Public Service
of New Hampshire

The Northeast Utilities System

PUBLIC SERVICE OF NEW HAMPSHIRE

DISTRIBUTION
GEOGRAPHIC INFORMATION SYSTEM
HIGH LEVEL DESIGN AND PLAN

June 24, 2011

Table of Contents

1. Introduction

The Settlement Agreement approved by the Commission in PSNH's most recent distribution rate case (Docket No. DE 09-035) required the implementation of a Geographic Information System (GIS) in order to support an outage management system (OMS):

> 6.3 Upon approval of the Settlement Agreement, PSNH will initiate and complete a High Level Design for the GIS project by July 1, 2011. The High Level Design will include project management details sufficient to establish milestones, base schedules, budget expenditures, and the vendor selection. PSNH commits to install and have operational those elements identified in accordance with the schedule established in the High Level Design by December 31, 2014. On a semi-annual calendar year basis commencing on July 1, 2011, PSNH will provide a progress report to the Settling Parties detailing project milestones and achievements for the prior 6-month project period. Additionally, the semi-annual reports shall include key project dates for the remainder of the project, comparison of capital and O&M expenditures to planned REP II budget amounts and a detailed definition of tasks for the upcoming 6-month and 12-month periods. The High Level Design will also incorporate design of a GIS-based Outage Management System (OMS), including an implementation schedule. Prior to the implementation of a GIS-based OMS, PSNH will continue to implement enhancements to its existing OMS that will provide improved outage restoration information to customers, state officials and the general public.

This document provides the High Level Design for the PSNH GIS in accordance with the Settlement Agreement.

1.1 Scope

This document provides the following:

- Identification of the high level functional requirements of the GIS
- A description of present data dependencies
- A preliminary deployment plan

1.2 Organization

1. Introduction
2. Functional Solution
3. Data
4. Deployment Plan
5. Conclusion

2. Functional Solution

A GIS is a critical building block of a smart grid which would provide PSNH's customers with twenty-first century technology and electric service. Figure 1 describes the typical systems which may be part of a smart grid. Many of these have a spatial or geographic component which can directly benefit from development of a GIS.

A GIS is a spatial database, linking the physical, geographic location of assets (powerlines, poles, transformers, etc.) to their records in other computer systems or applications. The database holds the latitude and longitude coordinates of all distribution system assets within PSNH's service territory, mapping PSNH's assets on a

digital representation of the service area. This digital map allows users to visualize assets against actual environmental data, political boundaries, roads, customers, and aerial photographs.

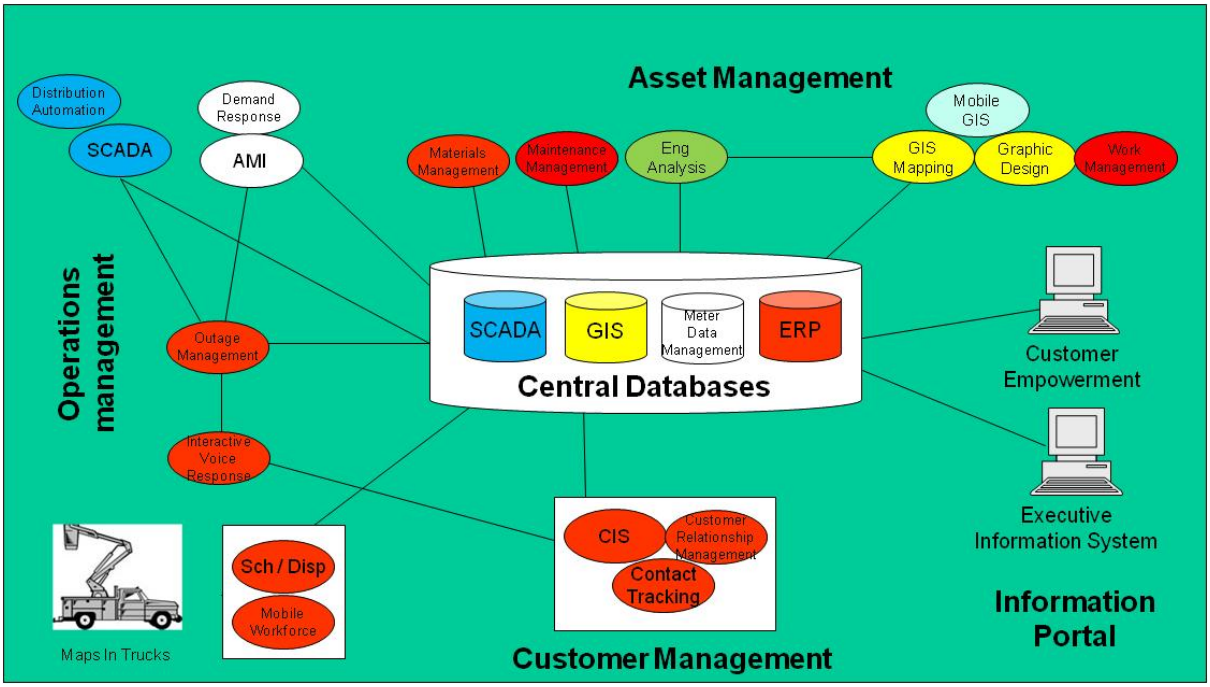

Figure 1: Systems of the Smart Grid

In the past, utilities simply used their GIS to create maps of their assets and the service territory. PSNH recognizes that today a GIS can provide considerably more functionality. The proposed GIS will provide PSNH with a complete electronic circuit model supporting future advanced applications such as outage management and load flow analysis.

Figure 2 describes the planned GIS. The left side identifies the initial data sources. The right side identifies the planned interfaces. It is anticipated the GIS will serve hundreds of users by providing a variety of information and tools. The initial group of 250 PSNH users will include:

- Vegetation Management
- Reliability Analysis
- Property Management
- GIS technicians responsible for data creation and maintenance
- Engineering and operations users accessing the GIS through the web

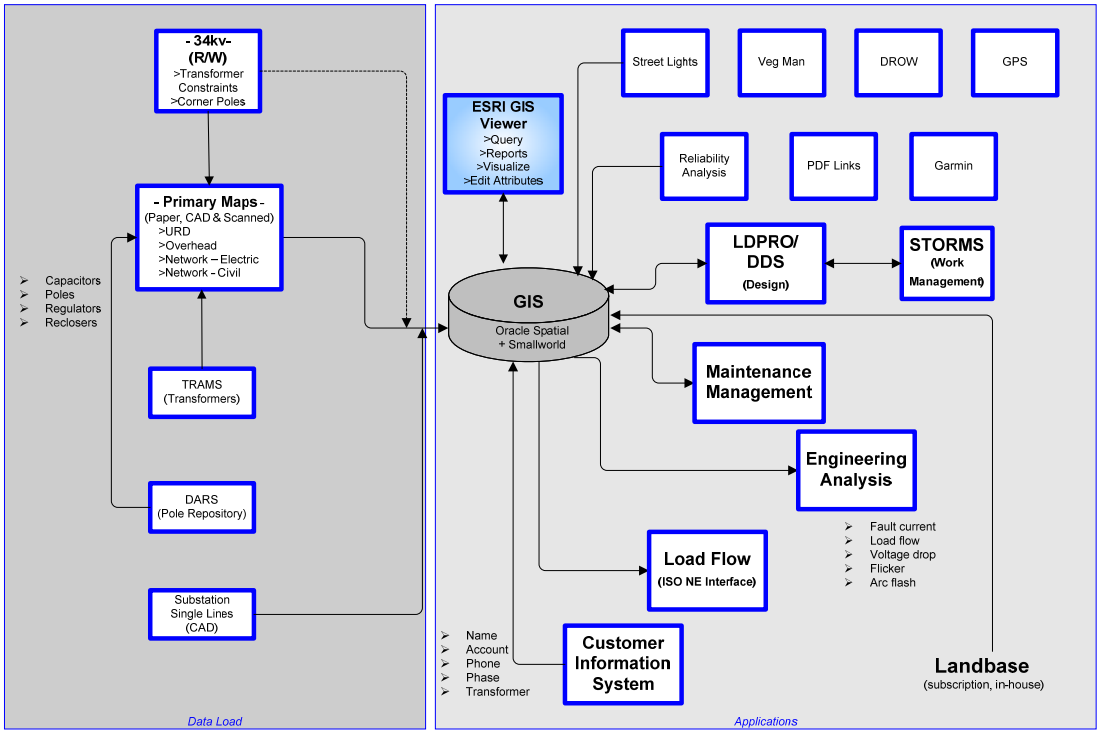

Figure 2: Planned Functional Architecture

This section describes:

- The planned GIS implementation
- High level functionality of the Reliability Analysis and Vegetation Management tools
- Data quality assurance and control
- Staging for the future, including OMS.

2.1 Phases of GIS Implementation

The GIS will be implemented in three phases:

Phase 1 - Discovery Phase.

PSNH will develop a data pilot. This provides a means of demonstrating the conversion process, allowing PSNH to identify potential data quality issues and mitigation strategies. PSNH anticipates the Pittsfield Area Work Center (AWC) and the distribution system it services will be the location of the initial pilot.

Phase 2 – Data Conversion

This will provide PSNH with the software platform for maintaining and performing data quality enhancements on the GIS data. During Phase 2, GIS will not yet be fully integrated into PSNH's work processes but will provide PSNH with the tools to perform data quality enhancement. Phase 2 provides PSNH with:

- ESRI web-based GIS viewer
- Data editor with quality control tools
- Links to the customer information system
- Tools to allow data exchange with external entities
- Ability to export data to engineering analysis tools

- Links to existing pole, asset, and trouble call management applications
- Links to documents and drawings
- Ability to import location information from hand-held GPS units.

Phase 3 – Full Integration

Complete integration of the GIS into PSNH's business processes and builds on the software and data implemented in Phase 2. At the end of Phase 3, PSNH will have data of a suitable quality to commence implementation of an outage management system (OMS). Phase 3 provides PSNH with:

- Electric system Reliability Analysis Tool
- Integration to a graphical design tool, eliminating duplicate data entry
- Vegetation Management Tool

2.2 Reliability Analysis Tool

Another key requirement of the rate case settlement is:

> Prior to the implementation of a GIS-based OMS, PSNH will continue to implement enhancements to its existing OMS that will provide improved outage restoration information to customers, state officials and the general public.

Within the scope of this project, PSNH anticipates implementing a Reliability Analysis Tool. This will provide PSNH engineers the power to make more informed planning and operating decisions, thus enabling reliability improvements. While the initial focus of the Reliability Analysis Tool implementation will be internal PSNH users, it is anticipated the existing PSNH.com outage report will be enhanced.

The Reliability Analysis Tool will provide PSNH with the following functionality:

1. Ability to geographically lay-out and color code reliability data by trouble location, device location and cause, and provide the number of customers affected, estimated outage duration, comments, weather, date, and SAIDI contribution.
2. Ability to indicate the number of operations of each protective device over a specified time period.
3. Ability to display historical troubles meeting certain specified criteria (e.g., display troubles over 2 hours, affecting 1,500 or more customers, copper wire, and 34.5 kV).
4. Ability to display a location's (i.e. customer's) outage history over a specified time period.
5. Ability to indicate where tree related troubles occurred where trimming permission was denied, and to calculate the SAIDI contribution due to permission denials.
6. Ability to export report results into ESRI and other formats, including but not limited to .xls, .txt, and .csv files.

In addition, the application will allow for calculation and visualization of the typical IEEE reliability indices (IEEE P1366-2003) by electrical connectivity (e.g., circuit or substation), voltage, conductor type and manufacturer.

2.3 Vegetation Management

The Vegetation Management department will rely on the following base GIS data:

- Distribution Right of Way (ROW)

- Rights, easements, special access instructions associated with the corridors and ROW
- Trimming history
- Identification of trimming activities by line and section

Utilizing basic work order management functionality, the Vegetation Management resources will be in a position to plan and schedule future ground and aerial patrols. The existing vegetation management planning and tracking system, currently performed on spreadsheets, will be migrated to the GIS.

With respect to environmental compliance, the GIS will identify sensitive areas tied to sets of government licensing requirements or restrictions. Each area will contain certain information, giving field personnel easy access to specific licensing requirements.

2.4 Data Quality Assurance / Quality Control Requirements

Thorough data quality assurance / quality control (QA / QC) is essential for successful implementation of a GIS. PSNH has developed a list of QA / QC rules that will be validated by the data conversion vendor, as well as on a nightly basis, once the GIS has transitioned to operational mode at PSNH. The rules will be improved upon in an iterative manner based on the prototype, pilot, and phased data deliveries. If major data gaps or discrepancies exist, they will be identified as anomalies by the data conversion vendor and validated by PSNH. Each data delivery will undergo a QA / QC examination by the vendor prior to delivery to PSNH (automated and visual checks), and will then be validated by PSNH staff familiar with the distribution infrastructure in order to verify that the vendor adheres to PSNH's acceptance criteria.

2.5 Preparation for a Future OMS

The GIS will be designed to provide for the implementation of an Outage Management System (OMS). An OMS requires a high level of data quality. GIS should provide the OMS with electrical connectivity from customer to transformer, through protective devices to the substation.

Based on the current schedule, PSNH anticipates initiating assessment of OMS options in the beginning of 2013, with start of OMS implementation the end of that year. Timely OMS implementation will be dependent upon PSNH's ability to address the following:

1. Customer-to-transformer and transformer-to-phase inaccuracies will require manual effort on the part of Customer Operations.
2. Distribution infrastructure updates need to be reflected in the OMS from the GIS in a timely manner.

2.6 Potential Future Applications

Once the GIS is in place, PSNH will have the option to explore the implementation of the following applications:

- Mobile workforce management application
- Geographic load forecasting providing tools to model growth, considering the impact of Demand Response (DR), Plug-In Electric Vehicles (EV), distributed generation (both conventional and renewable / DG), microgrids, and other conservation / load shifting technologies
- Real-time loading applications to assess dynamic transformer and underground conductor loading limits
- Property management tool to provide more efficient access to ROW, easement, and ownership data

- Expanded query and reporting (business intelligence)

3. Data Collection

The initial data will include the following sources:

- Poles in the 34kV distribution ROW derived from:
  - Mile sheets
  - Power line end points, end poles, knee poles
  - Poles from the poles database
- Primary circuit maps to include:
  - Underground, overhead, and network circuits
  - Transformers correlated to poles from transformer database
  - Poles, capacitors, regulators, reclosers, and switches will be assigned to a location based on pole reference

The plan anticipates data gaps will be filled in the following manner:

- Where poles do not exist on the map, pole locations will be estimated at reasonable intervals based on map numbering and databases
- Unknown transformers will be reconciled by field validation
- Initial and incremental uploads of customer information will be performed to associate customers to transformers
- Underground network connectivity may be represented with simple electric connectivity and a hyperlink to a scanned drawing
- Office-based validation of electrical route will be validated using commercially available landbase, ortho-photos, and Granit data.

A data source matrix has been created to guide the data conversion process. This matrix identifies where data will originate, a description of the electrical equipment represented, and manner in which it will be mapped into PSNH's GIS data model. An initial estimate of the conversion magnitude is presented below:

- Approximately 500,000 customers / meters
  - Rural 48%
  - Suburban 27%
  - Urban 25%
  - 9% of customers have an underground service delivery
- 4,738 primary maps (includes overhead and underground)
- 11,000 miles of distribution along the road
- 900 miles of distribution in rights of way
- 176 substations
- Over 600 circuits
- 420,000 poles
- 500,000 customers

Table 1 provides a count of the primary and underground residential distribution (URD) source maps. The source maps have all been converted by PSNH into an electronic format that can be imported into the GIS. PSNH has many key maps that reference primary and URD maps, as well as, approximately 1,000 mile sheets that represent Distribution ROW circuits.

Table 1: Map Counts

		Primary Maps	URD Maps	Total
Western	Hillsborough	123	43	166
	Keene	173	74	247
	Monadnock	106	38	144
	Newport	212	39	251
	Pittsfield	48	15	63
	Franklin	83	82	165
	Laconia	125	72	197
Southern	Bedford	209	298	507
	Derry	150	497	647
	Hooksett	232	253	485
	Milford	109	153	262
	Nashua	170	215	385
Seacoast Northern	Berlin	61	9	70
	Chocorua	108	52	160
	Epping	143	62	205
	Lancaster	136	33	169
	Portsmouth	101	98	199
	Rochester	191	225	416
TOTAL		**2480**	**2258**	**4738**

Due to the magnitude of data conversion activities and input that will be required, PSNH may employ the services of the data conversion vendor to perform the work order backlog over the course of the update.

The key challenge to any GIS project is data accuracy. Utilities have found that performing a field survey prior to having in place a mature process to perform GIS data maintenance results in rapid degradation of data quality. As a consequence, the approach taken by PSNH is to put in place the GIS and data without a field inventory, and to provide a process enabling ownership of the data by field and operations resources. PSNH anticipates that while the initial data conversion will undergo conversion vendor and PSNH QA / QC scrutiny, it will be necessary to continually improve upon the data quality.

4. Deployment Plan and Organization

It is anticipated PSNH will deploy a GIS based on industry proven products from the leading GIS vendors:

- ESRI Web-Based GIS Viewer
- Oracle Spatial
- GE Smallworld

Numerous utilities across the country utilize one or more of the above vendors for their GIS. Figure 3 presents a conceptual view of the proposed GIS. The GE Smallworld database provides an established and robust foundation for PSNH's GIS. The GE Smallworld GIS will be synchronized to an Oracle Spatial database to provide flexibility in access and a platform not only for additional applications but also for the ESRI GIS

viewer. The ESRI product is an industry standard which has many preexisting applications that can be purchased by PSNH. Figure 4 presents the proposed deployment plan for the GIS. This plan may be subject to revision based on the Discovery (Phase 1).

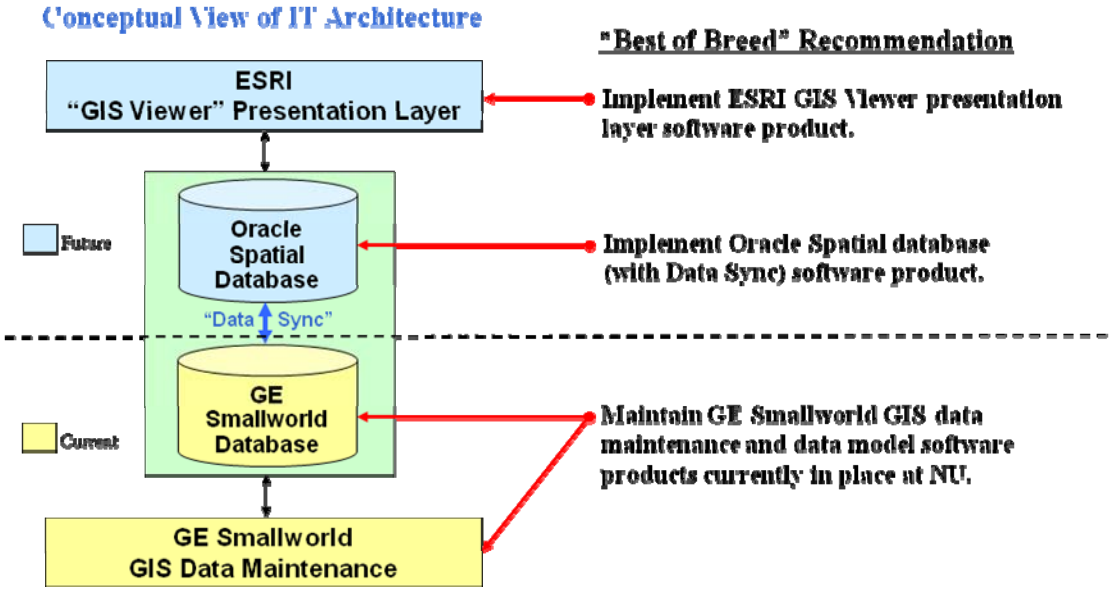

Figure 3: Northeast Utilities Enterprise GIS Architecture

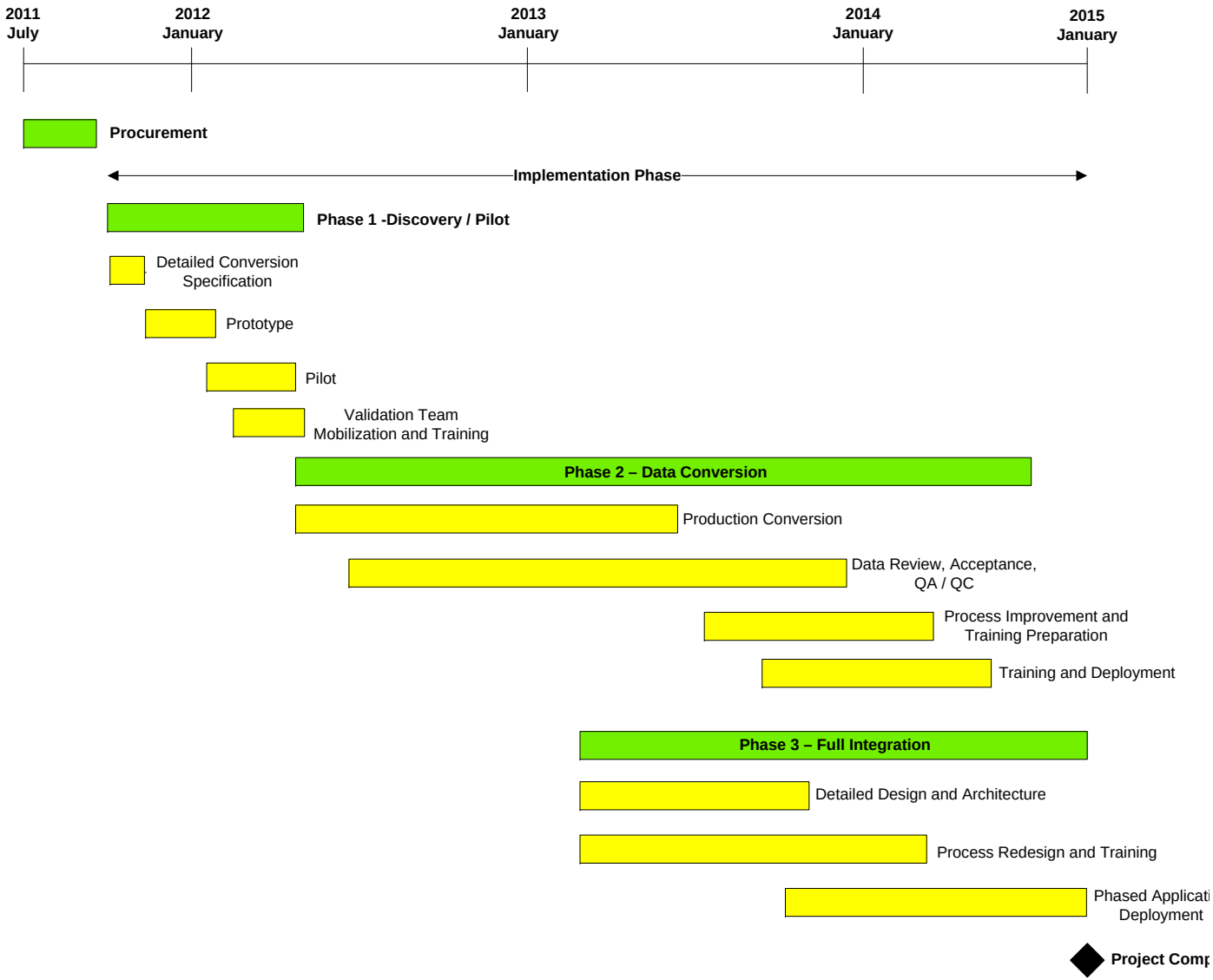

Figure 4: Project Timeline

5. Conclusion

The implementation plan described in this High Level Design presents the deployment of GIS, conversion of GIS data and associated applications for PSNH.

Phase 1 will provide PSNH with a small-area data prototype and pilot using the ESRI viewer to provide a test of the conversion process, data and initial viewer. At the present time, it is envisioned that the Pittsfield Area Work Center will be used for the pilot.

Phase 2 will provide PSNH with:

- ESRI web-based GIS viewer
- Data editor with quality control tools
- Links to the customer information system
- Tools to allow data exchange with external entities
- Ability to export data to engineering analysis tools
- Links to existing pole, asset, and trouble call management applications
- Links to documents and drawings
- Ability to import location information from a hand held GPS.

Phase 3 will provide PSNH with:

- Electric system reliability analysis tool
- Integration to graphical design tool eliminating duplicate data entry
- Vegetation management tool
- The ability to view the PSNH assets on Garmin GPS units installed in trucks.

The High Level Design provides the basis for an initial GIS plan to meet the PUC requirements. PSNH is currently evaluating bids from vendors for services related to the implementation. Over the course of the vendor selection and discovery phases of the project, there exists the potential for further refinements and changes as more information is known.