authors describe in detail. These procedures create additional attributes that define the initial data set for a user who may not be familiar with the collection methods, accuracy requirements or modifications made to the original data by the authorizing organization. Metadata is also useful in its ability to solidify such data standards as naming conventions and relationship definitions.

3.3 Populating the Database

In order to manage, edit, and update DOPR information, a custom MS Access database was developed by consultants who worked on the COK DOPR Master Plan 2014. A synchronizing function was not built into the MS Access database to update the GIS features. If this is accomplished in the future, this would allow multiple park staff to maintain data without having to do the edit using ArcMap, in ArcEditor mode. Once updates are completed in the database the results could then be automatically shown using the identify function in an ArcGIS Server Pro or ArcGIS.com. This functionality would provide real time access to the most current database information using this new DOPR Land and Asset Information System, if it could be built. Currently only three staff have access to to update the existing DOPR MS Access database, which is a free standing database not tied into the Kauai's GIS system, which also has a limited number of staff who have clearance to access it.

In the future the development of a web mapping application needs to be developed to integrate and deliver DOPR's large format e.g., CAD plans, documents and photographs. This functionality could be created by modifying the ArcGIS Server, Pro or ArcGIS.com identify tool which creates a custom hyperlink query to photos stored on a server and documents stored in

IBM's Content Manager. A list of photographs and a hyperlink to search for documents could be developed using ArcGIS Server, Pro or ArcGIS.com, HTML and JSP. Also a list of general park information including location, area and maintenance zone is available on the page. By clicking on the "Imaged Documents" hyperlink a new window will open with the list of documents from the IBM Content Manager application. These documents could then be easily sorted by clicking on the field name and then viewed by selected a specific document.

3.4 Use and Maintenance

The development of the database is the most time-consuming and costly aspect of the GIS implementation, and the data import and conversion are long–term and continuous operations. Ideally DOPR wants an inventory of their assets and facilities in the near future, and this information needs to tie into the existing Finance database of assets which documents facilities lifecycle. Figure 11 provides a screenshot of the finance inventory for DOPR. The summer intern attempted to correlate the finance data to their data but it proved to be complex for the interns to match id numbers of assets and text descriptions of the assets. Figure 12 is the inventory list from PW on DOPR facilities. DOPR also has requested that their new asset management program be integrated with the AS/400 system which runs the PW work orders. Most of the software systems reviewed in Chapter 2, can independently generate work orders that are accessible on mobile applications a functionality that the AS400 system does not provide. Most of these software do not work with AS/400 directly, such as supporting input/output export. It would require another contract with programmers from those software companies and the COK Information Technology (IT) to update the existing user interface. Users of any system would also have to maintain this new interface afterward in order for accurate reports to be generated. Users would be most of the management staff and workers who had computer access.

Figures 16 - 21 display the existing interface of the COK AS/400, also referred as the green screen. It is menu driven, no text can be added, no pictures attached, no cloud base service, and is not a readily searchable database unless the users knows exactly what to search for. Although the COK supervisors and other employees would like to have a new software interface that works with AS/400 now, given the budget and integration permissions needed from COK IT, it will not be possible to complete this action at the present time.

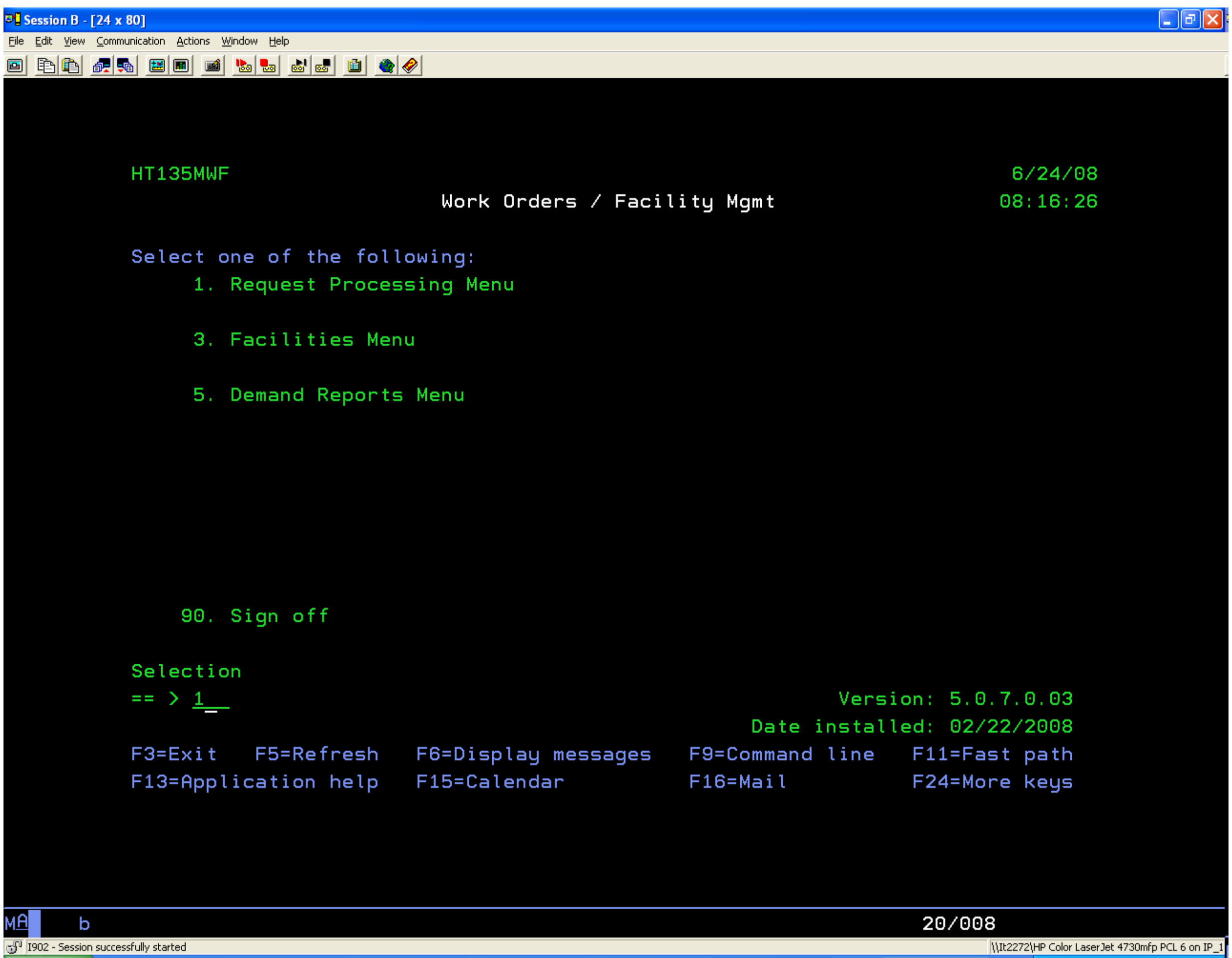


Figure 16 Screen shot of AS400 "Green Screen" Work Orders

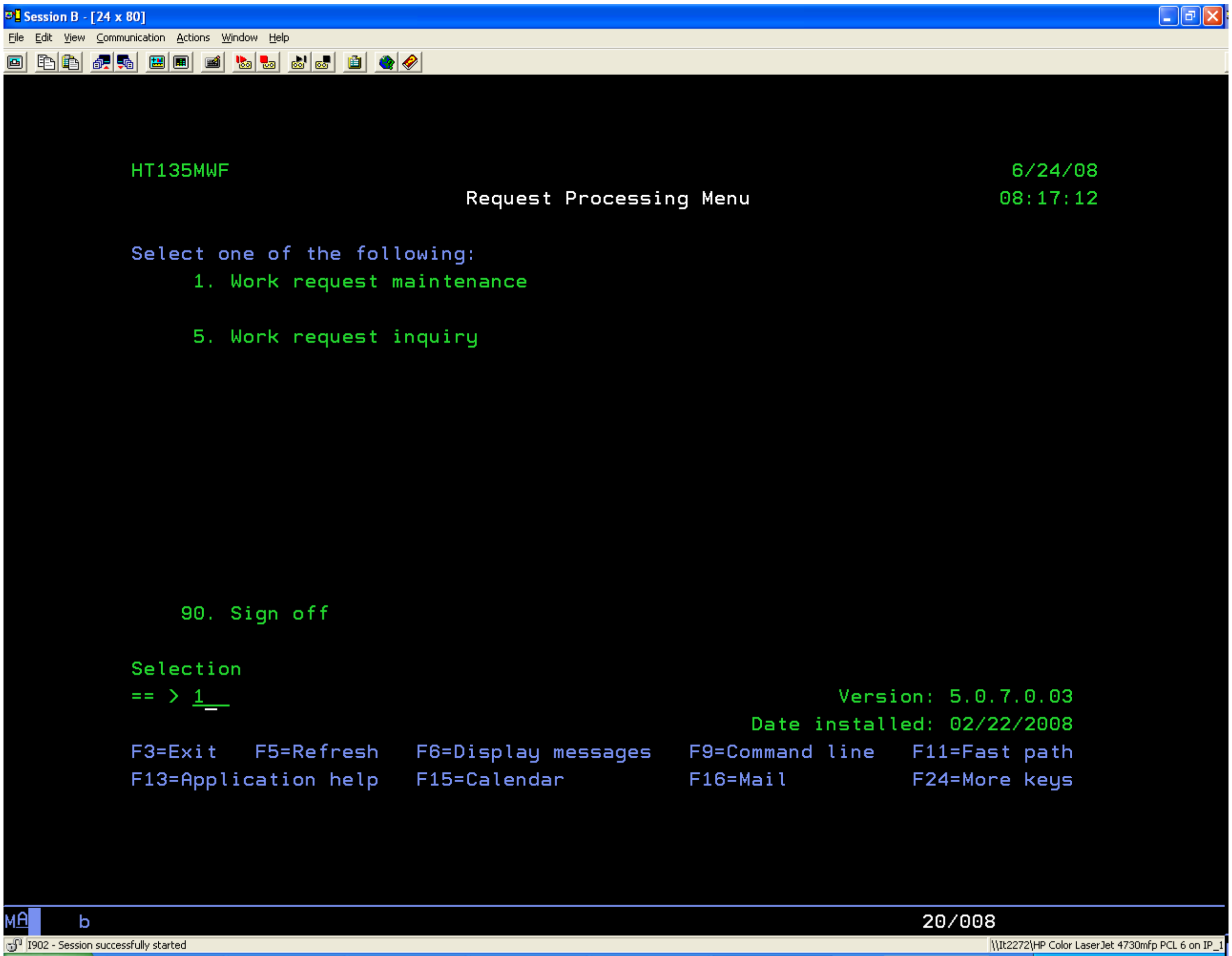


Figure 17 Screen shot of Work Order Request

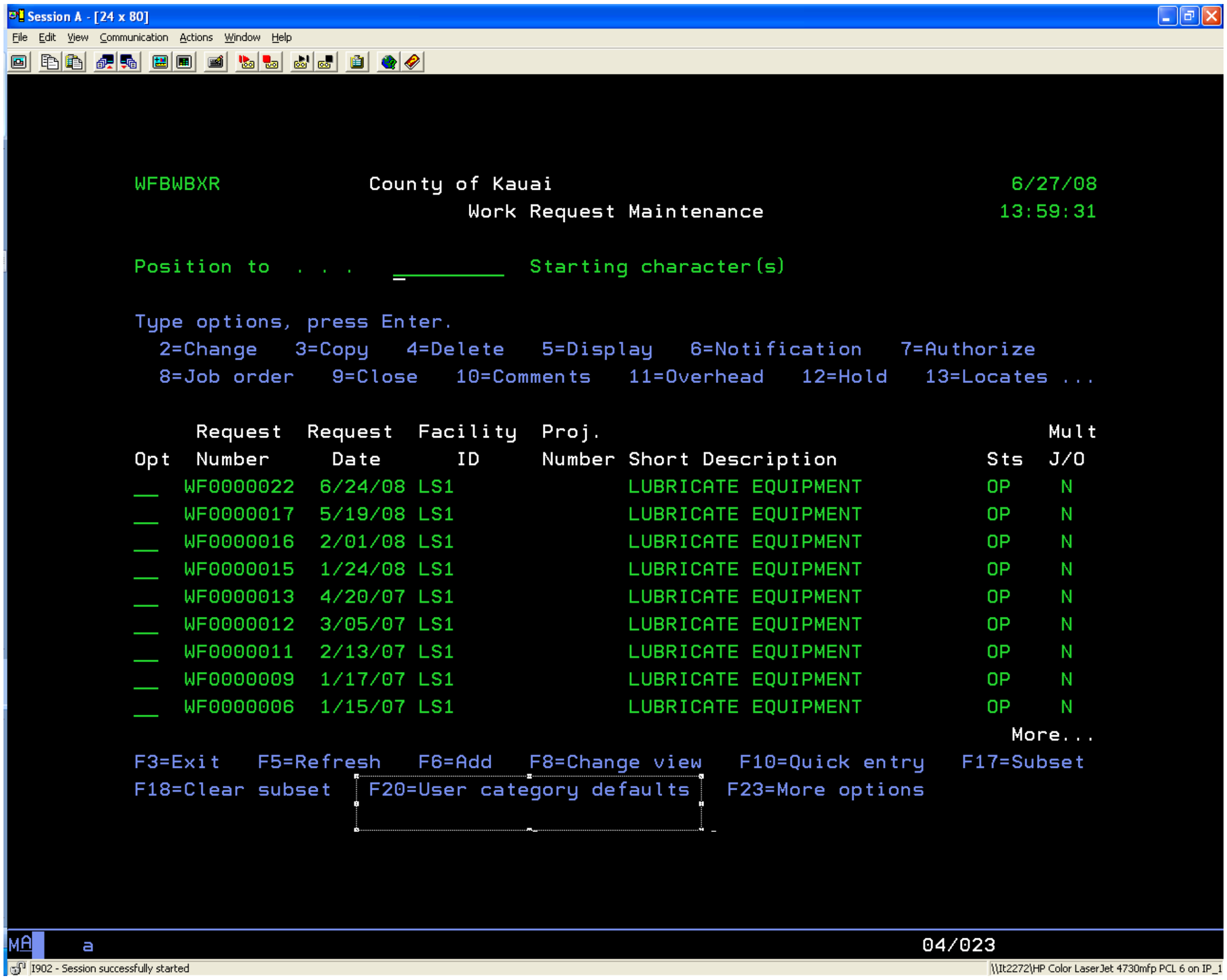


Figure 18 Screen shot of coding list

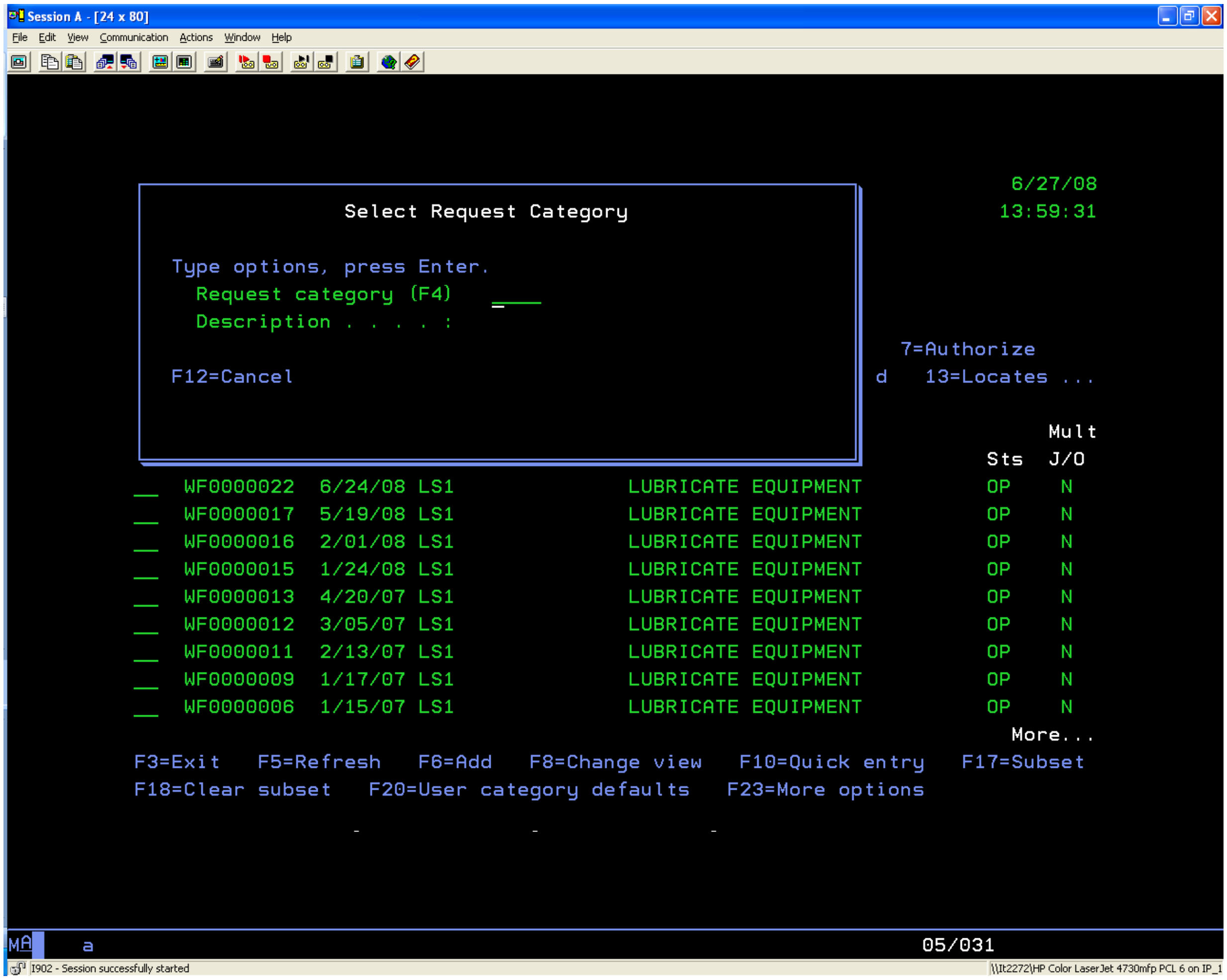


Figure 19 Screen shot of Category Selection

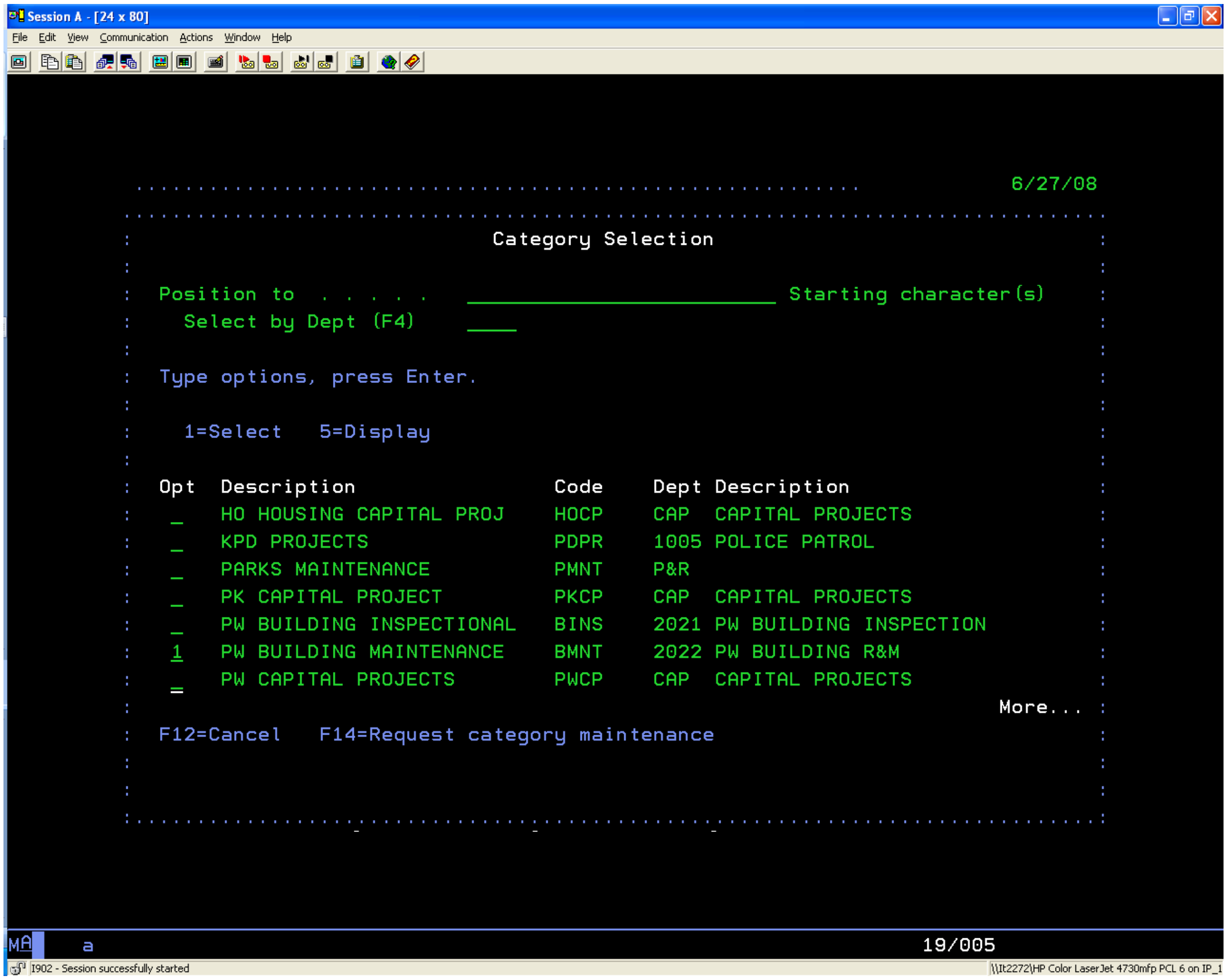


Figure 20 Screen shot of Department listing

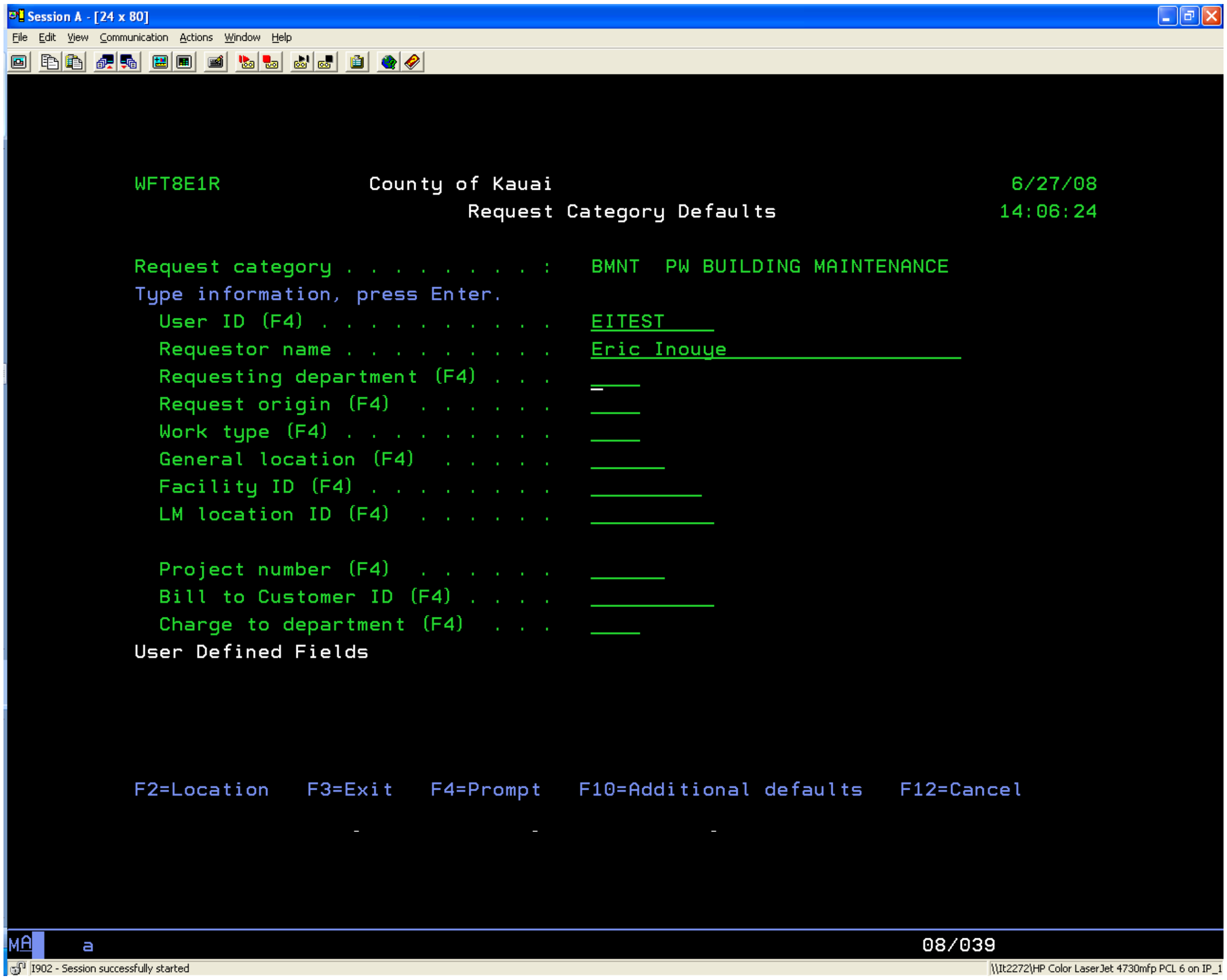


Figure 21 Screen shot of the Work Order Request form on AS400

Row	ASSET NO.	ITEM LOC	LOCATION	TAX MAP KEY	TYPE CONSTRUCTION	AREA	REPLACEMENT	COVERAGE	COST	DATE	CONTRACT	UNIT $	
347	91003070	041001	NAWILIWILI PARK COMFORT	3-2-04-05	HOLLOW TILE, BUILT-UP ROOF	190	32,300	40,000	3,026	1/1/1965		170	-24%
348													
349	91003071	042001	NIUMALU PARK PAVILION	3-2-02-01	WOOD FRAMED, ASPHALT SHINGLE ROOF	1,570	188,400	210,000	44,190	1/1/1978		120	-11%
350		042002	NIUMALU PARK SHOWER FACILITY	3-2-02-01		96 SF							
351													
352	91003162	066001	WAIKOMO PARK COMFORT STATION	2-8-26-01	HOLLOW TILE, ASPHALT SHINGLE ROOF	200	34,000	65,000	4,160	1/1/1967		170	-91%
353													
354		630001	WELIWELI PARK COMFORT STATION	2-8-22-14	HOLLOW TILE, ASPHALT SHINGLE ROOF	464	78,880	75,000				170	5%
355		630002	WELIWELI PARK PAVILIONS	2-8-22-14	WOOD FRAME, ASPHALT SHINGLE ROOF	140	13,300					95	100%
356		630003	WELIWELI PARK PAVILIONS	2-8-22-14	WOOD FRAME, ASPHALT SHINGLE ROOF	140	13,300					95	100%
357		630004	WELIWELI PARK PAVILIONS	2-8-22-14	WOOD FRAME, ASPHALT SHINGLE ROOF	140	13,300					95	100%
358		630005	WELIWELI PARK PAVILIONS	2-8-22-14	WOOD FRAME, ASPHALT SHINGLE ROOF	140	13,300					95	100%
359		630006	WELIWELI PARK PAVILIONS	2-8-22-14	WOOD FRAME, ASPHALT SHINGLE ROOF	140	13,300					95	100%
360													
361	91003080	47001	POIPU BEACH PARK COMFORT STATION - EAST	2-8-17-01	HOLLOW TILE, ASPHALT SHINGLE ROOF	800	186,000	180,000	186,000	1/1/1997	C5488	233	3%
362	5821	47002	POIPU BEACH PARK PAVILION - EAST B	2-8-17-01	WOOD FRAMED, ASPHALT SHINGLE ROOF	400	34,400	35,000	34,250	1/1/1997	C5488	86	-2%
363	5825	47003	POIPU BEACH PARK PAVILION - WEST A	2-8-17-01	WOOD FRAMED, ASPHALT SHINGLE ROOF	400	43,600	35,000	43,463	1/1/1997	C5488	109	20%
364	5822	047004	POIPU BEACH PARK PAVILION - EAST LARGE	2-8-17-01	WOOD FRAMED, ASPHALT SHINGLE ROOF	1,000	91,000	35,000	91,400	1/1/1997	C5488	91	62%
365	5823	047005	POIPU BEACH PARK PAVILION - EAST C	2-8-17-01	WOOD FRAMED, ASPHALT SHINGLE ROOF	400	34,400	35,000	34,250	1/1/1997	C5488	86	-2%
366	91003085	047006	POIPU BEACH PARK PAVILION AND COMFORT STATION	2-8-17-01	HOLLOW TILE, ASPHALT SHINGLE ROOF	1,320	224,400	35,000	13,800	1/1/1949	DAMAGED	170	84%
367													
368	91003079	046001	KOLOA NEIGHBORHOOD CENTER	2-8-08-17	HOLLOW TILE, SHAKE ROOF	5,200	780,000	1,300,000	106,682	1/1/1976		150	-67%
369													
370	91003075	044001	KOLOA PARK COMFORT STATION	2-8-05-04	HOLLOW TILE, ASPHALT SHINGLE ROOF	187	31,790	50,000	3,086	1/1/1963		170	-57%
371	91003076	044002	KOLOA PARK CONCESSION STAND	2-8-05-04	HOLLOW TILE, METAL ROOF	400	40,000	25,000	8,471	1/1/1976		100	38%
372	91003077	044003	KOLOA PARK ANNOUNCER BOOTH	2-8-05-04	WOOD FRAMED, METAL ROOF	96	19,200	20,000	2,040	1/1/1973		200	-4%
373	91003078	044004	KOLOA PARK ANNOUNCER BOOTH	2-8-05-04	WOOD FRAMED, METAL ROOF	96	19,200	20,000	2,040	1/1/1973		200	-4%
374	91003148	044005	KOLOA PARK COMFORT STATION	2-8-05-04	HOLLOW TILE, ASPHALT SHINGLE ROOF	500	85,000	125,000	10,796	1/1/1973		170	-47%
375	91003149	044006	KOLOA PARK STORAGE SHED	2-8-05-04					2,226	1/1/1973			
376	91003201	044007	KOLOA PARK STORAGE BUILDING	2-8-05-04					13,356	1/1/1973			
377	91007002	044008	KOLOA PARK SHELTER PICNIC TABLE	2-8-05-04	WOOD FRAMED, METAL ROOF	1,648	115,360	110,000	3,710	1/1/1973		70	5%
378		044009	KOLOA PARK DUGOUT - LITTLE LEAGUE FIELD	2-8-05-04	WOOD FRAMED, METAL ROOF	180	13,500	12,000				75	11%
379		044010	KOLOA PARK DUGOUT - LITTLE LEAGUE FIELD	2-8-05-04	WOOD FRAMED, METAL ROOF	180	13,500	12,000				75	11%
380		044011	KOLOA PARK DUGOUT - PONY LEAGUE FIELD	2-8-05-04	WOOD FRAMED, METAL ROOF	180	13,500	12,000				75	11%
381		044012	KOLOA PARK DUGOUT - PONY LEAGUE FIELD	2-8-05-04	WOOD FRAMED, METAL ROOF	180	13,500	12,000				75	11%
382		044013	KOLOA PARK DUGOUT - SOFTBALL FIELD	2-8-05-04	WOOD FRAMED, METAL ROOF	160	12,000	10,000				75	17%
383		044014	KOLOA PARK DUGOUT - SOFTBALL FIELD	2-8-05-04	WOOD FRAMED, METAL ROOF	160	12,000	10,000				75	17%
384		044015	KOLOA PARK BLEACHERS	2-8-05-04	WOODEN FRAME	119	2,261					19	100%
385		044016	KOLOA PARK BLEACHERS	2-8-05-04	WOODEN FRAME	119	2,261					19	100%
386		044017	KOLOA PARK BLEACHERS	2-8-05-04	WOODEN FRAME	119	2,261					19	100%
387		044018	KOLOA PARK BLEACHERS	2-8-05-04	WOODEN FRAME	119	2,261					19	100%
388		044019	KOLOA PARK BLEACHERS	2-8-05-04	WOODEN FRAME	119	2,261					19	100%
389		044020	KOLOA PARK BLEACHERS	2-8-05-04	WOODEN FRAME	119	2,261					19	100%

Facility List

READY AVERAGE: 3602795.591 COUNT: 78 SUM: 183742575.2

Figure 22 Facilities for Parks by Finance's List

Status	DPT	DIV	Asset No	Imp No	Type	Asset Item Description	Loc Code	Location Description	Acq Cd	Acq Month	Acq Day	Acq YR	Life Mon	Mon To Dt	Calc Cd	Salv Va
A	30	21	00004419	5	050	REC PI'IKOI 342 SQ FT 1.14%	034005	NEW COUNTY COMPLEX BLD C	CO	10	31	1993	480	232	C	$0
A	30	21	00006449	0	040	BLEACHERS, PORTABLE ALUMINUM 3 ROW 15' (2)	051001	KALAHEO NGH CTR BLD A	CO	2	19	1999	0	0	C	$0
A	30	21	00007196	0	400	HEATER, COMMERCIAL DELUXE GAS WATER	059011	HANAPEPE REC CENTER	PC	6	8	2000	0	0	C	$0
A	30	21	00007710	0	27A	CPU, COMPUTER PENTIUM III, DELL MINI TOWER	034004	NEW COUNTY COMPLEX BLD B	PC	3	5	2001	0	0	C	$0
A	30	21	00007808	0	27G	SATTELITE, ADC KENTROX 651 CSU/DSU	051001	KALAHEO NGH CTR BLD A	PC	12	13	2000	0	0	C	$0
A	30	21	00008335	0	60D	WALL PADDING	051001	KALAHEO NGH CTR BLD A	PC	8	25	2000	180	13	C	$0
A	30	21	00008585	0	251	KILN, CRESS ELECTRIC MDL FX27	079001	KEKAHA NHB CENTER	PC	12	21	2001	0	0	C	$0
A	30	21	00008705	0	27H	LAPTOP DELL, INSPIRON 8100 PENTIUM III W/CASE	034004	NEW COUNTY COMPLEX BLD B	PC	4	19	2002	0	0	C	$0
A	30	21	00009136	0	040	BLEACHERS, PORTABLE ALUMINUM 7 ROW KAPAA POOL	015Y&O	YARD & OUTSIDE	CO	5	14	2003	180	46	C	$0
A	30	21	00009137	0	040	BLEACHERS, PORTABLE ALUMINUM 7 ROW KAPAA POOL	015Y&O	YARD & OUTSIDE	CO	5	14	2003	180	46	C	$0
A	30	21	00009138	0	040	BLEACHERS, PORTABLE ALUMINUM KAPAA POOL	015Y&O	YARD & OUTSIDE	CO	5	14	2003	180	46	C	$0
A	30	21	00009139	0	040	BLEACHERS, PORTABLE ALUMINUM 7 ROW KAPAA POOL	015Y&O	YARD & OUTSIDE	CO	5	14	2003	180	46	C	$0
A	30	21	00009154	0	040	BLEACHERS, PORTABLE ALUMINUM 5 ROW WAIMEA POOL	072Y&O	YARD & OUTSIDE	CO	5	14	2003	180	46	C	$0
A	30	21	00009155	0	040	BLEACHERS, PORTABLE ALUMINUM 5 ROW WAIMEA POOL	072Y&O	YARD & OUTSIDE	CO	5	14	2003	180	46	C	$0
A	30	21	00009247	0	604	WHEELCHAIR ALL TERRAIN, LANDEEZ	400001	LYDGATE PARK	PC	9	9	2003	0	0	C	$0
A	30	21	00009248	0	604	WHEELCHAIR ALL-TERAIN. LANDEEZ	060Y&O	YARD & OUTSIDE	PC	9	9	2003	0	0	C	$0
A	30	21	00009249	0	604	WHEELCHAIR ALL-TERRAIN, LANDEEZ	047Y&O	POIPU BCH PARK YARD & OUT	PC	9	9	2003	0	0	C	$0
A	30	21	00009487	0	100	WRESTLING MAT SYSTEM, 716 FLEX 1 NAVY	536001	EMERGENCY OPERATING CENTR	PC	8	23	2004	180	61	C	$0
A	30	21	00009799	0	27C	PRINTER, LASERJET HP COLOR 3700DTN	034005	NEW COUNTY COMPLEX BLD C	PC	11	8	2005	0	0	C	$0
A	30	21	00009854	0	60E	POOL TABLE, IMPERIAL 8'DL 29-802	051001	KALAHEO NGH CTR BLD A	PC	2	24	2006	0	0	C	$0
A	30	21	00009888	0	100	RECUMBENT BIKE	015001	KAPAA NEIGHBORHOOD CTR	PC	1	6	2006	0	0	C	$0
A	30	21	00009889	0	100	TREADMILL, STANDARE COMMERCIAL	015001	KAPAA NEIGHBORHOOD CTR	PC	1	6	2006	0	0	C	$0
A	30	21	00010046	0	040	POOL CHAIR LIFT IGAT 180	015002	KAPAA POOL BATH HOUSE	PC	10	10	2006	0	0	C	$0
A	30	21	00010055	1	020	FENCE IMPROVEMENT	015Y&O	YARD & OUTSIDE	PC	11	12	2013	180	172	C	$0
A	30	21	00010659	0	25D	COPIER, XEROX TFW-015-491 MDL CC128	015001	KAPAA NEIGHBORHOOD CTR	VO	8	24	2007	0	0	C	$0
A	30	21	00010704	0	865	VACUUM W/PUMP, PORTABLE W/FILTER	072001	WAIMEA SWIMMING POOL BATH	PC	5	14	2008	0	0	C	$0
A	30	21	00010705	0	865	VACUUM W/PUMP, PORTABLE W/FILTER	072001	WAIMEA SWIMMING POOL BATH	PC	5	14	2008	0	0	C	$0
A	30	21	00010706	0	18M	SOUND SYSTEM, MEGAVOX	034005	NEW COUNTY COMPLEX BLD C	PC	6	18	2008	0	0	C	$0
A	30	21	00010929	0	100	VOLLEYBALL SYSTEM, ELITE ALUMINUM AA1 VS 300	061001	KAUMAKANI NEIGHBORHOOD CT	PC	5	20	2009	0	0	C	$0
A	30	21	00011575	0	100	SCOREBOARD, BASKETBALL KALAHEO REMOTE CONTROL	051001	KALAHEO NGH CTR BLD A	PC	7	1	2009	0	0	C	$0
A	30	21	00011608	0	040	SCOREBOARD, BASKETBALL W/WIRELESS CONTROL	009001	KILAUEA GYM	PC	8	11	2010	0	0	C	$0
A	30	21	00011609	0	040	INFLATABLE DOUBLE LANE SIP N DIPS W/BLOWERS	034005	NEW COUNTY COMPLEX BLD C	PC	8	11	2010	0	0	C	$0
A	30	21	00011610	0	040	INFLATABLE DOUBLE LANE SLIP N DIPS W.BLOWERS	034005	NEW COUNTY COMPLEX BLD C	PC	8	11	2010	0	0	C	$0
A	30	21	00011611	0	040	INFLATABLE DOUBLE LANE SLIP N DIPS W/BLOWERS	034005	NEW COUNTY COMPLEX BLD C	PC	8	11	2010	0	0	C	$0
A	30	21	00011612	0	040	INFLATABLE DOUBLE LANE SLIPS N DIPS W/BLOWERS	034005	NEW COUNTY COMPLEX BLD C	PC	8	11	2010	0	0	C	$0

Figure 23 Fixed Assets – Parks by PW List

CHAPTER 4 – RESULTS

This chapter provides a discussion of the results of the fieldwork and software review. In section 4.1, the results of the fieldwork are shown displayed overlain on Pictometry basemaps. Section 4.2 summarizes the outcome of of the literature and software reviews.

4.1 Fieldwork Results

The data collected by the summer interns was used to create imagery maps for each park, including generating labels for larger structures like pavilions and comfort stations. Figures 24 and 25, show these Pictometry-based maps for Anini Beach Park. Other examples are provided in Figure 26, from Salt Pond Beach Park, Figure 27, Waimea Pool and facilities and Figure 28, Vidniha Stadium and Baseball Complex. These figures correspond to the excel screen shots of the data provided in Figures 12 and 13. The interns' work was to provide a common ground for labels Park Rangers, DOPR management, DOPR Permits, and DOPR maintenance to identify facilities within these locations. However, as previously mentioned the data was not later correlated with the PW and Finance information (Figures 22 and 23). Also, work orders or other files like construction plans for permits were not able to be integrated or attached to these maps. As stated earlier, data collection, data management and data integration are an essential part of an asset management framework, critical to its success. Data collection is very much dependent on the intended use of the data and who is collecting the data, apparent in the level of detail and the depth required.

Data collection can be categorized in to the following three groups:

- *Location*: actual location of the asset as denoted using GPR coordinates.
- *Physical attributes:* description of the considered asset that can include: material,

type size, length, etc.

- *Condition*: condition assessment data can be different from one asset category to another. The data can be qualitative and generic (e.g. Good, Bad, etc.) or detailed and/or quantitative in accordance to established practices and standards. This was data was not collected by the interns and is not documented in any DOPR files. So it will have to be done by DOPR staff at some point.

Asset identifiers in a geodatabase are usually invisible to the user. But identifiers are import in mapping so that labeling and naming conventions are consistent. Park permit users are issues pavilion numbers if they have reserved those places. The interns worked with permit staff on their labeling, which was sometimes different from what was painted on the actual facility. It was assumed this same issued existed in the facilities list from PW and Finance. In being tasked with developing an asset management program or system for DOPR, the agency still needs to describe their vision, goals and objectives of what they want to accomplish with this program. DOPR did not know what they really have as far as physical property. DOPR plans to develop a detailed inventory of all their assets from facilities to supplies once a program is selected. Changes in staff roles and perhaps new personnel will be required for such a system to fully function as it should. Once a system is in place, staff training will also be needed. Then making sure all the users have the right tools to use the system properly will be needed. Figure 24 outlines the steps required for a comprehensive an asset management program. If these steps are followed, then the decision on repair or replace and resultant cost savings for the COK will be documented by the information provided in the program.

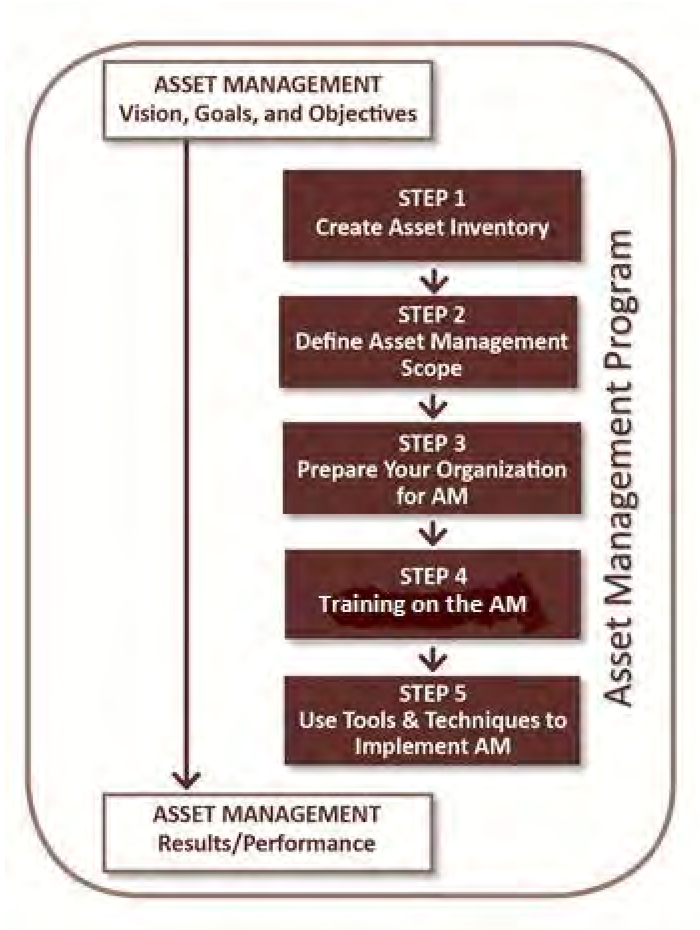


Figure 24 Asset Management Steps

Figure 25 Mapping by summer intern showing Anini Beach Park. Pavilion (P1-3) and Comfort Station (C1). GPS locations overlain on Pictometry oblique imagery

Figure 26 More of Anini Beach Park and Comfort Stations (C2-3). GPS locations overlain on Pictometry oblique imagery

Figure 27 Salt Pond Beach Park on overlain on Pictometry oblique imagery

Figure 28 Waimea Pool on Pictometry oblique imagery

Figure 29 Vidniha Stadium and Baseball Field on Pictometry oblique imagery

4.2 Analysis

DOPR has only $30K to spend in their budget for fiscal year 2015-2016 for an asset management program. The author contacted all the software vendors of the programs reviewed in Chapter 2. Most of the vendors gave a webinar demo, but only one would assist to populate and merge the data from PW, Finance and DOPR. Several vendors did submit to DOPR a cost proposal for their software. The factors to be considered include:

- Number of users
- Hosted or cloud base
- Integration of the data (characteristics of the already existing data)
- Volume of data
- Currently available information technology (status of ArcGIS, server, PC, mobile devices)

- Level of staffing and resource allocation that would be dedicated to the process
- Education of staff on use of the Asset Management Program and updating the data in the system

The vendors' proposals' listed costs that varied from 40K to 100K depending on the number of users, then there was a basic maintenance cost per year added into all the vendors' quotes. The pricing per user, or license, varied greatly. Some of the vendor's quantified the limits on some users with different rights on the software, thereby lower costs. DOPR asked for initial costs for 5 users. One vendor set the minimal number of users at 10.

Costs differences could also vary depending if the software is cloud-based or hosted by the COK. The COK IT preference is for them to host a program. Cost for many vendors were actually cheaper if the COK did host the program. If the asset management program is cloud based most of the professional staff could asset the program via their smart phone or tablet/iPad. The other good thing about cloud based it the software is updated all the time. The current trend is for cloud based for most technological storage. But this is a cost factor to consider. For DOPR this is actually a higher cost than having a cloud based service and leads to the next factor. DOPR does not issue tablets, iPad or cell phones to their employee. COK IT does provide tablets, iPad and smart phones but it is costs for the data service and level of employee that is issued COK equipment.

Another factor to consider is the current state of the COK's information technology. No all employees have smart phones, county email, or computer access. None of the vendors discussed this issue except COK IT with regard to the SunGard modules. DOPR would need to get tablet and data service connect to COK server to use the SunGard software. The following is some of the required system specifications needed to run for example CityWorks which uses their Asset

Management server (AMS) or Permits, Licensing and Land server (PLL):

CityWorks	Specifications for a Database (Intel®) Server:
Database Server	➢ Windows Server 2003 sp2, 2008, 2008 R2 or R2 sp1 (64-bit), 2012 ➢ 32GB RAM (or better) ➢ Intel Xeon® 8 core (2 chip) X5677 3.46 GHz (or better) ➢ 2 x 146 GB 15000 rpm Serial Attached SCSI (SAS) Disk Drives ➢ Gigabit NIC ➢ 17” high resolution color monitor; 1024 x 768 or higher
Server AMS or PLL	Specifications for a PC (Intel®) Client:
Client	➢ 2.0 GHz Intel Core® processor (or better) ➢ 2GB RAM (or better) ➢ Fast disk (7200 rpm) >40 GB of storage ➢ 100 Mbit NIC ➢ Windows 8/8.1 (32/64-bit) or Windows 7 Professional® (32/64-bit) ➢ 17” high resolution color monitor; 1024 x 768 or higher ➢ Silverlight 5 ➢ Firefox 29

- Internet Explorer 10 and 11
- Chrome 37, 38, and 39

Server AMS/PLL Specifications for an Application (Intel®) Server:

(~40 users)

- Windows Server 2008 R2 or R2 SP1/SP2 (64-bit), IIS 7.5
- Windows Server 2012 or 2012 R2, IIS 8.0/8.5
- 12GB RAM (or better)
- Intel Xeon® 4 core (1 chip) X5677 3.46 GHz (or better)
- 2 x 146 GB 15000 rpm Serial Attached SCSI (SAS) Disk Drives
- Gigabit NIC
- 17” high resolution color monitor; 1024 x 768 or higher
- .NET 3.5 Framework Windows Server features
- .NET 4.5 Framework (Installed on both application & GIS servers)

Server AMS/PLL Specifications for an Application (Intel®) Server:

(~80 users)

- Windows Server 2008 R2 or R2 SP1/SP2 (64-bit), IIS 7.5
- Windows Server 2012 or 2012 R2, IIS 8.0/8.5
- 24GB RAM (or better)
- Intel Xeon® 8 core (2 chip) X5677 3.46 GHz (or better)

- 2 x 146 GB 15000 rpm Serial Attached SCSI (SAS) Disk Drives
- Gigabit NIC
- 17” high resolution color monitor; 1024 x 768 or higher
- .NET 3.5 Framework Windows Server features
- .NET 4.5 Framework (Installed on both application & GIS servers)

Another important consideration is the level of staffing required to support the proposed project. To implement ARCHES, there would need to be an IT specialist to install the software, develop a separate the implementation from the graphical interface at a maximum a CSS (Cascading Style Sheets) file will be used. “The Cascading Style Sheets were created to provide a powerful, yet flexible means for formatting HTML content. CSS works much like style sheets in a word processing program – you define a “style” that contains formatting options that can be applied to document elements. All of the vendors except one stated that DOPR would have to integrate their data into the system. This would require either a bid from a consulting firm to do this work or additional staff. Also, to maintain the software and data an Asset Manager should be hired no matter what software is chosen. The cost factors for this could be from 50k – 100K.

Education is also needed on what are the advantages of an asset management program with GIS capabilities. It would be important to do some basic education on GIS itself, then there is training on software program that will be used. It will be imperative that staff know that information (work orders, inspections) must be updated and input consistent for the system to work and be productive to help the COK with financial decisions.

CityWorks was over minimum of 5 users, basic software 22k, yearly maintenance at 10K for the SaaS license and installation cost which were not discussed. They would not even consider any kind of integration with the AS400. Maximo which is an IBM solution, had only a service consultant on Oahu who stated 5 users would be 49K plus 20% of the list price for maintenance after the first year. They would recommend an outside contractor to work on an integration with the AS400. So this would be additional costs after that would have to go out to bid or having additional COK IT staff to work on this integration process. This costs were estimated for integration with Maximo to be around 80K. Another asset management vendor had a minimum of 10 licenses; (0-19 Licenses = $2,999/user; Unlimited Site License = $699,999). In addition, there's a $500 per named user fee for GIS integration. Lastly, the annual support & maintenance will be 20% of the total licensing fees. If the COK wants to procure a hosted model, it's $189 per month per named user. No vendor discusses another factor which is volume of data that would be used on the system. COK DOPR with 83 facilities is rather a small organization, so maybe after our preliminary discussion this was never a factor for the vendors. But the author's assumption is that as the database does increase and it storage on a cloud server, costs could change.

Users or license fees (costs), hosting (costs) and outsourcing for implementation or integration (costs) are really large considerations. GIS integration which was the focus of this thesis is a main consideration. Maximo is a huge system and expensive – it was initially designed for facilities maintenance in the manufacturing sector. SunGard NaviLine GIS ability is very limited and did not integrate with Esri's ArcGIS or ArcMap. Database server assumes a machine hosting the organization's SDE geodatabase (supporting both editors and viewers), and vendor's database (e.g. supporting users of Server AMS/PLL for CityWorks). Feature Access via a map service requires the GIS data to be stored in an ArcSDE geodatabase, a file geodatabase is not sufficient. Table 4 below is an example from CityWorks which shows the RDMS and Esri platforms that are supported by most of the software programs reviewed for this study. For the COK not all staff has ArcGIS/ArcMap access.

Table 4 Supported RDMS and Esri Platforms

Server AMS/PLL 2014 ArcGIS Server (Standard or Advanced Enterprise) 10.0 SP5, 10.1 SP1, 10.2, 10.2.1, 10.2.2, and 10.3 (10.3 requires 2014 SP2 and above) Oracle 10g R2 (Supported at 2014 SP1) Oracle 11g R1 (Supported at 2014 SP1) Oracle 11g R2 (Supported at 2014 SP1) SQL Server 2005 SQL Server 2008 SQL Server 2008 R2 SQL Server 2012 SQL Server 2014	**Server AMS/PLL 2014** ArcGIS Server (Standard or Advanced Workgroup) 10.0 SP5, 10.1 SP1, 10.2, 10.2.1, 10.2.2, and 10.3 (10.3 requires 2014 SP2 and above) SQL Server Express 2005 (4GB limit) SQL Server Express 2008 (4GB limit) SQL Server Express 2008 R2 (10GB limit) SQL Server Express 2012 SQL Server Express 2014

Given no limits, financial, technology tools, ideally the best software from those reviewed from this study that really works well with GIS is the CityWorks. CityWorks was designed for the public sector. CityWorks' seamless integration with GIS gives it unique GIS capabilities other systems do not possess. Its work orders and service requests can be easily customized to the specific needs of an organization, saving IT staff a great deal of time and effort. Because CityWorks only utilizes the geodatabase as the asset database, it allows for integration with other applications that are accessing the geodatabase as well. One example is hydraulic modeling where the modeling software and CityWorks are both able to access the asset information and share the activities within the Esri framework.

CityWorks provides much more than a "map." Using a variety of tools within CityWorks such as Event Layers, Heat Map Manager, and the Asset Analytics tools, the map becomes the tool to help identify trends. Also, by exploring the data in the geodatabase, one can explain the reasons for higher levels of activities and costs in certain areas. No decision tree was necessary in deciding an asset management program for COK DOPR. The cost factor for most government agencies is critical. In the long term, an asset management program should help the DOPR save money and prioritize their needs. So having the state of the art asset management program would be in their best interest. The only software M-PET.NET by Four Winds Group Inc. which is already in use by the COK PW Roads Department, Water Department, and Wastewater Department has agreed to put us on as a user of the existing PW Roads contract. M-PET.NET would also give us 5 users on the system, Four Winds Group Inc. would help get the asset management system running for DOPR and work on getting an interface in the future with the County's AS400 work order system. No other software will do this. Four Winds Group Inc., initial phase costs were under the $30K which was below the other vendors. At the time of finishing this thesis, DOPR is talking to purchasing on next steps.

The main reason for choosing M-Pet.Net is that it is already in use in three other departments at the COK. COK work order and cost codes are already in the system. COK facilities and roads are already in the system. The cost factor is a major consideration. Four Winds Group Inc. proposal fits DOPR's budget. Of all the vendors reviewed and analyzed they agreed to populate the database with the current information DOPR has in order to get the system going as soon as possible. Unlike other CMMS products, its platform sits on top of the GIS database and does not require a separate database for data storage. Having a separate GIS and CMMS to constantly keep in sync with each other can be frustrating and tedious because each database is being populated by different sources. With this process of keeping both databases in sync eliminated, the district can now save time and money. M-Pet.Net will be used to keep track of maintenance, create work orders and maintain an inventory of assets. Four Winds Group Inc. provided DOPR with a mock-up of how the system would work. Figure 29 is a screenshot of M-Pet.Net maintenance object listing. Figure 30 is screenshot of the detail that could be included about a Park. The author made the recommendation to DOPR administration that based on budget and needs that the M-PET.NET would provide a basic asset management program.

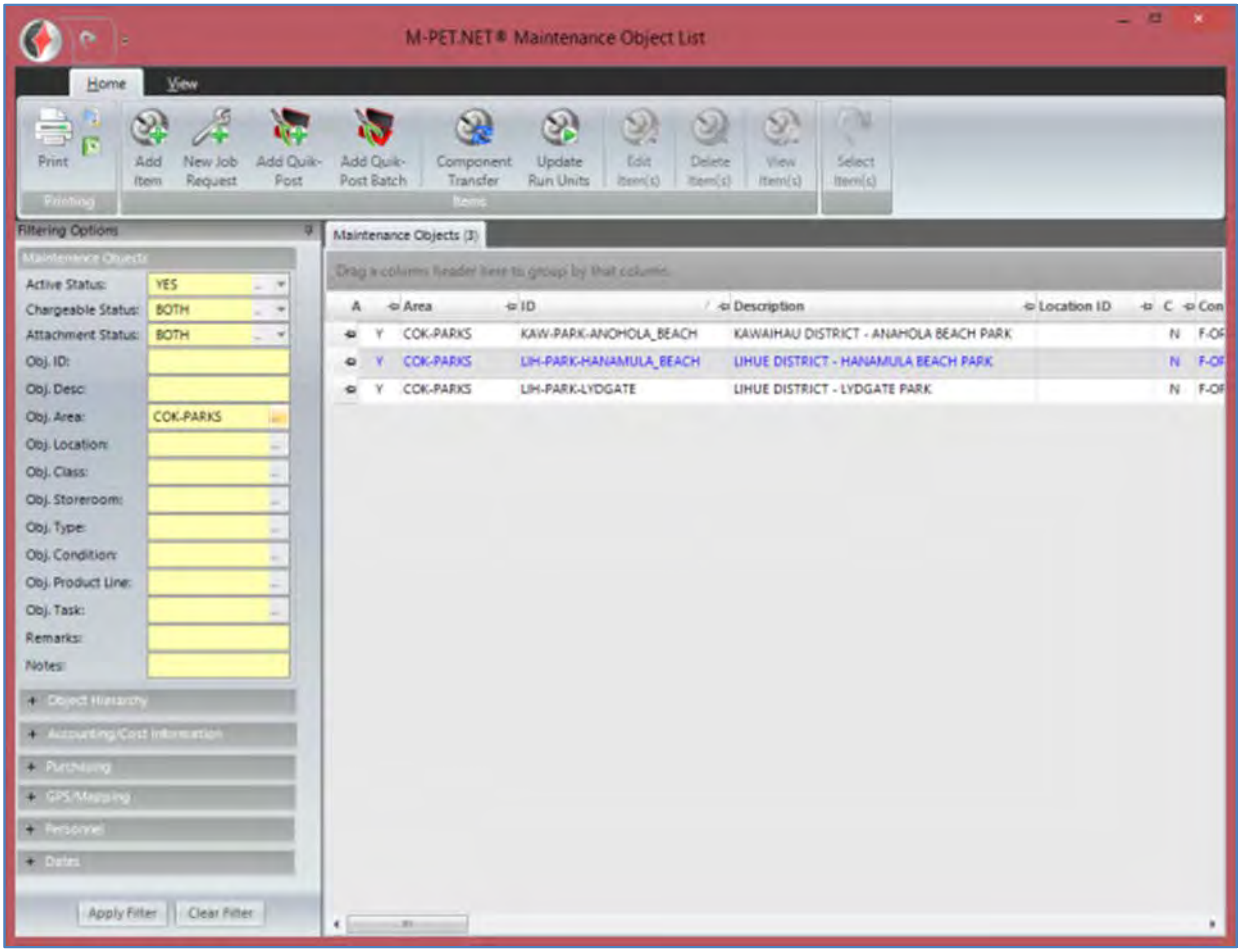


Figure 30 M-Pet.Net Mock up for DOPR of maintenance object listing

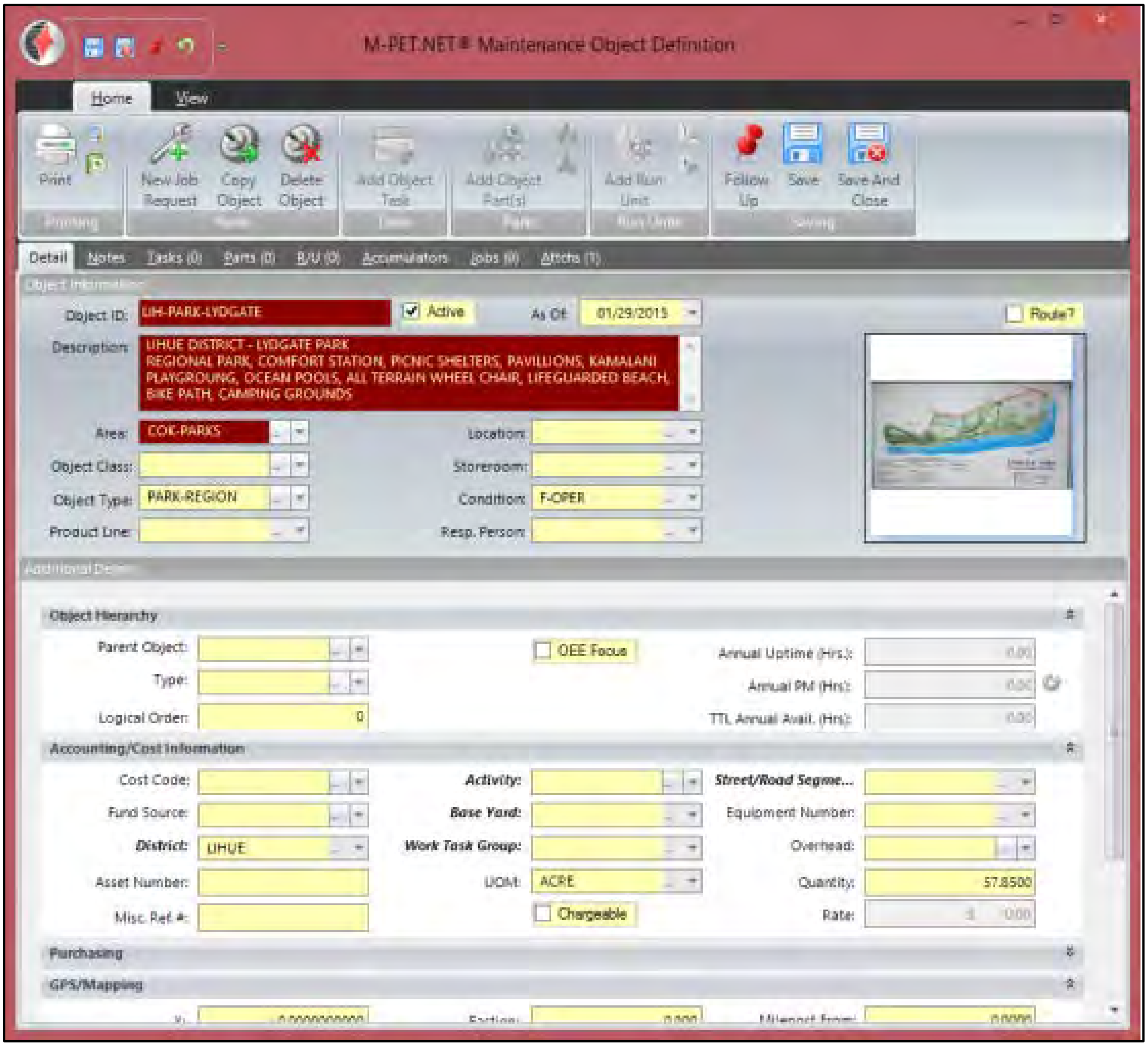


Figure 31 Screen shot of M-PET.NET showing a Park and details within the Park

CHAPTER 5 – CONCLUSIONS

This final chapter describes the contribution of the study to improve the County of Kauai Department of Parks and Recreation's understanding of their needs regarding an asset management program with a GIS capability, given the limited funds available and how the proposed system will help manage the DOPR's expenditures in the long term. This chapter then concludes with a discussion of potential future directions.

5.1 Summary

Maintenance management can only be performed with an accurate asset inventory. Today, most maintenance management systems have incorporated the practices of asset and maintenance management together into a single application. The COK DOPR needs an asset management solution which means acquiring an EAM or CMMS system. CMMS systems contain functionality to facilitate the repair of assets through the assignment of work orders. To assist in determining when such functionality would be required, the use of customized fields would allow for the establishment of alert levels for value, condition, and maintenance costs. Once each of these reaches a certain level a work order could be auto-generated to begin the repair or replacement of an asset. Existing CMMS applications have the capability of scheduling maintenance for assets, which could be carried forward into the proposed asset management system. The need to constantly review data ensures that it remains current and accurately reflects the spatial information it represents. Along with the ability to schedule maintenance, the system should also be able to record if maintenance does not occur at the scheduled time to ensure that deferred maintenance costs are taken into account.

An asset maintenance history built over time and stored in searchable database provides a predictive standard for when similar assets may fail and how assets typically fare in the given area, climate, and other important local factors. For many assets, the clustering, frequency, and costs of unplanned maintenance activities alone – analyzed and visualized using ArcGIS tools – provide enough evidence to make an intelligent investment decision of when, where, and how maintenance and rehabilitation should take place. Often, unique attributes (or characteristics) of the asset stored in the geodatabase (such as type) contribute more insight than age or expected life as to likelihood of failure. For high-risk assets, maintenance history and ArcGIS analytical tools can provide insight and prioritization for where to utilize limited budgets for increased inspection, monitoring, and condition assessment.

Measuring the success of a geographic data asset management system is much like measuring the benefits of the use of geographic data. The system should be able to meet the requirements of both an asset management system, effectively cataloging, tracking, and organizing the maintenance of data, while including geographic data specific attributes, tracking processes, and condition assessment capabilities. Quantifiable results of such a system may include market rates, compatibility with existing GIS software, interface customization and scalability. The ability to develop such a system using established principles of asset management, a common set of metadata attributes sanctioned by the federal government, and utilizing tested software and methods will speed the acceptance of a system that proposes to manage geographic data in this manner.

After helping the Master Plan consultant finalize a MS Access database for DOPR, then a year reviewing asset management software, building an Excel inventory with summer interns, the data is still far from complete. The condition of DOPR facilities has never documented. Once a basic system is implement this information will need to be inputted through an inspection process. It is a missing element of the steps of an asset management program. Based on the budget of $30K, the only vendor that would integrate the four sources of data (PW, Finance, DOPR's MS Access database and the 2015 excel spreadsheet), into a basic asset management program that is cloud based, has Esri GIS capabilities was the Four Winds Group Inc.'s M-Pet.Net and train staff with a 5 user license for a year. Their initial proposal for the first year to get this information and populate the data into their program cost was under $30K.

Four Winds Group Inc. also agreed to further populate the DOPR database for those little items like fire pits and benches by digitizing the information. Digitizing is a method of converting information from one format to another using a trace methodology. Traditionally, digitizing has meant the creation of a spatial dataset from a hardcopy source, such as a paper map or a plan. On-screen digitizing is the creation of a spatial dataset by tracing over features displayed on a computer monitor with a mouse. They will trace over these items on Esri imagery and sketch images to digitize them and, thus, to turn them into vector data. The subsequent year Four Winds Group Inc. agreed to try to interface their program with the AS/400 to that work orders could be done on one system from DOPR and not be a duplicate effort to input the information separately into the AS/400. The cost proposal for this work at the time of writing this thesis was not submitted. The interns work for the summary of 2015, helped the DOPR inventory all the major assets at their facilities that were not included in the other COK departments or even the MS Access Database, because it was a real field inventory. It still did not account for the fire pits, some of the benches or picnic tables. The concerns with these assets is to repair or fix them are outside the unionized labor classification that DOPR has. PW labor has to repair these items which is generated through the

AS/400 work order system. Once DOPR does have an asset management solution in place, then these items can be tracked.

5.2 Limitations

There are maintenance requirements to upkeep the information about each asset once it is in the database and accessible. Staff will need to document conditions, inspections, repair (both major and minor). Then this information will need to be updated in to the program by the district maintenance manager, region supervisor, and/or neighborhood center director. This could be seen as a major limitation in any asset management program. Optimizing the workflow is a major part of any successful asset management system. Accurate accounting for work orders, ensures the assets are being properly cared for. Ideally as stated early in Chapter 4, having an asset manager to keep track of the system and making sure staff are trained on software updates, new technologies, keeping track of their work and facilities inspections would be optimum.

Given this maintenance limitation, the asset management program should be re-evaluated by the administration as to the cost-effectiveness of the program. With the COK procurement process the contract is only for 1 years with the possibilities of extension of that contract for year every year. So every year the contract, the program, the data should be re-evaluated not only from the fiscal side but from the practical field side to verify updates in the field are being transferred into the data about each asset.

M.Pet-Net has been in use with Wastewater since 2007. Four Winds Group Inc. the developers of M.Pet-Net has been in existence since 1989. Although they are a small company, their CMMS software should have a lifetime span of at least another 10 years. From being an on-site server to now being cloud based and incorporating GIS, their technology is evolving with the current trends in CMMS.

5.3 Future Directions

Further improving this process are innovations that are becoming pervasive throughout the GIS community. Beyond direct integration with existing GIS platforms, the ability to access data in real-time either through server-based GIS or from the field using wireless access will allow for users to maintain data in real time, reducing errors and improving data tracking. Technology will continue to improve the data asset management process through organizational techniques, reporting, and value calculations, but it remains the responsibility of those using any system to ensure that data, and its integrity, remains the focus throughout its entire life cycle.

Implementing an asset management system using GIS can be a very powerful tool for managing and predicting risk factors for assets. The DOPR Land & Asset Management application could prove to be a useful an effective tool for DOPR staff assisting them with the management of the parks system by providing a "one-stop-shop' for DOPR mapping data and related information. The application integrates information into an easy to use and access system that allows for the efficient management and delivery of information throughout the organization. Esri's ArcGIS Server, Pro or ArcGIS.com is a powerful, cost effective tool that can be customized to develop applications that integrate different data types into effective information management systems.

The DOPR Land & Asset Management System application could be developed using an ArcIMS interface to provide staff with access to all departmental data and information. It should be understood that ArcIMS is no longer be supported with the release of ArcGIS 10.3. ArcGIS Server 10.3 has phased out SDE! ArcGIS Pro, ArcGIS Server 10.3+ and ArcGIS.com is going to be supported best by Esri in the coming years. So for small municipalities' who are not upgraded to ArcGIS 10.3 using ArcIMS and SDE can still be used. This solution provides an effective tool for managing and delivering DOPR information to all staff members via the COK's intranet. In order to integrate the SDE GIS data, MS Access database information, and IBM's Content Manager application unique ID's common within each application could be created, linking all related data and information. This would involve creating new GIS data, a new MS Access database, and using an IBM Content Manager application. This would also take merging the summer 2015 excel data, photographs and Pictometry imagery with the existing MS Access database.

Access to the 2,400 large format documents and plans that were currently in the COK's files could be integrated with the system by modifying index fields based on parcel numbers assigned to DOPR Lands. This would allow staff to access documents related to DOPR lands using an ArcIMS application, which COK does not have. The SDE GIS feature data would be joined to the MS Access database attribute information. This will allow DOPR staff that had no GIS data editing experience the ability to update the GIS attributes via the MS Access database. In addition, this allowed staff to access the database information using an ArcIMS application.

New GIS datasets could be developed in ArcInfo and stored in SDE features for the application. Parks land had been previously inventoried and mapped and this layer could be used as the base GIS data for the Parks land layer. Additional GIS layers could be created using the COK's current aerial photography to digitize structures, buildings, parking lots, and other visible asset. Other GIS layers could be developed by site inventories of parks that included fixtures, irrigated areas, recreation areas, planted areas, sidewalks and trails, fences, retaining walls, and trees. Each of these features could be given a unique ID and assigned to a unique DOPR Land ID.

The best solution would be for the COK to buy an off-the-shelf product and implement it. It will also take getting an Asset Manager position to make sure all the information about the facilities is correct, the correlation of the data with both Finance and PW is correct and streamlining the work order process. The information system solution that was selected included a custom GIS application that utilized and integrated ArcGIS Server, Pro or ArcGIS.com, MS Access, and IBM Content Manager.

Current funding priorities for COK DOPR maintenance does not provide the levels of service that meet community expectations. Park maintenance procedures need to be expanded to allow for maintenance of a variety of facilities. In conjunction with development of this Asset Management Program (AMP), DOPR's asset maintenance specification is to be developed which will include maintenance strategies and intervention levels and response times for the various asset groups. The asset maintenance specification will guide future maintenance subject to allocation of appropriate resourcing. DOPR's AMP.

A Risk Management Plan could also be developed and identify risks that require planned and priority action. The Risk Management Plan would inform and support responsible asset risk management and will assist in guiding DOPR's asset management in the future.

There are two key high-level indicators of cost to provide the Parks and Recreation service. The life cycle cost being the average cost over the life of the asset, and the cost of emergency maintenance. An AMP and a Risk Management Plan based on GIS applications will greatly help the COK budget wisely on DOPR’s lands. DOPR’S ultimate goal is to have a fully automated asset management system.

The system will need trained personnel who are designated to perform several specific job or functions which will include system management, database administration, system analysis and operation (asset manager). There will need to be training for new staff to DOPR on the use of the system.

REFERENCES

Allen, D. 2011. *Getting to Know ArcGIS: Model Builder.* Redlands, CA: Esri Press.

American Heritage Dictionary 2015. American Heritage Publishing Company

American Society of Civil Engineers (ASCE). 2009. ASCE Report Card for America's Infrastructure.

American Water Works Association (AWWA). 2012. Buried no Longer: Confronting America's Water Infrastructure Challenge.

Anonymous. 2007. Focus on O&M: Asset Management. *Power*

Arlinghaus, S. L., ed. 1994. *Practical Handbook of Digital Mapping: Terms and Concepts*. CRC Press, Boca Raton, Florida.

Australia and New Zealand National Asset Management Steering Group (NAMS). 2011. *International Infrastructure Management Manual.* New Zealand: NAMS Group.

Baird, G. 2011. Building a Solid Foundation During an Enterprise Asset Management Revolution. *Water Utility Infrastructure Management.*

Barr, R., and Masser, I. 1997, "Geographic Information: a Resource, a Commodity, an Asset or an Infrastructure?" *Innovations in GIS 4*. Ed. Zarine Kemp. London: Taylor & Francis, Ltd., 1997. 234-248.

Belanger, D. 2012. *A CMMS Best Practice - Don't Take Shortcuts.* http://reliabilityweb.com/index.php/maintenance_tips/a_cmms_best_practice_dont_take_shortcuts1/

Crothers, H. 2010. GIS and Enterprise Asset Management.

De Sitter, W. R. (1984). Costs for service life optimization: The "Law of Fives". *Durability of Concrete Structures Workshop Report* (pp. 131-134). Copenhagen, Denmark: Ed. Steen Rostam.

Doyle, M and Rose, D. 2001. Protecting your Assets. *Water Environment and Technology*. 13:7.

Gunther, O., and Voisard, A. 1997, "Metadata in Geographic and Environmental Data Management." *Managing Multimedia Data: Using Metadata to Integrate and Apply Digital*

Data. Ed. W Klas and A Sheth. McGraw Hill, 1997. 1-31.

Halfway, M and Figueroa, R. 2006. Developing Enterprise GIS-Based Data Repositories for Municipal Infrastructure Asset Management. *Joint International Conference on Computing and Decision Making in Civil and Building Engineering.* Montreal, June 14, 2006.

Harlow, K. 2000. Part 1: Asset management: A key competitive strategy. *News for Public Works Professionals.*

Harlow, K. 2000. Part 4: Asset management: Getting Serious. *News for Public Works Professionals.*

Hyer, C. 2010. Improving Utility O&M and Capital Decisions by Incorporating the Concepts of Asset Condition, Criticality and Risk. WEFTEC 2010 Proceedings, Session 1-10, pp 167-175.

Hyer, C. 2011. Building a Comprehensive Asset Management Program using Consistent Condition, Consequence of Failure and Risk Scoring. Texas Water Convention, 5-8 April, Fort Worth, TX.

Kapp, A. 2013. *CMMS and GIS are taking park maintenance to the next level.* Parks and Recreation Publication.

Kimura International 2013. *Kauai Parks & Recreation Master Plan.* County of Kauai Department of Parks & Recreation

Lo, Chor P., and Albert K. Yeung. 2002, *Concepts and Techniques in Geographic Information Systems*. Upper Saddle River: Pearson plc, 2002. 63-101.

Lutchman, R. 2006. *Sustainable Asset Management: Linking Assets, People, and Processes for Results.* Lancaster, PA: DEStech Publications, Inc.

Management Resources Group, Inc. 2013. *EAM and CMMS Implementations: Are you getting what you paid for?.* White Paper.

McKibben, J and Davis, D. 2002. Integration of GIS with Computerized Maintenance Management Systems (CMMS) and Asset Management Systems. 22nd Annual Esri International User Conference, 8-12 July, San Diego, CA.

New Mexico Environmental Finance Center. 2006. Asset Management: A Guide for Water and Wastewater Systems.

Office of the Legislative Auditor County of Hawai'i 2011. *Limited Scope Performance Audit of the Department of Parks and Recreation's Facilities Asset Management.*
Pitney Bowes, 2015. "Taking Infrastructure Asset Management to the Next Level", White Paper

"Research Report on Asset Management Practices, Instruments and Challenges: 2014-2019," Reliabilityweb.com, Accessed December 9, 2014. http://www.reliabilityweb.com/index.php/articles/asset_management_practices_investments_and_challenges_2014-2019/

Schultz, A.J. 2012. *The Role of GIS in Asset Management Integration At The Otay Water District.* Master's Thesis Geographic Information Science Technology University of Southern California.

Shahidehpour, M and Ferrero, R. 2005. Time Management for Assets: Chronological Strategies for Power System Asset Management. *Power and Energy Magazine, IEEE*

Shamsi, U. 2005. *GIS Applications for Water, Wastewater and Stormwater Systems.* New York: Taylor and Frances.

Shamsi, U. 2002. *GIS Tools for Water, Wastewater and Stormwater Systems.* New York: Taylor and Francis.

Sinha, S. n.d. Municipal Water and Wastewater Infrastructure Asset Management Primer. Penn State Department of Civil and Environment Engineering.

Snavely, K. 2004. Rivers. The Gale Encyclopedia of Science. Ed. K. Lee Lerner and Brenda Wilmoth Lerner. 3rd ed. Vol. 5. Detroit: Gale, 2004. 3460-3464. Gale Virtual Reference Library.

U.S. General Accounting Office (GAO). 2004. Water infrastructure: Comprehensive Asset Management Has Potential to Help Utilities Better Identify Needs and Plan for Future Investments (GAO-04-461).

U.S. Environmental Protection Agency (EPA). April, 2008a. Asset Management: A Best Practices Guide (EPA 816-F-08-014).

U.S. Environmental Protection Agency (EPA). June, 2008b. Effective Utility Management: A Primer for Water and Wastewater Utilities. Vanier, D J. 2000, “Asset Management 101: a Primer.” NRCC/CPWA Seminar Series Innovations in Urban Infrastructure, APWA International Public Works Congress. 2000.

Vanier, D. J. 2001, "Why Industry Needs Asset Management." *Journal of Computing in Civil Engineering* 15 (2001): 35-43.

Vanier, D. J., and N. H. Danylo. 1998, "Municipal Infrastructure Investment Planning: Asset Management." *Innovations in Urban Infrastructure*, 13 Sept. 1998, Las Vegas, NV. 25-39.

Vanier, D. 2004. *Geographic Information Systems (GIS) as an Integrated Decision Support Tool for Municipal Infrastructure Asset Management.* National Research Council Canada.

Ward, M. 2005. *A Guide to Asset Management for Small Water Systems.* National Environmental Services Center

Zhao, M and Stevens, G. 2002. Implementing GIS for a Water Distribution at Otay Water District. International Users Conference, Esri. San Diego, CA. July, 2002

Zhao, M and Stevens, G. 2003. Elevating GIS to an Enterprise Solution at Otay Water district. International Users Conference, Esri, San Diego, CA. July, 2003

Zhao, M and Stevens, G. 2009. ROI through GIS: Cutting Cost and Time. *Geospatial Today*. 28:4.

Zhao, M and Stevens, G. 2011. GIS and Asset Management: A Cost Effective Enterprise Solution. 2011 Annual Esri International Users Conference, San Diego, CA. July.