Pipeline Engineering: How to Plan for Everything

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Abstract

Every large pipeline project has its own unique design elements and surprises. Anticipating and knowing how to prepare for these potential issues is critical to the successful design, construction and operation of the pipeline. During Preliminary Engineering for pipeline projects there are a few guiding principles that every team should follow to plan the project effectively. Since a thorough Preliminary Engineering evaluation is fundamental for a project's success, these guiding principles cannot be ignored.

This paper provides the planning principles and a detailed checklist for owners and engineering managers to utilize during the planning stages of a major pipeline project. Utilization of these tools will help identify potential surprises encountered on each pipeline project earlier than before. These principles and checklist have been developed through experience of planning and design of over 400 miles of large diameter pipelines in mostly urban environments. Planning for everything may seem too cumbersome to accomplish, but this paper will simplify the process for a majority of the typical challenges and include examples from previous lessons learned.

Introduction

Pipeline Engineering is a vital part of the civil engineering field; yet, because the final product resides below-ground most of the work goes unnoticed. By their very nature the design of underground projects comes with many unknowns. What lies below-ground cannot always be discovered before digging begins, which is why it is imperative to plan effectively during the preliminary engineering stages. The more planning completed and problems identified before construction, the higher the probability of a successful project.

Throughout an engineer's career, lessons are learned from both positive and negative experiences. Learning from these lessons and incorporating them into current projects is an important part of an engineer's professional development, and can directly impact the project timeline and budget. The list of lessons learned for an engineer is constantly growing, but the five lessons in Table 1 below can help engineers and project managers at any stage in their career.

Table 1 – Lessons Learned

Lessons Learned for Pipeline Projects	
Lesson 1	Field verify conditions
Lesson 2	Develop clear and concise communication
Lesson 3	Set due dates 1-2 days before submittals are due
Lesson 4	Develop a plan and work the plan
Lesson 5	Identify potential stumbling blocks

Lesson 1: Field Verify Conditions

Knowing the potential jobsite can have a large impact on the amount of effort that goes into a project and the project's success, whether the site is a newly developed piece of land or landfill from the early 1900s. If the design team is unfamiliar with the land the project will be on, they will surely have difficulties developing the best design for installing pipeline. However, knowing what conditions need to be dealt with can make an engineer's job less problematic. An Environmental Site Assessment and Geotechnical Report will reveal many details about the land, but some engineers leave out one very important step: performing a detailed and accurate topographic survey which cannot be substituted with basic field visits by the design engineer.

Some common questions that arise during preliminary engineering can almost always be identified during field verification. For example, is the manhole really where the surveyor mapped it? Is the gas line really abandoned? Is the water line really as deep as the plans show? How accurate are the as-builts from 1980? Did the contractor that laid this concrete 15 years ago take any short cuts? Field verification might not be able to answer the more complex questions, but it will identify discrepancies that might occur. Knowing what questions to ask will at least point the design team in the right direction and enable them to request additional data. A site visit that lasts an

hour or even a day may seem like wasted time for some but it may save the client a substantial amount of money from change orders or schedule delays in the future. Field verification will help the design team familiarize themselves with the site conditions yield a more efficient design.

Example: Field Verify Conditions

On a treated wastewater effluent pipeline project in California, the preliminary alignment called for the pipe to run through an open concrete box girder in a roadway bridge. The as-built drawings for the bridge showed that openings for future utilities had been cast into the box girder, and the plan was to route the pipeline through these openings.

During construction, it was discovered that the openings had not been constructed per the as-built drawings and were not sufficiently aligned to allow installation of the planned steel pipeline. Fortunately, changing the pipe material to High-Density Polyethylene (HDPE) allowed enough flexibility in the line to "snake" it through the openings and avoid costly modifications to the bridge structure. If access to the interior of the bridge girders had been obtained during design, the flaw could have been discovered prior to construction, and the appropriate pipe materials included in the bid documents.

While this is clearly an unusual example, it is illustrative of the types of field conditions that are not always obvious from topographic surveys, aerial photos, and as-builts. Other conditions that are not immediately obvious without visiting the site include high-traffic businesses that would be disrupted by long-term construction such as coffee shops, service stations, shopping malls, school drop-off/pick-up zones and routes, and large trees that could be adversely affected by trenching. Additionally, when choosing between multiple potential pipeline routes, sometimes the superior choice is much more obvious from a site visit than from reviewing maps and photographs.

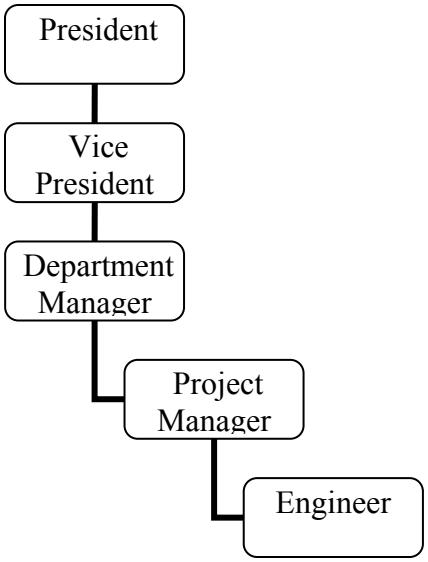
As shown from the example above, taking a proactive approach can minimize unnecessary costs and schedule delays. Even though all problems that occur during construction cannot be solved during design, it is important to incorporate all information gathered from field conditions and lessons learned to avoid repeating problems from the past.

Lesson 2: Develop Clear and Concise Communication

Developing clear and concise communication may seem like a simple task, but communication can be very complex in its different forms. Clear and concise communication between all groups involved in a project will have a tremendous impact on the overall project and its success. As outlined by Hillary Hart in *Engineering Communication,* almost every phase of engineering work requires communication (Hart, 2009). Engineers communicate through email, phones, face to

face, reports, memos, journals and publications, and even snail mail. The typical stereotype of engineers is one of being quite and working alone but engineers communicate with a variety of people on a daily basis. This communication defines our ability to express our ideas to our coworkers, clients, boss and the dedicated workers who build what we design.

Developing clear and concise communication must first start with the Project Manager. They must establish their role as well as the role and responsibilities of others. These responsibilities include following the formal channels of communication for each person. There are two common types of communication channels described by Ricky Griffin: Vertical Communication and Horizontal Communication. As shown in Figure 1 and Figure 2 below, Horizontal Communication "involves colleagues and peers at the same level of the organization" and Vertical Communication travels "up and down the organization, usually along formal reporting lines" (Griffin, 2008). Establishing the correct way for information to be distributed will ensure the accuracy of the details when they are received.



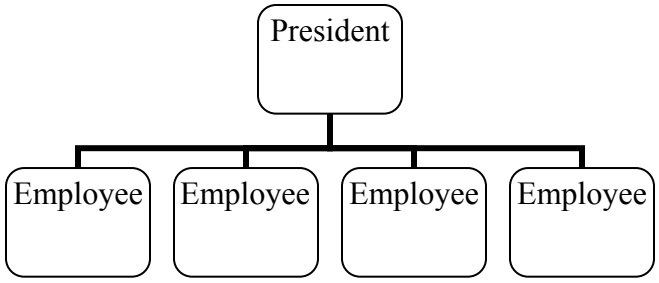


Figure 1 – Vertical Communication Figure 2 – Horizontal Communication

Many Engineering firms group their engineers into specialties such as structural, traffic, water, and geotechnical. Pipeline projects typically require the collaboration of many of these groups, therefore communication is essential. It may be necessary to set up weekly or biweekly progress meetings when a project is kicked off. Even a brief thirty minute meeting can help set the pace and increase productivity for a team.

Knowing the target audience of the information to be delivered is another important part of clear and concise communication. Between internal and external communication, "civil engineers communicate with many audience types and written and verbal communications must span a wide breadth of styles" (Grigg, Criswell, Fontane, and Siller 2001, ASCE). Identifying the target audience will determine what

style of communication to use for each audience and the formality of how it is delivered. When dealing with the client, stakeholders, other agencies and firms, it is important to be very detailed and organized with presented information. Formal guidelines are used when sending memos and notifications such as using company letterhead. When the public is the target audience, it is important to give the necessary information in an understandable manner through an accessible medium such as newspaper article, press release, door hangers, and letters. Internal communication within a company will be established by company rules and may vary between horizontal and vertical communication.

Example: Develop clear and concise communication

One example of establishing clear and concise communication that many engineers do not plan for in a pipeline design is the opposition of the public through local residents or businesses. Although the design engineer may only be concerned with making the pipeline fit within the right-of-way, it is the often the project manager's responsibility to mitigate any issues that arise with the public. It may be necessary to schedule meetings with stakeholders, neighborhood boards, and concerned citizens or even make a statement to the local news station. Planning to inform these sources in advance will keep the project manager from being caught off guard.

Lesson 3: Set Due Dates One to Two Days Before Submittals are Due

Deadlines are almost always non-negotiable and turning in a submittal on time can be stressful depending on the size of the project. Anticipating changes before an important due date and setting aside additional days for review can relieve the anxiety that comes with a significant deadline. Reports and submittals always require a large effort in addition to the design and research that is already required.

Engineers are technical writers, but this skill does not come easy for all. Therefore, setting extra time aside will reduce the last minute scramble to put everything together. Many people know how it feels to experience the crunch of time right before a deadline arrives. Many errors can be made which could easily be avoided when proactive measures are taken throughout the beginning stages of a project schedule. Whether it is a broken copier or a computer crash – Murphy's Law, "if anything can go wrong, it will" (Avidor), always has a way of sneaking up on the most important deadlines. Giving the team an extra day could determine whether or not there is time to send out the final report to have copies made in time due to an empty ink cartridge.

Example: Set due dates 1-2 days before submittals are due

Two separate schedules should be made for a project's duration. There should be an external schedule which is shown to the client and an internal schedule which

is what the project team will follow. The external schedule will show submittal dates, milestones, and any other information the client may require. The internal schedule will contain the same information as the external schedule but also include important meetings with subcontractors, review times, and other dates to keep the project on task. Continuous coordination with subcontractors will ensure that their submittals are received in enough time to incorporate into the final submittal. It is important to allow enough time for QA/QC and additional review before the submittal is due a minimum of one week before the milestone deadline.

The last item of work usually completed before making a design submittal is printing and assembling the documents. Anyone who has worked in a modern office has experienced a broken plotter, printer or copier. Even if the documents are prepared by an outside print shop, unexpected delays are not unheard of. Setting internal deadlines a day or two in advance of the final due date can provide the cushion needed to mitigate these unforeseen issues.

If no unexpected problems arise and the project goes exactly per plan, the submittal can always be delivered early—a situation that is always preferable to delivering it late.

Even when a project design is on schedule it can be easy to fall behind when many people are responsible for different portions of a submittal or report. Establishing clear and concise communication pathways in a group as shown in lesson two will help ensure that every person involved in the creation of the submittal is on task. If everyone stays on task and the submittal is complete one to two days before it must be turned into the client any last minute changes will be easier to incorporate. Also, this will allow time to apply strategies "for planning, rehearsing, and controlling nervousness [that] apply to team presentations as well as individual ones" (Hart, 2009).

Lesson 4: Develop a Plan and Work the Plan

The list below identifies some basic key items that must be addressed when designing a pipeline. These items will vary from project to project such as geotechnical issues and easement acquisition but in order to work the plan a plan must first be developed. This plan must incorporate the needs of the client such as milestones and deadlines for meetings, presentations and submittals.

Pipeline Planning Items

- Alignment selection
- Right-of-way
    - Easement acquisition
- Geotechnical issues
- Material selection
- Hydraulic performance

    - Pressure
    - Velocity
    - Transients
- Pipe sizing
- Design Criteria
    - Manhole/access manway spacing
    - Valve spacing
    - Pipe drains/blowoffs
    - Air release/vacuum valves
- Trenchless Crossings
- Project stakeholders
    - Owner
    - Customers
    - Regulators
    - Public
- Constructability
    - Construction access
    - Abandoned lines
- Operation and Maintenance
- Permitting
- Preliminary Costs
- Public Outreach program

Once a plan is established, working the plan will be the next step in keeping a project on schedule and on budget. In many cases, whether the project is in the design or construction phase, scope changes will affect many different areas of work. By working the plan that is in place, some items may be negotiated with either price or time.

Example: Develop a plan and work the plan

If the original plan on a pipeline project is to take a route that goes around a school it may seem as if that is the only option due to interfering with the children. The route around the school may be more expensive and cost the client more money, time and resources than if the route could go through the school grounds. Working the plan may involve working with the school while it is out for summer when there will be minimal activity in the area. If the work can be completed during that time, then this route may now be a feasible option. Here, the overall goal is still maintained with providing the final product to the client but time and money were saved by using the other route and working the plan.

Another way to work the plan is by making sure that permits are obtained as soon as allowed. Delaying a permit can delay a project depending on the requirements for

obtaining the permit. All permits required and the process to obtain these permits should be identified early in the project to ensure they are available when needed.

Lesson 5: Identify Potential Stumbling Blocks Early

This lesson incorporates all of the lessons learned on every project since day one. Identifying potential stumbling blocks early should be an easy task if previous problems that have occurred are identified first. Knowing what works and what does not work will save time and effort in any design because the same mistake will not be made twice.

Using a project template from project management software such as FastTrack Schedule will establish a basic timeline to create a schedule with critical upcoming events. These events include, but are not limited to, submittal deadlines, permitting due dates and final milestones. Using a template from another project that has incorporated lessons learned will be beneficial to upcoming projects because "with failures come experience, and by studying failures methods can be developed to avoid them in the future." (Grigg, Criswell, Fontane, and Siller 2001, ASCE). Each project should minimize past failures and maximize successes which is possible when lessons learned are applied. Since each project is unique, it is important to look for things that could impact the project schedule and deal with them before it becomes an issue.

Some obvious occurrences to think about when planning a project are the weather and time of year. No one wants to experience a tremendous weather delay but events such as flooding, tornados and hurricanes are always a possibility. As shown in *Civil Engineering Practice in the Twenty-First Century,* "civil engineers are on the firing line in planning and designing against failures from these causes" (Grigg, Criswell, Fontane, and Siller 2001, ASCE). Even though these events cannot be predicted months in advance, a plan should be established for potential disasters during bad weather seasons.

Example: Identify Stumbling Blocks Early

On a wastewater pipeline project in the San Francisco Bay Area, a micro-tunnel launching shaft was constructed in front of one of three driveways to a strip-mall parking lot. Access to the remaining two driveways was unobstructed, and all parking for the strip mall remained available at all times. Despite this, one business owner complained loudly and constantly, creating a host of problems for the Contractor's crew and the Project Owner. The business owner was a continual nuisance, even going so far as to knock over traffic control delineators with his car door as he exited his business at the end of the day.

Upon discussing the situation with other business owners in the project area, the project team learned that this particular business owner had a reputation for being difficult, and his reaction to the project was no surprise to those who

knew him. If the design team had spoken to project area business owners, either by going door-to-door or through a community meeting in the project area, this difficult business owner might have been identified early, and the design could have been modified, or his concerns addressed prior to construction, saving significant headaches for the Contractor and Owner.

Utilizing lessons learned and incorporating them into a project early will typically result in a project that will run more smoothly. At the very least, the same mistakes will not happen twice on a project and cause unnecessary delays.

Conclusion

In conclusion, the five lessons learned provide the project manager with key information on how to plan for the vast majority of challenges on a pipeline project. With the checklist in Table 2 below, the many obstacles that are faced while planning the perfect project can be reduced.

Table 2 – Checklist

	Checklist for Owners and Engineering Managers
	Field verify conditions
	Become as familiar as possible with site conditions
	Request additional resources after field verification if necessary
	Establish clear and concise communication pathways between different groups
	Have weekly or bi-weekly meetings for status updates
	Use meeting minutes and action item lists to ensure each project team member understands their responsibilities.
	Identify the target audience of all information mediums
	Meet with potential public groups such as stakeholders and business owners
	Set due dates 1-2 days before actual submittal is due
	Create an external schedule for the client
	Create an internal schedule for the project team
	Plan for Murphy's Law and expect the unexpected
	Assembling submittals early is always preferred to assembling them late
	Develop a plan and work the plan
	Review key items list and add additional items depending on project needs
	Address possible designs that may not be the first option if time and money are saved
	Identify stumbling blocks and problem items early
	Use a scheduling program such as FastTrack to create a template for similar projects
	Research experience on previous projects. Select input on potential problems from project area residents and businesses
	Identify past lessons learned and incorporate into the new project plan

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