A COMPARISON OF FOUR TYPES OF SEWAGE DROP STRUCTURES THROUGH PHYSICAL MODELLING

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WATER NEW ZEALAND'S MODELLING SIG - AUCKLAND REGIONAL MEETING

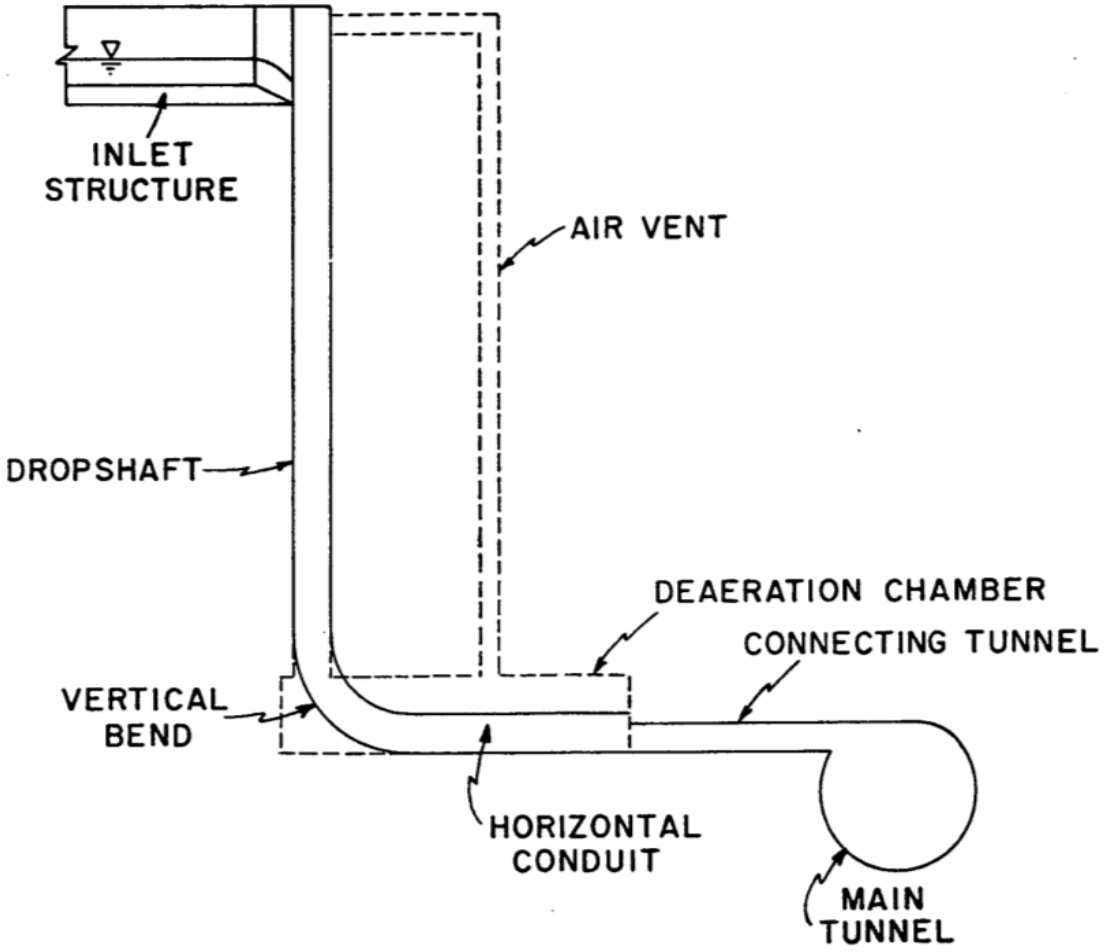
15 – APRIL - 2015

AGENDA

- SAFETY MOMENT
- WHAT IS A SEWAGE DROP STRUCTURE?
- SEWAGE DROP STRUCTURE HYDRAULICS
- SEWAGE DROP STRUCTURE CHALLENGES
- TYPES OF SEWAGE DROP STRUCTURES
- QUESTIONS AND ANSWERS

WHAT IS A SEWAGE DROP STRUCTURE?

FOR THIS PRESENTATION, A SEWAGE DROP STRUCTURE IS DEFINED AS A MANMADE DEVICE DESIGNED TO DROP SEWAGE IN A MANAGED WAY THROUGH A LARGE DISTANCE (I.E., GREATER THAN 10 FEET / 3 METERS).



Components of Many Sewage Drop Structures

DROP STRUCTURE HYDRAULICS

- THREE PHASE FLOW PHENOMENON
- AS WATER DROPS, IT ACCELERATES
- FLOW IS FOUR-DIMENSIONAL
- AS A RESULT, ANALYSIS IS CHALLENGING

Engineer: A person who assumes a cow is a sphere to make the math easier.

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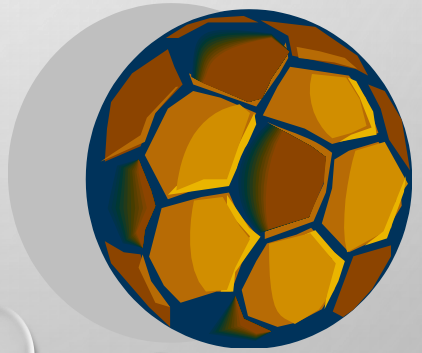


DROP STRUCTURE HYDRAULICS

- "TERMINAL" DROP VELOCITY CAN EXCEED 15 M/S (50 FPS)
- WHAT IS TERMINAL VELOCITY OF A BRICK?
- AT THESE VELOCITIES, NUMEROUS CONCERNS ARISE:
  - NOISE
  - CAVITATION
  - EROSION
  - VIBRATION
  - IMPACT LOADS

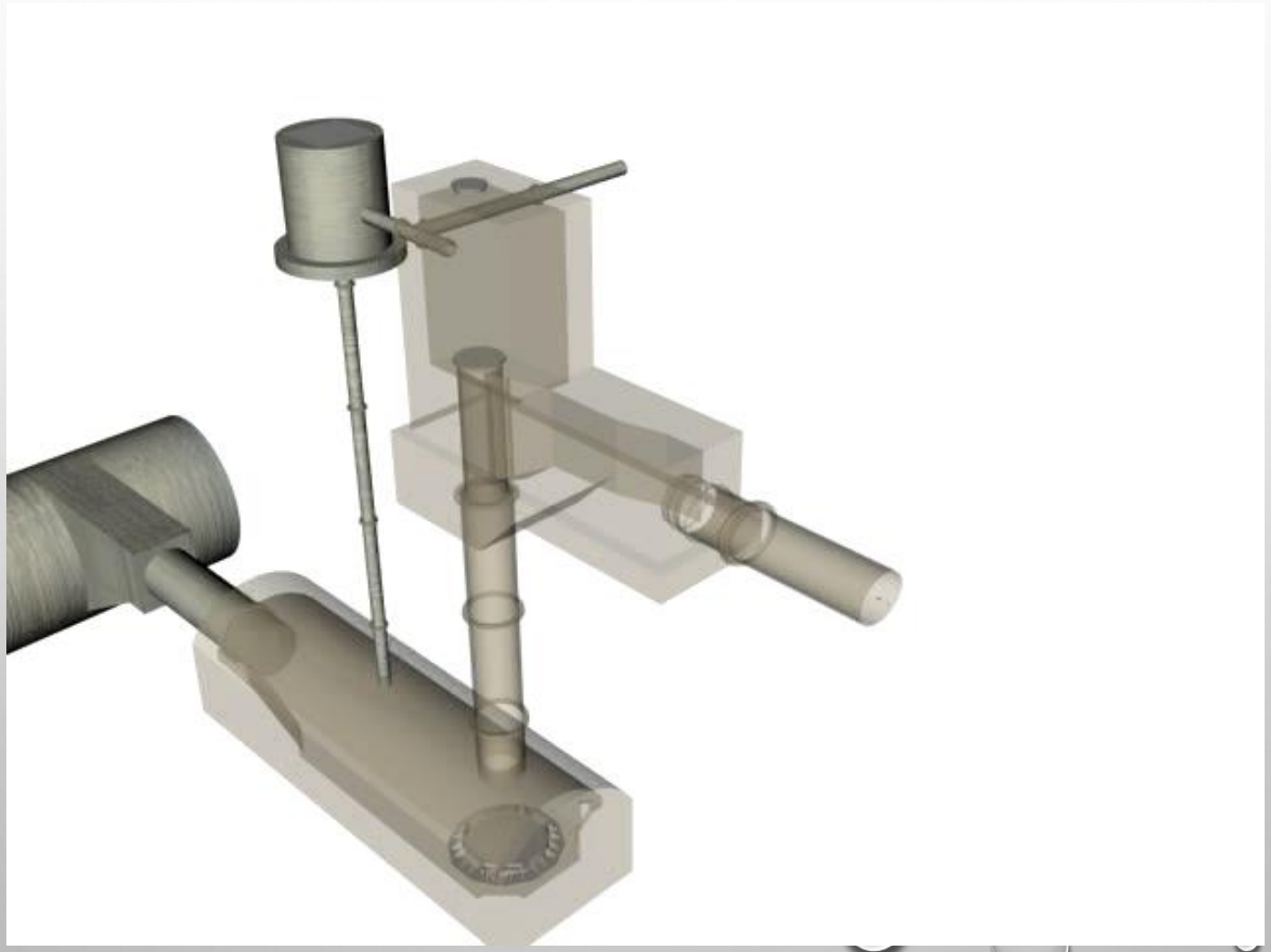
DROP STRUCTURE CHALLENGES

- HOW TO DISSIPATE ENERGY?
- HOW TO PREVENT UNDESIRABLE EFFECTS OF HIGH VELOCITY?
- HOW TO MAINTAIN A STABLE, PREDICTABLE FLOW REGIME?
- HOW TO PREVENT UNDESIRABLE EFFECTS OF AIR FLOW?
- HOW TO FIT INTO SITE, GEOLOGY, ETC.?
- HOW TO HANDLE DEBRIS, SOLIDS, & GRIT?
- HOW TO DESIGN A SEWAGE DROP STRUCTURE?
  - MATHEMATICAL MODELS (E.G., CFD)
  - PHYSICAL MODELS

TYPES OF SEWAGE DROP STRUCTURES

- MOST POPULAR DROP STRUCTURES
  - VORTEX DROP
  - HELICOIDAL RAMP
  - PLUNGE DROP
  - CASCADE (BAFFLE) DROP
  - OTHERS (DC WASA, PORTLAND MODEL, DRILL DROP, CHICAGO “BOOT,” ETC.)

VORTEX DROP STRUCTURE



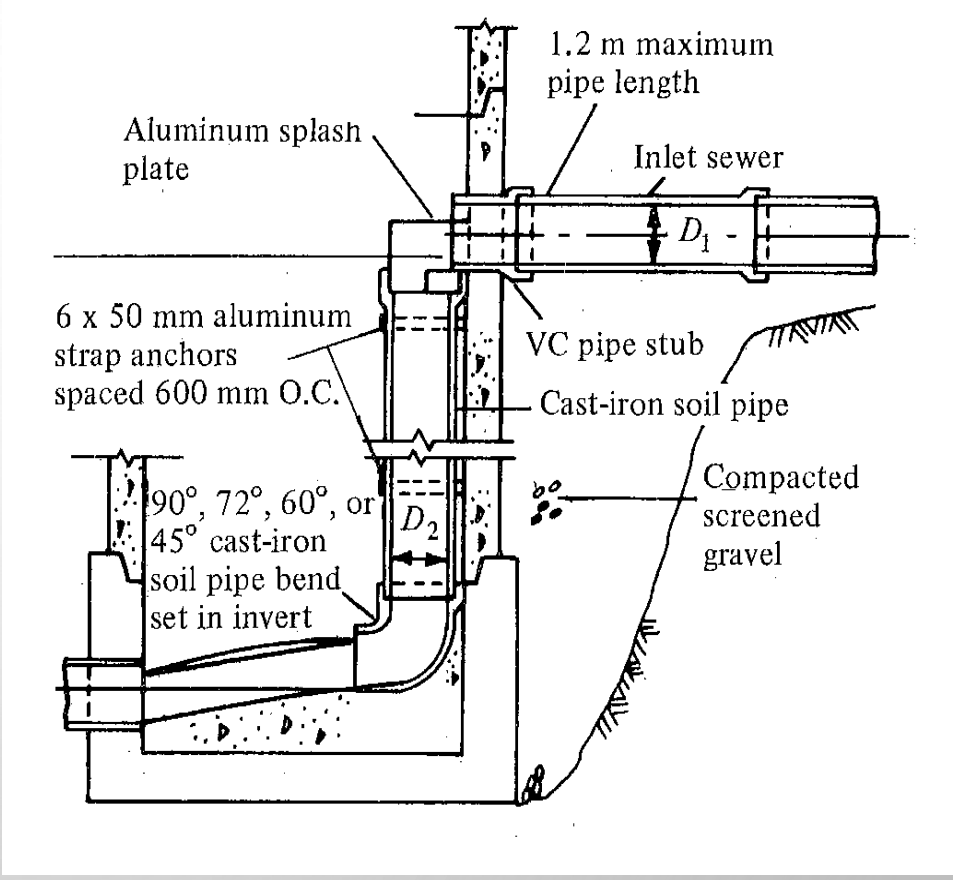
VORTEX DROP STRUCTURE

HELICOIDAL RAMP

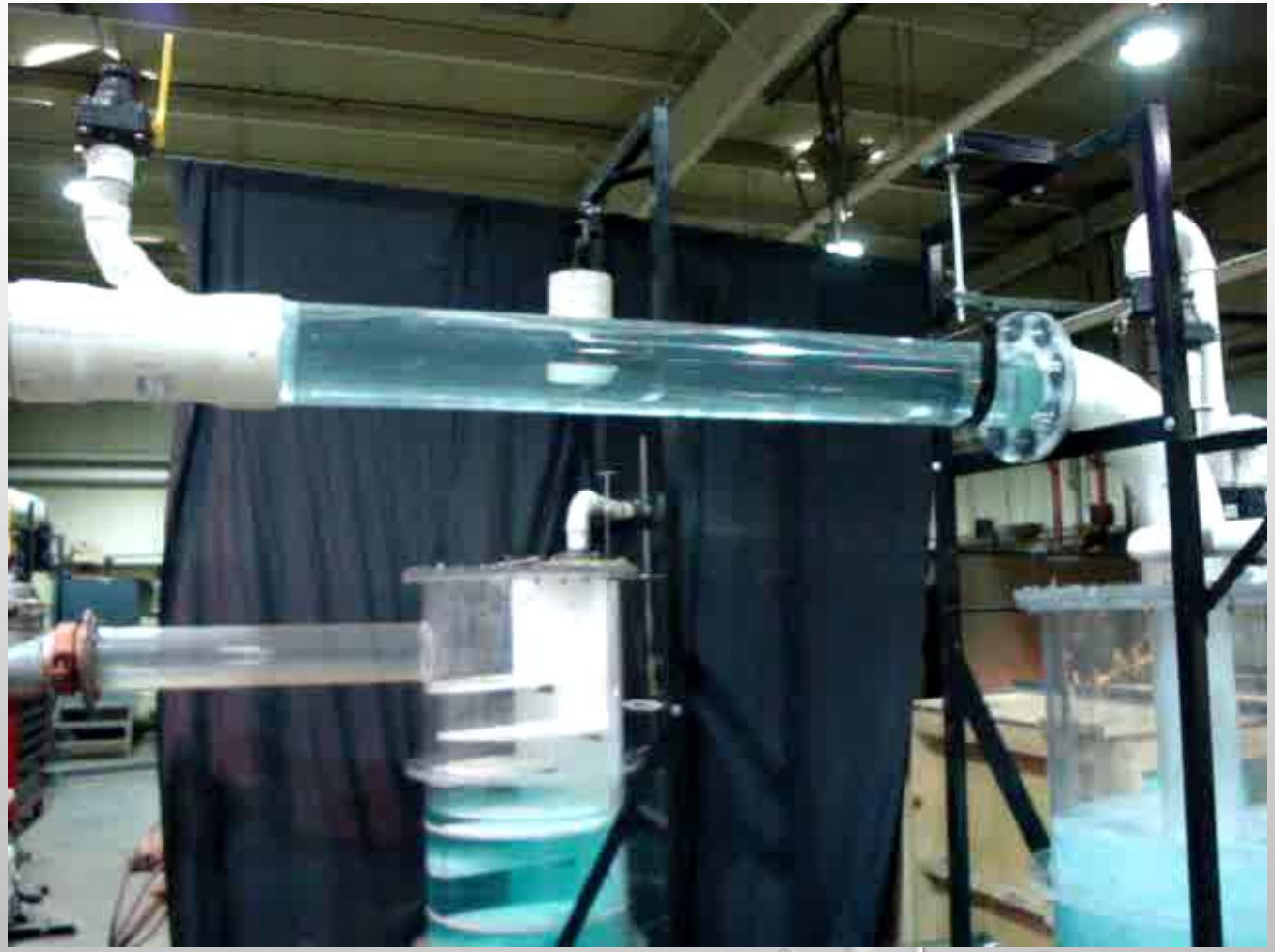
HELICOIDAL RAMP

PLUNGE DROP

- OLDEST DROP
- SIMPLE AND CHEAP
- COMMON FOR SMALL FLOWS AND SHALLOW DROPS
- NOT USUALLY USED FOR MOST TUNNEL SYSTEMS, DUE TO:
  - FLOW INSTABILITY
  - AIR ENTRAINMENT
  - POOR ENERGY DISSIPATER
  - RELEASES ODORS
  - NOISY
  - PRONE TO VIBRATION



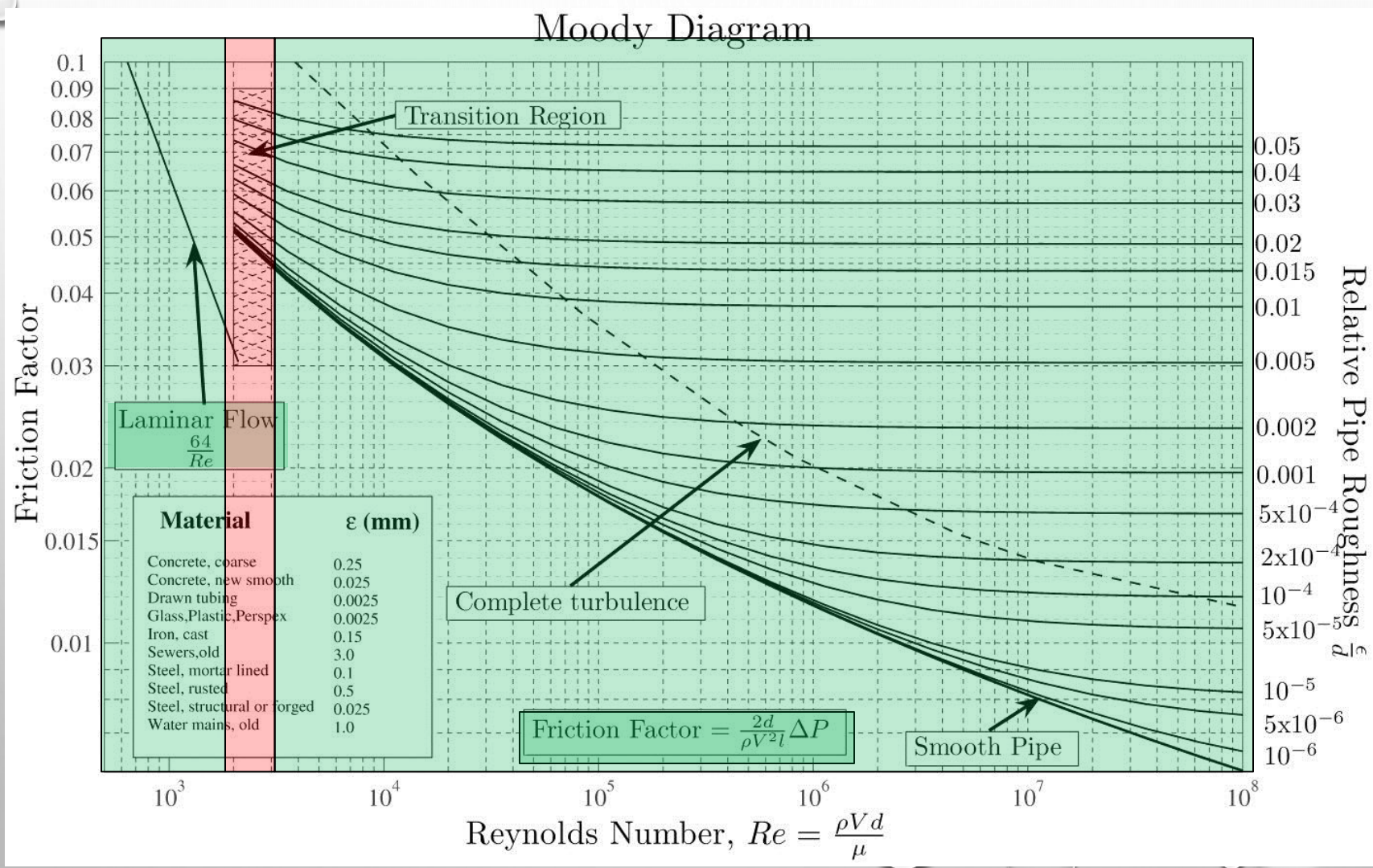
PLUNGE DROP



CASCADE (BAFFLE) DROP

CASCADE (BAFFLE) DROP

COMPARISON OF DROP STRUCTURES



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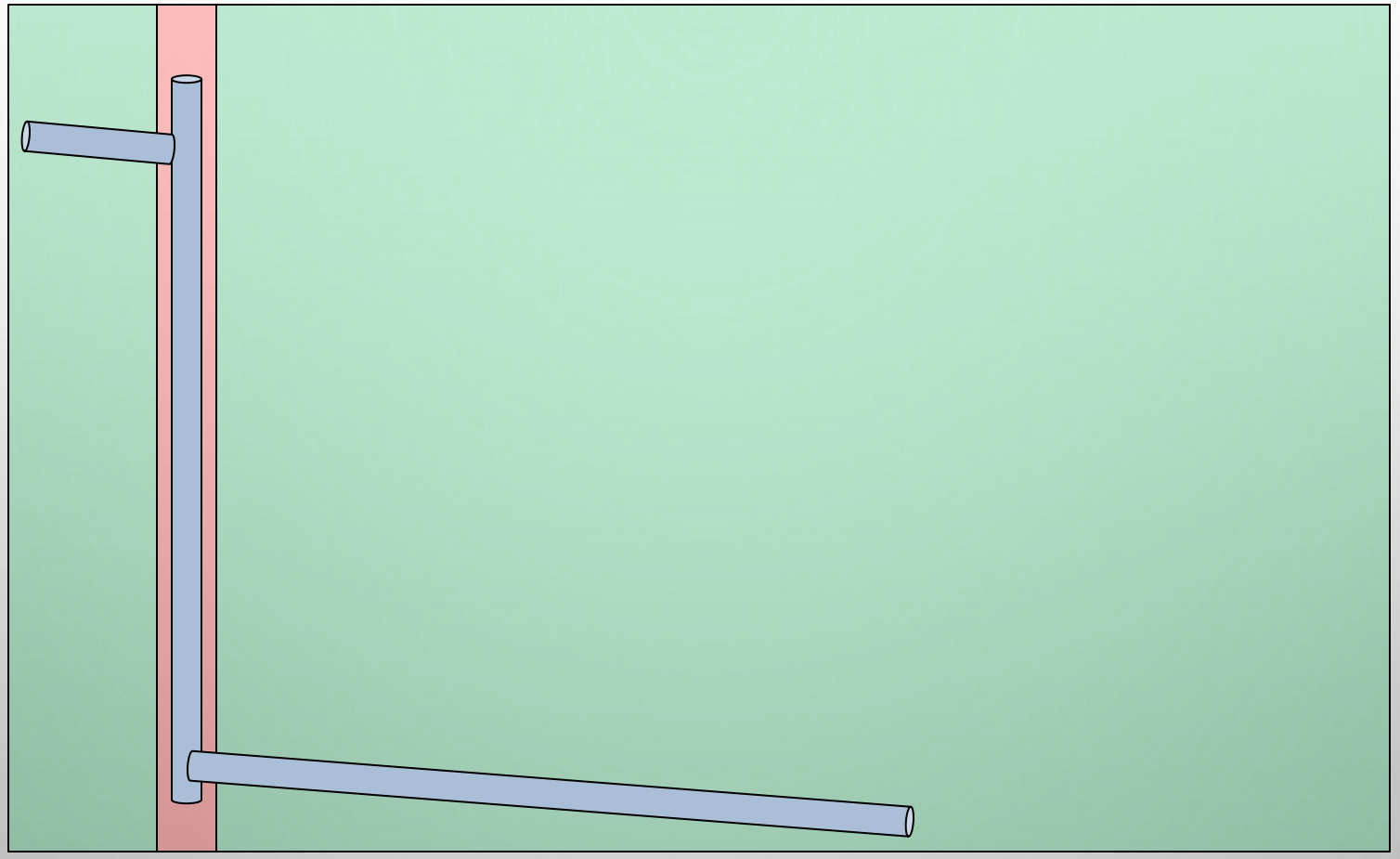

COMPARISON OF DROP STRUCTURES

CASE STUDY: LARGE REGIONAL SEWER DISTRICT IN THE USA

- SEVERAL HUNDRED KILOMETRES OF SEWERS, INCLUDING OVER 120 KILOMETRES OF SEWAGE TUNNELS

- 316 SEWAGE DROP STRUCTURES:
  - 32 VORTEX DROP STRUCTURES
  - 18 CASCADE (BAFFLE) DROP STRUCTURES
  - 266 OTHER TYPES OF DROP STRUCTURES (MOSTLY PLUNGE DROPS)

- ONLY FIVE ODOUR CONTROL FACILITIES ON DROP STRUCTURES:
  - FOUR ODOUR CONTROL FACILITIES ARE ON VORTEX DROPS
  - ONE ODOUR CONTROL FACILITY IS ON A PLUNGE DROP
  - NO ODOUR CONTROL FACILITIES ON CASCADE (BAFFLE) DROPS

COMPARISON OF DROP STRUCTURES

Feature	Vortex	Plunge	Helicoidal	Cascade
Total number of sewage installations	++	+++	-	+
Commonly used in sewage tunnels	+++	+	+	++
Hydraulically efficient	++	+++	++	+
Provides access for equipment/people	+	+	-	+++
Surge mitigation built-in	+	++	+	+++
Costs less to build	+	+++	+	++
Commonly built over top of tunnel	+	+++	???	++
Accommodates multiple inlet sewers	-	+	-	+++
Minimizes air entrainment	+++	-	+	+++
Minimizes odour	++	-	???	+++
Self-cleaning	++	-	+	+++
Minimizes need for flow conditioning	+	+++	-	+++
Suitable for a wide range of flows	+	+++	++	+++

QUESTIONS AND ANSWERS