Contents

Appendices

List of Figures

Chapter 3 DESIGN FOR CONSTRUCTION

This chapter presents Design Standards and Guidelines (DSG) for project constructability.

Choices made during the design process not only determine what the final product is and how it functions, but also influence the Contractor's selection of equipment, working hours and schedules, risks, liabilities and insurance needs, and, of course, bids. Contractors want fewer constraints, an easy place to set up and, generally, the quickest way to get done and on to the next project. Design engineers need to balance the purposes of the project and the requirements of the permits with the desires of the Contractor, to try to minimize construction costs and impacts. It is important to remember that the costs of the temporary parts of the work, like shoring or traffic control, can be much more expensive than the final product. Design for construction means trying to meet the following constructability goals:

- Know that there is at least one practical way to build the design.
- Make the drawings and contract documents clear to all parties.
- Optimize that balance between the project's and Contractor's needs to minimize costs and impacts to the environment, to the customers, and to the public.

The primary audience for this chapter is Seattle Public Utilities (SPU) engineering staff.

3.1 KEY TERMS

See Standard Plan 002 for abbreviations for general use on Drawings.

3.1.1 Abbreviations

Abbreviation	Term
AC	Asphalt concrete
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
BMP	Best Management Practice
CAD	Computer-Aided Design
CB	Catch basin
CDF	Controlled Density Fill
CO	Change Order
CMD	Construction Management Division
CPM	Critical Path Method
CSEC	Construction Sedimentation and Erosion Control
CSO	Combined Sewer Overflow

Abbreviation	Term
CY	Cubic yard
DC	Design Change, Detector Check Meter (for fire service)
DIP	Ductile Iron Pipe
DWW	Drainage and Wastewater
FA	Force Account
GIS	Geographic Information System
I&C	Instrumentation & Controls
MH	Maintenance hole
PCC	Portland cement concrete
PIT	Pilot infiltration test
PM	Project management / manager
PVC	Polyvinyl Chloride
PSE	Puget Sound Energy
RFI	Request for Information
ROW	Right-of-Way
SCADA	Supervisory Control and Data Acquisition
SCL	Seattle City Light
SDCI	Seattle Department of Construction & Inspections
SDOT	Seattle Department of Transportation
SPU	Seattle Public Utilities
TCP	Traffic Control Plan
TVSP	Tree, Vegetation, and Soil Protection
UIC	Underground injection control
WM	Water main
WMBE	Women and Minority-Owned Business Enterprise

3.2 CONSTRUCTION ENGINEERING AND QUALITY MANAGEMENT

The construction supervisor assigned to your project is your most valuable resource when considering constructability and how to design and prepare specifications for construction. The Construction Management Division (CMD) has documented some best practices and expectations in these documents:

- Seattle Public Utilities Construction Management Quality Manual
- SPU Office Engineering Manual
- Construction Engineering Inspector's Quality Assurance Handbook

Each project also needs to consider how to staff the construction management team, asking how much inspection is needed and who can provide expertise for complex project elements. Early identification of the project inspection needs and discussion can help the project manager and construction supervisor locate internal and external resources to support construction management. For inspections that are outside of construction management's core work of water, drainage, and wastewater, additional inspection resources may be required. Examples of inspection roles the Resident Engineer is not automatically expected to perform include:

- Commissioning authority, including equipment testing and system testing and O&M Manuals.
- Electrical, for code and compliance with SPU standards.
- Instrumentation & Controls (I&C) and SCADA.
- Landscaping.
- Special inspection required by permit or regulation (such as Seattle Department of Construction & Inspections (SDCI)).
- Structural or Architectural, including mock ups and coating inspections.
- Geotechnical, including piling, infiltration testing, or on site checking of subgrade for green stormwater Best Management Practices (BMPs).
- Settlement and vibration monitoring.
- Specialty materials testing or review. Discuss with Materials Lab if supplemental testing or review is required and with the design team about the availability of acceptable products.

Most projects require survey and all should have record drawings. Some may require additional or independent survey verification or record drawings, which may be just a step in finalizing the project commissioning. For clarity, discuss your choices and requirements in the bid documents and for staffing the construction management team.

3.3 LEVEL OF COMPLETENESS

Contract documents are never complete and a project that strives for design perfection will generally not get built. Design for clarity and make conscious decisions about how much investigation and design polishing is needed for clear construction documents and to limit changes during construction. Consider the tradeoffs in time now vs. later, as well as design costs now vs. payments to the Contractor, since additions and changes after bidding cost more.

3.3.1 Design During Construction

During construction, the design team should be able to provide timely support and contributions to the following documents:

Submittals. Standard contract requirements can be found in Specification 1-05.3. In most cases, the engineer of record will be responsible for review of all technical submittals including most items that have special provisions called out. Some examples are shop drawings, Contractor designs, and technical procedures. For complex projects, the design team should prepare a submittal control document (or draft control document) for inclusion in the Project Manual, since the design team is more familiar with the contract requirements at time of bid and award. A draft document can be amended and submitted by the Contractor. During construction, this document will be used by Construction Management Division (CMD) and the Contractor to track submittals.

The SPU Materials Lab generally reviews submittals for materials that have well established specifications.

Tip: *There are 2 types of material submittals: source forms, and material specific information. A source form simply allows a material to come from a given supplier; the material specific submittals include specific information about a given material. SPU CMD staff will approve source forms. The design team may approve some material specific submittals. If the specification calls for submittal of a sample, be clear about who will receive the sample and provide acceptance.*

Requests for Information (RFIs) are generally provided by the Contractor when some element of work is not clear to the Contractor. Often the resident Engineer will ask for design team input. An RFI is not an authorization for added work or increased contract cost.

Design Changes (DCs) often follow RFI. Design changes are issued when some design or contract issue needs to be clarified or altered. A DC may authorize additional work and costs by the Contractor.

Change Orders (COs) often follow DCs. A DC may request a cost proposal; a Change Order will require and define added work and includes how that work will be paid for. Change Orders include 1 or more of the following 3 elements:

1. **No cost.** Changing a Women and Minority-Owned Business Enterprise (WMBE) subcontractor, adding time; or a cost neutral change in Contract requirements
2. **Credit.** A reduction in cost either from the deletion or replacement of some parts of the Contract
3. **Additive.** An increase in Contract value.

3.3.2 Use of "To Be Determined By the Engineer"

The plans and Project Manual need to define the work for bidding, so there are limited situations where it is reasonable to say "To be determined by the Engineer":

- Where the units for the associated work are unit costs, and the resident engineer (or other pre-determined project team members) will determine the exact location of unit cost items.
- Where the work cannot be quantified at the time of bid and there is a Force Account (FA) bid item associated with the work. In this case, the design team would set a fixed value for the FA item.
- Where the work has been quantified and specified, but the project team wants to control the product and direct the Contractor. Work as directed by the commissioning authority is one example. Similar to the Force Account situation above, the design team would set a fixed value for the directed work.

Ensure that the Construction Manager on your team is notified when you do add that leader to a drawing.

3.4 PRESENTATION STANDARDS

Describes standards for Drawings, notes, and Specifications, as well as why format matters for the City's record keeping and in communicating with the Contractor. See DSG section 4.2 Presentation Standards.

Tips: *Make an early decision and revisit the question of what type of contour information is appropriate for your project. For roadway projects, contour lines are not standard (profiles and curb return data are), but many consultants will propose drainage and grading sheets that may not be a good communication tool for the Contractor or surveyors. For earthwork, ask how many points and how much staking might be needed? Will the Contractor need to work from a civil 3-D model? Which elevations and contours are critical and may need verification by an independent survey?*

When designing slopes, keep the slope angle changes to a minimum. For example, in swales it is much easier to set 2 points for a slope, top and bottom, than it is to add intermediate slope break points. It is hard to dig a slope with an excavator with multiple slope break points.

It is much easier to work in the field off multiple plans sheets – such as removal, utilities, landscaping, and paving – when all sheets have the same scale, stationing, and match lines. There have been many cases when the landscape drawings are in a different scale and with different match lines than the utilities, or there are conflicts between the civil grading and utility drawings. Because they are difficult to cross check, these conflicts may not be encountered until construction.

3.4.1 Notes

Notes can be a useful addition to clarify or highlight requirements. Notes can also be used to reduce plan sheet clutter and create a global annotation (about materials, for instance). Develop and edit notes carefully since notes can also create confusion, or unintentionally modify contract requirements.

Appendices 3B through 3I include sample note sets that may be useful as a starting point as you think about what notes make sense for your project.

Generally, notes that are required to obtain a permit should be incorporated into the contract. A major exception is the note sets SDOT makes available for developers on their Street Improvement Permit web site. The notes for water and drainage were developed specifically in the context of a development permit, not City projects. The web site set of General Notes include language that contradicts the basic contract, especially about the authority of the Engineer. Appendix 3I includes a set of modified SIP General Notes that are a better match with a City of Seattle project.

Tips: *Be specific when writing notes. Be aware of how each note is backed up within the drawings and technical specifications. Beware notes that could be construed as repeating or modifying Division 1 or the general provisions of the Contract. Even though the specifications take precedence, that type of note creates confusion. Use supplementary specifications instead.*

It is ok to reference out incidental specifications to the Seattle Standards from a CSI Project Manual. For example, your paint specification for a building does not work for channelization in the street that is a small component of the work. Just refer out.

3.5 SURVEY CONTROLS

For information on survey monumentation and construction impacts, see Survey Monument Protection at the SPU Engineering web site.

Basemaps should show all existing monumentation and drawings should identify an expectation for each monument potentially disturbed by the construction. Avoid conflicts, especially sewer maintenance holes (sewers are often under the monument) that would require permanently relocating a monument. It is easier for survey to tie out the location and restore the monument to its proper location or establish a reference monument after construction.

Clarity on survey expectations in the Project Manual is important and should be discussed with the SPU survey section. See Specification 1-05.5 on construction stakes and discuss whether that specification covers the project needs.

Some projects, especially operable facilities, have critical control needs and SPU will require a high level of certainty about the location and elevation or relational elevations for programming and/or operating the facility. Consider adding a step and have it shown on the CPM schedule for SPU survey or an independent surveyor to confirm the control information.

Tip: *Timing of a post-construction survey is critical. It should be after construction, but before live flows are introduced and before the SCADA programming.*

3.6 CONSTRUCTION STAGING, LAYDOWN AND EQUIPMENT

Figure 3-1
Limited Site Access

Working where there is often limited room for staging materials and equipment often influences the Contractor's bid and work plan. Whenever possible define limits for staging and laydown in the Specifications or Project Manual.

Tip: *Where staging is limited and/or the project is linear, with some parts a significant distance from the staging area, consider designing with materials that can be installed or worked out of a dump truck. For example, because of staging limitations it may be more cost effective to haul out all excavated material and to backfill with imported material. CDF placement requires the least amount of equipment.*

Define a staging area in the Contract, if possible. When sizing the staging area, even if it is not included in the Contract, it is important to consider:

- Size of equipment
- Depth of excavation
- Overhead obstructions
- Width of roadway
- Spoils handling, including any special segregation of wastes
- Materials storage
- Site Access and truck routes
- Construction Roads
- Staging Plan
- Trenchless technologies space requirements
- Construction offices
- Power

3.7 CONSTRUCTION STORMWATER AND POLLUTION PREVENTION

Every construction project, no matter the size, is required to consider construction stormwater controls. For standard minimum contract requirements for Construction Stormwater Pollution Control Plans, see Specifications 1-05.13(3) and 8-01. For design guidance and checklists, see Volume 2 of the Stormwater Manual – Construction Stormwater Control.

One approach is to review the 19 elements listed in Specification 8-01.3(1) and document your response to these questions about each element:

1. Does this element apply to the project?
2. Is there a permit associated with this element, and, if so, will the project apply for the permit, or require the Contractor to apply, or apply for the permit and amend the application with details only the Contractor can supply (most likely)? See Chapter 2.
3. What BMPs could be used to satisfy each requirement? What appears to be the cheapest or easiest to implement? Does the BMP require engineering and should the designer or Contractor be responsible for the engineering? What appears to be the most

protective? How do the choices change through project phases? Do you want to limit the Contractor's choices?

4. How are your choices, requirements and expectations for each element best presented to the Contractors: as a conceptual plan (preferred), notes, or specifications?
5. Does construction management concur that each element is enforceable with the proposed contract approach? Are specialists required for monitoring and documentation, and, if so, should those specialists be third party and what reporting relationship is appropriate?

3.7.1 Construction Stormwater and Erosion Control (CSEC) Plan

The preferred approach is for the design engineer to prepare a conceptual CSEC Plan. A contract that does not contain a conceptual CSEC Plan or specific performance requirements carries risks to the environment, regulatory compliance, schedule and budget. Without a conceptual plan, contractors will often submit a plan that is inadequate. And without a conceptual plan, the Contractor may not be reasonably expected to bid an adequate plan by lump sum per Specification 8-01.4.

Projects with very simple stormwater controls with few required elements and short timelines could summarize the requirements in notes. Or several conceptual plans for different phases could be required for more complex projects. For extreme risk cases, the team could choose to manage the work through Force Account.

A conceptual plan for the CSEC Plan elements on the project site is preferred because it:

- Allows the designer to show minimum requirements and quantities with sufficient detail for bidding;
- Allows the designer to show sizing constraints;
- Provides a drawing for review and checking constructability; and
- Allows the Contractor to modify and resubmit for review with all of the other items required by Specification 8-01.3(2)A, which can simplify and speed up the review cycles considerably.

Maintenance and removal requirements are typically handled with notes. Concrete washouts are typically identified by the Contractor and are not part of the conceptual plan.

See **Appendix 3A** for 2 sample CSEC Plans: *Sample Water Main* (curb and gutter roadway) and *Sample Bioretention* (ditch and culvert).

Tips: *The most common construction BMP in the city is Protect Inlet, but too often in Seattle the inlet structure is too small (see Inlet type 164 and look for them in the field) to use a manufactured filter sock with an overflow, which is the only approved kind. Fabric under the inlet is still in widespread use, but is not an approved BMP because it blocks the drainage function and is prone to spilling sediments into structures during handling. When the inlet is isolated from the traveled way, consider use of a compost sock around the grate. The BMP to clean inlets and CBs is not popular, but it works when protect inlet doesn't.*

One common error in preparing a CSEC Plan in the city is to fail to coordinate with the plan to maintain traffic and pedestrian access. See Section 3.16.2: Traffic Control Plans.

Figure 3-2
Compost Sock Around Grate Outside of Travel Lane

3.7.2 Tree, Vegetation, and Soil Protection (TVSP) Plan

Standard contract requirements include provisions for a Tree, Vegetation, and Soil Protection (TVSP) Plan. Consider providing a conceptual plan in the bid documents to communicate permit conditions, community expectations and details of protective measures in the bid documents. Often, the TVSP conceptual plan information is shown with the CSEC Plan or landscape plan. Especially, since most protective measures are fencing and exclusion, or soil amendment and new plantings.

For standard plans on tree protection during construction, see Standard Plans 132 and 133. When the work could impact a planting strip, consider Option 2 of Standard Plan 132a. To fence off an entire planting strip instead of just around the trees for a conceptual TVSP Plan, avoiding compaction and disturbance of the planting strip soils reduces the additional work associated with amending the soil, planting, and landscape establishment.

Projects that are installing permeable pavements or any infiltrating BMP are required to protect or restore the infiltrative capacity of the soil. The BMP area should be protected from compaction or sedimentation, or have requirements to restore the function. See Sample Bioretention CSEC Plan in **Appendix 3A**.

Tips: *SDOT Urban Forestry is tasked with protecting street trees and can provide expertise early in the project for tree evaluations, tree trimming, tree moving, tree removals, and explaining the consequences of tree damage. As soon as you identify any potential impact to street trees (remember to look up for backhoe to branch conflicts), let the project manager know that you need Urban Forestry's help. It is better to work together to form a common vision with SDOT Urban Forestry during the design process than to argue with them after award. Managing tree conflicts during construction carries the risk of high cost and schedule impacts.*

It is important to be aware of 'standard vertical clearances' if trees in the work zone are lower than standard vertical clearances. See Specification 8-01.3(2)B, #1 in "General Protective Measures."

3.7.3 Spill Plan

Minimum requirements for a spill plan are described in Specification 8-01.3(2)C. It is not standard practice to provide a conceptual spill plan in the bid documents. The project team should consider providing supplemental information and/or requirements for the spill plan when:

- Hazardous, dangerous or contaminated materials are known to be on site. At a minimum describe what is known and consider providing a waste characterization prior to the bidding. Note that different disposal sites have differing requirements and paperwork.
- Work is below a high water line, near a waterway, or there are nearby sensitive areas, environmental critical areas, or complicated drainage pathways. Consider providing a site map beyond the construction zone for the Contractor’s use.

3.7.4 Temporary Discharge Plan

The temporary discharge plan is concerned with all process water, stormwater, groundwater, and drinking water to be discharged from a project. Process water includes wastewater produced by the project, may include high pH water from contact with curing concrete, and highly chlorinated drinking water from disinfection. Good discharge plans minimize the amount of process water needing disposal by isolating the process water from stormwater. Control of runoff through the construction site should be shown on the CSEC Plan. Stormwater is the rain falling on and running through the site and, when not carrying pollutants from the site, may follow the existing drainage pathways. When stormwater comes into contact with construction materials and exposed soil, collection and treatment of that stormwater is required prior to discharge. Groundwater may be clean and subject only to volume and flow rate disposal restrictions, or contaminated and also subject to pollutant limits.

Drinking water, when de-chlorinated, is a permissible discharge to the drainage system, but may be subject to flow rate restrictions. Drinking water discharged to the sewer does not require de-chlorination, but large quantities may be subject to volume and flow rate restrictions. Drinking water discharges are generally the responsibility of SPU field operations and not the Contractor’s designated lead for temporary discharges.

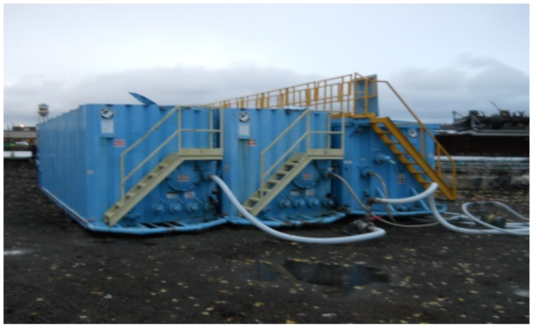
The drawings and Project Manual need to incorporate, at a minimum:

- Restrictions on systems, including volumes, the Contractor can discharge to. The detailed plan described in 8-01.3(2)D, which would be down to the CB or MH connected to and the details of treatment system, can wait for the Contractor’s preferences. However, which systems the Contractor can discharge to is an SPU decision, not Contractor’s choice.
- All permit restrictions as to quantity and quality of discharge.
- Quantity and quality of discharge requirements established by SPU.

More complex system impacts or concerns about contamination may require a more developed conceptual temporary discharge plan be part of the Project Manual and may require further restrictions on the qualifications of the Contractor’s temporary discharge lead, or may require hiring of a third party for verification. Consider when:

- Complex system hydraulics could result in combined sewer overflows from the temporary discharge.
- Complex treatment trains and testing requirements are needed due to contamination transport risks.

Figure 3-3
Settling Tanks Need Space



3.7.5 Dewatering Plan

See Specification 2-08 on dewatering and maintaining a dry excavation. The requirement to define a temporary dewatering lead in Specification 1-05.13(3) Construction Stormwater Pollution Prevention Coordination links the need and responsibility for design of a system that can provide that dry excavation with the responsibility for controlling temporary discharges.

Design of temporary dewatering is usually a Contractor designed item. It is not uncommon for design estimates (imagine you have a hydrogeologist on your design team) and the Contractor's well designer to develop different estimates. Discuss ranges and contingencies with the design team hydrogeologist to minimize surprises and delays during construction.

See sections 3.15.3.2 Groundwater Characterization and Infiltration Potential under Geotechnical Services and 3.9.4 Settlement Monitoring if groundwater pumping can lead to ground or utility settlement.

Tips: *When excavating at locations with tidally influenced variable ground water levels, rather than calling out extensive excavation sealing or dewatering, consider utilizing variable work hours so that excavation can occur during periods of lower ground water. Design and allow some of the work to occur in a wet, partly water filled excavation.*

When excavating at the edge of ground water elevations, consider engineering controls to reduce groundwater pumping needs, especially for structures like maintenance holes where a foot can make a significant difference. For example: when a maintenance hole needs to be set over an existing line, a saddle MH can be set, the base poured in the wet, then within the MH the existing pipe can be opened.

Figure 3-4
Boiling Sands Along the Duwamish

3.8 DEMOLITION, REMOVALS AND DECONSTRUCTION

Clarity in the bid documents about removals is important both for the construction period and for asset tracking. Standard practice is to show abandon in place, abandon and fill and removals on the plan view of each discipline drawing. Remove inlet (REM INL), for instance would be on the drainage plan, and abandon and fill water (ABAN & FILL 12 W) would be on the water plan. Prepare a removal/demolition drawing for removal of items not shown on a discipline sheet to be removed. For example, clearing and grubbing, tree removal, building removal, or foundation removal.

Seattle supports reuse and recycling of building materials and many building materials are hazardous to health and the environment. Asbestos pipe can be found in both the water and sewer system and underground storage tanks. Lead paint is in many facilities. Separate contracts for salvage and environmental remediation should be considered, so it is important to notify the project manager when hazards or salvage opportunities are identified. Beyond the requirements contained in the Specifications, some useful resources are:

- CAM 1302 Building Material Salvage and Recycling
- King County's site "What do I do with...?"
- SDOT Street and Sidewalk Pavement Opening and Restoration

Tips: *Somewhat common harder to remove items around the City include pilings and abandoned streetcar ties. Do not call out for standard pavement removal if the existing pavement section is 18 inches deep with wood rail ties imbedded. It is often easier to remove the entire panel than to try to cut and preserve the section.*

When working on composite asphalt over rigid base pavement look for information on the panel layout beneath the asphalt, or reflective cracking. And, consider where trench cuts can preserve as much of the underlying rigid pavement as possible. It is difficult to cut close to an existing joint and preserve just a small section, which can lead to an expanded area of pavement restoration as a field decision or SDOT field requirement.

Watch for granite curbs, which are a historic resource in central Seattle. See Specification 2-02.3(7)E on salvage of gutter brick, pavement brick, cobblestone, and granite curbs.

3.9 UNDERGROUND CONSIDERATIONS

In our ever more crowded underground space, this section raises questions that affect the constructability of new underground utilities.

3.9.1 Hazard Analysis

Prior to laying out new underground work, the designer should review the basemap and research for any impacts and construction hazards associated with:

- Charged water mains (WM) and thrust blocks:
  - Locate WM bends and avoid excavation behind them. Losing support of a thrust block could result in the charged pipe pulling apart. Most of SPU older and some newer water mains contain unrestrained slip joints. Some sort of alternate bend thrust blocking may be needed if the project requires excavation within the zone of influence of WM blocking.
- Gas:
  - Explosion and fire risk and mass evacuations are a danger when excavating near gas. Hitting or moving high pressure is always more difficult and risky than low pressure.
- Underground electrical vaults and duct bank impacts should be considered whenever an excavation is within 15 feet. See Specification 1-05.2(2) on the role of the electrical safety observer.
- Telecommunications disruption does not carry the same direct risk of death as the electrical power system, but damage can be very expensive and disruptive, especially fiber optics.
- Traffic signal impacts can be a hazard; while they do not explode, the fallout from outages in signal operations can have huge consequences to the commute.
  - Identify type and location of vehicle sensor loops.
  - Identify type and locations of all conduit.
  - Assure that foundations of any signal head is not compromised.
- Olympic pipeline is a high hazard utility. Any digging adjacent to an Olympic Pipeline may require a full time inspector from Olympic Pipeline. Contact them at their website so the constraints can be defined and adjustment can be made in the design, if needed or cost effective.
- Be wary of underground and unseen foundations, areaways, and tiebacks:
  - In the Pioneer square area, and a few other parts of the City, areaways extend beneath the walk and sometimes beyond.
  - The designer needs to consider that pole, bridge, building, and other foundations or their zone of influence may extend into proposed excavations.
  - Many downtown building foundations, some bridges and retaining walls have tiebacks that extend into the right-of-way. Do the research to determine if these extend into your projects, and when needed determine if they can be removed (cut out of the way), or if they must remain intact. As a rule, private tiebacks are required to be relaxed once the building comes out of the ground. Active

underground construction indicates tiebacks that cannot be disturbed without high risk.

- Contaminated soils and/or groundwater, both known and suspected, need to be identified. In addition to managing contractor exposure, remember that SPU crews may also be in those trenches.

Tip: *Identify hazards for trenchless construction that may not be an active hazard during standard excavation from the surface. Relaxed and abandoned-in-place tiebacks may not be a risk while excavating down, but steel caught up in a trenchless excavation can bring any type of tunneling machine to a halt.*

Figure 3-5
Offset MH Cone Between 2 Ducts

Figure 3-6
MH Cone in Conflict with Gas and Duct (Modified)

3.9.2 Excavation and Shoring

Figure 3-7
Trench Box Without Ground Support

After completing the hazard analysis, special excavation and shoring considerations may need to be included in the design. There are 2 basic types of shoring or trench protection:

1. Trench Boxes are designed to protect workers, but they allow some excavation soil movement behind them. See Specification 2-07.3(2). A trench box allows for quick and efficient excavations as long as there is not significant risk of damage associated with soil movement to adjacent utilities that are above and close to the trench. Some variations for worker protection include:
   a. Sloping trench sides back.
   b. Jacks with or without plates behind them.
2. Support and safety systems per Specification 2-07.3(3) protect workers, prevent sloughing of trench edge soils, and can be designed for control of groundwater (tight shoring). The support and safety system bid item is the most common callout when adjacent structures or utilities need support during excavation. Tight shoring to prevent the lateral movement of groundwater into the excavation is costly, and if steel sheets or similar items are vibrated in place, there can be a risk of vibratory damage. Other options include:
   a. Drilling in piles and putting lagging between them when lateral groundwater movement is not a concern.
   b. Soil freezing is costly in time and money, so usually used only for extremely deep excavations in still (movement is warming) groundwater.
   c. PCC soldier piles, often with lean concrete placed between them and a tremie seal to resist uplift at the bottom.
   d. Tiebacks added to sheets or lagging as a temporary support, especially for structures.

In choosing the right shoring system the design must consider:

- If design by the Contractor's competent person is sufficiently protective, or to require Contractor engineered shoring design or to provide shoring design on the drawings (not standard).
- Zone of Influence of the proposed excavation impact to foundations of other utilities, including thrust blocks and structures.
- Excavations over 25 feet are required by law to be designed by a licensed Professional Engineer. Designers need to either provide a prescriptive shoring design, or clearly state that the Contractor must hire a PE to design the shoring.
- Support of utilities through shoring or crossing excavations and whether a separate utility support plan submittal is required.

Figure 3-8
Water Main Supported with Nylon Strap

- When groundwater is expected in an excavation the design should contain enough information for the Contractor to effective quantify the work in the bid and an engineered design of a dewatering system, if needed. The Contract should include:
  - Any records of groundwater depth;
  - Estimated groundwater inflow rates;
  - Any seasonal or tidal variations in groundwater depths;
  - Discharge locations and any limitation on discharge rates; and
  - Permits and/or anticipated permit restrictions.

3.9.3 Utility Locates, Relocations, Protection and Coordination During Construction

Relocation of most utilities has a long lead time. Many systems may be very expensive, and in some cased cannot be moved. Consider whether you can work around it. Remember that the utility to be moved will need time to develop plans, obtain permits, and do the construction.

When looking at basemaps the locational accuracy of various utilities may vary. Note any question marks shown on plans, profiles, or basemap research. Note that locations of bored installations cannot be as tightly defined as trench installed utilities even when good record drawings are available.

There are 3 difference ways that locate wires are installed:

1. Direct buried wires
2. Wires in conduit
3. Wires in conduit duct bank encased in concrete

Miscellaneous specific information on various buried utilities:

- Seattle City Light. When excavating next to SCL high voltage, SCL requires a SCL safety observer. See Specification 1-05.2(2).
- Communication. Damaged fiber optics can be very expensive to repair.
- Puget Sound Energy. In many cases PSE will require a safety observer when excavating near PSE lines. PSE is in the process of replacing their old iron lines with HDPE and other plastic lines often installed by directional drilling. Whenever possible identify abandoned gas lines.
- Seattle Steam. These lines often have an exterior insulation coating of asbestos.
- Olympic Pipeline. Try to avoid. Almost impossible to have relocated. If digging nearby, an Olympic safety observer is required.

Tip: *Consider working with utilities to have them moved prior to general contract work. They can become critical path obstacles and lead to delays and change orders.*

3.9.3.1 When to pothole?

Figure 3-9
Damage and Danger to Conduit

In a perfect world, all utilities will be located during the design phase and there will be no need for the Contractor to pothole existing utilities. In the current schedule-driven world, the design team may need to shift some of this responsibility to the Contractor. When any crossing or potential conflict is critical information (project stopping vs. project adjusting), potholing responsibility should not wait until the Contractor is on board.

The type of work that usually requires potholing is trenchless, particularly directional drilling. In this case, it may be best to make any potholing incidental to the work. Whether incidental or separately bid and paid, potholing expectations of the Contractor need to be clear and enforceable.

Tips: *For gravity fed systems where there is limited flexibility in the elevation of improvements, direct the Contractor to pothole early on in the project. Early knowledge of conflicts allows designs to be modified if needed without adversely impacting the schedule.*

Consider restoration cost before requesting potholing in concrete roadways. Even a 1 foot square hole for potholing may trigger the SDOT pavement restoration policy for panel replacement. In some cases, potholing for multiple utilities can be clustered into a limited number of panels.

Figure 3-10
Beam and Strap Utility Support

3.9.4 Settlement Monitoring

The designers should consider including settlement monitoring whenever projects require excavation deeper than adjacent utilities or other structures that might be at risk because of construction activities. Cast iron water mains and walls within the zone of influence are two high risk items.

See *DSG Chapter 5, Water Infrastructure*, section 5.10.1.2 for monitoring settlement of water mains. Settlement monitoring of water mains along with surface monitoring can sometimes provide good information for analysis of potential impacts to SPU's deeper pipe assets, like sewers. When settlement contours indicate a need to evaluate potential damage to the sewer system, the most common method is to CCTV the pipes before and after construction for evaluation and documentation of any damage.

Project teams should evaluate settlement risks to adjacent structures and consider requiring settlement monitoring when the work is in the influence zone of a foundation, soils are liquifiable, or other indicators of risk are present. In addition to clear and realistic measurement requirements, it is important to clearly identify settlement limits and consequences. Consider adding geotechnical expertise on settlement to your team and developing a conceptual settlement monitoring plan. For tunneling projects, always include settlement monitoring in the design scope.

During construction, it is important to clearly identify who on the project team will be responsible for review of settlement reports from the Contractor, which could be received daily. Do not assume this is the responsibility of the resident engineer.

Tip: *When requiring settlement monitoring, it is important to clearly define an area or points to be monitored.*

3.9.5 Charged Water Mains

For construction around water mains, consider how to protect the existing in service water system, even if it will be abandoned later. On the plans clearly identify all water mains, including materials and joint type that will have adjacent excavation and include large laterals to services and fire hydrants since a break anywhere in the system can be catastrophic. Basemaps will not show thrust blocks, but should be assumed at bends and tees. Define in the Contract:

- The extent of the trench safety and support system (as opposed to a trench safety system only) to support the water main during excavation.
- The extent of saw cutting and removal of concrete pavement over a cast iron water main saw cutting and moving sections is more protective from impact and vibration and instead of allowing pavement breaking directly over a lead joint pipeline.
- Consider restricting the length of open excavation within the zone of influence of a charged water main to expose only one pipe joint at a time.
- When crossing under a water main, stay as perpendicular as possible and restrict the length of water main needing support through an excavation.
- Require the Contractor to submit a support plan before excavating below the water main.

For information on thrust blocks, see *DSG Chapter 5, Water Infrastructure*, sections 5.6.3.9 Types of Pipe Restraints, 5.6.3.10 Temporary Restraint, and 5.6.3.6C Temporary Supports During Construction.

Tip: *Loss of soil support to a thrust block can result in pipe separation and system failure.*

3.9.6 Asbestos Pipe Abandonment and Disposal

Identify any asbestos pipe on the drawings and plan for disposal. Small sections of asbestos can be left in the trench and buried in the backfill. Working with asbestos pipe requires special training and equipment. See SPU policy on Asbestos Handling.

3.9.7 Confined Spaces

The Contractor is responsible for their own safety program on confined spaces and SPU personnel entering a confined space need to be aware of the risks and SPU policy on confined space entry, but also follow the Contractor's safety plan.

There are two areas of special concern where extra planning and coordination is typically required when contractors need to enter existing SPU confined spaces:

- Work in an existing pipeline or tunnel where any rescue plan is particularly difficult or hazardous. This can include consultations with the fire department.
- Work that requires SPU to lock out and tag out equipment to increase safety requires coordination and a communication plan to maintain the integrity of the lock out.

Tip: *Do not rely on standard monitoring records. Characterize the system; look for valves, pumps, and sources; and consider the risk as if your life is at stake.*

3.10 ABOVEGROUND CONSIDERATIONS

Aboveground considerations include:

- Poles and guy wires
- Overhead wiring
- Buildings
- Walls and bridges
- Railroads

Trees are not included in this section; see section 3.7.2 Tree, Vegetation and Soil Protection. Streets are also not included in this section; see section 3.16 Traffic and Public Access.

3.10.1 Poles and Guy Wires

Keep planned excavations away from poles and guy wires to the extent practicable. Guy wires indicate an end pole or turning pole, so look up at the wires. Strain poles probably also have a street lamp on them, but they will also have traffic signal or trolley wires. Strain poles, turning, and end poles are much less able to withstand loss of soil support than a pole on a straight wire run that is only to support for the sag (similar to thrust blocks on water mains). Depths of pole foundations are not typically shown on basemaps. When planning excavation that could undermine a pole, check the record drawings for foundation detail and coordinate with the pole owner — most often SCL, SDOT, or Metro. Mitigating impacts to poles and guy wires can be an additional project within the project.

Tip: *Joint use of poles means that when you move a pole, first SCL installs the poles and another crew transfers wires. This is followed by the other utilities, one by one. Each pole has a designated utility that is the last off and responsible for removing the old pole — frequently CenturyLink. You may need to make provisions for removal and you do need to assume that this process takes a very long time, so coordination usually needs to start before the Contract is signed.*

3.10.2 Overhead Wiring

Required equipment clearances from electrical wires are a minimum of 10 feet and are greater for higher voltage lines. See Specification 1-07.17(2)C. Overhead wires may not be shown on basemaps. Request that they be shown, if important for the anticipated construction. Trolley, streetcar, and light rail wiring are typically lower than power, so maintaining the required 10 foot clearance is difficult and may not be feasible. The lower communication wires do not have the same safety concerns and clearances.

Tip: *Think about the construction impact of overhead wires. Without deactivating, and possibly relocating or temporarily removing the wires, it may be almost impossible to dig a deep excavation or set a heavy structure.*

Figure 3-11
Low Electrical Service

3.10.3 Buildings

Aboveground, buildings are usually obvious to avoid, but close construction is sometimes necessary. Know as much as you can about the building and building foundation. Some building records are kept by SDCI. See Seattle Department of Construction and Inspections Public Resource Center and see the microfilm library.

Figure 3-12
Excavation Next to a Building

Figure 3-13
Trench Side View

3.10.4 Walls and Bridges

When considering excavations near walls and bridges it is important to review the construction record drawings and understand all potential impacts. Basemaps may not show all foundations and will not give overhead clearances, unless requested. Always ask for survey and basemap research show all critical information needed for design and construction. Also, it is important to assure tiebacks or foundations are not compromised. Structural calculations for SDOT-owned structures are available and may be helpful in analyzing risk to major structures from adjacent excavations.

Reviews by the structure owner can add complexity to the review process and special requirements and permit conditions should be expected. Incorporate all requirements and conditions into the drawings and Project Manual.

Tip: *Excavators working under a structure are constrained and low head equipment may be needed. Recognize that the Contractor's special equipment needs may have long lead times.*

3.10.5 Railroads

Work around railroads includes heavy rail, light rail, and streetcars. There a variety of rules permits and ownership (franchise vs. rail property) that can make a project around rails difficult. The approach for clearances, safety procedures, and special permit conditions should be incorporated into the drawings and Project Manual. Learn heavy rail rules and include extra review time in the schedule whenever you are within 30 feet of the center of rail. For light rail, streetcar, and trolley bus disruptions, see Specification 1-07.28.

3.11 SEWER AND DRAINAGE BYPASSES

When working on wastewater pipes, the sewage cannot be turned off. A contractor can request a customer not flush, but cannot rely on it. It also may rain, which will change both the sewer flow (especially in combined sewers) and drainage flow with the potential to jeopardize the work area and the safety of any workers in an excavation. Sewer backups, flooding, and property damage are not acceptable. During design, project teams should identify these backup and flooding risks and measures to minimize them.

If sewer flows cannot be maintained in the excavation, a bypass plan is necessary. Mainline pipes frequently require bypassing, and in some cases each service will also need to be bypassed. Less frequently, catch basins will need to be bypassed.

The design engineer identifies at least one feasible bypass scenario during design and, if there is only one acceptable scenario, develops a conceptual bypass plan for inclusion in the bid documents. A conceptual bypass plan should include requirements that pipes and pumps should be sized to convey the maximum expected flow during the construction period. Any project bypassing constraints or requirements should be clearly noted on the conceptual bypass plan. Specific equipment callouts are not typically part of the conceptual plan, but should be in the Contractor's submitted bypass plan, along with expected durations and locations.

The design engineer should provide both a low flow estimate and a high or maximum expected flow for the Contractor in the bid documents, when available. If flow estimates are not provided and the team has decided to rely on the Contractor's observed or measured flows, require the Contractor to report observations and measurements in the submitted bypass plan.

Tips: *Supporting and maintaining a closed pipe system while building a structure around it can be cheaper and easier. A MH built that way is called a saddle MH and it can be cheaper and easier to construct than a bypass. After the structure is installed, the channel is built to conform to the existing pipe and then the pipe is broken open at the top.*

When timing construction for low flows, always have a fall back plan, in case it rains. Remember that low flow August typically includes at least one large thunder storm.

Check for potential roadway flooding for the period that a catch basin will be out of service. It is generally cheaper and preferable to use the roadway to move stormwater to the next downstream catch basin. If the structure is at a closed contour, have a plan to bypass catch basins as well.

The following are SPU minimum standards for bypassing existing utilities:

- Flow must be bypassed when it cannot be handled through the excavation.
- Flow must be bypassed when it would prevent the proper construction of the foundation, bedding, structure or pipe, and backfill.
- Pump and bypass conduit must be of adequate size and capacity to handle the flow. The effluent level in the bypass pumping maintenance hole must not cause any back-ups to any adjacent buildings or facilities. In most cases, it must not be allowed to rise more than 1 foot above the crown of the incoming sewer pipe. Work must follow Specifications 1.07.5(2) and 7-17.3(2)K.

3.12 MAINTAIN WATER SERVICE

For each project that has a water shut down, consider how to keep SPU customers receiving water. Clearly present timing restrictions, customer service expectations, and requirements for coordinating with SPU crews for water shut downs, reinstatements, and service connections in the contract documents.

3.12.1 Construction Sequencing to Maintain Service to Water Customers

Basic steps for replacing a section of water main are:

1. Request Operations help in determining shutdown limits and testing available valves to see which ones leak.
2. Isolate a section from valve to valve(s).
3. Double check that no other water source is connected.
4. Expand the area of shut down, or require the installation of additional blocking, as necessary to prevent pipe pulling itself apart if you excavate next to a live main. Determine what soil friction is required and identify potential additional valve closures away from the excavation.
5. Ask what customers are affected and which fire hydrants will not work. Draw a circle enclosing all service meters and hydrants around the affected area.
6. Work with Customer Service for a service list and restrictions on outages. Work with Customer Service and Operations staff to determine whether a temporary service is required. If so, see Temporary Services. Example questions:
    a. Are there critical customers (hospitals, kidney dialysis) without a separate feed?
    b. Are there hotels, restaurants, or laboratories that would be shut down without water?
    c. Will the transfer of connections require more than an 8-hour shut down?
    d. How many shut-offs would there be at a single property (no more than 3 allowed)?
    e. Does the Fire Department require a hydrant be kept in service? Is a working hydrant within 350-feet of every building?
7. Plan the sequencing to:

a. Schedule crews to replace services identified as needing replacement (for example, plastic and galvanized).
b. Construct new pipes and valves (construction schedules will vary for various reasons including other construction, traffic control, and soils).
c. Pressure test new pipes and valves.
d. Water quality test new pipes and valves (3 days minimum each test).
e. Schedule crews to make connection to live water main.
f. 2 live water mains.
g. Schedule crews to transfer services from old water main to new main.
h. Identify how and where to dewater the old pipe (obtain permits, if required).
i. Schedule crews to blind flange the point of connection of the old pipe to the existing water system. Go back to step 4, if necessary.
j. Abandon, or abandon and fill the old pipe.

If the plan is so complicated, you can only identify one way to accomplish the sequencing, add an allowable sequence to the drawing and specifications.

Tips: *When the valves are a long way apart, consider adding additional valves and blocking prior to WM removal or cut and cap. Talk to your supervisor and Operations.*

Water in a pipe that is shut down for more than 14 days needs to be disposed of and the pipe will need disinfection. Plan sequencing to avoid a shutdown of this length.

3.12.2 Temporary Services

Try to build new water mains in parallel to the existing main with an offset, so that you can keep the existing main in service until you are ready to transfer to the new main. The reason for this is that on average a temporary main installation (even above grade) will cost between $50k to $100k per 400 ft block depending on the number and size of the temporary services.

If you need a temporary service, some items to consider are:

- Any **critical** customers in any of the shutdown areas to setup the temporary (especially hospitals, retirement homes, and home kidney dialysis patients).
- You will have to come up with a special plan to maintain service if you have Critical customers in your work area.
- Size of the largest fire service (DC, detector check meter). The temporary will have to be at least that large.
- How many services are there and the kind of services:
  – Review customer water usage and figure out how much water will be needed in the temporary main for regular domestic use.
  – What is the pressure in your area and will the temporary be any different? A difference might change sizing or where you make your connection.
  – Are any buildings with fire service connected together or very close to each other? If so, consider upping main size to accommodate both fire services together.
  – Which services are for businesses that need water to operate? Can you minimize shutdown impacts?

- Where will you connect your temporary main?
- Will the connection points for a temporary service impact vehicle traffic? If so, you will need to minimize the traffic impacts as much as possible to satisfy SDOT.
- Will your temporary service impact sidewalk use? If so, can you still accommodate ADA access requirements? If not, you will have to reroute pedestrian traffic as well, and need to work with SDOT.
- Will your temporary service impact a bike lane? If so, you will need to reroute bike traffic.
- Try to minimize customer impacts outside of the temporary zone by minimizing shutdowns as much as possible.
- Can you connect to the existing services as is, or will you need to rehabilitate the service? Are they ductile iron or cast iron pipe? Do they have tie-rods?
- What is the likelihood of vandalism? Do you want to use DIP for the temporary? Galvanized pipe (when <= 2")? Or blue tube, as traffic and vandalism risk may affect your choice in materials.
- Will the temporary be in use in the winter? If so, this will affect your choice in above or below grade installation or may force you to come up with some kind of insulation or heat tape, affecting the overall cost of the work.
- Should you consider having the Contractor build, protect, and maintain the temporary main? Or should SPU Operations install both the temporary main and services? Discuss with Operations, especially if the temporary main is hundreds of feet long or complex.

3.13 WORKING IN A CREEK OR STREAM

Designing work in creeks and streams can be a special challenge because it often combines art, hard engineering, and biology.

3.13.1 Fish and Permits

Figure 3-14
Fish Removal in Conjunction with Bypass

It is often necessary to capture and relocate fish either at the beginning of a project or just prior to, or in conjunction with (or both), steam dewatering. Prior to capture and relocation, some sort of fish barrier, often in the form of nets, needs to be installed at the upstream and downstream end of the project.

Tip: *Because of regulatory concerns, it may be prudent to include provisions in the contract for SPU staff or other experts to do the fish relocation.*

Work in streams always requires permit(s). The permits generally have a defined fish window — a date-limited time when bypassing and in-stream work is allowed. Obtain the permits required for in-stream work prior to bidding, and make meeting the fish window a clear contract requirement.

3.13.2 Stream Bypass

The Contract should provide the Contractor with clear requirements for estimated flows and pump capacity. The Contract should also draft bypass line routing. In addition, the Contract should be designed and specified to ensure that if a storm occurs and the bypass system is overwhelmed, the overflow will not significantly damage the project under construction, or surrounding properties.

Tip: *Many of Seattle streams are at or near the water table. For any bypass longer than about 50 feet, consider including intermediate pumping (and possibly discharge) locations.*

3.13.3 The Art of Stream Structure Placement

Steam remediation projects are often designed to look like a natural stream. Some of the material most often used includes boulders and other finer sized aggregates; logs, logs with root wads, and living plants. These materials have non-uniform dimensions. Placing rocks to make a weir and plunge pools, or a log to force flow beneath it to create a pool can only be shown in basic concept on the plans. The actual details of placement of the materials may require an outside expert to be on site during their installation. The consultant for this must be chosen with care. They need to be able to get it right the first time to not adversely impact the Contractor's production.

3.13.4 Access Considerations

Many Seattle steams have limited access for some or all of the following reasons: in-steam or adjacent private property; being in steep narrow channels; and property owner or permits limiting the type or size of equipment allowed along some sections of the stream.

Tip: *Be sure the project is constructible, given access or equipment limitations. Clearly state these limitations in the contract documents.*

Figure 3-15
Hand-carried Logs for Stream Structure

Figure 3-16
Stream Bypass Intake

3.13.5 Measure and Payment

As a rule, having a measured or survey cubic yard (CY) bid item for common or stream bed excavation is not practical. In order to stabilize slopes the Contractor may need to install boulders or other features immediately after excavation; the excavations are often an irregular size that is difficult to measure; and having a survey crew on site for multiple days to cross section excavations is expensive. Consider making excavation lump sum, or payable by the truck loaded CY.

3.14 WORKING IN THE WATERSHED

Figure 3-17
Conduit Installation on Tolt Dam Lake

Figure 3-18
In-Water Barge Operations on Chester Morse

Since both the Cedar and Tolt Watersheds provide drinking water supply to Seattle and its ratepayers, working in the watershed requires extra consideration not often thought about for in-city work. Some things to consider:

- Security plan development and access through the CAPS process (Cedar River Watershed Access Permit System) or the SPU Security Process. The process will depend on which watershed your project is in and where in that watershed (i.e. projects in Landsburg follow the SPU Security Process, but projects upstream of Landsburg follow the CAPS process).
- Lack of utilities that would normally be available for in-city construction, such as power, communications, water, sewer, and drainage. Projects in the watershed should account for temporary utilities, such as generators, radios, water coolers, and portable toilets.
- Longer haul routes and supply chains:
  - May need custom PCC requirements such as retarders and relaxation of ACI standards if it takes more than one hour to get to the job site.
  - Consider alternatives to cast in place PCC, such as pre-cast elements.
  - A large staging area can help mitigate the longer haul routes for some durable items that can be stockpiled on site.
- The sanitary and spill prevention and cleanup requirements will likely be enhanced via SPU's water quality and protection regulations.
- Prevention of Aquatic Nuisance Species (SPU water quality requirements) is a policy for any work conducted on any surface waters (including rivers and streams) within the

watershed. Contact SPU Water Quality Lab for latest procedure and documentation requirements.

- There may be a greater likelihood of encountering an archeological site. Within the Cedar River Municipal Watershed (CRMW), you will most likely encounter logging debris, old garbage dumps, railroad ties, and dilapidated structures. Contact SPU's Public and Cultural Programs Manager to obtain guidance and requirements. Depending on the activity, you may need to obtain approval from local tribes via SPU's Public and Cultural Programs Manager.
- Red Flag or high wildfire risks may shut down construction. Contact SPU Watershed Protection for the latest SPU Fire Resource Manual and its requirements.
- Other cost and schedule risks that should be considered with working in the watershed:
  - Tribal hunting season
  - Watershed operations (roads, trees, fish, and wildlife)
  - Fish window
  - In-water work and lake levels associated with water supply and demand
  - Permitting through County, State, and Federal agencies

3.15 GEOTECHNICAL SERVICES

The Geotechnical Engineer's characterization of the subsurface conditions is critical during project initiation and options analysis phases. To this end, the Geotechnical Engineer evaluates available subsurface information, and performs additional subsurface explorations and laboratory testing when needed.

Tip: *It is highly recommended the geotechnical engineer-of-record project responsibilities be assigned to the Geotechnical Engineer engaged during initiation and options analysis.*

3.15.1 Provide Available Project Information

Any project information is useful to the Geotechnical Engineer to anticipate the project's geotechnical needs.

Tip: *Provide all available proposed project details, preliminary or not (i.e. structure types, depths/elevations, plans, and loads), so the Geotechnical Engineer can anticipate design considerations and the best methods to obtain data in support of analyses.*

3.15.2 Available Subsurface Information

Available existing information may allow the Geotechnical Engineer to characterize the subsurface without need for additional explorations. Typically, information obtained within a horizontal distance of 150 feet and which extends to at least 10 feet below the minimum design elevation of the proposed structural components may be applicable to a project site. The Geotechnical Engineer may require additional explorations and laboratory tests to characterize the site.

Tip: *Adequate characterization of the site helps designers with design elements (e.g. bearing capacities, lateral earth pressures, uplift forces, groundwater elevations, and subsurface improvement/stabilization) and contractors with construction methods and estimates (e.g. shoring systems, excavation/fill quantities, and material disposal). Note that anticipated subsurface conditions/materials should be confirmed during construction, so that any significant changes may be incorporated into design elements/construction methods (for example, over excavation and imported backfill may be required to provide a competent subgrade).*

3.15.3 Additional Subsurface Information

The number, depth and type of additional subsurface explorations are specified by the Geotechnical Engineer to obtain information to develop geotechnical design recommendations, and they vary based on specific project requirements. If there are any indications or existing environmental issues associated with a project or site, it is advisable to have an Environmental Site Assessment (Phase I) performed during the project initiation and options analysis phases. If the Phase I findings suggest a sampling and testing program (Phase II) be performed, it is advisable to carry it out while performing geotechnical subsurface explorations.

Tip: *Having a Phase I and II in place will not only allow contractors to estimate disposal quantities and costs, but will enable delineation of extents of contamination during construction. Delineation and characterization will also allow the Contractor and SPU to develop appropriate safety plans.*

3.15.3.1 Subsurface Exploration Methods

Some subsurface exploration methods may be implemented quickly and require very little site disturbance (such as cone penetration tests, push-probes, and geophysical methods). Other methods generate spoils that may require disposal (such as hollow-stem, mud-rotary and roto-sonic drilling methods, and test pits). The Geotechnical Engineer should determine which method will yield the data for the appropriate degree of characterization required for the project.

Tip: *Subsurface explorations may require significant coordination and permits, so their associated resourced timeline for procurement should be factored into the project schedule. See Chapter 2 for permitting information.*

3.15.3.2 Groundwater Characterization and Infiltration Potential

Groundwater monitoring wells should be installed at any proposed project sites that may be affected by the groundwater table elevation, whether during construction or for permanent design. Sites where determination of groundwater elevation is important include: sites with documented high groundwater or flooding; sites with complex groundwater regimes; sites with soil that may liquefy or soften; and/or sites where dewatering will be required to complete construction.

Tip: *In addition to providing data to capture groundwater seasonal elevation changes, monitoring wells allow hydrogeologists to estimate preliminary dewatering volumes and permeability of materials to allow designers/contractors to design and permit dewatering (temporary) and groundwater control (permanent) systems where needed. Dewatering and disposal can be a* *major project cost. Sometimes, judiciously-placed monitoring wells may also be used to assess the effectiveness of dewatering systems. Upon completion of a project or if impacted by construction, groundwater monitoring wells need to be decommissioned by a licensed driller per Washington State Department of Ecology guidelines.*

At project sites with proposed infiltration facilities, the Geotechnical Engineer should rely on infiltration test data to determine the infiltration characteristics of subsurface materials. Depending on the size and type of facility, a simple infiltration test, pilot infiltration test (PIT), large PIT, or deep underground injection control (UIC) infiltration test will need to be performed. Monitoring wells will be required for certain sizes and types of facilities.

Tip: *Note that some geotechnical explorations and tests must be performed by a State of Washington licensed professional engineer, geologist, engineering geologist, or hydrogeologist, experienced in infiltration and groundwater testing and infiltration facility design. For further clarification, consult the Stormwater Manual.*

3.15.4 Construction Support

During the construction phase, the Geotechnical Engineer provides construction observation to confirm that the subsurface conditions encountered during construction are consistent with those indicated by the explorations and used for the engineering recommendations, and to verify that the geotechnical aspects of construction comply with the contract plans and specifications. Where projects have acquired a Seattle Department of Construction and Inspections (SDCI) building permit, the Geotechnical Engineer performs geotechnical special inspections during construction as the geotechnical engineer-of-record.

Tip: *The SPU resident engineer overseeing the project should rely on the Geotechnical Engineer's confirmation of subsurface conditions and materials. Rely on the Geotechnical Engineer's direction if conditions and/or materials encountered are different from anticipated and warranting changes to design or construction. Examples of such instances include deficient subgrade, differing groundwater elevations/conditions, obstructions (such as boulders or trees and roots), voids, and contamination.*

3.16 TRAFFIC AND PUBLIC ACCESS

Most projects in the Right-of-Way (ROW) will require some sort of traffic control plan (TCP). Do not assume that Specification 1-07.23 alone will take care of site traffic and public access needs.

3.16.1 Work Sequence and Staging

Consider how much of the site, road, and sidewalk can be closed at any given time. Also consider possible adverse impacts if work occurs on adjacent streets at the same time.

Tip: *Consider changing road alignment whenever possible. An alignment shift has much less impact than a closure.*

3.16.2 Traffic Control Plans

Figure 3-19
Residential Street Closure

Choose whether the TCP should be included with the plan sheets (mostly for larger or high impact projects), or whether having the Contractor responsible to submit to SDOT will be sufficient. When there are no SDOT requirements, have the Contractor submit a plan to the Engineer only. The Project Manual should clearly identify requirements and elements of the plan that add costs.

Determine if flagging will be needed; where traffic signals need to be overridden, uniformed police officers are required.

Detours. Unless permission is granted by SDOT, traffic on arterials cannot be detoured to non-arterials.

Tips: *If arterial to non-arterial detours would be the most cost effective for the Contractor, try to get this permission before the project is advertised so that detour requirements are clear. The answer from SDOT in most cases will be no.*

In the fall of 2015 it took, on average, 6 weeks to get a Contractor's TCP reviewed by SDOT.

Building Access. Understand how building access will be impacted; and ways to mitigate this impact, if necessary.

Driveways. Remember that when concrete driveways are being replaced, the property owner may not have access to the driveway for more than a week for removal, grading, forming, pouring, and cure time. For parking lots and some structures, determine if there are multiple entrances. If so, consider phasing access replacement as needed.

Pedestrians. Consider in your design how children and other pedestrians will get through the construction site, and any other public safety considerations.

Figure 3-20
Temporary Pedestrian Bridge

Bikes. Cyclists tend to ignore detour signs; consider bike riders' safety in TCP requirements. It is very hard to detour bikes, so avoid if possible.

Fire Access. The design and PM team will need to work with the Seattle Fire Department to assure fire access.

Trolleys and Street Cars. The design and PM team will need to work with Metro and Sound Transit to assure public transportation impacts are mitigated. In many cases individual bus stops can be temporarily relocated or closed. In most cases Metro will allow temporary conversion of overhead electric trolleys to diesel buses only on weekends at the requesting party's expense. The Project Manager will need to know when shutting down stops or lines are unavoidable for early coordination with Metro.

- Solid Waste Pick Up and Deliveries:
  - Know where solid waste is picked up in your projects.
  - Determine if the project is in an area when ongoing deliveries can be expected?

Tips: *For Solid Waste consider one or more of the following:*

- *Requiring concrete placement for alley approaches only on the day or two after pick-up, for locations were solid waste is picked up in alley. Use high early strength concrete (HES).*
- *If solid waste vehicles cannot access their traditional pick-up location, have clear Contractor requirements to bring all solid waste containers to a location where they can be picked up.*
- *Set up a communication requirement with Solid Waste in the contract.*

3.16.3 Temporary Pavement

In addition to removal of existing pavement and final pavement restoration, designers should plan for any significant duration temporary surfacing, including quantifying for bidding.

Possible temporary surfaces include:

- **Crushed rock** base may be possible for short durations in arterials and in non-arterials where there is limited traffic or temporary pedestrian routes. Before using, consider:
  - Surface water flowing across it. Crushed rock cannot be used if significant volumes of water are expected when rain is possible, because of erosion/silt bearing water leaving the job site.
  - How much traffic will be traveling on the rock.
  - The extent of the gravel. While it might work for a CB connection, it likely will not work for an entire lane.

Figure 3-21
Temporary Crushed Rock Pavement

- **Cold Mix AC** has its place in areas with small patches, but compared to temporary hot mix, it has these limitations:
  - Needs to be maintained, as it shifts and spalls under traffic.
  - Can be tracked off site. In areas where there is pedestrian traffic, the City has paid claims for carpet cleaning and other tracking issues.
- **Temp Hot Mix AC** Volumes placed at one time greater than about 5 tons are cost comparable to cold mix, but hot mix does not have the limitations noted above for cold mix. There are disposal costs for both mixes.
- **Permanent base AC paving**. In some cases where the final AC pavement will have several layers, it can be cost effective to use some of the lower layers as a temporary driving surface.
- **Signs and striping** may be required for the temporary pavement. For arterial streets, coordinate with SDOT temporary striping to maintain traffic functions.

Tip: *Understand how temporary pavement edges will tie into existing pavement and castings. In some cases, the best approach may be a hybrid of materials such as Permanent base AC with cold mix at the edges. Sometimes the decision is best made as a field adjustment. If that is your plan, discuss the bid items needed with the construction management supervisor on your project.*

3.16.4 Signs

Specification 8-21 gives some general information about signs, but only provides limited details about mounted pre-designed detour routing signage (as opposed to those in a standard or more basic TCP). Using the somewhat complex 8-21 measurement and payment, including a square foot measure and pay provision for signs, may not be advisable. For projects that have a designed detour route that includes mounted signs, consider developing a special provision to cover the cost for such signs using a lump sum bid item.

3.17 SITE RESTORATION

Much of SPU work involves installing underground systems. The designer needs to be aware of restoration at the ground surface level, and account for it on the drawings and bid item list. The plans need to clearly define what final condition of all areas impacted by the work will look like.

In most cases, the primary stakeholders will be SDOT, adjacent property owners, and in some cases other agencies. In almost every case where there is some disturbance in the ROW, a SDOT Street Use Permit will be required. SDOT will require that restoration be done in accordance with the Street and Sidewalk Pavement Opening and Restoration Rule. It is up to the Project Team to determine if SPU or the Contractor will obtain the permit. For a larger project, the project team will typically obtain the permit. For some smaller projects, such as spot water or Sewer repairs, it may be more cost effective for the Contractor to obtain the permit.

As a rule, a project with an approved street use permit will have a well-defined pavement restoration plan including a plan for restoration of signs and striping, signal loops, and any other SDOT assets. It should also include plans for soil amendment or soil import of disturbed areas, landscape restoration, and any disturbed irrigation systems and mailboxes.

3.18 INSPECTION, TESTING, AND REJECTION CRITERIA

Refer to the Construction Engineering Inspector's Quality Assurance Handbook for a checklist for inspecting some of the most common construction items like pipelines and pavement. For information on commissioning operable facilities, refer to Infrastructure Commissioning Guidelines.

For construction inspection of less common items or sequenced projects, it is important for the project team to establish expectations for inspection and quality assurance. Projects where SPU takes on some operational functions while Contractor testing and commissioning are ongoing require more thought. With phased projects, consider:

- Clearly defining facility responsibility and ownership by phase. Once SPU takes on some operational functions, it becomes more difficult to hold the Contractor responsible for problems.
- Consider using multiple phases of liquidated damages (LD). For example, one LD for substantially completing the bricks and mortar construction and another for SCADA completion and/or operational testing.

See each of the discipline chapters for inspection and testing criteria.

3.19 FINAL ACCEPTANCE PROCEDURES

Final acceptance procedures vary with the complexity of the project. For operable projects, see Infrastructure Commissioning Guidelines. For most City projects, Specification 1-05.11 describes substantial and physical completion.

Below is a short summary for some typical project types:

3.19.1 Sewer Lining Projects

The Resident Engineer approves each section. Approval requires successful pressure test, CCTV, and physical inspection. When there are specific design issues not clearly defined in the Contract the SPU Designer may be asked to determine if a section is acceptable.

Tip: *Overcutting the laterals after lining is a possible defect to watch for and can especially be a problem with PVC tees (core taps and inserta tees are common). When reviewing a plan for repair, it is helpful to identify at least one acceptable alternative (preferably trenchless).*

3.19.2 Spot Sewer Repair Projects and New Drainage and Wastewater Pipes

See *DSG Chapter 8, Drainage and Wastewater Infrastructure*, section 8.10.3 on Acceptance Procedures for Drainage and Wastewater Infrastructure.

- When there are not quality issues, or unique design issues, the Resident Engineer approves each section. Approval requires successful pressure test, CCTV, and physical inspection of various elements.
- When pressure testing by other than low pressure air method (infiltration test or exfiltration test) is required, it can be helpful to call that out on the drawings. If exfiltration testing is required due to proximity to an environmentally critical area, identify the critical area on the drawings. It may not be obvious.
- The SDOT Street Use Inspector approves the surface restoration. Until the SDOT Street Use Inspector closes the street use permit associated with the work, the project cannot be closed out. Note that sometimes for larger DWW projects the SPU design/PM team obtains the street use permit. In these cases, the SDOT part of the work will be closed out, either during the final inspection or when the Street Use permit is closed out.

- When there are specific design issues not clearly defined in the Contract the SPU Designer may determine if a section is acceptable.
- If DWW lines are installed on another agency's property (e.g. Seattle Parks Department), that other agency also needs to accept surface restorations.

3.19.3 Water Mains

See DSG section 5.10.3 Construction, Startup, and Acceptance Procedures for Water Infrastructure. The approval process for water mains requires extensive coordination with several units in Water Operations. See the Quality Assurance (QA) Inspectors Handbook for details. When designing water main work outside City limits, the design team should identify the local agencies that will be part of the approval process. It is best to get concurrence from those agencies on what the final restoration will address.

3.19.4 Bioretention and Biofiltration

The acceptance procedure for CIP bioretention projects is not yet fully established. Inspector's checklists and changes to Specification 7-21 (bioretention) are under development. Check with your supervisor and CMD on staffing for inspection of soils and landscaping.

Tip: *For facilities that have UIC wells (deep ground water injection) be sure to include in the Contract specifications clear requirements for flushing the cells prior to introducing water into the UIC wells. In addition, the facility needs to be designed so that the cell can be flushed. Connections to the well must be blocked, and there needs to be a gravity bypass or other ways for the cells to be pumped.*