CE 3372 WATER SYSTEMS DESIGN

DESIGN GUIDELINES – DRINKING WATER SUPPLY PART 1 (FALL 2020)

WATER DISTRIBUTION DESIGN

- Design is the management of constraints.
  - Non-negotiable constraints are dictated by laws of physics, chemistry (and to some extent mankind); examples of these are: water flows downhill unless power (lift station) and money (capital cost to build, operation cost to pay for electricity to run pumps) are applied; Chemical disinfection residual will decay over time unless replenished; this constraint encourages using treated water relatively quickly.
  - Negotiable constraints are the design variables that can be adjusted to satisfy the non-negotiable constraints and the desired system performance; the main components of this category are money to pay for things, time to build (and operate), aesthetics (pipe alignment/channel geometry); system performance under various anticipated conditions.

WATER DISTRIBUTION DESIGN

- The water system designer's goal is to satisfy a need (some level of performance) by manipulating negotiable constraints. The analytical tools herein are used to test the design before committing to an actual build (presumably so that full-scale experiment fails are avoided).
- Design guidelines encapsulated in regulatory documents, design manuals, professional, and manufacturer's literature represent guidance based upon centuries of observation and experimentation (and a lot of failures); the value is that they generally work, and reduce commercial risk for routine water system components.

WATER DISTRIBUTION DESIGN ELEMENTS

- Four basic elements of water distribution design are:
    1. How much water will be used?
    2. Where are the raw water supply locations?
    3. Where are the water consumption locations?
    4. What is the water use as a function of time?

WATER DISTRIBUTION DESIGN ELEMENTS

- When designing new systems, calculating demands is not a straightforward process. The designer needs to know the expected demands, possible fire demands, and future expansions.
- There are some publications that provide average demands for residential,commercial facilities, and production/industrial facilities.
  - Finding/building a modern database of such information wopuld be a good data science project

WATER DISTRIBUTION DESIGN ELEMENTS

- Different demands need to be accounted for:
  1. Customer demand Average use needed to meet non-emergency needs.
  2. Fire flow demand The computed system capacity required for ensuring minimum fire protection while maintaining a minimum working pressure in the system.
  3. Ultimate expansion to the system

WATER DISTRIBUTION SYSTEMS

- Water distribution systems convey water from a source to a customer. Sources include:
  - Ground water: Series of municipal wells usually requiring chemical treatment, at least to the extent of chlorinating (disinfecting).
  - Surface water: Drawn from lakes or rivers just below the surface. Ocean-desalination plants on or near coastal regions.
  - Precipitation: Large municipal reservoirs collecting rain runoff and snowmelt (rainwater harvesting).

TRANSMISSION AND DISTRIBUTION MAINS

- Transmission lines are categorized as mains that carry large volumes of water, great distances, such as between a treatment plant and local storage facilities.
- Distribution lines are smaller pipes including valves, hydrants, fittings, and appurtenances, that deliver treated potable water to the customers.

SYSTEM TYPES

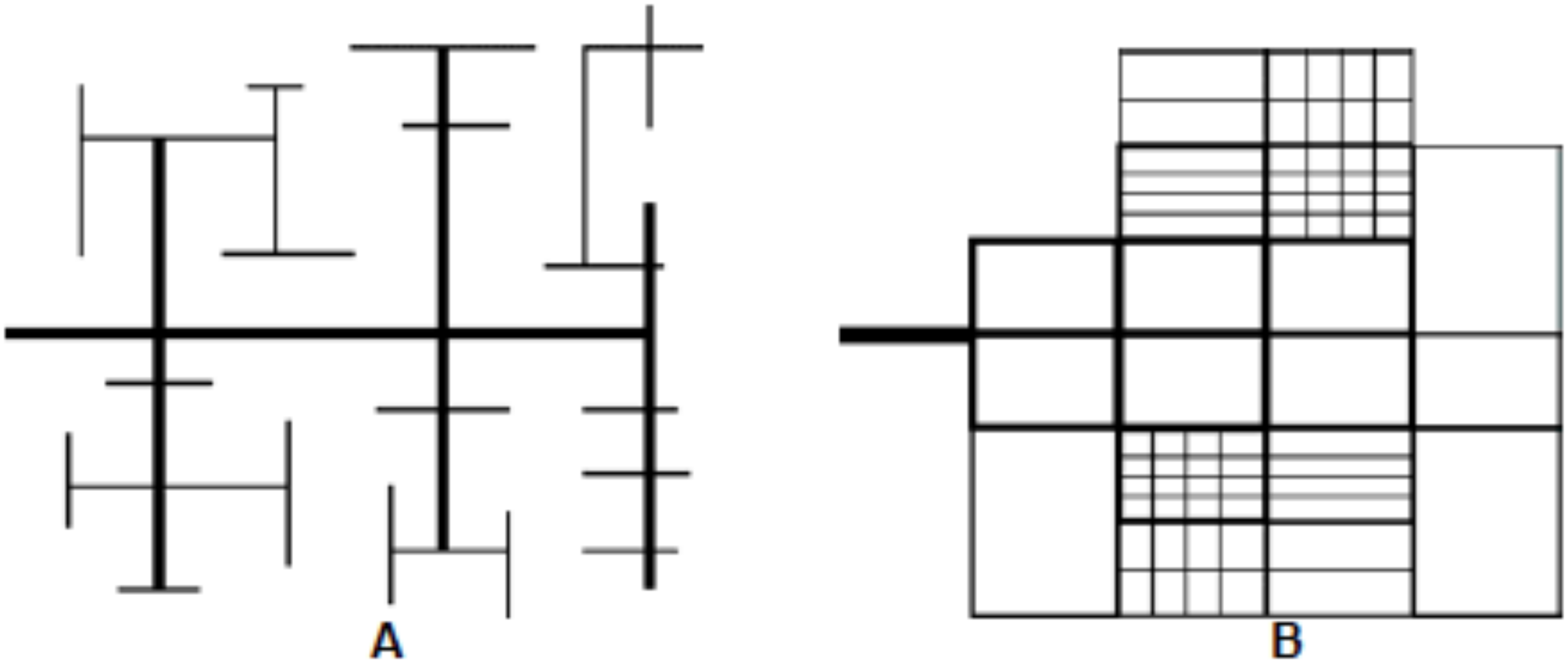


FIGURE 1-3 Two Basic Configurations for Water Distribution Systems. (A) Branched configuration. (B) Looped configuration.

LOOPED SYSTEM FEATURES

- Advantages:
  - Fluid velocities are lower, reducing head losses, resulting in greater capacity.
  - Main breaks can be isolated to minimize loss of service to customers.
  - Fire protection is greater due to greater capacity and ability to isolate breaks.
  - Looped systems usually provide better residual chlorine content due to inline mixing and fewer dead ends.
- Disadvantages:
  - Looped systems generally cost more because there are pipes that become inadvertently redundant in order to create the loops.

BRANCHED SYSTEM FEATURES

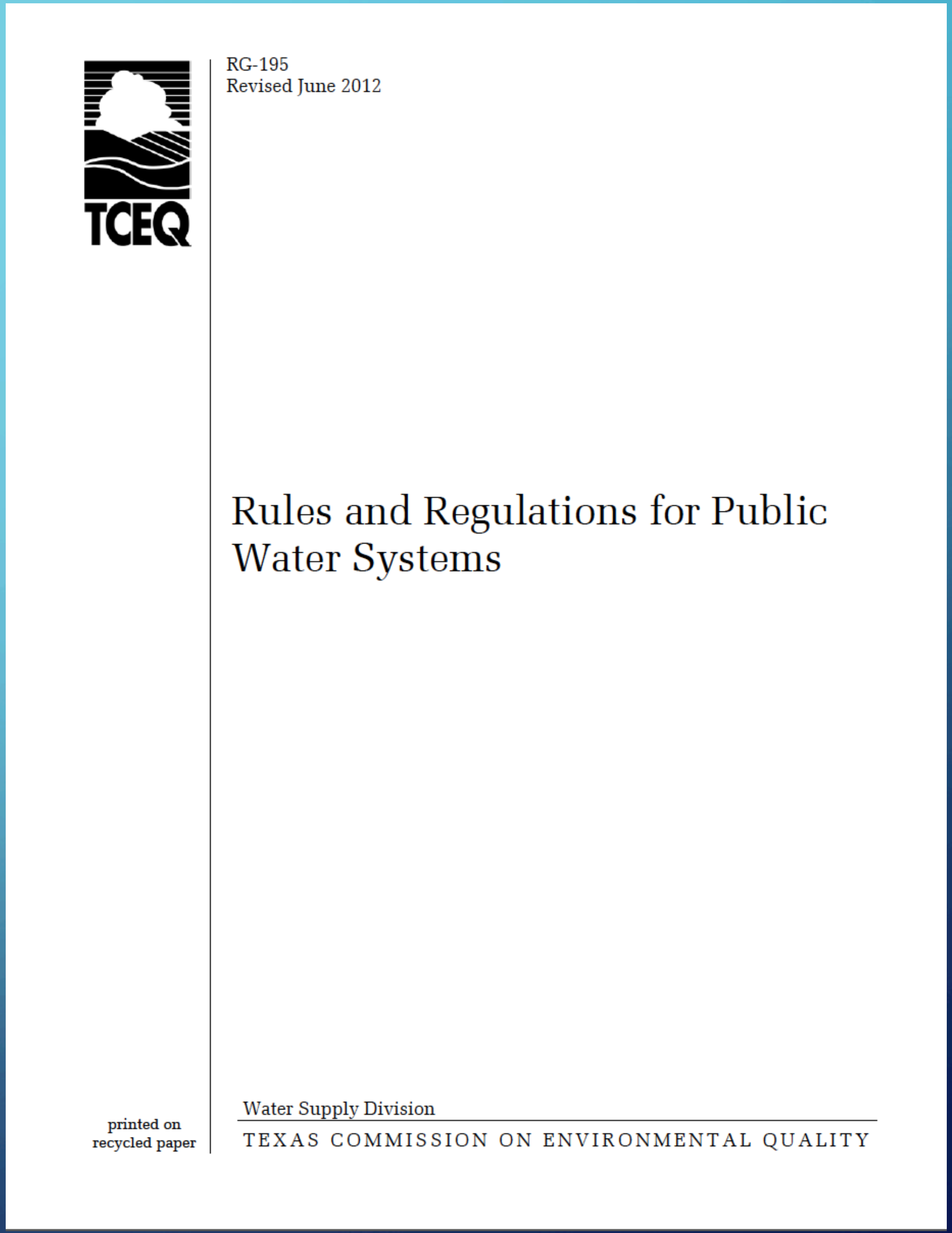
- Advantages:
  - Lower costs: Avoiding construction of pipes and appurtenances just to create a looped system reduces the cost.
  - In smaller rural communities, branched systems may be the only type that is feasible, logistically and monetarily.
- Disadvantages:
  - Main breaks take all downstream customers out of service.
  - Branched systems cause poor chlorine residuals in low demand areas and may require periodic flushing of hydrants in order to pull chlorinated water into the system.
  - Velocities are faster, head losses greater and capacity reduced especially during high demand.
  - Fire protection is at risk due to inability to isolate a break.

REGULATORY GUIDANCE DOCUMENTS

- Regulatory guidance documents are a principal tool in system design, along with the designers creativity, and the owners access to right-of-way.
- The EPA (Environmental Protection Agency) writes federal regulations for construction, maintenance, treatment and operation of potable water facilities.
- State's EPAs(or equivalents) are charged with regulating the standards and permitting. States may write more stringent regulations if they do not violate the intent of the federal code. The various documents are precise, but teduous.

TEXAS RG-195

- Representative of a State Level document
- Examine selected content



TCEQ

RG-195
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Rules and Regulations for Public Water Systems

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Water Supply Division
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

REPRESENTATIVE COMMUNITY MANUALS

- Washington State
- City of Houston
- City of Lubbock
- City of San Marcos

PROFESSIONAL LITERATURE

- For unusual situations the designer will have to visit the professional literature for guidance
- Order of preference for a designer will be a manual of practice, vendor literature, and finally the academic literature.
- A manual of practice or even vendor literature is preferred over the academic literature simply because of a perception that the technologies are proven in these documents (proven in the litigation sense).

VENDOR LITERATURE

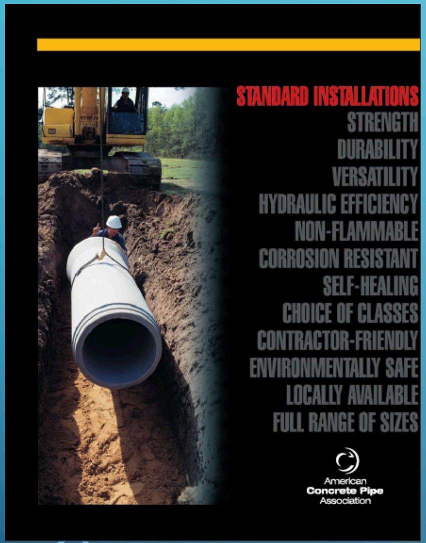
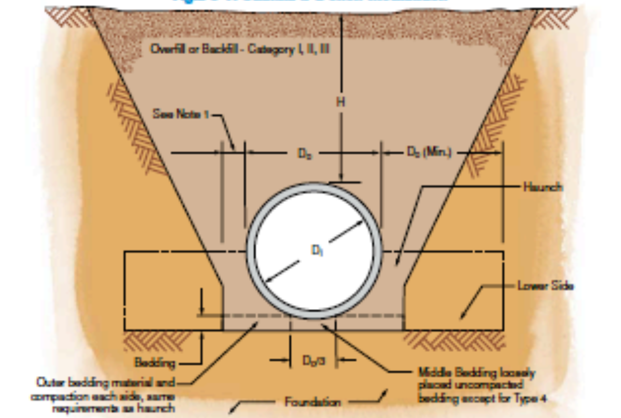


Figure 1. Standard Trench Installation



Note 1: Clearance between pipe and trench wall shall be adequate to enable specific compaction, but not less than $D_o/6$.

SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	Do/24 minimum; not less than 3 in. If rock foundation, use Do/12 minimum; not less than 6 in.	95% Category I	Undisturbed natural soil with firmness equivalent to the following placed soils: 90% Category I, 95% Category II, or 100% Category III, or embankment to the same requirements
Type 2	Do/24 minimum; not less than 3 in. If rock foundation, use Do/12 minimum; not less than 6 in.	90% Category I or 95% Category II	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 3	Do/24 minimum; not less than 3 in. If rock foundation, use Do/12 minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 4	No bedding required, except if rock foundation, use Do/12 minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.
Note 2. When the trench width specified must be exceeded, the owner shall be notified.
Note 3. The trench width shall be wider than shown if required for adequate space to attain the specified compaction in the haunch and bedding zones.
Note 4. Embankment loading shall be used when trench walls consist of embankment unless a geotechnical analysis is made and the soil in the trench walls is compacted to a higher level than the soil in the backfill zone.
Note 5. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.
Note 6. "Dumped" material without additional compactive effort will not provide the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

5

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