Countywide GIS Implementation Strategy

Prepared for the County of Calaveras
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SECTION 1—INTRODUCTION

Objective

There is wide acceptance within the County of Calaveras that GIS is a proven information technology essential to delivering a broad spectrum of local government services. What remains is how to build the information systems and organizational infrastructure necessary to support a successful countywide implementation of GIS.

The objective of this report is to provide the County of Calaveras and its data partners with a three-year strategy to effectively implement a countywide GIS.

Background

Over the past year, the County of Calaveras has made great strides in advancing the use of geographic information systems (GIS) within the county. Some of the most significant accomplishments are listed as follows:

- **Parcels:** The creation of a continuous countywide GIS parcel base that was used to submit newly organized fire districts to the State Board of Equalization.
- **GIS MOU:** The adoption of a GIS Memorandum of Understanding (MOU) with the City of Angels Camp, Calaveras Council of Governments, and the Calaveras County Water District. The GIS MOU provides a cooperative arrangement for the coordination and sharing of GIS data between these organizations.
- **Roads:** The County is in the process of collecting the GPS (Geographic Positioning Systems) location of road centerlines as part of a pavement management effort.
- **GIS Unit:** The County has created a GIS Unit within the Technology Services Department. A GIS Coordinator and a GIS Technician have been hired.

Numerous County departments and other regional organizations have started implementing GIS. These semi-autonomous GIS starts have highlighted the importance of having an "enterprise" or countywide strategy for the effective development, maintenance, coordination, and deployment of GIS data and applications. In early 2000, the County of Calaveras Technology Services Department contracted with VESTRA Resources (VESTRA), a GIS consulting firm, to perform a GIS Needs Assessment that would then be the basis for a GIS Implementation Strategy.

GIS Implementation Planning Activities

On February 24, 2000, VESTRA, in association with Environmental Systems Research Institute (ESRI), initiated the GIS implementation planning effort by conducting a GIS Orientation Workshop. The workshop was held at the Calaveras County Water District and was widely attended.

Over the spring/summer of 2000, VESTRA then conducted 16 informal interviews with potential participants in a countywide GIS implementation. The organizations that were interviewed were primarily County departments along with local data partners (See Appendix A). A Countywide GIS Applications and Information Needs Assessment report was presented and discussed at a workshop on July 6, 2000. Appendix B contains a Summary of Key Findings from this report.

On July 20, 2000, VESTRA conducted a GIS Implementation Strategy Workshop. A GIS data coordination and distribution model was presented along with a GIS implementation "Road Map". The Road Map provided a detailed schematic of the proposed GIS implementation strategy over a three-year period. The workshop participants were overall supportive of the implementation planning direction that was presented.

On July 24, 2000, VESTRA and the Technology Services Department, presented a status report to the County of Calaveras Board of Supervisors on the GIS implementation. Current and future uses of GIS were discussed along with required funding levels for the current fiscal year. The Supervisors present were complimentary of the implementation efforts to date and were looking forward to realizing the benefits of GIS.

This GIS Implementation Strategy is the culmination of the preceding planning efforts. The plan presents a three-phased road map to implement the countywide GIS over the next three years. The implementation phases are:

- Phase I: Countywide GIS Infrastructure
- Phase II: Departmental GIS
- Phase III: Integrated Applications & Analysis

Section 7 of this report, "GIS Implementation Phases", provides a detailed description of the recommended activities for each of these phases.

SECTION 2—COUNTYWIDE GIS VISION

Scales of GIS Implementation

GIS is an information technology that can be implemented within an organization at different scales. GIS implementation is typically categorized into four scales that are shown in Figure 1 and described below:

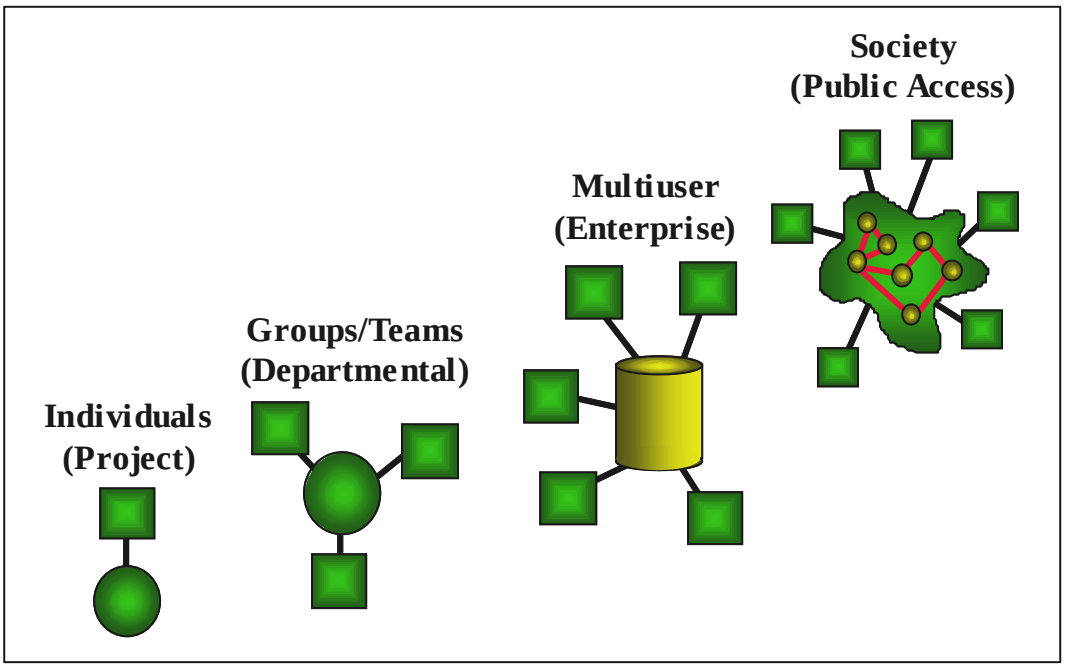


Figure 1. Scales of GIS Implementation

Project GIS—Desktop GIS software on a stand-alone personal computer used for project-level mapping and analysis.

Departmental GIS—Multiple staff within a department using desktop GIS software for mapping and analysis on personal computers that are connected via a local area network.

Enterprise GIS—Multiple departments across the organization collaborating to centrally store and distribute shared spatial datasets and applications.

Public Access GIS—The organization sharing appropriate spatial datasets and applications with other key organizations and the public using Internet-based technologies.

The County of Calaveras's current scale of GIS implementation is primarily at the Project GIS level. Numerous departments have desktop GIS or CAD systems in place on a limited number of personal computers supporting project-specific needs. Because GIS use is in its infancy, there is limited collaboration occurring within and between departments with regard to spatial datasets and GIS applications.

The Technology Services Department has implemented a prototype property information application on the county intranet that demonstrates the potential that GIS technology has in efficiently distributing information across departments and with the public. The application represents a hybrid Enterprise and Public Access GIS implementation because the spatial data is centrally stored and the application uses Internet-based GIS technologies to broadcast the information.

Countywide GIS

A countywide GIS implementation is really a collaboration of project, departmental, enterprise, and public access GIS implementations. Key spatial data layers such as parcels, roads, streams, public land survey, imagery, and so forth are created and maintained by the departments or organizations with domain expertise. These key spatial layers are then stored in a central repository for efficient distribution across the enterprise and to data partners and the public.

An example of the power of an integrated countywide GIS is the ability to use it to instantaneously obtain a comprehensive understanding of a particular location. Each county department typically maintains information bases tied to parcel, address, or road number. The GIS could provide the key link to consolidating departmental datasets into a single view. An emergency response officer would be able to see contact information for the parcel owner from the Assessor, the presence of hazardous materials from Environmental Management, a premises alert from the Sheriff's Office, planned road closures from Public Works, the hospital response zone from Public Health, and numerous other pieces of key cross-organizational information that could improve the emergency response action.

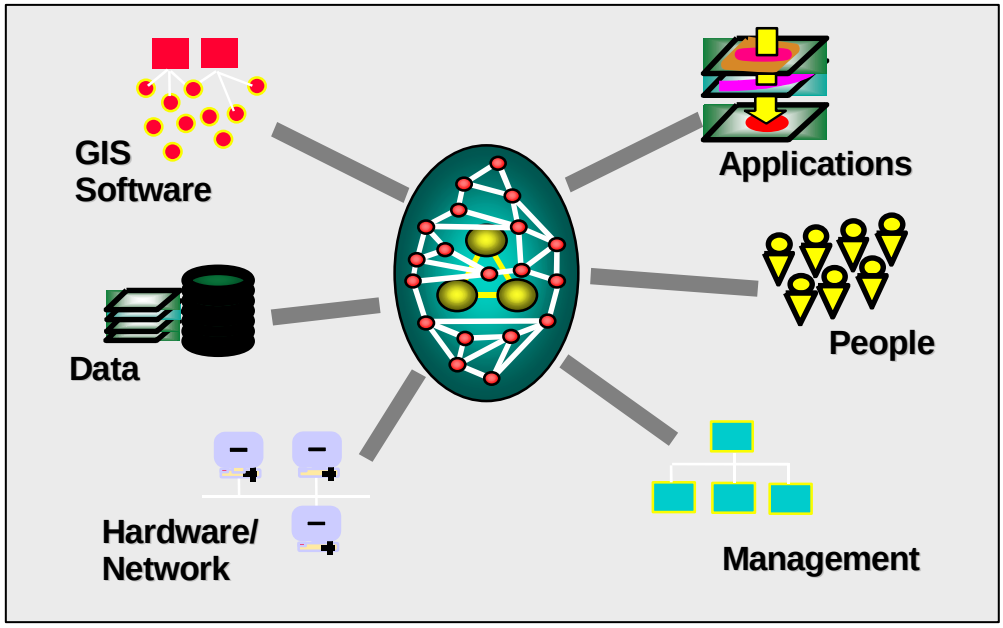
A countywide GIS extends beyond the enterprise to reflect the fact that counties must interact with a tremendous number of outside organizations during the course of delivering services. Many of these organizations actively use GIS and would be willing GIS data partners; others would realize workflow benefits in having easy access to the central countywide GIS and place less demands on limited county resources. The County of Calaveras has already taken action to formalize its relationship with key GIS data partnerships by entering into the GIS Memorandum of Understanding (MOU) with the Calaveras Council of Governments, Calaveras County Water District, and the City of Angels. Expanding the GIS MOU in the future to include additional second tier data

partners would further reduce the county costs of building additional spatial datasets and increase overall collaboration that could result in broad regional benefits.

SECTION 3—GIS IMPLEMENTATION COMPONENTS

GIS implementation requires more than just a procurement of computer hardware and software technology. Effective implementation usually requires some changes in business processes, database development and maintenance procedures, and skill levels of professional and technical staff. Local governments that have been most successful at incorporating GIS into their day-to-day activities have actually taken more of an evolutionary (as opposed to a revolutionary) approach to implementing GIS. An evolutionary approach refers to a GIS implementation that occurs incrementally over time as opposed to a revolutionary approach that occurs in dramatic fashion "overnight". It is virtually impossible for local governments or any other organization to have the necessary funding, staff, data, applications etc. ready at a single point in time to do a "complete" GIS implementation. In fact, like most information technologies, even after the initial GIS implementation, technological advances and changing organizational requirements will require that the geographic information system further evolve over time to meet these changing opportunities and needs.

As depicted in Figure 2, there are six principal components that need to be considered in



a GIS implementation:

Figure 2. GIS Implementation Components

- **Applications**—The ways in which GIS is integrated within the day-to-day workflow of an organization. It is through these applications that the benefits of GIS are realized.
- **People**—GIS technology is of limited value without the people who use the system and apply it to real-world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.
- **Management**—A successful GIS operates according to an established set of policies and business rules that are unique to a given organization. It is also necessary to specify how these policies will be developed and modified through time.
- **GIS Software**—Provides the functions and tools needed to store, analyze, and display geographic information.
- **Data**—Possibly the most important component of a GIS. Geographic data and related tabular data can be collected in-house, shared with other agencies, or purchased from commercial data providers.
- **Hardware/Network**—The computers on which a GIS operates. GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

When implementing GIS, it is important to include specifications and recommendations for all these components to ensure that the overall objectives and expected benefits are achieved.

SECTION 4—GIS DATA COORDINATION

GIS Data Coordination Conceptual Approach

The basic concept for coordinating data creation, maintenance, and use among the various organizations in a multi-participant GIS has been developed by the Federal Geographic Data Committee (FGDC) and is known as the National Spatial Data Infrastructure (NSDI). At the heart of NSDI are standards for documenting and sharing key spatial data layers referred to as "Framework Data."

Framework data is created and maintained at the highest-possible level of accuracy by local governments and is made available along with documentation about the data (also known as metadata) through a network of clearinghouses located throughout the country. Framework datasets are created and maintained cooperatively by local agencies that have the primary responsibility and necessary knowledge to provide the best possible data. Framework data include:

- Geodetic control
- Cadastral (public land survey and land parcels)
- Governmental units (census / demographics and jurisdictions)
- Orthophotography
- Transportation
- Hydrography
- Elevation

Other important data layers are created cooperatively using the framework datasets as a base, including:

- Soils
- Land use
- Land cover
- Utilities
- Slope
- Geotechnical hazards

Although FGDC has provided substantial standards for data sharing and metadata publication, the issue of creating and maintaining framework datasets has been left up to the local agencies to coordinate.

Calaveras County has assumed a leadership role in providing the coordination that is needed to develop and maintain framework data layers through local and regional partnerships. Section 7, County GIS Road Map, describes the general path that should be followed to develop these important framework data layers that will serve local needs. These data sets can also represent Calaveras County's contribution to the NSDI.

In a way, contributing to the NSDI network is analogous to constructing roads. Roads are built using a framework of agreed upon standards in order to easily connect to roads in other jurisdictions to form a national highway system that benefits all citizens. By using the NSDI framework approach to building, managing and publishing local and regional GIS datasets, County of Calaveras will be able to easily integrate its data with other jurisdictions on a national information highway system.

There are many situations where being a GIS node or participating on the broader NSDI network will benefit an area. A regional transportation-planning project can easily use base data supplied by the various localities. Local, state, and federal agencies can respond quickly to a natural disaster by combining data. A county can use watershed data from beyond its boundaries to plan its water resources. Local jurisdictions can more easily comply with state and federal reporting requirements. A business evaluating an area for relocation will be able to quickly access and use multi-jurisdictional information. Overall, participating within the NSDI framework saves money, improves data consistency and enhances decision-making for any participating organization.

GIS Data Partnerships

Common spatial datasets such as parcels, roads, streams, etc. are of value to not only county departments, but also to outside agencies and organizations. Initiatives to cooperatively develop and share a common regional spatial dataset eliminate costly redundancy and facilitate communication between organizations. The County of Calaveras has already officially recognized the importance of data partners by entering into a GIS Memorandum of Understanding (MOU) with the City of Angels Camp, Calaveras Council of Governments, and the Calaveras County Water District. The GIS MOU provides a cooperative arrangement for the coordination and sharing of GIS data between these organizations. It is anticipated that the GIS MOU will be expanded over time to include additional formal data partners.

In addition to the primary data partners, there are numerous other organizations such as federal and state agencies, utilities, private timber companies and conservation groups that maintain robust spatial datasets within the county. A number of these second tier potential data partners were active participants in the countywide GIS implementation planning process:

- U.S. Forest Service
- California Department of Forestry and Fire Protection
- California Department of Transportation

The county and its formal data partners would benefit from developing data sharing arrangements with these and other potential second tier partners. While the county and its formal data partners have successfully collaborated to develop a countywide parcel

layer, there are still numerous other framework and other important spatial data sets that will need to be developed. Working with a broader group of second tier data partners to develop these mutually beneficial layers will reduce overall data development costs and shorten the timeframe for delivering and integrating additional spatial data sets into the county government workflow. Instead of building duplicate data sets, the county can further collaborate with other organizations to jointly develop data sets and divert precious resources into GIS analysis and application development.

GIS Data Accuracy

Spatial or positional data accuracy is the degree to which information on a map or in a digital database matches true or accepted locations. Determining an appropriate level of accuracy for GIS data sets is a complex endeavor, especially where it is expected that the GIS data will be created and maintained by more than one department or agency. It is recognized that the spatial accuracy of various data sets that will be used in the countywide GIS will vary according to original source information, and available time frames and budgets for development and maintenance of the data. Accuracy is expected to vary both within and across spatial data sets due to the large countywide extent that they cover.

One approach to choosing a spatial data accuracy level involves evaluating the potential applications and decisions that will ultimately be supported by the data, and selecting the *highest* level of accuracy (typically 1- to 2-foot accuracy for local government applications). Although it is certainly desirable to have a GIS database with the highest possible accuracy, because of the large physical extent of Calaveras County, it becomes cost prohibitive to develop data sets at such a high level of accuracy. The cost to create a base map with 1- to 2-foot spatial accuracy for the County of Calaveras could easily exceed $2 million.

An alternative approach, that is favored for the County of Calaveras, is to determine the *minimum* level of spatial accuracy to support a set of applications that provide immediate benefits. As benefits from the use of GIS are derived, additional investments for improving data quality can be made through time. This approach also provides for modest initial investments in spatial data while leveraging existing data sources.

Typically, accuracy will vary within the same dataset as it is improved over time. For example, as new subdivisions are developed, improvements in surveying technologies result in more accurate representations of the parcel layer for the recently divided lots. Managing a spatial data set with differing levels of accuracy can be challenging, but it highlights the importance of good documentation or metatdata. Keeping metadata on how the spatial data set was created and updated over time is essential to understanding the limitations and proper uses of the data.

Additional documentation of varying accuracy levels within a spatial dataset can also be accomplished by associating accuracy information with specific geographic features. To track accuracy levels within a spatial data set, features such as road segments or property lines can be attributed with an accuracy code. Accuracy codes that might be used are as follows:

Accuracy Level	Accuracy Code	Accuracy Category Description
1	CM	Centimeter Accuracy
2	SM	Sub-Meter Accuracy
3	12K	Derived from 1:12,000 scale mapping
4	24K	Derived from 1:24,000 scale mapping
5	100K	Derived from 1:100,000 scale mapping

The use of accuracy codes within a spatial data set will provide users with a clear understanding of the accuracy of the features within the specific location that they are viewing.

It is important to point out that data produced by others may not be adequate for County purposes. For example, many state and federal GIS datasets are at a macro scale that may be useful for a regional perspective but may not be suitable for site-specific analysis. Site-specific analysis will probably require additional data collection efforts to improve the data within the study area.

GIS Data Standards

An important role for the GIS Technical Committee is to establish data standards. The following are preliminary recommendations for key data standards:

- **Coordinate System**—A standard coordinate system is essential for the efficient use and distribution of spatial data across county departments and agencies. The following coordinate system is recommended for the County of Calaveras: ***State Plane Coordinate System (CA Zone III), North American Datum of 1983.***
- **GIS Metadata**—GIS metadata is information about the GIS dataset. Each GIS dataset to be available in the countywide Spatial Data Warehouse should be fully documented. The County should adopt a GIS metadata standard. At a minimum, each data layer should have the following information:
    - Dataset name
    - Brief description
    - Dataset accuracy
    - Source information
    - Geographic feature type

- Data dictionary of codes used
- Date of last update
- Contact information
- Known limitations / disclaimer

It is also recommended that this metadata be maintained on-line in a format similar to the Spatial Metadata Catalog developed by the California Geographic Information Association (CGIA) (http://www.cgia.org) under a grant from the Federal Geographic Data Committee. The catalog is now on-line and maintained by the California Resources Agency CERES program (http://www.ceres.ca.gov). The metadata catalog allows users to browse the catalog and determine the applicability of a particular data set for meeting a particular mapping or spatial analysis need.

- **Tabular Data Key Fields**—The link between spatial and tabular datasets is important for GIS application development. The format of the assessor's parcel number (APN) and street address (situs) are typically the most important fields to standardize. The APN field format should follow the same format as the Assessor's property information system (Megabyte System). The situs should be formatted to facilitate GIS address matching or geocoding.
- **Digital Submission Standards**—To facilitate data exchange and incorporation of cooperator data into the GIS Data Warehouse, digital standards and procedures need to be established. Digital submission standards will reduce the cost of assembling data into a common countywide data structure that will help keep published datasets current.

GIS Data Stewardship

In a multi-participant GIS, it is important to establish formal responsibilities for the creation and maintenance of GIS datasets that will be broadly distributed and used. It is expected that within two years the countywide GIS will have over 100 spatial datasets from a variety of sources. To avoid redundant efforts, a Data Steward should be identified for each dataset that is locally maintained. For example, the Data Steward for the parcel layer would be the mapping expert(s) in the Assessor's office. Initially, the Data Steward for many of the layers will be the GIS Coordinator, but as GIS expertise and capabilities increase, more of the data stewardship responsibilities will be with the department experts most familiar with the datasets. In addition to care taking specific GIS datasets, the Data Steward will also have the responsibility for creating and maintaining metadata.

Figure 3 shows the flow of GIS information between the department GIS Data Stewards and the GIS Coordinator. The GIS Data Steward creates and maintains both the GIS data and metadata. At regular intervals, the GIS Data Steward sends the GIS data and metadata to the GIS Coordinator. The GIS Coordinator checks the data per established

standards and loads the data into the centralized Spatial Data Warehouse for further distribution. The GIS Coordinator also updates the central Spatial Data Catalog.

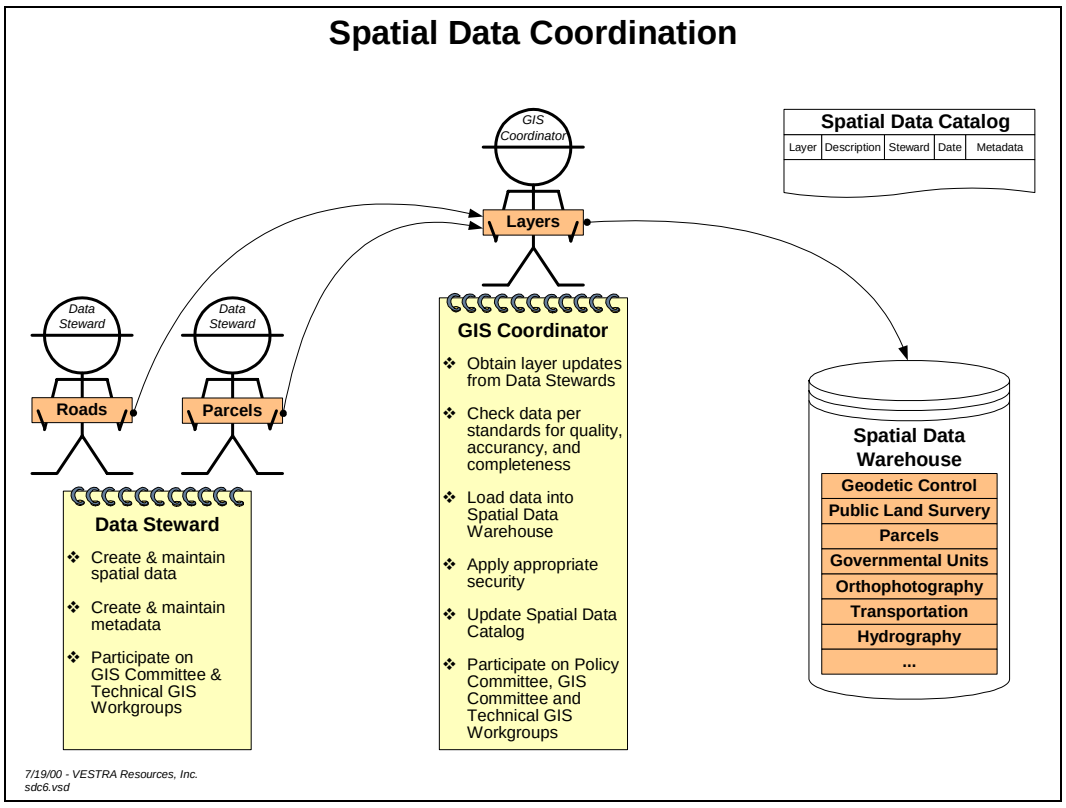


Figure 3. Spatial Data Coordination

The three main components of GIS Data Coordination are reviewed as follows:

Data Steward (Decentralized)—Data Stewards are the domain experts with GIS capabilities that create and maintain GIS datasets in the countywide GIS. Expertise using ESRI ArcInfo 8 software will be required.

GIS Coordinator (Centralized)—The GIS Coordinator is the catalyst for the countywide GIS. The GIS Coordinator maintains the master list of countywide GIS layers and data stewardship responsibilities. The GIS Coordinator checks spatial data from data stewards per the standards set by the GIS Technical Committee to assure that the countywide GIS layers are consistent and properly documented. The GIS Coordinator loads the spatial datasets into the Spatial Data Warehouse and maintains and publishes a Spatial Data Catalog and metadata. The GIS Coordinator works closely with outside data partner organizations.

Spatial Data Warehouse (Centralized)—The central GIS Data Server that uses ArcSDE (Spatial Database Engine) to store the countywide GIS layers in a relational database

management system (RDBMS) such as Microsoft SQL Server. Serves "raw" GIS layers to web-based applications as well as to professional and desktop GIS users.

SECTION 5—GIS DATA DISTRIBUTION

A countywide GIS requires a central library to store the shared GIS datasets as well as a mechanism for distributing this data to a large and diverse audience of users. This function requires large-scale information systems technologies that are typically implemented within an organization's Information Technology group. Figure 4 illustrates a simple systems model for the creation, storage, distribution and use of GIS data throughout the county.

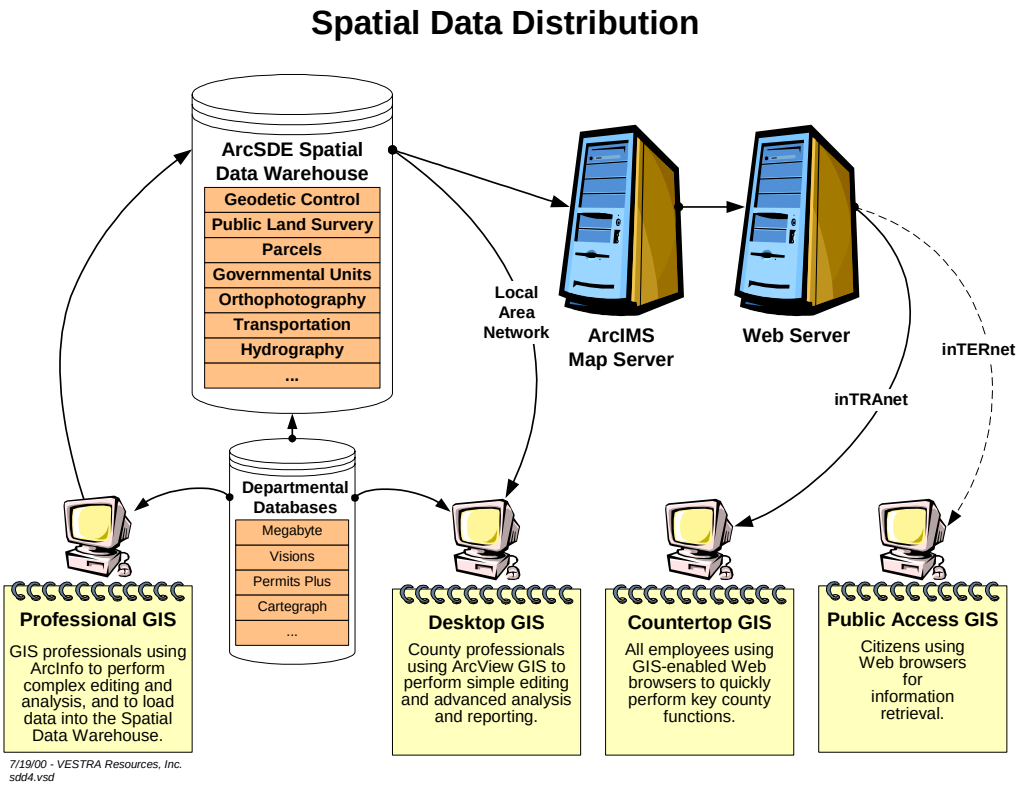


Figure 4. Spatial Data Distribution

A Data Steward using professional level GIS software maintains GIS data and metadata for a specific layer. The Data Steward provides a regular update of the GIS data and metadata to the GIS Coordinator. The GIS Coordinator checks the GIS data and metadata and loads the information into the centralized Spatial Data Warehouse. The Spatial Data Warehouse is composed of a GIS Data Server, a Relational Database Management System (RDBMS) and a gateway such as ESRI ArcSDE to efficiently store the spatial data in the tabular RDBMS. The GIS Coordinator may require assistance from a Database Administrator (DBA) to properly load the GIS layers and to apply the appropriate level of access (security).

Once in the Spatial Data Warehouse, users of professional and desktop GIS software clients can directly access the GIS data. The GIS data in the Spatial Data Warehouse is in a "raw" form without symbolization, labels, color, or classification. Users of professional and desktop GIS software clients must be proficient at incorporating this "raw" GIS data into their projects. In addition to accessing the GIS data, these users will also require access to key departmental databases in order to join the spatial data with tabular data for further analysis and reporting.

The primary mechanism for distributing GIS data to casual countertop and public access users is through the use of Web-based technologies. The two key Web-based technologies in Figure 4 are the GIS Map Server and the Web Server. A Web-based GIS application must first be developed to provide quick access and viewing of spatial data. A user makes a simple request from a Web browser to the Web Server, the Web Server hands the GIS request to the GIS Map Server, which then retrieves the appropriate spatial data from the GIS Data Warehouse to be sent back to the Web browser via the Web Server. Given the popularity of Web browsers, Web-based GIS applications have the potential of reaching broad audiences on the county's intranet as well as across the Internet. A key advantage of Web-based GIS applications is that the user will be able to use geographic information without possessing GIS expertise or specialized GIS software.

SECTION 6—GIS GOVERNANCE & COORDINATION

The development, maintenance and use of GIS in the County of Calaveras should be guided by the important policy and business needs of the County. County departments and agencies, as well as other organizations (public, private, and non-profit) that operate in the County, may have a common interest in coordinating efforts to meet their diverse business needs. Other sections of this document discuss the benefits of coordinating GIS development and maintenance across various County departments. There are even greater potential benefits if GIS development and maintenance efforts can be extended across a wide range of organizations and levels of government that share a common geographic location.

There are two primary roles that need to be addressed for efficient coordination of GIS effort: 1) a structure within County government for ensuring effective implementation of GIS to meet the County's business needs, and 2) a forum to encourage collaboration and partnerships.

Over the past year, the County of Calaveras has introduced some key organizational changes that will be important to the successful integration of GIS into County workflow. The Board of Supervisors has established a GIS Unit in the Technology Services Department under the direction of the Chief Information Officer (CIO). The GIS Unit has been staffed with a GIS Coordinator and a GIS Technician. These organizational changes are consistent with the overall direction of this GIS Implementation Strategy. Figure 5 below shows the management structure for GIS activities already in place within the County.

The GIS Coordinator will help to facilitate and coordinate GIS activities across County departments and with external data partners. While the overall Technology Services Department and the GIS Unit will play a predominant role in GIS operations, significant contributions will need to be made to the County GIS effort by GIS Data Stewards in various County departments such as the Assessor's Office, Public Works, and Planning.

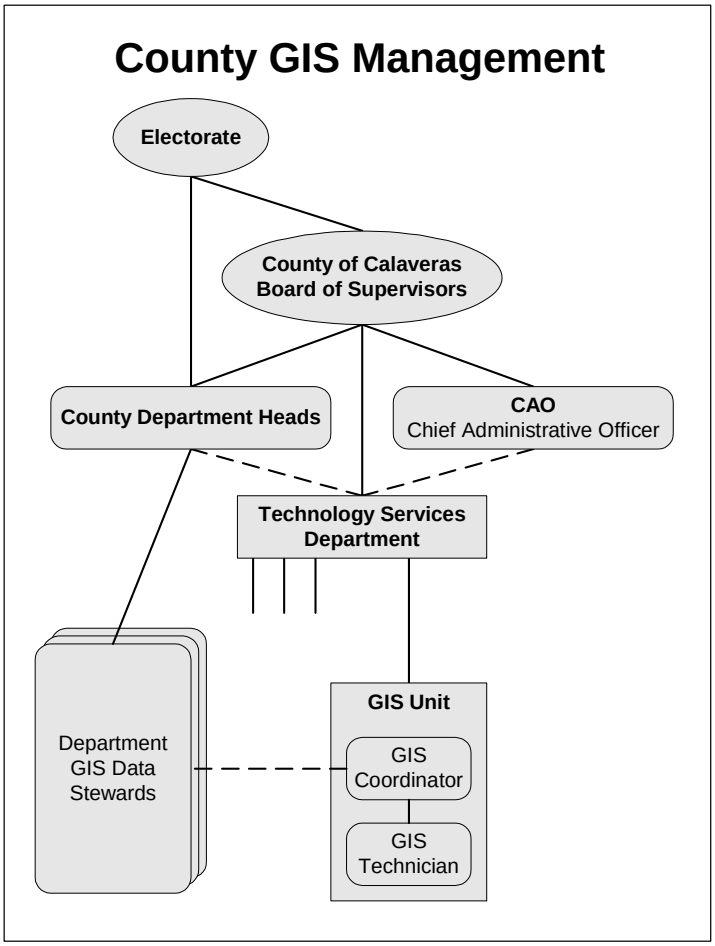


Figure 5. County of Calaveras GIS Management Structure

The success of the countywide GIS implementation will be largely determined by the active participation by representatives from all of the County departments and non-county organizations that have been participating to date. Additional departments and organizations should be encouraged to participate as the GIS implementation progresses.

The large number of County departments and non-county organizations involved in the countywide GIS implementation will require effective top-level governance. The County of Calaveras is fortunate to have already established an initial GIS governance structure. A GIS Memorandum of Understanding (MOU) exists between the County of Calaveras, Calaveras County Water District, City of Angels Camp and the Calaveras Council of Governments. The GIS MOU defines two decision-making committees, the GIS Executive Committee and the GIS Technical Committee.

Figure 6 "Countywide GIS Governance and Coordination" provides a schematic view of the relationship between the overall coordination efforts of GIS, Countywide.

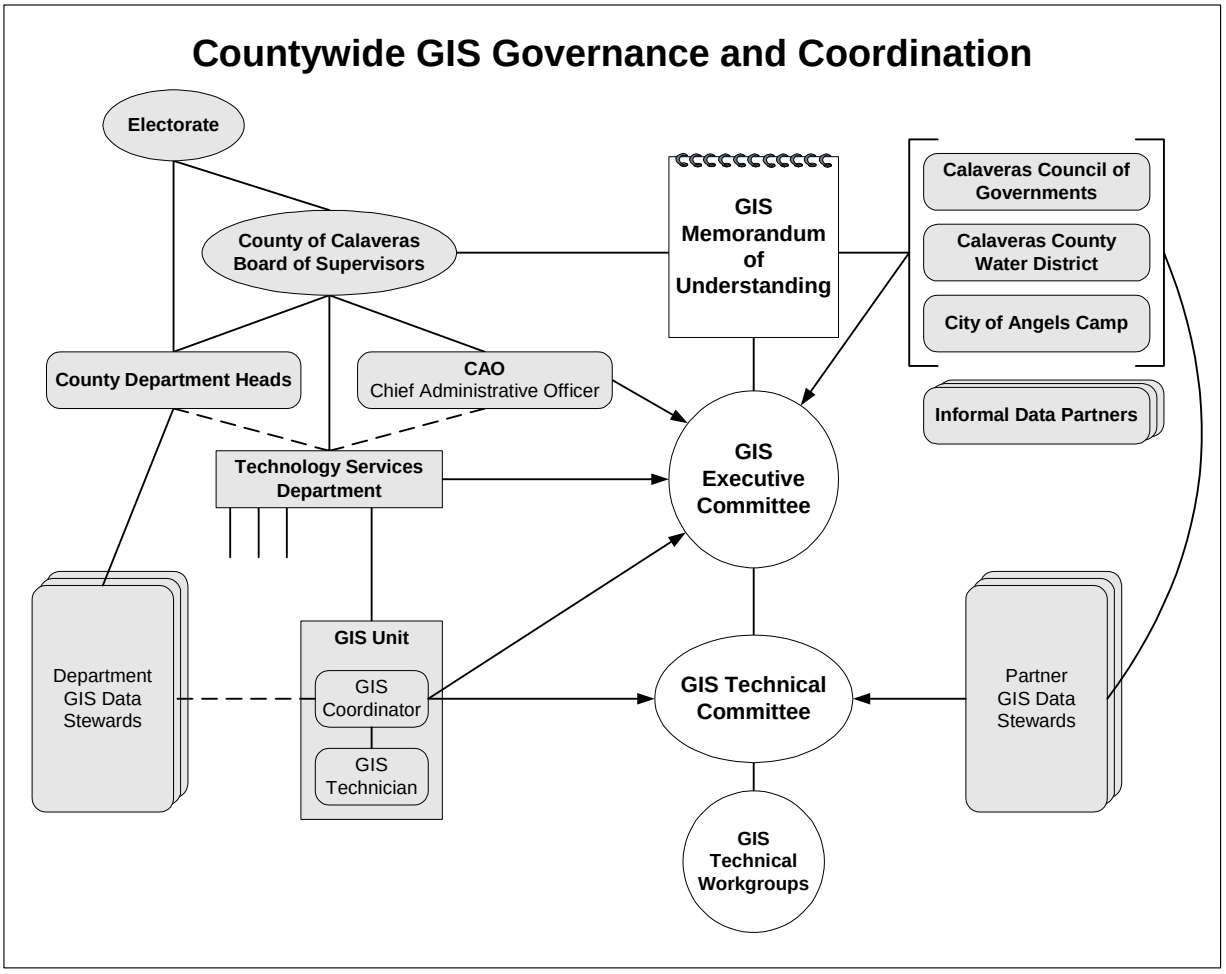


Figure 6. Countywide GIS Governance and Coordination

The GIS Executive Committee (a.k.a. GIS Policy Committee) is composed of high-level officials and GIS Coordinators from each organization to provide policy, coordination and direction for the development of the GIS. The role of the GIS Executive Committee is to address the common uses of GIS and shared geographic information. Specifically, the GIS Executive Committee should identify, prioritize, coordinate, and seek funding sources to achieve solutions that are common among organizations (Figure 7). In turn, representatives to the GIS Executive Committee from the various member organizations need to be responsible to their organizations to manage and implement data and applications that will meet their policy and business needs.

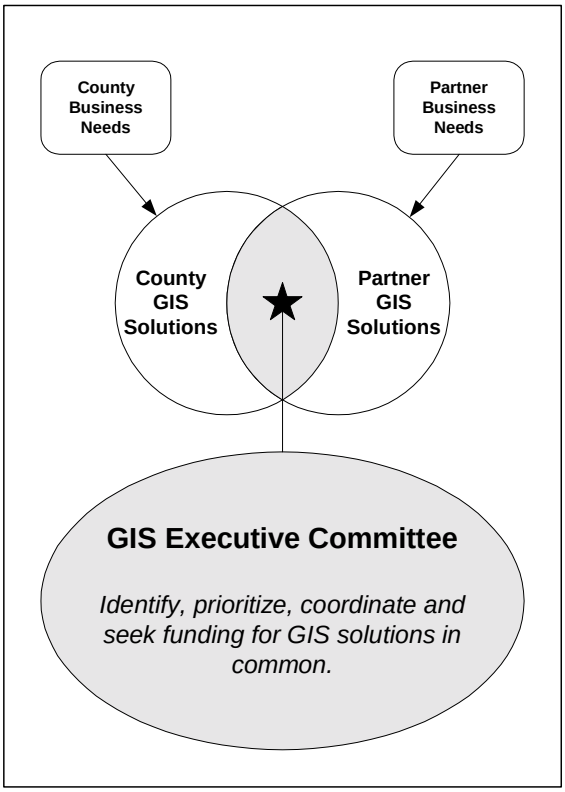


Figure 7. GIS Executive Committee

The Technical Advisory Committee (a.k.a. GIS Technical Committee) is composed of GIS Coordinators, GIS Users, and Information Technology Directors from the participating organizations. The GIS Technical Committee will develop common standards for spatial data and metadata along with procedures for updating, storing and distributing the geographic information.

In addition to these committees, the County of Calaveras and its data partners should establish smaller data and applications working groups. These GIS technical work groups will be lead by either the County GIS Coordinator or the GIS Data Steward with responsibility for the spatial data set or GIS application. Work groups will provide focused technical forums to develop standards and address technical issues for endorsement by the GIS Technical and GIS Executive committees.

Figure 8 illustrates the general work and decision-making flow between the GIS Executive Committee and the GIS Technical Committee. The GIS Executive Committee identifies business and policy needs that shared GIS solutions across the partner organizations might address. These needs are prioritized and likely funding sources are identified. The GIS Technical Committee analyzes the needs and formulates work plans

that include the appropriate technology, efforts and standards that will be required. The work plans are then evaluated by the GIS Executive Committee for approval and funding. Finally, the GIS Technical Committee coordinates the multi-participant work plan activities.

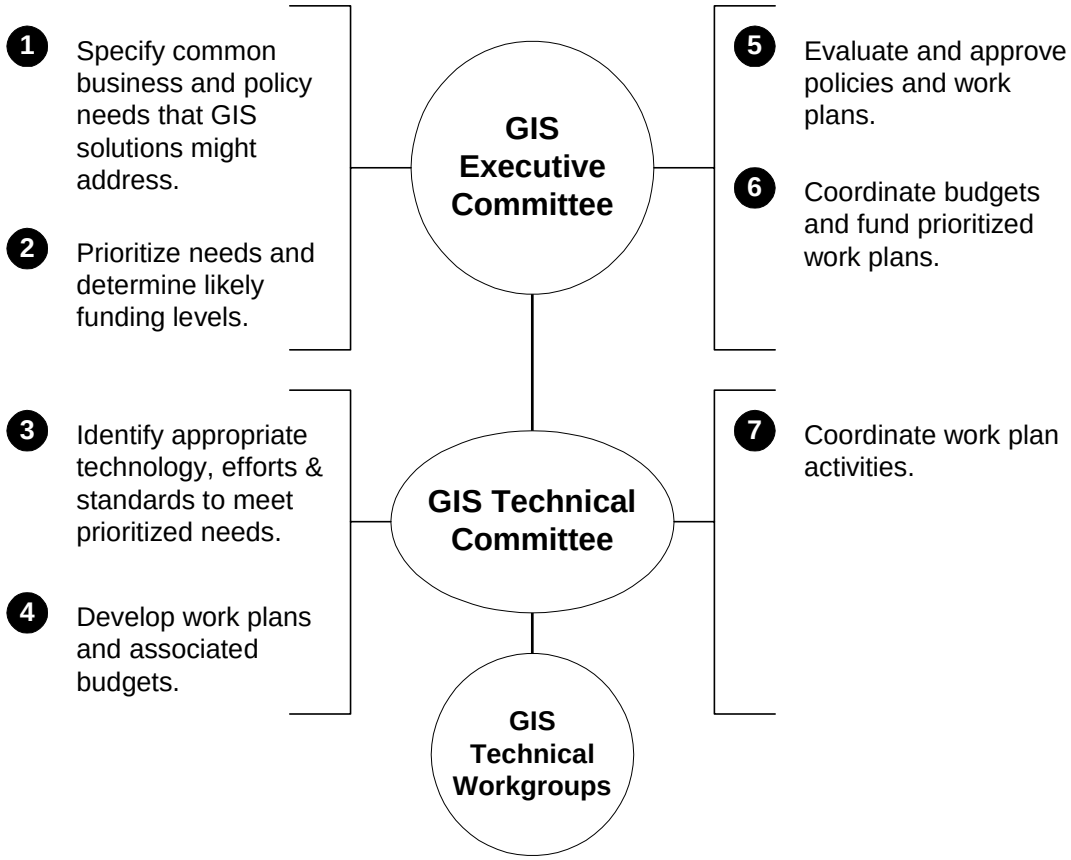


Figure 8. Overview of Workflow between GIS Committees.

It is important to emphasize that Figure 8 represents a generalized example of workflow between the two key GIS Committees. The GIS Executive Committee should consider the above workflow a starting point rather than an ending point and use the diagram as a discussion item early in the GIS implementation process.

SECTION 7—OVERVIEW OF GIS IMPLEMENTATION PHASES

Using an incremental or phased approach to implementing GIS provides for a gradual acceptance and understanding of how the technology can be used most effectively. It also provides a phased investment process that allows managers to more carefully evaluate the benefits and to scale future expansion accordingly. This type of approach provides for incremental improvements and avoids unrealistic expectations and demands that often accompany large procurements.

Based on discussions during departmental interviews and various factors such as realistic expectations for staffing, budget levels and technology trends, implementation of a countywide GIS for Calaveras County should take place over the next three to five years. Three implementation phases have been identified to guide the countywide GIS. Each phase is designed to accomplish a specific set of goals and to provide a solid foundation for continued progress toward the longer-term, countywide objective of integrating a common spatial database into the day-to-day operations.

The three primary phases that have been identified for County of Calaveras are as follows:

- **Phase I: Countywide GIS Infrastructure:**
  The primary focus of this phase is to create the foundation for the countywide GIS. This not only includes the pre-requisite technology systems, but also the people systems. The committees of GIS participants will begin meeting to establish GIS policies, procedures, and standards. The County GIS unit will be staffed and equipped. Readily available GIS data from County departments and data partners will be collected and stored on a centralized GIS Data Server. Departments will begin using GIS for simple mapping and viewing of available spatial data.

- **Phase II: Departmental GIS**
  Key GIS datasets and systems to support the effective use of GIS within county departments will be completed during this phase. A centralized GIS Data Warehouse and GIS Map Server will provide a robust means of distributing spatial data across the county network and also to the public via the Internet. Departments will have enough GIS tools, expertise and spatial datasets available to noticeably improve work processes.

Phase III: Integrated Applications & Analysis

GIS applications will be created which will be integrated with large department business systems. Web-based GIS applications on both the intranet and Internet will advance the County closer to the concept of having a virtual front counter. Mobile GIS technologies will allow staff in the field to have real-time access to spatial datasets. Specialized GIS expertise utilizing 3D analysis and modeling will develop in certain departments.

As was mentioned earlier in this plan, a successful GIS implementation requires six principal components to be in place: people, management, data, hardware / network, software, and applications. It is important to attend to all of these components in each phase of the implementation. The following figure shows the basic structure for the implementation activities across and within phases. In each phase, there are activities associated with GIS Coordination (people / management), Data Development (data), GIS Systems (hardware / network, software) and Priority Applications (applications).

The figure further emphasizes a point that organizations implement GIS for the purpose of deploying applications. Resources are invested in GIS committees, GIS data development and GIS systems to deliver priority GIS applications that meet expressed needs. The need for solutions (GIS applications) determines the activities associated with GIS coordination, data development and systems deployment.

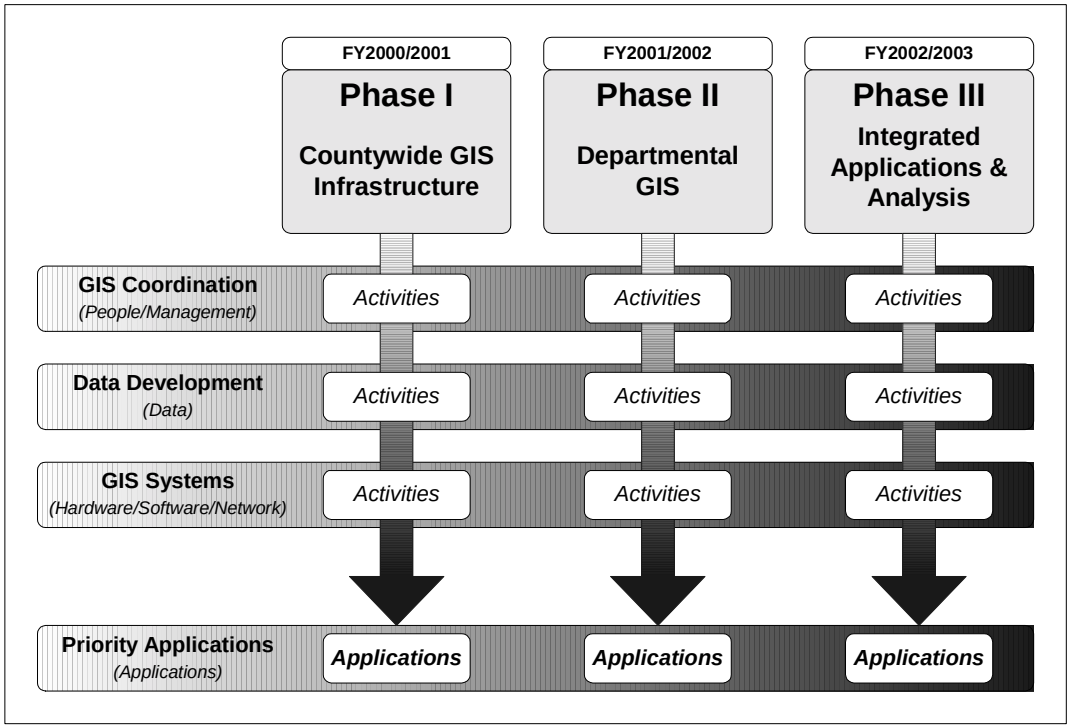


Figure 9. GIS Implementation Activities Format

The remainder of this section presents the recommended GIS implementation activities over the next three-years, first with a series of figures, and then with a description of each activity. The Calaveras County GIS Implementation "Road Map" shown in Figures 10, 11, and 12 summarize recommended activities in the areas of GIS coordination, GIS data development, GIS systems and priority applications for each of the three GIS implementation phases. Figure 13 provides a single page diagram of the summarized activities over all three GIS implementation phases.

Many of the activities and applications in later phases are dependent upon the successful completion of activities and applications in earlier phases. For example, in order to deploy the "Real-time Emergency Response Dispatching System with GIS" in Phase III, activities such as "Complete GPS Capture of Roads" in Phase I, and "Resolve Problems with Addressing Data" and "Attribute Roads with Address Ranges" in Phase II will need to be completed.

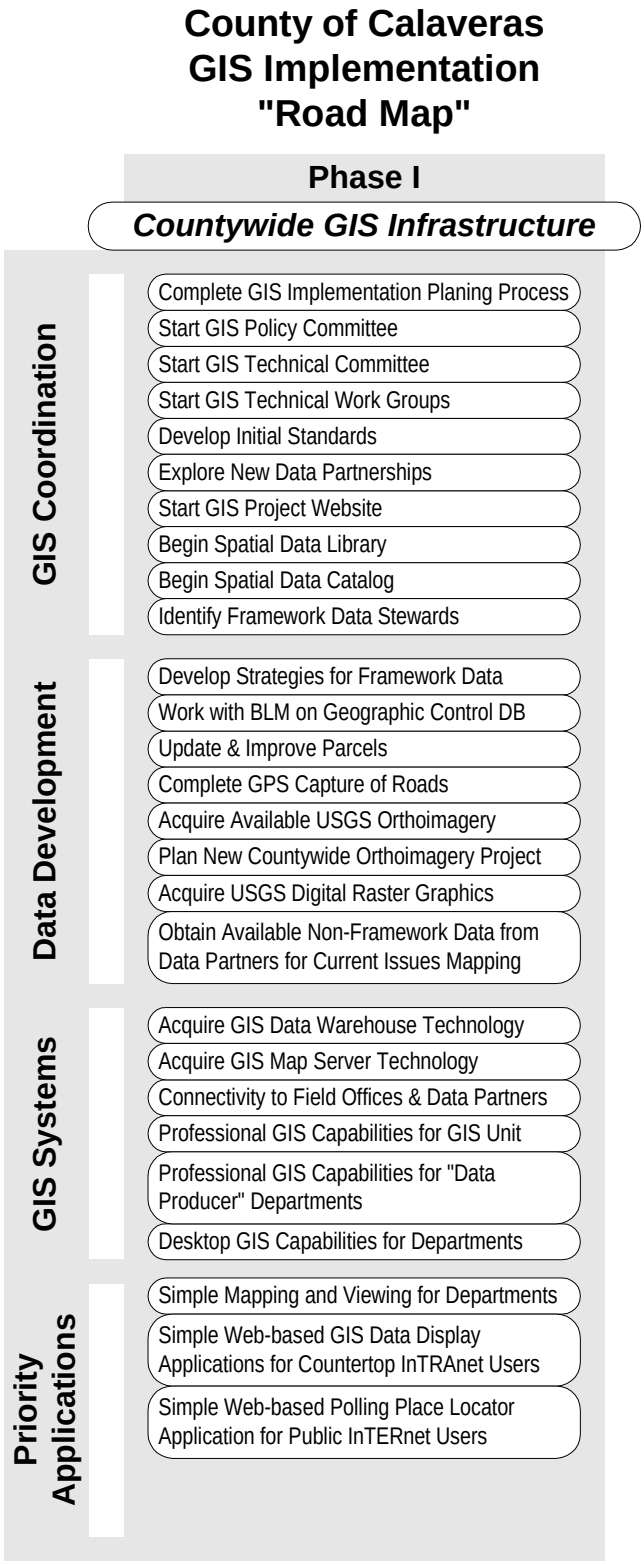


Figure 10. County of Calaveras GIS Implementation “Road Map” – Phase I

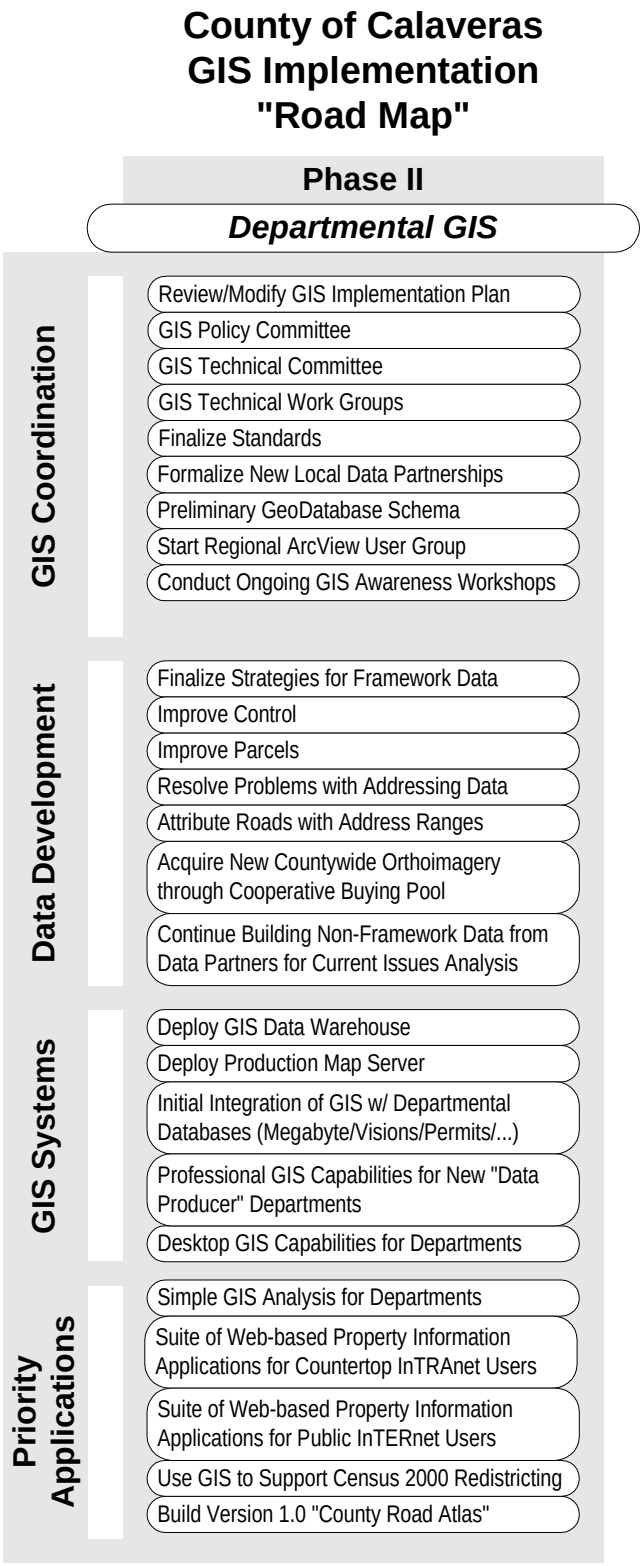


Figure 11. County of Calaveras GIS Implementation “Road Map” – Phase II

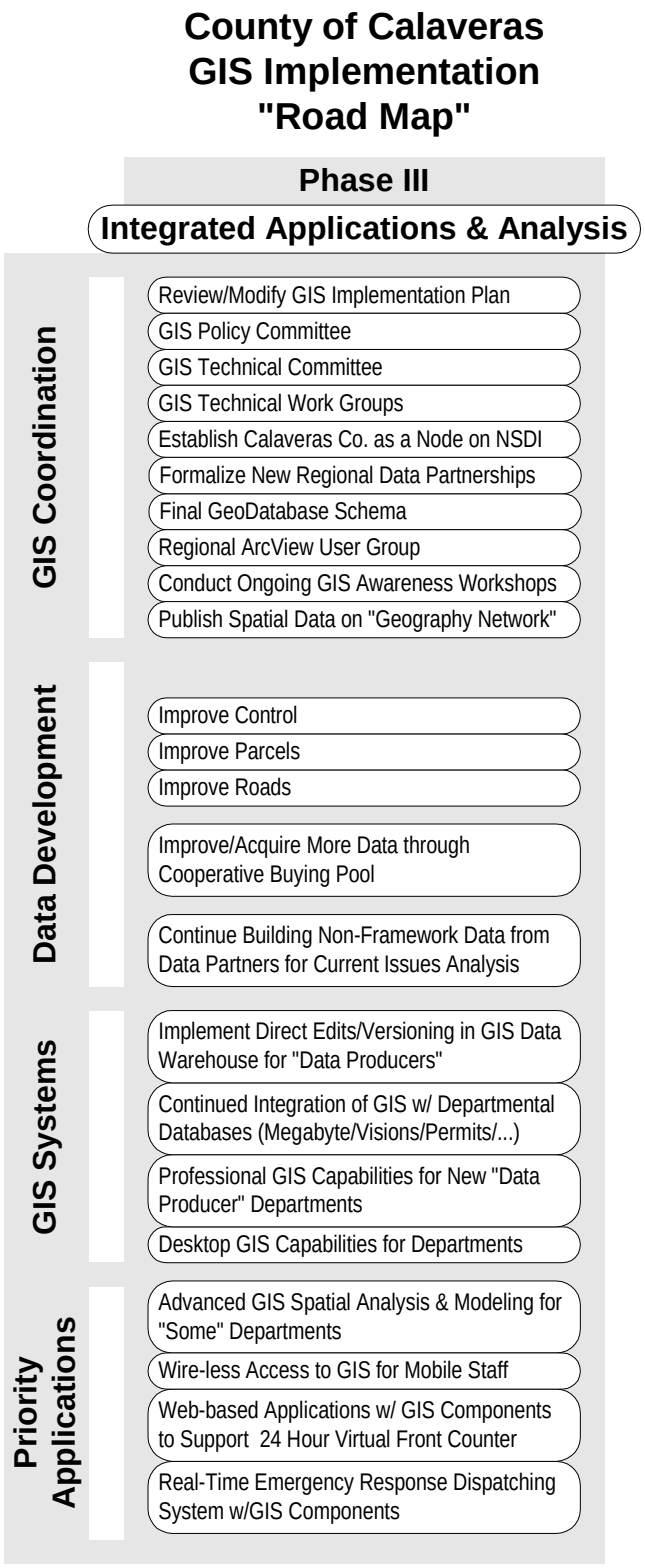


Figure 12. County of Calaveras GIS Implementation “Road Map” – Phase III

County of Calaveras GIS Implementation "Road Map"

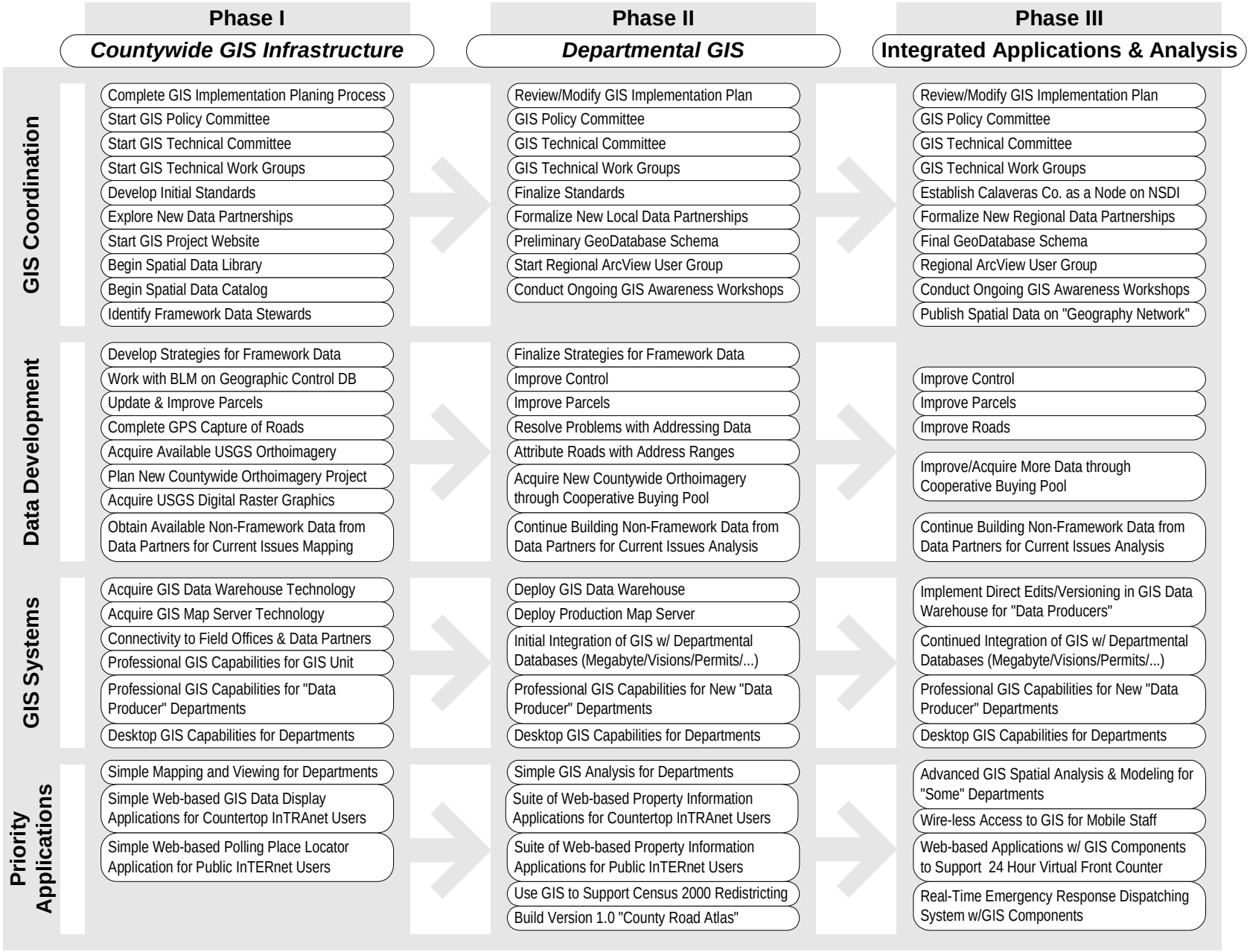


Figure 13. County of Calaveras GIS Implementation “Road Map”

Phase I – Countywide GIS Infrastructure (FY2000/2001)

GIS Coordination (Phase I)

1. **Complete GIS Implementation Planning Process**
   The current Countywide GIS Implementation Plan should be completed and widely distributed. As the implementation progresses, it is expected that a number of new participants will join the effort. The Applications and Information Needs Assessment (companion document) and this GIS Implementation Plan will provide newcomers with a good background on the initial direction of the countywide GIS implementation.

2. **Start GIS Policy Committee (GIS Executive Committee)**
   The GIS Policy Committee, as defined in the GIS Memorandum of Understanding, should begin meeting as soon as possible now that the County's GIS Coordinator is in place. The Policy Committee should encourage the GIS Technical Committee to develop some initial spatial data standards and to begin identifying "Data Stewards". Initially, the GIS Policy Committee should be meeting on a monthly basis to stay abreast of the implementation activities. Overtime, the GIS Policy Committee will probably only need to meet on a quarterly basis.

3. **Start GIS Technical Committee**
   The GIS Technical Committee, as defined in the GIS Memorandum of Understanding, should begin meeting on a monthly basis. During one of the GIS implementation workshops, it was mentioned that "non-technical" GIS representatives should feel free to attend these meetings. This plan refers to this committee as either the GIS Technical Committee or the GIS Committee, and suggests that highly technical matters be addressed by smaller, focused GIS Technical Work Groups

4. **Start GIS Technical Work Groups**
   Based on GIS implementation experiences in other similar counties, the GIS Committee should start a number of GIS Technical Work Groups. The GIS Coordinator would attend all of these meetings, but in many cases other department staff with domain expertise may lead the groups. The following GIS Technical Work Groups are recommended:

- Standards Work Group
- Geodetic Work Group
- Cadastral Work Group
- Transportation Work Group
- Governmental Units Work Group

5. **Develop Initial Standards**
   One of the first priorities for the various GIS Committees is to begin the process of setting spatial and metadata standards. With almost 20 different county departments and outside organizations interested in sharing spatial data, standards will insure that data flows smoothly between the partners.

6. **Explore New Data Partnerships**
   The County of Calaveras already has some valuable formal and informal data partners. The direct benefit of data partnerships is that it lowers and spreads out the highest cost of GIS, which is data development. Data partnerships also help to develop collaboration with organizations that the County does business with which should result in more effective delivery of citizen services. There are many other local and regional organizations that have the potential of becoming important data partners. The GIS Coordinator and other participants should make a strong effort to seek new data partnerships.

7. **Start GIS Project Website**
   The GIS Coordinator should work with the County Webmaster to start and actively maintain a "Countywide GIS Project" Web site on the Internet. This will become an excellent forum for communicating with the large number of GIS participants.

8. **Begin Spatial Data Library**
   One of the most valuable resources in a countywide GIS is participant access to a central "GIS Library". The GIS Coordinator should begin to develop a directory structure and make the initial GIS data sets available.

9. **Begin Spatial Data Catalog**
   In order to find things in the "GIS Library", a simple catalog should be created which lists the spatial dataset name, description, location on the GIS Data Server, version, and a reference to the metadata (additional documentation) for the layer.

10. **Identify Framework Data Stewards**
    There are a number of key data layers that provide the "framework" for building other spatial data layers. For the County of Calaveras, framework layers would include parcels, roads, and geodetic control (survey monuments). The GIS

Committee should begin the process of identifying the "caretaker" or "steward" for these key framework layers. In order to avoid costly duplication of effort, a single department / organization should be responsible for each layer.

Data Development (Phase I)

1. **Develop Strategies for Framework Data**
   Most GIS applications will require framework data, and a significant amount of initial county GIS resources will need to be devoted to developing and maintaining these fundamental datasets. Framework data development or acquisition strategies need to be established. A few of the key framework layers are addressed below.

2. **Work with BLM on the Geographic Coordinate DB**
   The Bureau of Land Management's (BLM) Geographic Coordinate Data Base (GCDB) is a collection of geographic information representing the Public Land Survey System (PLSS) of the United States. The majority of Calaveras County is within the BLM's GCDB project, and to date, the BLM's GCDB is the best available source of PLSS. Calaveras County should work closely with BLM to maintain and improve this important GIS layer.

3. **Update & Improve Parcels**
   During the summer of 1999, VESTRA Resources, Inc. assisted the Assessor's office with the creation of a countywide parcel GIS layer. The immediate focus of the project was the Tax Rate Area (TRA) submission of newly organized fire districts to the State Board of Equalization. Various partners such as Calaveras County Water District, City of Angels, Volcano Telephone, Ebitts Pass Fire District, and the United States Forest Service contributed valuable data to this effort.

   Future key GIS applications will depend on a robust and well-maintained countywide parcel layer. County of Calaveras should develop the in-house capabilities and procedures necessary to maintain and improve the parcel layer.

4. **Complete GPS Capture of Roads**
   During the summer of 2000, Calaveras County Public Works Department initiated a project with QUAD KNOFF and VESTRA Resources, Inc. to inventory pavement condition and to develop a pavement management system that could

be integrated into the countywide GIS. A key aspect of the project is the Global Positioning System (GPS) capture of roads. The completion of this effort will result in the best available GIS road "line-work" for county and state maintained roads along with major private roads.

5. **Acquire Available USGS Orthoimagery**
   In partnership with federal agencies such as the United States Forest Service, the United States Geological Survey (USGS) has acquired aerial photography for much of California. USGS post-processed these aerial photographs into a product called Digital Orthophoto Quads (DOQs) which can be used in a GIS. County of Calaveras should acquire currently available DOQs. The DOQs provide a cost-effective means of quickly introducing aerial photography into the county GIS. At current USGS pricing, County of Calaveras could acquire black and white imagery (1993-1998 one meter resolution) for all thirty quads for approximately $1,000. However, it should be noted that USGS is currently processing the majority of DOQs for the County. County of Calaveras and its data partners should contact USGS to help accelerate the processing of these images.

6. **Plan New Countywide Orthoimagery Project**
   The USGS DOQs are an excellent initial source of imagery for the countywide GIS, but the DOQ spatial accuracy and resolution is not expected to meet user requirements in the not-so-distant future. The county and its formal and informal data partners should begin planning for the acquisition of complete and up-to-date orthoimagery for the entire county. Depending on the level of resolution and accuracy, countywide custom imagery could easily exceed $30,000 which highlights the importance and necessity of cost sharing partnerships. Partners should begin to identify requirements, evaluate imagery options, and to develop some initial cost-sharing strategies.

7. **Acquire USGS Digital Raster Graphics**
   The USGS Digital Raster Graphics (DRGs) are scanned and registered topographic maps. Although most County of Calaveras staff are unfamiliar with GIS, they are very familiar with USGS topographic maps. In fact, many departments currently rely on these paper maps during their normal course of business. Providing the DRGs to new GIS users provides a familiar reference layer in the GIS, and eases the transition from paper systems to automated systems. There are numerous private and public vendors of scanned USGS topographic maps. One of the best sources of DRGs for California is the State of California, Stephen P. Teale Data Center.

8. **Obtain Available Non-Framework Data from Data Partners for Current Issues Mapping**
   The creation of quality GIS datasets is often costly and time consuming. Whenever possible, the county should leverage off of existing GIS datasets developed by other organizations. In addition to the creation or acquisition of framework datasets such as parcels, roads, orthoimagery, etc., the county should seek existing non-framework datasets to help support current issues mapping and analysis. The sooner that local data is available to county staff, the sooner they will be able to start integrating GIS into their departments to improve workflow. Even if the initial datasets do not entirely meet staff data requirements, the experience gained with these initial GIS forays is invaluable.

GIS Systems (Phase I)

1. **Acquire GIS Data Warehouse Technology**
   The Calaveras County Technology Services Department currently has a centralized computer server to store GIS data. This server is also known as the GIS Data Server and it will serve as the GIS data library. Currently the GIS Data Server is able to serve file-based spatial datasets on the County Local Area Network (LAN). Distributing file-based spatial datasets in a large organization will result in an inordinate amount of network traffic and there will be performance issues. The Technology Services Department should implement more efficient spatial data storage and distribution technology on the GIS Data Server. Microsoft SQL Server 7 and ESRI ArcSDE 8 are technologies that could be implemented on the existing GIS Data Server to transform it into a more robust GIS Data Warehouse.

2. **Acquire GIS Map Server Technology**
   The Calaveras County Technology Services Department currently has an older server that is functioning both as an intranet Web server and as a prototype GIS Map Server. The GIS Map Server allows County staff to access simple parcel lookup applications via a Web browser on the County Intranet. A significant number of future County applications will be delivered to staff and the public through Web browsers. The Technology Services Department should acquire a new contemporary GIS Map Server to be poised to deliver new Web-based

applications using spatial datasets. In addition, a new production Intranet Web Server should also be acquired to replace the failing current system so that the map serving and intranet Web serving are on separate production-level systems.

3. **Connectivity to Field Offices & Data Partners**
   County of Calaveras has established network connectivity with one of its formal data partners, the Calaveras County Water District. Network connectivity does not currently exist to the other formal data partners, the City of Angels and the Calaveras Council of Governments. In addition, some county department field offices also lack network connectivity to the main county facility. Network connectivity is essential to the success of a multi-participant, countywide GIS. The Technology Services Department should implement appropriate connectivity solutions to County field offices, along with formal and informal GIS data partners.

4. **Professional GIS Capabilities for GIS Unit**
   During the summer of 2000, the County of Calaveras created a GIS Unit in association with the Technology Services Department. A GIS Coordinator and a GIS Technician have been hired. In order to function, the GIS Unit needs specialized GIS equipment and software. Basic GIS hardware includes computer workstations, large-format scanner, digitizer board, large-format color plotter, small-format color printer, and a GPS receiver. The GIS Unit will need "professional" level GIS software to provide them with a robust environment for spatial data creation.

5. **Professional GIS Capabilities for "Data Producer" Departments**
   In addition to the GIS Unit in the Technology Services Department, additional county departments with data stewardship responsibilities over key framework layers, such as parcels and roads, will also need professional GIS capabilities. Initially, the Assessor's Office and the Public Works Department will need additional hardware, software and training to become proficient at the professional GIS level in order to create and maintain key county spatial datasets that will be used by all departments and data partners.

6. **Desktop GIS Capabilities for Departments**
   The "map intensive" departments that have been participating in the countywide GIS implementation should begin by developing basic desktop GIS capabilities. This would include the acquisition of a desktop GIS software package (ArcView GIS) with formal or informal training.

Priority Applications (Phase I)

1. **Simple Mapping and Viewing for Departments**
   Integrating GIS into the workflow of departments is an evolutionary process. Departments with desktop GIS capabilities can begin with simple viewing and mapping of existing spatial datasets housed on the GIS Data Server in the Technology Services Department. One example might be a planner viewing the parcel and flood zone layers to determine if a particular property is within a flood plain. Another example might be an environmental specialist that needs to view parcels and the underlying geology layer to determine what groundwater ordinance applies to an application for a well drilling permit.

2. **Simple Web-based GIS Data Display Applications for Countertop Intranet Users**
   Current Web-based GIS technologies provide features to quickly and easily publish existing spatial datasets for simple viewing by Web browsers. The Technology Services Department should begin to publish existing spatial datasets to countertop Intranet users in advance of building Web-based GIS applications that have longer development cycles.

3. **Simple Web-based Polling Place Locator Application for Public Internet Users**
   Elections provide an excellent opportunity to build simple Web-based GIS applications to assist the public in locating polling places. Such applications could be created without a tremendous development effort and would be an excellent demonstration of simple Web-based GIS on the Internet.

Phase II – Departmental GIS (FY2001/2002)

GIS Coordination (Phase II)

1. **Review/Modify GIS Implementation Plan**
   Planning is an ongoing process, and the GIS Policy Committee and GIS Technical Committee should review and modify as necessary this GIS Implementation Road Map.

2. **GIS Policy Committee (GIS Executive Committee)**
   The GIS Policy Committee, as defined in the GIS Memorandum of Understanding, should continue to meet on a regular basis. After the initial GIS implementation phase, it is suggested that the GIS Policy Committee meet on a quarterly basis. The GIS Policy Committee will need to address a number of issues associated with the development, use and distribution of spatial data which include security, privacy, cost sharing, and second-tier partnerships.

3. **GIS Technical Committee**
   The GIS Technical Committee (GIS Committee), as defined in the GIS Memorandum of Understanding, should continue to meet on a regular basis. It is suggested that the GIS Committee meet once per month.

4. **GIS Technical Work Groups**
   GIS Technical Workgroups are small focused working groups created by the GIS Technical Committee to address highly technical issues. These working groups are created as needed.

5. **Finalize Standards**
   The GIS Technical Committee should finalize spatial and metadata standards. The standards should be widely distributed with a primary focus on those departments that have data stewardship responsibilities. The GIS Coordinator needs to insure that spatial data stored on the GIS Data Server (GIS library) adheres to these standards.

6. **Formalize New Local Data Partnerships**
   The value of GIS continues to increase as new datasets become available and consumers of GIS data increase. The County of Calaveras and its formal data

partners should continue to consider formalizing relationships with other local organizations using GIS.

7. **Preliminary GeoDatabase Schema**
   The GIS data model is undergoing a dramatic transformation from "primitive" or "simple" features (points, lines, polygons) to an object-oriented model referred to as the geodatabase. The County of Calaveras should stay abreast of industry consortiums that are working to standardize geodatabases for framework layers such as parcels, roads, streams, etc. The County should begin to evaluate industry standard geodatabase schema (design) for future county use.

8. **Start Regional ArcView User Group**
   Over the last few years, localized GIS user groups have become popular forums for GIS users to gather, share knowledge and data, and to address regional GIS issues in an "informal" setting. ESRI's ArcView GIS software is often times the common GIS denominator between various organizations and individual users. The County should take a leadership role in the formation of a local ArcView GIS User group.

9. **Conduct Ongoing GIS Awareness Workshops**
   GIS is a new technology to County of Calaveras, and departments will have different rates of adoption. The GIS Committee should conduct periodic workshops to demonstrate the uses and benefits of GIS to broader audiences.

Data Development (Phase II)

1. **Finalize Strategies for Framework Data**
   The County should finalize its strategies for developing initial framework datasets. As the GIS implementation progresses and more staff and data partners integrate spatial data into their day-to-day workflow, the County will also need to develop strategies to maintain and improve framework layers. Over time, new technologies and resources will also become available to facilitate the improvement of key spatial datasets.

2. **Improve Control**
   County efforts with the BLM Geographic Coordinate Database and local surveyors will facilitate regular improvements to the Public Land Survey System

layer. Other GIS layers that are dependent on this layer can then also be improved.

3. **Improve Parcels**
   A continuous parcel layer is perhaps the most important component in a Countywide GIS. It is essential to devote appropriate resources to maintain and improve parcels on a regular basis. As the underlying control improves (Public Land Survey System), the County will also be able to improve the spatial accuracy of the parcel layer. It should also be noted that the completed GPS capture of roads and new orthoimagery will also facilitate the improvement of the parcels.

4. **Resolve Problems with Addressing Data**
   Street address is contained as a common location reference within nearly all county databases. Because addresses have such important and widespread uses, it is critical for the County to have a consistent, accurate system of assigning and maintaining address information within all County databases. Having consistent, accurate address information provides a common frame of reference between otherwise independent databases (e.g. business licenses and health inspections), and allows the mapping of this information using a GIS capability referred to as geocoding.

   In geocoding (also referred to as address matching), an electronic dot can automatically be placed on the GIS map based on the house number, street and community name. Departments requiring address matching depend on a consistent addressing scheme in order to benefit from the use of GIS.

   An example of the importance of consistent and accurate data would be an application that would route emergency response vehicles to an incident based on an address. To achieve maximum benefits from the GIS implementation, it is important to resolve these addressing inadequacies as soon as possible. The County should develop and maintain a single addressing database that contains official road names, valid addresses and community/city names that all departments and agencies can share.

5. **Attribute Roads with Address Ranges**
   The initial GPS capture of roads will provide quality line work and road segments will be attributed with road name and pavement management information. The road segments will not include address ranges. In order to use the GIS for future emergency response routing applications, the road segments will need to be attributed with address ranges.

6. **Acquire New Countywide Orthoimagery through Cooperative Buying Pool**
   The County's formal and informal data partners should enter into a cooperative cost sharing arrangement to acquire updated orthoimagery for the entire county. With new satellite technologies providing cost effective imagery, the buying pool should consider a plan to update the imagery on an annual basis. Higher resolution aerial imagery may be required for more developed areas of the County.

7. **Develop Spatial Data for Current Issues Analysis**
   Integrating GIS into the workflow of County departments will require the development of industry-specific datasets. Departmental and countywide GIS resources will have to prioritize the development of datasets. Datasets that can support current issues mapping and analysis efforts should have priority.

GIS Systems (Phase II)

1. **Deploy GIS Data Warehouse**
   The Technology Services Department should install, configure and test a Relational Database Management System (RDBMS) and spatial data gateway such as ArcSDE on the GIS Data Server. These technologies collectively are referred to a GIS Data Warehouse. Developing and implementing a strong security scheme will allow departments to confidently store sensitive data in a centralized location.

2. **Deploy Production Map Server**
   The Technology Services Department should migrate from a prototype GIS Map Server to a production GIS Map Server. The GIS Map Server will house Web-based GIS applications for both the intranet and Internet.

3. **Initial Integration of GIS w/ Departmental Databases (Megabyte/Visions/Permits Plus …)**
   The majority of GIS applications will depend on the integration of spatial data sets with existing departmental tabular databases. The Technology Services Department needs to work with various county departments and third party vendors to understand the data structure and to develop efficient techniques for accessing these systems. The initial integration may require a process that requires manual updates.

4. **Professional GIS Capabilities for New "Data Producer" Departments**
   As GIS matures, additional departments will become responsible for creating and maintaining new spatial datasets. These departments may need additional hardware, software, and training to become proficient at the professional GIS level.

5. **Desktop GIS Capabilities for New Departments**
   As GIS matures, additional departments will need to perform basic desktop mapping and analysis. These departments may need to acquire a desktop GIS software package (ArcView GIS) with formal or informal training.

Priority Applications (Phase II)

1. **Simple GIS Analysis for Departments**
   As GIS expertise develops, county department GIS users will begin to perform simple spatial analysis in addition to simple viewing and mapping of spatial datasets. Additional formal or informal training may be required.

2. **Suite of Web-based Property Information Applications for Countertop Intranet Users**
   The Technology Services Department and the Assessor's Office should jointly develop and deploy a suite of Web-based property information applications for countertop Intranet users.

3. **Suite of Web-based Property Information Applications for Public Internet Users**
   The Technology Services Department and the Assessor's Office should jointly develop and deploy a suite of Web-based property information applications for public Internet users. Issues of security and data confidentiality will need to be addressed.

4. **Use GIS to Support Census 2000 Redistricting**
   Once Census 2000 data is available, County of Calaveras can use desktop and professional GIS software to support the redistricting effort.

5. **Build Version 1.0 "County Road Atlas"**
   Once the GPS capture and attributing of the roads layer is complete, an effort

should be initiated to create an up-to-date county road atlas. Both a paper and a Web-based digital road atlas would serve many critical county uses.

Phase III – Integrated Applications & Analysis (FY2002/2003)

GIS Coordination (Phase III)

1. **Review/Modify GIS Implementation Plan**
   Planning is an ongoing process, and the GIS Policy Committee and GIS Technical Committee should review and modify as necessary this GIS Implementation Road Map.

2. **GIS Policy Committee**
   The GIS Policy Committee, as defined in the GIS Memorandum of Understanding, should continue to meet on a regular basis. After the initial GIS implementation phase, it is suggested that the GIS Policy Committee meet on a quarterly basis. The GIS Policy Committee will need to address a number of issues associated with the development, use and distribution of spatial data which include security, privacy, cost sharing, and second-tier partnerships.

3. **GIS Technical Committee**
   The GIS Technical Committee (GIS Committee), as defined in the GIS Memorandum of Understanding, should continue to meet on a regular basis. It is suggested that the GIS Committee meet once per month.

4. **GIS Technical Work Groups**
   GIS Technical Workgroups are small focused working groups created by the GIS Technical Committee to address highly technical issues. These working groups are created as needed.

5. **Establish Calaveras County as a Node on the NSDI**
   The National Spatial Data Infrastructure is defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community. The County of Calaveras and its data partners should consider becoming a local partner in this national effort.

   The cooperation between Calaveras and its data partners outlined in the GIS Memorandum of Understanding and currently in practice already meets the spirit of the NSDI framework. The NSDI approach leverages individual

geographic data efforts so data can be shared. In this environment, users can perform cross-jurisdictional analyses and operations, and organizations can funnel their resources into applications, rather than duplicating data production efforts. Participation in the larger NSDI effort would be a natural extension for the local partnership. Becoming a "node on the NSDI" not only means becoming an organizational partner, but it also means publishing local framework datasets to broader audiences and having convenient access to other regional datasets. The National Spatial Data Infrastructure represents the information highway for geographic data. Participating in the NSDI would help insure that GIS data in the greater Calaveras County area maintained by multiple federal, state, local and private organizations is in a consistent format, fits together and is easy to use.

6. **Formalize New Regional Data Partnerships**
   The value of GIS continues to increase as new datasets become available and consumers of GIS data and applications increase. The County of Calaveras and its local data partners should continue to consider formalizing relationships by looking to other regional organizations using GIS. These regional organizations might include associations of adjacent counties, transportation authorities, bioregional councils, interagency emergency response teams and other entities addressing cross-jurisdictional issues. The aggregation of more accurate and up to date local data into regional data sets will serve to improve both local and regional decision-making. Cooperating with broader regional organizations using GIS would also increase cost-sharing opportunities for local data development.

7. **Final GeoDatabase Schema**
   The GIS data model is undergoing a dramatic transformation from "primitive" or "simple" features (points, lines, polygons) to an object-oriented model referred to as the geodatabase. In Phase II, the County of Calaveras should stay abreast of, and if possible participate in industry consortiums that are working to standardize geodatabases for framework layers such as parcels, roads, streams, etc. In Phase III, the County should begin to adopt and integrate industry standard geodatabase schema (design) into county spatial datasets and applications. Using industry standard data models will promote interoperability and sharing between similar organizations. By using industry standard models, the County will also be in a position to use affordable commercial off-the-shelf (COTS) software being developed for these standard data models rather than relying on more costly custom software solutions.

8. **Regional ArcView User Group**
   The County should continue to be an active participant in the regional ArcView GIS User group established in Phase II. The group will provide an excellent forum to gather, share knowledge and data, stay abreast of new software and technology developments and to address regional GIS issues in an "informal" setting.

9. **Conduct Ongoing GIS Awareness Workshops**
   GIS is a new technology to County of Calaveras, and departments will have different rates of adoption. The GIS Committee should conduct periodic workshops to demonstrate the uses and benefits of GIS to broader audiences.

10. **Publish Spatial Data on "Geography Network"**
    There will be increasing demands on the county for distributing spatial data. The county should evaluate the feasibility of publishing its spatial data in live GIS catalogs on the Internet. As a user of ESRI enterprise software such as ArcIMS, the County of Calaveras will be well positioned to publish its data in one such live GIS catalog, the Geography Network. The Geography Network is a collaborative, multi-participant system that provides the infrastructure needed for publishing, sharing, and using geographic information on the Internet. Publishing spatial data on the Internet will provide citizens with easy access to key county and regional geographic datasets and applications eliminating the need to manually service these requests.

Data Development (Phase III)

1. **Improve Control**
   County efforts with the BLM Geographic Coordinate Database and local surveyors will facilitate regular improvements to the Public Land Survey System layer. Other GIS layers that are dependent on this layer can then also be improved.

2. **Improve Parcels**
   A continuous parcel layer is perhaps the most important component in a Countywide GIS. It is essential to devote appropriate resources to maintain and improve parcels on a regular basis. As the underlying control improves (Public Land Survey System), the County will also be able to improve the spatial accuracy of the parcel layer.

3. **Improve Roads**
   As updated orthoimagery becomes available on a regular basis, the County will be able to develop procedures to routinely improve the line work of the roads layer. In addition to line work improvements, the roads layer will need regular updates to attributes such as road names and address ranges to support emergency response routing applications.

4. **Improve/Acquire More Data through Cooperative Buying Pool**
   The cooperative buying pool that was established to update the orthoimagery should identify other common data layers that could be updated and purchased or developed with shared resources.

5. **Develop Spatial Data for Current Issues Analysis**
   Integrating GIS into the workflow of County departments will require the development of industry-specific datasets. Departmental and countywide GIS resources will have to prioritize the development of datasets. Datasets that can support current issues mapping and analysis efforts should have priority.

GIS Systems (Phase III)

1. **Implement Direct Edits/Versioning in GIS Data Warehouse**
   The Technology Services Department should implement advanced features of the GIS Data Warehouse such as versioning and direct edits. GIS Data Warehouse technology is transactions-based and can be configured to allow versioning. Versioning would allow users to rollback the spatial dataset to an earlier point in time, which would be useful for land records management datasets such as parcels. Another advanced feature is the direct editing of spatial data. "Data Producer" departments should have the ability to directly edit the datasets that they are responsible for. All other users would have "read only" access to the data.

2. **Continued Integration of GIS w/ Departmental Databases (Megabyte/Visions/Permits Plus …)**
   The Technology Services Department needs to work with various county departments and third party vendors to develop real-time GIS application access to these systems.

3. **Professional GIS Capabilities for New "Data Producer" Departments**
   As GIS matures, additional departments will become responsible for creating and maintaining new spatial datasets. These departments may need additional hardware, software, and training to become proficient at the professional GIS level.

4. **Desktop GIS Capabilities for New Departments**
   As GIS matures, additional departments will need to perform basic desktop mapping and analysis. These departments may need to acquire a desktop GIS software package (ArcView GIS) with formal or informal training.

Priority Applications (Phase III)

1. **Advanced GIS Spatial Analysis & Modeling**
   Desktop and professional GIS software is capable of complex spatial analysis and modeling. As GIS knowledge and skills increase, and high quality spatial data becomes available, the County of Calaveras will be in a position to perform some high-end spatial analysis. This advanced analysis will probably be limited to a few pockets of GIS expertise within the County. One department that has expressed a desire to perform this type of analysis is the Environmental Health Department.

2. **Wireless Access to GIS for Mobile Staff**
   Virtually every county department has staff that spends a significant amount of time in the field collecting data or delivering services. Tremendous advances in mobile computing will allow the county to extend its GIS datasets and applications to employees in the field.

3. **Web-based Applications w/ GIS Components to Support 24-Hour Virtual Front Counter**
   The increasing popularity of the World Wide Web as a platform for doing business (e-commerce) can be extended to county services. The county should implement an e-government initiative of conducting as much business as possible on the Web. The concept of a virtual front counter that citizens could visit 24 hours per day has tremendous benefits. GIS datasets and Web-based GIS functionality would be key components of the virtual front counter.

4. **Real-Time Emergency Response Dispatch System w/ GIS Components**
   The County should work with local emergency response organizations to develop a dispatch system that routes and tracks emergency response vehicles. Geotechnologies such as GPS and GIS would be key components in this application. The ability to implement this emergency response application will depend on the county's ability to successfully resolve inaccuracies and inconsistencies in the county's addressing and road naming data sets. Refer to Data Development (Phase II) "Resolve Problems with Addressing Data" activity.

   Another driving force behind this application is the Federal Communication Commission's (FCC) requirement to begin processing and dispatching wireless 911 calls. Implementation of this will require the use of GIS. Initial wireless 911 GIS-based dispatching is scheduled to begin in October of 2001 in California.

GLOSSARY OF TERMS

Accuracy
The degree to which information on a map or in a digital database matches true or accepted values. The closeness of an estimated (measured or computed) value to a standard or accepted value of a particular quantity. Accuracy relates to the quality of the result and is distinguished from precision, which relates to the quality of the method by which the measurements were made.

Application (GIS Application)
A software program that automates a specific set of functions to assist a person to accomplish work tasks (e.g., looking up the zoning and soil type for a particular parcel by either selecting the parcel from a map or typing in the parcel number on a computer form). A computer database is often required to support these computer applications.

Base Map (Base Layer, Base Data)
The basic level of map data on which other information is placed for comparison or correlation.

CAD(D)
Computer-Aided Design (Drafting). An automated system for the design, drafting, and display of graphically oriented information.

Cadastral
The term comes from Latin base term Cadastre referring to a registry of lands. Cadastral commonly refers to land ownership information. Formally, of or relating to an official register of the quantity, value, and ownership of real property used in apportioning taxes; showing or recording property boundaries, subdivision lines, buildings, and related details.

Data Warehouse (Spatial Data Warehouse)
A centralized storage location (database) to provide users with easy and efficient access to spatial (geographic) and associated tabular information. The defining characteristic of a data warehouse is its purpose. A data warehouse collects, organizes, and makes data available for the purpose of analysis - to give users the ability to access and analyze information about its organization. A Data Warehouse can reduce or eliminate the duplication of effort across an organization by spatially enabling the data and making it an agency- or organization-wide data resource

Enterprise
An entire organization or group of organizations. When used in reference to data processing or information technology, an *enterprise system* is one with the capability to serve large groups of users at high speeds. Enterprise systems also have capabilities for storing, managing and administering the distribution and access to the information throughout the enterprise.

ESRI
Environmental Systems Research Institute. The developer of popular GIS software such as ArcView GIS, ArcInfo, ArcIMS and ArcSDE. (http://www.esri.com)

FGDC (Federal Geographic Data Committee)
The Federal Geographic Data Committee (FGDC) is an interagency committee, organized in 1990 that promotes the coordinated use, sharing, and dissemination of geospatial data on a national basis. The FGDC is composed of representatives from seventeen Cabinet level and independent federal agencies. (http://www.fgdc.gov)

Framework Data
Geographic data users from many disciplines have a recurring need for a few themes of basic data. The FGDC (Federal Geographic Data Committee) uses the term framework data to refer to these seven key GIS layers:

- Geodetic Control
- Orthoimagery
- Elevation
- Transportation
- Hydrography
- Governmental Units
- Cadastral Information

The framework is a collaborative community based effort in which these commonly needed framework data themes are developed, maintained, and integrated by public and private organizations within a geographic area. Local, regional, state and federal government organizations and private companies see the framework as a way to share resources, improve communications, and increase efficiency.

GIS
Geographic information system. An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

Geodetic Control
Geodetic Control is a network of monumented points that have been established to

support consistent and compatible data for surveying and mapping projects. These points are permanent physical monuments placed in the ground and precisely marked, located, and documented. Objects located with respect to these monuments can be relied upon for known position and accuracy.

Geographic Data (GIS Data)
The locations and descriptions of geographic features. The composite of spatial data and tabular (or descriptive) data.

Geographic Database (GIS Database)
A collection of spatial data and related descriptive data organized for efficient storage and retrieval by many users.

Geographic Feature
A user-defined geographic phenomenon that can be modeled or represented using geographic data sets. Examples of geographic features include streets, sewer lines, manhole covers, accidents, lot lines, and parcels.

Geo-Technical Hazards
Existing or potential hazards associated with a location's geologic processes and material. These hazards include such things as earthquake faults, rock fall, landslides and other debris flows, erosion, and sink holes.

Global Positioning System (GPS)
A system of earth satellites, each providing precise time and position information which enables a GPS receiver to compute the distance to each satellite. The distance measurements of at least three satellites are required to fix the receivers position in latitude and longitude. Measurements from a fourth satellite are required to provide vertical (altitude) positioning.

Hydrography
Hydrography is a science that deals with the measurement and description of the physical features of bodies of water. Refers to information about surface water features such as lakes, ponds, streams, rivers, springs and wells.

Internet
An international consortium of wide area networks that operate using a standard set of addresses allowing machine-to-machine connectivity on a global scale. The Internet is an outgrowth of a Defense Advanced Research Projects Agency (DARPA) research project in the early 1970s to provide connectivity between scientists running computer simulations in different locations. Additional regional, private, and public networks

have joined the Internet over time. At this point there are millions of computers that now have direct access to the resources on the Internet.

Intranet
A locally controlled and administered network that functions using similar computer and communications technology as the Internet. Intranets are administered to provide information *within* an organization such as a county government.

Metadata
Put simply, metadata is data about data. Metadata provides information about the content, structure, relationships, and the use context of the data set that it describes. The Federal Geographic Data Committee (FGDC) has established a national spatial metadata standard that describes how GIS data sets should be documented.

Network
Computer data communications technology that connects computers. Computers and terminals on a network can share data and peripheral devices, such as printers and plotters. Networks are composed of cabling and special data communications hardware and software.

NSDI (National Spatial Data Infrastructure)
The National Spatial Data (NSDI) Infrastructure was initiated through an Executive Order executed by President Clinton in 1994. The NSDI is defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community. The NSDI was developed by the Federal Geographic Data Committee (FGDC), a consortium of 17 federal agencies, in cooperation with state and local government, and the private sector. (http://www.fgdc.gov/nsdi/nsdi.html)

Orthophotography
Digital images that are produced by making corrections to scanned aerial photographs resulting in images with the geometric qualities of a map. Aerial photographs contain distortion due to the camera angle, lens geometry, aircraft altitude and the relief displacement (hills, stream valleys, buildings) and can not be used for reliable measurement or spatial analysis. The distortion in aerial photography is removed by unwarping the effects of terrain, removing the perspective projection of the camera, and by fitting the image to a particular map projection to create an "image map" that has a uniform scale and a known accuracy. Orthophotography can be used as a map whereas aerial photography cannot.

Precision
A measure of the tendency of a set of random measurements to cluster about a number

determined by the set. The usual measure is either the standard deviation with respect to the average. Precision relates to the quality of the method by which the measurements were made and is distinguished from accuracy which relates to the quality of the result.

RDBMS
Relational database management system. A database management system with the ability to access data organized in tabular files that can be related to each other by a common field (item). An RDBMS has the capability to recombine the data items from different files, providing powerful tools for data usage.

Server
A computer system that provides centralized access to a particular type of information. The information may be geographic data (referred to as a data server), or access to resources on the World Wide Web (referred to as a Web server). The computer system is designed to process requests from multiple *clients* (users or other computer applications).

Spatial Data
Information about the location and shape of, and relationships among, geographic features. In a GIS database, spatial data is stored as coordinates within computer files. The spatial data may also contain links to other data tables that contain information about the attributes of the geographic features.

Tabular Data
A set of data elements that has a horizontal dimension (rows) and a vertical dimension (columns) in a relational database system. A table has a specified number of columns but can have any number of rows. Tabular data in a GIS contain descriptive information (or attribute information) that can be related to geographic features.

Web Browser
A software program that allows a user to browse information on the World Wide Web. Examples of Web Browsers include Netscape Navigator and Microsoft Internet Explorer.

World Wide Web (WWW)
Developed by the European Laboratory for Particle Physics (CERN) Consortium in Switzerland as a distributed hypermedia server. It allows one to prepare electronic documents that are composites of, or pointers to, many different files of potentially different types scattered across the world. It employs a hypertext markup language (HTML) to create the documents it serves and to follow “links” known as Universal Resource Locators (URLs) to fetch the document from elsewhere on the Internet. The

WWW can be accessed using Web browser software such as Netscape Navigator, or Microsoft Internet Explorer.

APPENDIX A—
COUNTYWIDE GIS POTENTIAL PARTICIPANT CONTACTS

Organization	Contact Names
County Departments	
Agriculture and Environmental Management	Jearl Howard (Agricultural Commissioner/Director of Weights & Measures) Sal Fichera (Assistant to Agricultural Commissioner)
Assessor	Grant Metzger, Jr. (Assessor) Dudley Meyer (Assistant Assessor) Dona Queirolo (Cadastral Assessment Analyst) Dan Rios (Cadastral Assessment Analyst)
Building Department Planning Department	Ray Waller (Director of Building) Kim Hansen (Director of Planning) Martin Redmond (Senior Plan Examiner) Julie Russell (Planning Aid)
Elections	Debbie Smith (Elections Coordinator) Sandra Rader (Elections Supervisor)
Environmental Health	Brian Moss (Director) Janice Harrington (Permit Technician) Paul Feriani (Registered Environmental Health Specialist) Tony Maris (Registered Environmental Health Specialist) Terry Mingo (Environmental Health Specialist)
Fire	Jim Miner (Fire Chief) Art Hastings (Consultant)
Public Health	Linda Parker (Director) Suzanne Whitley (Community Health Assistant)
Public Works	Robert Kawasaki (Director of Public Works) Bob Williams (Deputy Director of Public Works) Bruce Child (Deputy County Surveyor) Rob Houghton (Solid Waste Division) Dave McNown (Engineering Technician II) Linda Stowe (Fiscal Supervisor)
Sheriff's Department	Debby Parsons (Manager, Communications/Data Services) Jo Musgrov
Technology Services Department GIS Unit	Howard Stohlman (Director) Stan Diamanti (Systems Administrator) Pam Mundale (Programmer/Web Developer) Dave Pastizzo (GIS Coordinator) Doug Polzoni (GIS Technician) Hans Weidhofer (Web Content Coordinator)

Organization	Contact Names
Other Organizations	
Calaveras Council of Governments	George Dondero, II (Executive Director)
Calaveras County Water District	John Gomes (Systems Administrator)
California Department of Forestry and Fire Protection, Tuolumne/Calaveras Ranger Unit	Rich Strazzo (Fire Captain Specialist)
California Department of Transportation, District 10	Jane Wegge (Senior Transportation Planner) Carol Wilbon (Associate Transportation Planner)
City of Angels	Tim Shearer (City Administrator) Valerie Maschal (Finance Director) Judy King (Administrative Secretary)
United States Forest Service, Stanislaus National Forest	James Schmidt (GIS Coordinator/Land Management Planning Specialist) Lynn Goolsby (GIS Technician)

APPENDIX B—SUMMARY OF KEY OBSERVATIONS

Summary of Key Observations

During the course of the GIS Applications and Information Needs Assessment interviews, a number of preliminary observations were made. In some cases, the observations also include brief implementation suggestions.

1. Groups of departments/organizations have similar uses of GIS. These "GIS Application Groups" **regularly need to coordinate their efforts**.

2. The **primary data priorities** to support these GIS Application Groups are:
- **Parcels** and associated property information
- **Roads** and address information
- **Orthophoto imagery**

3. **Key organizational elements** to support a countywide GIS implementation are in place:
- A **GIS Memorandum of Understanding** between the County, Council of Governments, City of Angels and Calaveras County Water District is in place.
- A **GIS Unit** has been created in the Technology Services Department and a GIS Coordinator and GIS Technician have been hired.

4. **GIS awareness and the use of GIS technology are extremely limited in county departments.**

5. **GIS is a recognized systems priority.** The Calaveras County Technology Committee ranked GIS as the #2 priority project out of 50 projects considered. The #1 priority project is the Assessor's property information system (Megabyte), which is also an essential GIS data priority.

6. **County departments find it difficult to provide field services without an updated roads map.**

7. A majority of Calaveras County departments are undergoing a significant transformation from paper-based record keeping to specialized electronic database applications. **GIS needs to interface with these relatively new departmental systems** (Megabyte, Visions, Sierra Permits Plus, Envision, CarteGraph).

8. Departments recognize the need for a **centralized spatial data library** with stewardship responsibilities clearly delineated to eliminate redundant activities and to facilitate data distribution.

9. Wide Area Network (WAN) or Virtual Private Network (VPN) **connections are needed for key data partners** and some departmental field offices to fully participate in the countywide GIS.

10. Significant progress has been made on key framework layers, but additional work is required.
    - **Parcels**: An integrated countywide parcel base map was completed in 1999. **A strategy and the capabilities for maintaining and improving the data are needed.**
    - **Roads:** Roads are currently being captured via GPS and a base roads layer should be completed in the fall of 2000. **County roads will need address ranges and integration with other private, state and federal roads datasets in order to be a useful countywide GIS roads layer.**

11. **Standardized addressing is needed to support GIS applications.** Unique road naming and situs addressing needs to be in place.

12. **Orthophoto imagery is a key framework layer that is noticeably absent**. As a start, existing USGS Digital Orthoquarter Quads should be acquired. Action should also be taken to expedite USGS's schedule for completing the processing of remaining imagery for the county.