

ENGINEERING SERVICES PROPOSAL
LAKE HAVASU CITY
ARC FLASH STUDY & IMPLEMENTATION
LHC PROJECT NO. CI1010
SCOPE OF WORK

GENERAL PROJECT DESCRIPTION

In May 2016, Lake Havasu City (City) requested Carollo Engineers, Inc. (Consultant) to provide and perform arc flash hazard studies for various facilities throughout the City. The facilities requested by the City included:

- Wastewater Lift Stations.
- Wastewater Treatment Plants.
- Water Booster Stations.
- Water Treatment Plant.
- Traffic Signals.
- Airport.
- Lighting Systems & City Buildings.

In June 2016, the Consultant toured the facilities with the City to determine if the facility required an arc flash study and to perform preliminary investigations for the size and extent of the electrical distribution system at each facility. The facilities visited on June 15th and 16th were the following:

- Mulberry Wastewater Treatment Plant (WWTP).
- Island WWTP.
- North Regional WWTP.
- Influent Lift Station.
- Bombay Lift Station.
- North Palo Verde Lift Station
- Lake Havasu City Airport.
- Lake Havasu City Water Treatment Plant (WTP).
- Ranney Well.
- Booster Station No. 1.
- Booster Station No. 1C.

- Lake Havasu City Operations Facility.
- Lake Havasu City Hall.
- Lake Havasu Police Station.
- Rotary Park.
- Traffic Signals.
- Street Lighting (2 locations).
 - 240/120V, 1-phase, 600-Amp service.
 - 240/120V, 1-phase, 200-Amp service.

During the field investigations, it was determined that the Traffic Signal locations were powered from a small 240/120V, 1-phase service. The current standards for performing arc flash hazard calculations (IEEE 1584 – IEEE Guide for Performing Arc Flash Hazard Calculations) notes that equipment fed from a power source below 240V and fed from a transformer less than 125kVA need not be considered for arc flash hazard calculations. The Traffic Signal sites and Street Lighting 200A site meet this requirement and, for the purposes of this Scope, will not have a detailed arc flash hazard analysis performed, but will have a site specific arc flash label created identifying the appropriate shock boundaries.

In addition to the facilities listed previously, the Scope includes electrical system studies for an additional seventy-three (72) Lift Stations and twenty-six (26) Booster Stations. The Scope of Work and associated fee rely upon assumptions about these additional facilities that were not visited. The assumptions for these additional facilities are based on discussions with City staff. City staff indicated that the additional facilities have a similar electrical distribution system and similar amount of equipment.

Due to the number of facilities requested to be included in the Scope of the Project, the Consultant will perform the Project in three (3) phases. Phase 1 will include the Wastewater Treatment Plants and Lift Stations, Phase 2 will include the Water Treatment Plant and Booster Pump Stations, and Phase 3 will include all other remaining City facilities (Police Station, Operations Building, Airport, etc.). The tasks and deliverables noted below will be completed for each Phase of the Project. The intent is that each phase will be completed prior to moving to the next Phase. Some overlap of Work, however, may occur as the Project progresses.

SCOPE OF WORK

TASK 1 – ELECTRICAL SYSTEM STUDIES

1.1 Preliminary and Field Investigations

The Consultant will review existing documentation available for the electrical distribution systems to determine an appropriate Work sequence for the facilities.

1.1.1 Existing Documentation Review

Prior to the Consultant's field visits for the detailed field investigations in Task 1.1.3, the Consultant will review the City-provided information to better understand the existing electrical distribution system at each facility.

1.1.2 Facility Shutdown Coordination and Work Sequence Creation

Facility shutdown coordination will be conducted with the City's operations and maintenance staff to establish a schedule for the field investigation of each facility. More specifically, for each facility, the individual components of the electrical power distribution system and the associated process equipment will be evaluated to determine how and when the equipment can be de-energized to allow for visual inspection and investigation. The Consultant will rely on the City's staff to provide input on the timing of these shutdowns to minimize the impact to overall operations. To every extent possible, the field investigation shutdowns will be sequenced to occur during periods of normal facility maintenance shutdowns. However, we understand from experience that normal maintenance shutdowns are rare. Where equipment cannot be de-energized for field investigation, we will collect data with full protection suitable for the expected incident energy level. Since these are the first arc flash hazard analyses performed at these facilities, the tables in NFPA 70E will be utilized to determine the appropriate PPE.

The Consultant will meet with the City on three (3) separate occasions to discuss the Work sequence. The first will be for the Phase 1 facilities and is planned to be three (3) days, four (4) hours per day. The Phase 2 facilities is planned to be two (2) days, four (4) hours per day. The Phase 3 facilities will also be planned to be two (2) days, four (4) hours per day.

Deliverable:

- *Work sequence document identifying the dates and shutdown durations associated with the field investigation for each facility that has been developed collaboratively with City's staff.*
- *GIS map identifying all facility locations.*

1.1.3 Field Investigation

After the successful completion of Tasks 1.1.1 and 1.1.2, the Consultant will begin field investigation of the existing facilities. Specific activities that will occur during field investigation include:

- De-energization of electrical equipment by Consultant's Electrical Subcontractor.
- Testing to confirm absence of voltage.
- Inspection and documentation of existing equipment ratings via photos and field notes.
- Documentation of condition (internal and external) of existing electrical equipment.
- Return of equipment to its original energized state by Consultant's Electrical Subcontractor.

All individuals present during the field investigations will be required to adhere to the City's electrical safety procedures and the estimated arc flash hazard levels. The Consultant will provide the necessary personal protective equipment (PPE) up to Category 2 for the members of our team conducting field investigation.

Although the primary objective of the field investigation is to gather the equipment data needed to create the software models of the power system, the Consultant will also use it as an opportunity to discuss and document any operational concerns or problems that should be addressed for each facility.

The sequencing of the field investigation of the facilities will be based on the Work sequence document developed as part of Task 1.1.2. The Consultant assumes that all field investigation and planned shutdowns will be completed as developed in Task 1.1.2.

The Consultant will itemize and document the manufacturer, model number, electrical ratings, and age of the existing electrical equipment. Electrical equipment in all facilities identified in this Scope will be included under these field investigations.

The Consultant will use the Consultant's standard mobile data collection apps and standard tools to document all electrical equipment.

1.1.4 Electric Utility & Generator Information

The energy contribution from the electric utility and onsite standby generators are one of the most influential inputs to the Fault Current and Arc Flash Hazard Analysis. As such, the accuracy of the calculations is highly dependent on the data provided by the utility and generator manufacturer(s). Furthermore, incorrect assumptions about this data can greatly affect the outcome of the Arc Flash Hazard Analysis. Improper or inadequate information can produce results that are overly conservative in the application of PPE (which can be cumbersome for O&M personnel and create unnecessary hazards), or not require enough PPE and put personnel in danger. For these reasons, coordination with the utility and generator manufacturer(s) is a critical step in the completion of the overall arc flash study for the facility.

The Consultant will coordinate with the utility to obtain the following information for each of the facilities included in the study:

- Minimum and normal operating service voltage levels.
- Minimum and maximum three-phase, short circuit MVA and X/R ratio.
- Line-to-ground short circuit MVA and X/R ratio at the point of connection.
- Utility upstream protective device information.

The Consultant will coordinate with the generator manufacturer(s) and the City to obtain the necessary electrical characteristics of the existing generators.

If necessary, Consultant will arrange and conduct a meeting with utility representatives to expedite this data-collection effort. The meeting will coincide with the field investigations and is estimated as a 2-hour meeting.

1.2 Electrical System Studies

1.2.1 Model Construction

The information gathered during the utility coordination effort and the data collected during the field investigation will be used to create a software model of the power system for each of the City's facilities included in this study.

With respect to the power system software, the Consultant will model the facility electrical systems in ETAP by Operation Technology, Inc.

The actual software data files will serve as the final deliverable associated with the software models of the power system. These files will allow the City to perform future electrical studies in response to electrical system changes without needing to recreate the entire database; however, the Consultant will not be providing ETAP software licenses for the City.

1.2.2 Initial Calculations and Draft Electrical System Study

After all pertinent field data is collected and power system models are created, initial short circuit, protective device coordination, and arc flash incident energy levels will be calculated for all medium voltage, 480V, and 208/240V equipment served by transformers 125kVA and larger. Arc Flash incident energy levels for 208/240V equipment served by transformers smaller than 125kVA will be based on guidance provided by current codes and regulations.

The initial short circuit and arc flash incident energy results will be based on the gathered field data. This study will serve as a basis for comparing proposed changes to the systems and alternate protection settings that the Consultant provides. Separate reports will be provided consisting of short circuit studies, protective device coordination studies, and arc flash hazard analysis.

Each load in the distribution system will be individually modeled to determine short circuit contributions and local arc flash incident energy levels. Contributions from motors powered from variable frequency drives without bypass capability and other loads connected to the system via power electronics will be ignored because power electronic equipment does not significantly contribute to an arcing fault.

All reports will contain individual X and R impedances for each fault and show contributions from different sources. As required, the study will model multiple configurations that represent possible operating scenarios for the facility. Input from the City is critical to determine operational scenarios and resulting arc flash incident energy levels. These scenarios are very important to determine the minimum and maximum short circuit contributions, because worse case incident energy can be either minimum or maximum short circuit conditions. Any identified areas of concern associated with under-rated equipment, unsafe settings, etc., will be reported to the City immediately along with recommended corrective actions.

Short Circuit Analysis

The short circuit study results will include:

- A tabulated list of short circuit ratings for all equipment collected from the field with the calculated, largest short circuit current for each bus.
- 3-phase, bolted fault, line-to-line fault, line-to-ground fault, and double line-to-ground fault.
- Short-circuit, 1/2-cycle, momentary symmetrical and asymmetrical root mean-square (RMS).
- 1½- and 4-cycle, interrupting symmetrical RMS.
- 30-cycle, steady state, short circuit current values at each piece of equipment in the distribution system.

Protective Device Coordination Study

The study includes time-current curves with an analysis of coordination issues. Coordination will be performed by the Consultant in accordance with IEEE Standard 242. Small, low-voltage distribution systems will be examined to determine if their nonadjustable protective devices create a dangerous or unreliable situation. Coordination issues and recommendations will be tabulated in a report and presented for the City's review.

The time-current curves will include the electric utility protective device immediately upstream of the service transformer when available, and continue down to and including the largest adjustable or fixed-trip circuit breaker in the distribution system or the main breaker in lighting panels. Equipment damage curves will also be shown to confirm adequate protection is provided with the modeled protection settings.

Arc Flash Hazard Analysis

The arc flash hazard analysis utilizes the results of the short circuit and protective device coordination studies, with settings obtained during the field investigation to calculate preliminary arc flash incident energy levels. Specific information in the study will include:

- Arc fault magnitude.
- Duration of arc.
- Device clearing time.
- Arc flash boundary.
- Working distance.
- Incident energy.
- Shock hazard boundaries.
- PPE requirements.

Draft Electrical Systems Study

The Draft Electrical Systems Study for the facility will summarize the results of the initial short circuit study, protective device coordination study, arc flash hazard analysis, and identify any insufficient equipment ratings or other concerns related to the operation or condition of equipment. The initial arc flash incident energy results presented in the draft report will be based on the existing settings for protective devices obtained during field investigation. Adjustment to protective device settings will be discussed as part of the Arc Flash Philosophy Meeting in Task 1.2.3.

The Draft Electrical Systems Study will be reviewed and analyzed by senior level electrical engineers, prior to being submitted to the City.

A separate Electrical System Study report will be provided for each facility.

Deliverables:

- *Draft Electrical System Study:*
 - *3 Hard copies of each report spiral bound for all facilities.*
 - *PDF copy.*
 - *ETAP model files.*

1.2.3 Draft Report Presentation and Arc Flash Philosophy Meeting

Shortly after submitting the Draft Electrical Systems Study, the Consultant will conduct a presentation to the City's staff to review the contents of the study. In addition, the Consultant will provide a brief overview on the basics of reading time-current curves, arc flash, and short circuit results as well as equipment protection philosophy and relay/breaker settings. The Consultant's objective will be to ensure that all of the City's staff reviewing the draft study and participating in the Project have a fundamental understanding of the technical issues that affect the results and implementation of the study.

As part of the Draft Electrical Systems Study presentation, the Consultant will conduct an Arc Flash Philosophy meeting, in which the City and Consultant will work together to determine appropriate protective device setting adjustments or equipment recommendations to balance coordination with incident energy levels. The team will provide practical recommendations to achieve the City's safety goals within the parameters of arc flash hazard analysis and will evaluate areas of concern by evaluating each of the arc flash incident energy results on a case-by-case basis. The Consultant's team encourages participation from City's staff in this and all discussions. This is an important collaborative process with the City to develop practical solutions that meet operational needs and reduce arc flash incident energy levels.

An Arc Flash Philosophy Meeting will be provided for each Phase of the Project. The meeting for Phase 1 is planned to be two (2) day, four (4) hours/day, the meeting for Phase 2 is planned to be two (2) day, four (4) hours/day and the meeting for Phase 3 is planned to be two (2) day, four (4) hours/day. The Consultant assumes that the City will invite the necessary stakeholders to discuss the results of the study at each meeting. The Consultant assumes that for each phase, different stakeholders will attend the meetings and the general overview of the basis of

reading time-current curves, arc flash, and short circuit results, as well as equipment protection philosophy and relay/breaker settings will be discussed with each set of stakeholders.

The Arc Flash Philosophy Meeting will only be attended by the Consultant's Senior Engineer working on the project.

Deliverables:

- *Meeting Agenda (provided 1 week prior to meeting).*
- *Meeting Minutes (provided 1 week after meeting).*
- *Minutes will include a list of decisions made and action items with the responsible party identified.*

1.2.4 Compile Final Electrical System Study

The Consultant will incorporate the philosophies and discussions from Task 1.2.3 into the coordination study and provide time-current curves indicating proposed modifications to settings of protective devices. Updated time-current curves will demonstrate the protection philosophies and settings to balance arc flash incident energy levels with protective device coordination goals, as discussed in the Arc Flash Philosophy Meeting. The discussion will include remaining arc flash and coordination issues along with possible mitigation options that the City may want to consider as part of future Work or upgrades.

A settings table will be developed to summarize the settings for each protective device for the City's records. The table includes the device identification, type, style, rating, functions, and the settings for each device at each facility. These settings tables provide a consolidated resource for the City to adjust their protection equipment in the field and to verify settings in the future. It will be the City's responsibility to modify current settings to correspond to those settings recommended in the study.

As part of the Final Electrical Systems Study, the Consultant will provide revised arc flash bus detail sheets, an arc flash evaluation summary spreadsheet, and an arc flash report summarizing the arc flash study, including conclusions and mitigation recommendations. The final study will also include the calculations from the short circuit study.

The arc flash model will be provided to the City for future edits and updates. The Final Electrical Systems Study will be reviewed, analyzed, and signed and sealed by Kevin Angle (Project Manager), prior to being submitted to the City.

A separate Electrical System Study report will be provided for each facility.

Deliverables:

- *2 Hard copies of each report in spiral bound for all facilities.*
- *CD-ROM with:*
 - *All final reports in Microsoft Word and PDF.*
 - *All ETAP one-lines in PDF.*
 - *All ETAP model files.*

- *Excel spreadsheet with all Electrical Equipment assets identified by site and equipment designation.*

1.2.5 Arc Flash Hazard Label Production & Installation

Based on the results of the arc flash calculations, the Consultant will provide and install vinyl arc flash hazard labels in the following locations:

- Each 480V panelboard and disconnect.
- Each 208/240V panelboard served by a 125kVA and larger transformer.
- Each motor control center section.
- Each low-voltage switchboard section.
- Each switchgear section.
- Each bus tie breaker, based on dual feeds.
- 480V vendor control panels.
- 480V disconnects.

Deliverables:

- *Arc flash labels installed.*

1.2.6 Formal Arc Flash Training

Once the study is complete, the Consultant will conduct a final training session tailored to the actual identified hazards and covering electrical safety in the workplace. The Consultant will tailor the training materials to describe actual safety issues and recommended procedure considerations for the City's facilities – not hypothetical conditions at arbitrary industrial plants. A PPE overview will be provided and integrated with a discussion of actual plant hazards. The training session will be one per phase with a total of three (3) training sessions. Each session will be four (4) hours for up to twenty (20) staff in each session.

Each training session will be geared to the operations and maintenance staff associated with the phase of the Project. The training session will be eligible for continuing education units (CEUs).

The Arc Flash Training will be conducted by the Consultant's Senior Engineer working on the project.

Deliverables:

- *Hard copy of training PowerPoint.*
- *Electronic copy of training PowerPoint.*

1.3 Project Management Services

Consultant will perform various project management and monitoring activities throughout the Project duration, as delineated in the following tasks.

1.3.1 Project Progress Meetings

Consultant anticipates six (6) progress meetings (tri-monthly). For budgeting purposes, it is estimated that the Consultant (two (2) team members) will participate in the progress meetings via conference call with WebEx as required. One (1) hour meetings are assumed.

Deliverable: Progress Meeting Agendas and Minutes – submitted to City electronically.

1.3.2 Project Administration

Consultant will manage the Project budget and submit monthly progress reports along with Project invoicing. Consultant will manage the deliverables and communicate regularly with the City regarding Project progress between progress meetings.

PROJECT SCHEDULE

The duration of the Project is eighteen (18) months from the Notice to Proceed (NTP).

ESTIMATED MAN-HOURS AND COSTS

The Estimate of Man-hours and Costs associated with completion of the Scope of Work is provided in *Exhibit A*.

PROJECT ASSUMPTIONS

1. The Project is expected to have a duration of eighteen (18) months.
2. The City will have a single point of contact with the Consultant for all invoicing and project correspondence.
3. The Consultant assumes the work sequence will allow for investigation facilities in a manner to limit the amount of travel between facilities.
4. The Consultant will utilize a subconsultant (licensed electrical contractor) for the field investigations. The subconsultant will assist with opening panels, recording breaker information, cable sizes, etc.
5. No physical testing (thermography, hi-pot, insulation resistance, etc.) of electrical equipment or cables will be performed.
6. The Consultant assumes equipment can be taken off line during normal working hours Monday through Friday, 8 am – 5 pm for the duration of the field investigations. The Consultant assumes the police station and the airport cannot be taken off line and the investigations will be completed while equipment is energized.
7. A detailed electrical safety plan is not covered under the Scope of this Work.
8. The Draft Electrical System Study Reports will be reviewed within 20 business days.

9. The City will provide a suitable location for the arc flash training that will accommodate up to 20 people.
10. The City will provide addresses for all facilities in an excel spreadsheet.
11. The work sequence document will be created using a spreadsheet, Microsoft Project or other scheduling software will not be utilized.
12. Individual airport lights will not include arc flash labels or hazard analysis.
13. Installation of arc flash labels will be completed by the Consultant's subconsultant.

STANDARD OF CARE

Carollo Engineers shall be responsible to the level of competency and standard of care presently maintained by other practicing Professional Engineers performing the same or similar type of Work at the time notice to proceed is issued. Carollo and the City mutually agree that standard of care, as applied to design professionals, shall be defined as the ordinary and reasonable care required and established by expert testimony of what a reasonable and prudent professional would have done under the same or similar circumstances.

Carollo shall not be responsible for the means, methods, techniques, sequences, or procedures of construction selected by contractors or the safety precautions and programs incidental to the Work of contractors and will not be responsible for Contractor's failure to carry out work in accordance with the Contract Documents.

Carollo has no control over the cost of labor, materials, equipment, or services furnished by others, or over Contractor's methods of determining prices, or other competitive bidding or market conditions, practices, or bidding strategies. Cost estimates are based on the Carollo's opinion based on experience and judgment. Carollo cannot and does not guarantee that proposals, bids, or actual Project construction costs will not vary from cost estimates prepared by Carollo.

TASKS, MAN-HOURS and BUDGET ESTIMATE
Lake Havasu City - ARC FLASH STUDY IMPLEMENTATION
LHC PROJECT NO. CI1010

TASKS	Man-Hours						Total Man-Hours Per Task	Labor Cost Per Task	Other Direct Costs			Total Other Direct Costs	Subconsultants	Subconsultants Markup (10%)	Fee Per Task
	Project Principal	Project Manager	Project Engineer	Engineer	Technician	Word Proc./ Clerical			Travel and Subsistence	Mileage	Printing				
Task 1.0 Electrical System Studies															
1.1 Preliminary and Field Investigations							986	\$145,056				\$20,150	\$85,000	\$8,500	\$258,706
1.1.1 Existing Documentation Review			18	60			78	\$11,460				\$0		\$0	\$11,460
1.1.2 Facility Shutdown Coordination and Work Sequence Creation		32	106	322			460	\$69,436	\$6,100	\$250		\$6,350		\$0	\$75,786
1.1.3 Field Investigation			48	320			368	\$52,960	\$13,800			\$13,800	\$85,000	\$8,500	\$160,260
1.1.4 Electric Utility & Generator Information				80			80	\$11,200				\$0		\$0	\$11,200
1.2 Electrical System Studies							2156	\$299,776				\$9,600	\$0	\$0	\$309,376
1.2.1 Model Construction				320			320	\$44,800				\$0		\$0	\$44,800
1.2.2 Initial Calculations and Draft Electrical System Study	124		100	560		260	1044	\$147,156			\$1,500	\$1,500		\$0	\$148,656
1.2.3 Draft Report Presentation and Arc Flash Philosophy Meeting			58	40			98	\$15,460	\$2,550			\$2,550		\$0	\$18,010
1.2.4 Compile Final Electrical System Study		50	56	136		260	502	\$63,680			\$1,500	\$1,500		\$0	\$65,180
1.2.5 Arc Flash Hazard Label Production & Installation				72			72	\$10,080			\$1,500	\$1,500		\$0	\$11,580
1.2.6 Formal Arc Flash Training			60	60			120	\$18,600	\$2,550			\$2,550		\$0	\$21,150
1.3 Project Management Services							78	\$14,748				\$0	\$0	\$0	\$14,748
1.3.1 Project Progress Meetings		12		12			24	\$4,056				\$0		\$0	\$4,056
1.3.2 Project Administration		54					54	\$10,692				\$0		\$0	\$10,692
Total Hours	124	148	446	1982	0	520	3220								
Hourly Rates	\$214	\$198	\$170	\$140	\$115	\$97									
Total Costs	\$26,536	\$29,304	\$75,820	\$277,480	\$0	\$50,440		\$459,580	\$25,000	\$250	\$4,500	\$29,750	\$85,000	\$8,500	\$582,830