Impacts of Flow Velocities and I/I in Wastewater Collection Systems
Anvil Centre, New Westminster, BC
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Inflow and Infiltration

The amount of wastewater that must be handled by the system is determined by an analysis of the present and future quantities of domestic, commercial, industrial and institutional flows.

As well, **infiltration** from ground water as the pipe deteriorates and **inflow** from surface runoff must be factored in.

**storm overflow**
Ideally, systems should be built to convey the max estimated flow when the service area is fully developed.
However, this can result in oversizing of large transmission mains, particularly during the early period of development affecting the ability to maintain sufficient velocities if the design capacity is much greater than the actual flow.

Combined sewers from older areas within the catchment area can also have an influence on capacity during periods of high precipitation.
Pipelines are therefore often built to handle peak flows over a 10 - 30 year range with the provision to expand as actual flows increase, and before exceeding design limits.

This is accomplished by twinning pipelines or redirecting flows to neighbouring catchment areas.
Pipelines are designed to carry discharges accumulating from:

- Domestic
- Commercial
- Industrial
- Institutional and
- Inflow and Infiltration
Population estimates (in 30 years) are based on:

- percentage growth factors
- census predictions
- graphical comparisons to larger cities
Domestic discharge per capita flow averages are approximately...

400 litres or 100 gallons per day per person.
Institutional, Commercial and Industrial

Los Angeles, Ca design parameters:

• Hospitals: 500gpd per bed (surgical)
  85gpd per bed (convalescent)
• Schools: 10gpd (elementary)
  15gpd (high school)
• Offices: 50gpd per capita
• Hotels: 500gpd per room
• Industrial: 15,500gpd per acre
Inflow and Infiltration

Inflow (surface water) and Infiltration (ground water) occurs due to:

- pipe submersed in high ground water table
- number of manholes and connections
- poor construction techniques
- cross-connections of stormwater drains
- surface ponding at manholes lids
- structural failure caused by root intrusion
Design Flows

Inflow and Infiltration

- Pipe submersed in high ground water table
- Poor construction techniques
Design Flows

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cross-connections of storm drains

surface ponding at manholes lids
Design Flows

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- Structural failure
- Root intrusion
Design Flows

Inflow and Infiltration

I and I design parameters:

- Vancouver, BC: 1,500 gpd per acre
- Seattle, Wa: 1,400 gpd per acre
- Alma, Mi: 140 gpd per acre
- Springfield, Ma: 2,000 gpd per acre
Flow Variations

Wastewater flows fluctuate throughout the course of the day depending on the characteristics of the community.

It is important that wastewater in a pipeline travels at a speed that will prevent the deposition and build up of solids in the line.

This is often referred to as **scouring velocity**.
Through testing and observation, it has been determined that minimum velocities should be kept at no less than 0.6m/sec (2ft/sec) to ensure a scouring effect is maintained throughout the pipeline.
Excessive velocities however, can cause solids to separate from the flow and excessive turbulence at junction points as well as erode the invert of the pipe. Velocities in a gravity flow system should **not exceed** 3m/sec (10ft/sec).
As velocity is a critical component of the system, operators must be diligent in monitoring the actual velocities of wastewater flowing through the piping network.
Velocity

Velocity is defined as distance over time and can be measured as such:

\[
\text{velocity} = \frac{\text{distance}}{\text{time}} = \frac{\text{metres}}{\text{second}} = \frac{\text{miles}}{\text{hour}}
\]

Velocity is typically measured in m/sec or ft/sec
Field velocities can be determined by actually measuring the distance of the line between manholes and timing an object as it travels through the section of pipe:

The distance travelled is divided by the time taken to obtain the actual velocity of the wastewater in the system.
During periods of lower flows, fluorescent tracer dyes may be used however, caution should be taken when determining the travelling time as dye will be visible in the downstream manhole over a period of time.

The average should be calculated by measuring the time dye is first seen \( t_1 \) and the time it eventually disappears \( t_2 \).

\[
\frac{t_1 + t_2}{2} = \text{Ave time}
\]
During periods of higher flows, floats are most desirable when measuring travel time to determine system velocities. These can be float rafts or a variety of simple items such as sticks, balls, orange peels etc, essentially anything that will travel unobstructed and can be easily seen from the downstream manhole.

Proteus Sewer Inspection Float Raft
When using this method, keep in mind that surface floats travel 15-20% faster than the average velocity due to differences between water flowing at the surface in the middle of the pipe, and at the bottom or sides of the pipe.
Velocity of the wastewater will vary depending on three factors:

- the slope of the pipe
- the material the pipe is made of and
- the depth of the wastewater flowing through the pipe.
Manning’s formula states that:

\[
velocity = \frac{S^{1/2} R^{2/3}}{n}
\]

Operators will not be required to calculate velocity with this formula but it is important to recognize the factors that can have an effect on velocity.

Velocity changes as does \( S, R \) and \( n \)
Sewer systems must be capable of carrying peak flows at all times. It is unacceptable if the piping network is unable to contain the wastewater resulting in regular flooding or discharges to the environment.
Flow Rates

The rate of flow is defined as volume over time:

$$Q = \frac{\text{volume}}{\text{time}} = \frac{\text{cu metres}}{\text{day}} = \frac{\text{cu feet}}{\text{second}}$$

Flow rates (or sometimes referred to as discharge) can be measured in many different units depending on the quantity:

- cu m/sec, l/min, Ml/day, gals/min etc
The overall carrying capacity of a sewer is essentially influenced by the 3 factors impacting velocity:

- the slope of the pipe
- the roughness coefficient $n$
- the depth of the wastewater

as well as a 4$^{th}$ factor:

- the x-sectional area or size of pipe.
Operators must be aware of instantaneous flows which can fluctuate throughout the day and be prepared to deal with peak flows which can result from inflow and infiltration due to storms, combined sewers, or special events.
Thank You