BUILDING A WORLD OF DIFFERENCE

19 September 2019

Long distance pumping of wastewater along undulating pipelines

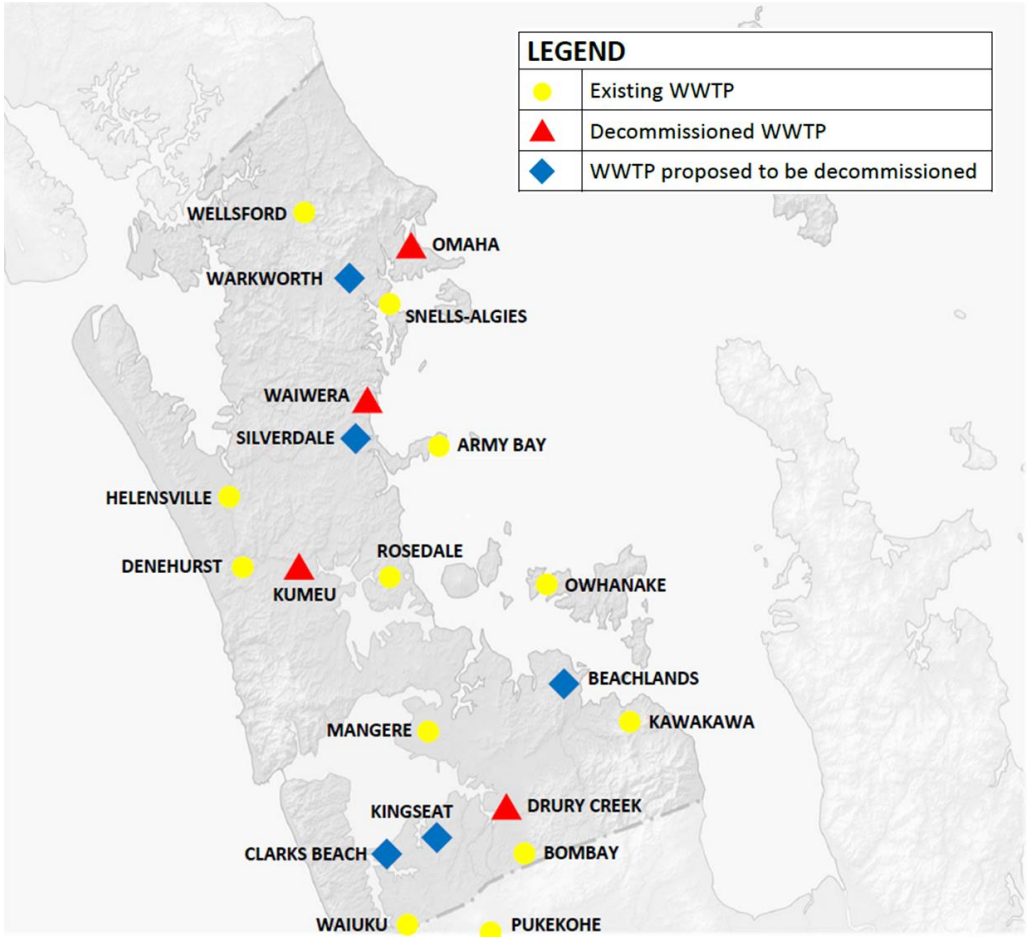
Tom Scott & Langford Sue

BUILDING A WORLD OF DIFFERENCE®

Beca

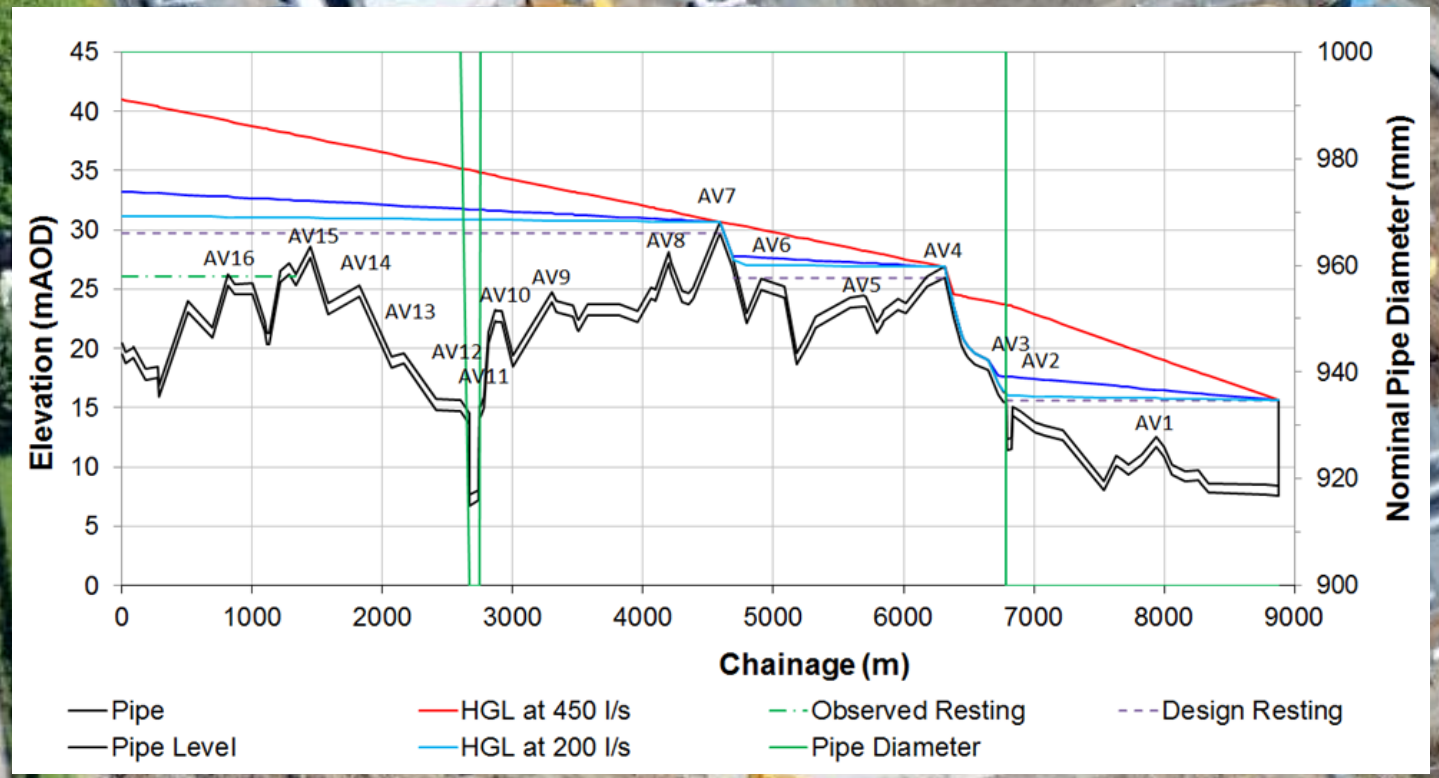
BLACK & VEATCH

Context

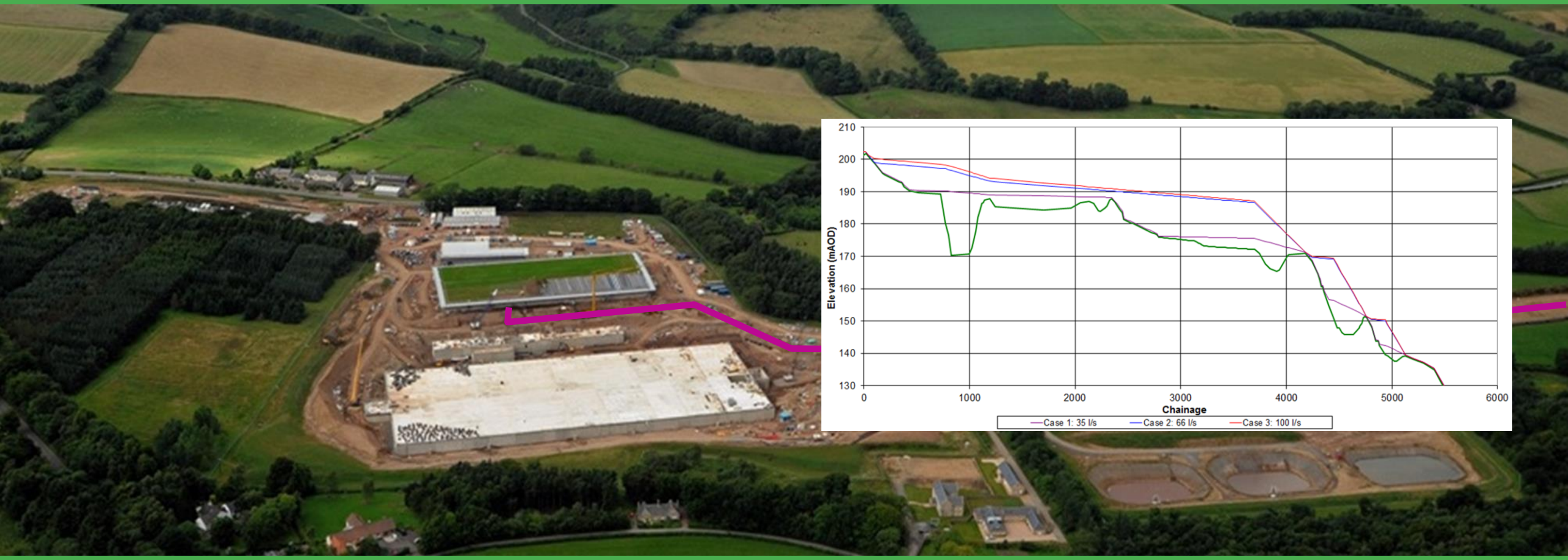


- Treatment plants are consolidating
- Smaller plants are being decommissioned
- Communities are expanding
- Pumping over long distances is becoming more common
- The terrain is undulating

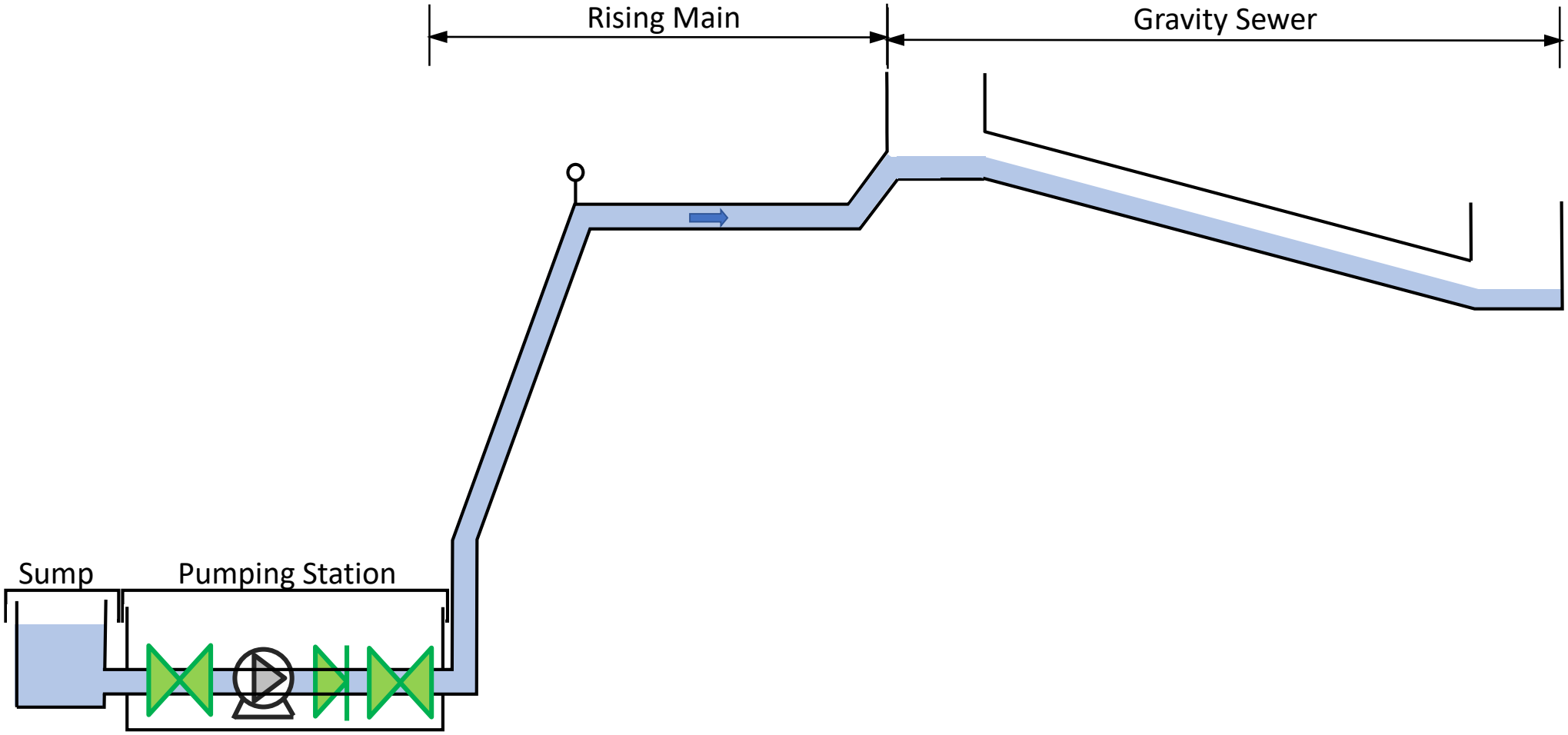
Meadowhead & Stevenston – Kilmarnock Pumping Station



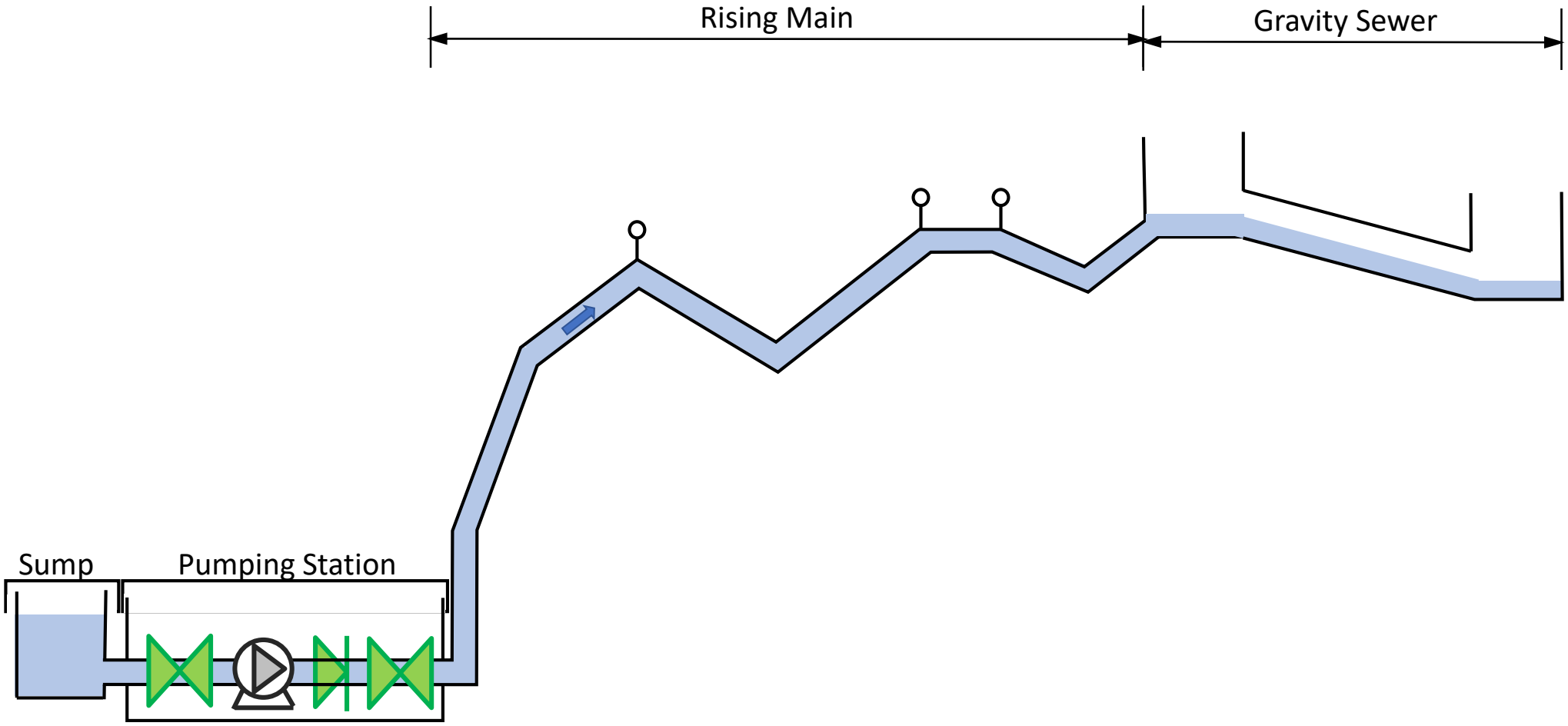
Glencorse WTW Sludge Main



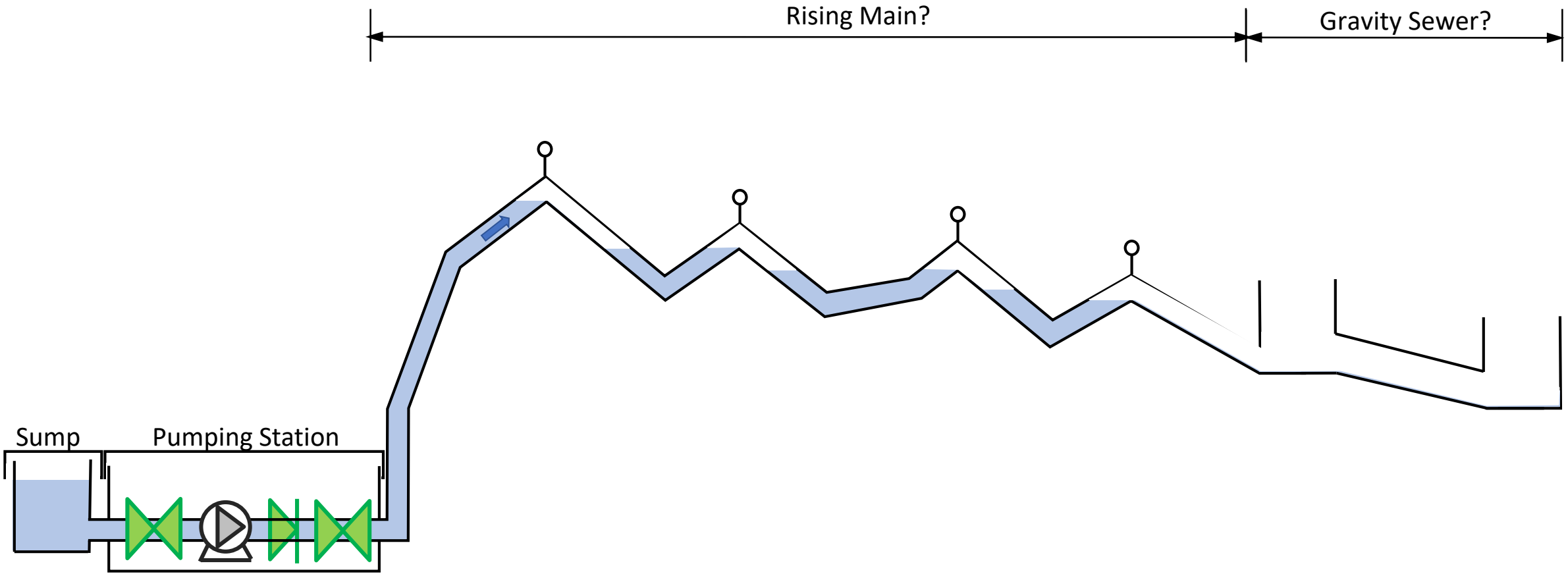
Rising main and gravity sewer



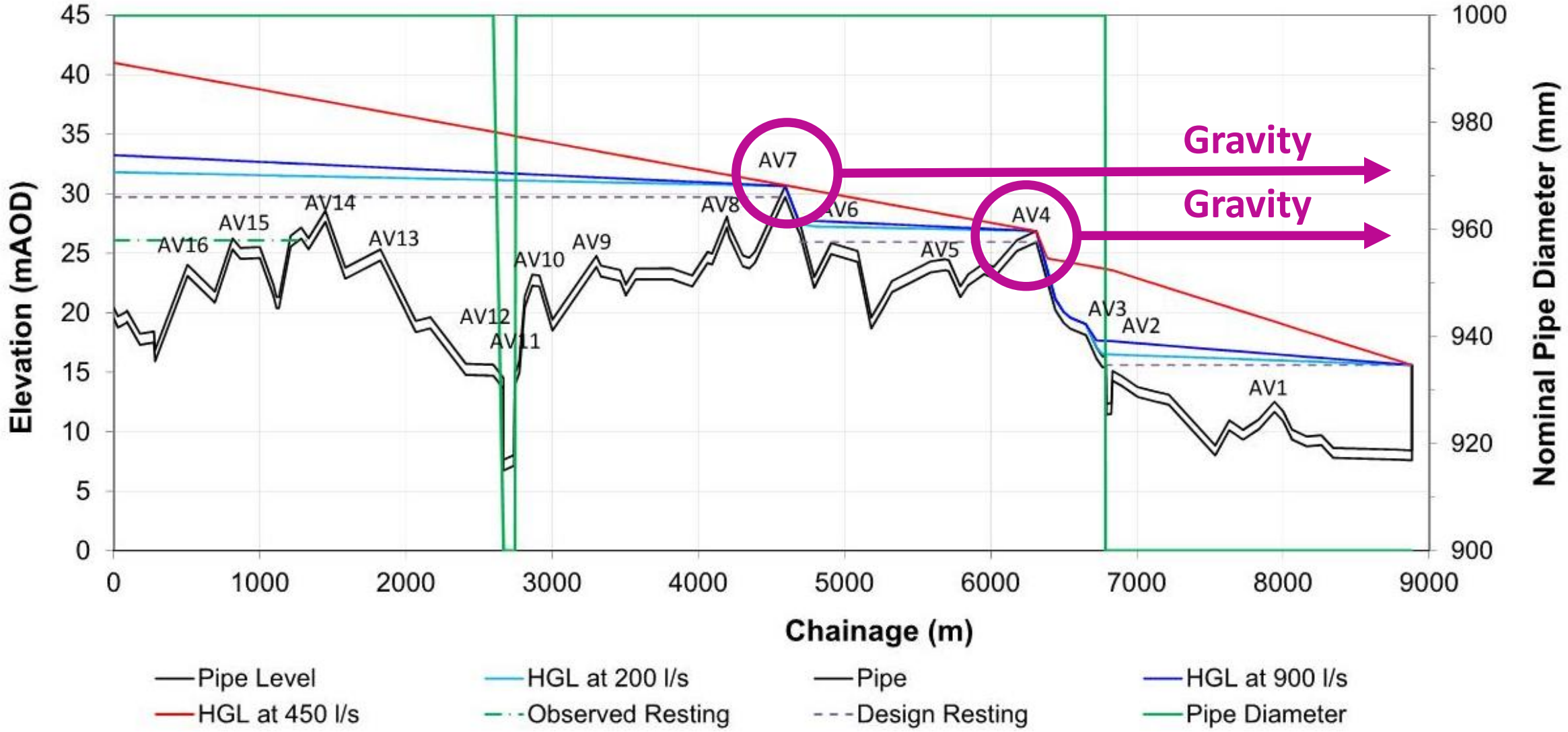
Rising main and gravity sewer



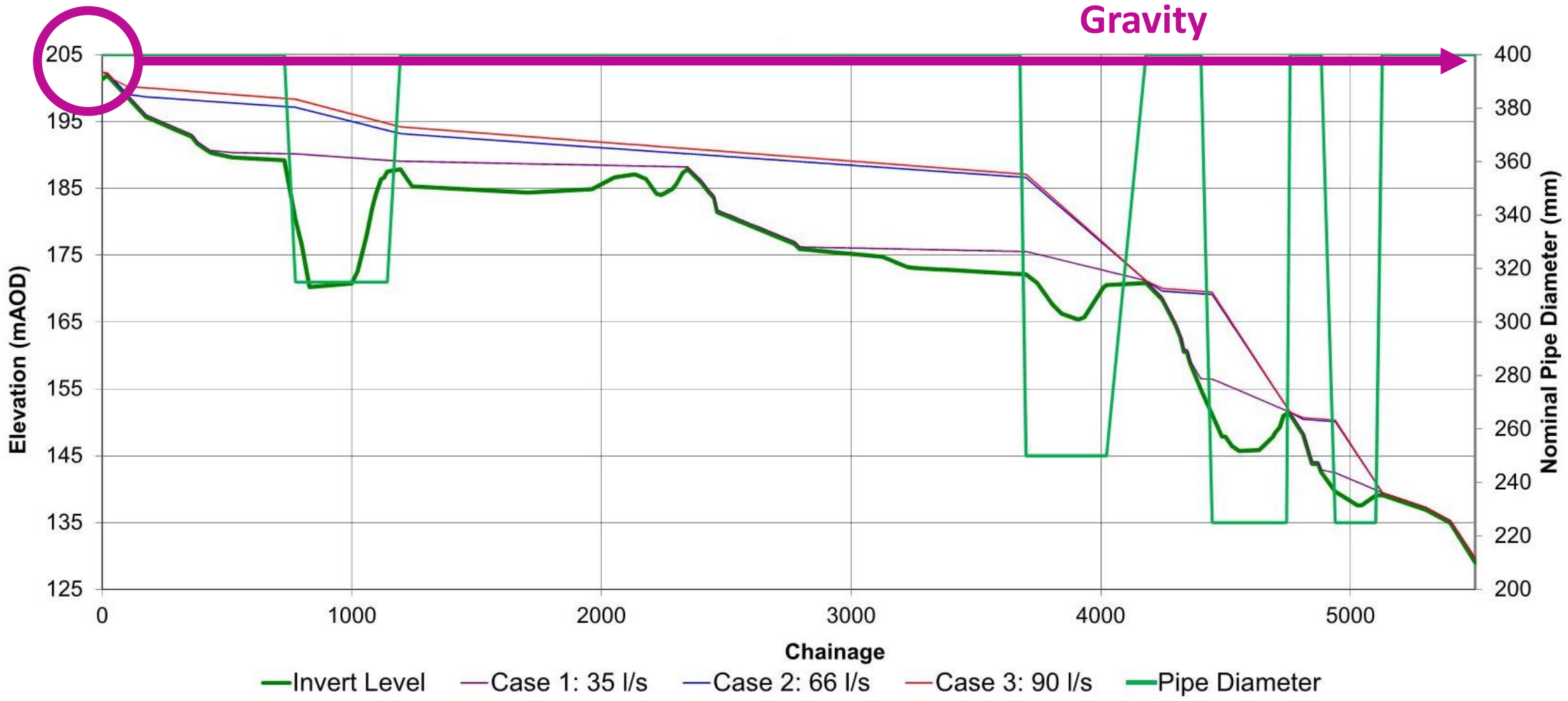
Rising main and gravity sewer?



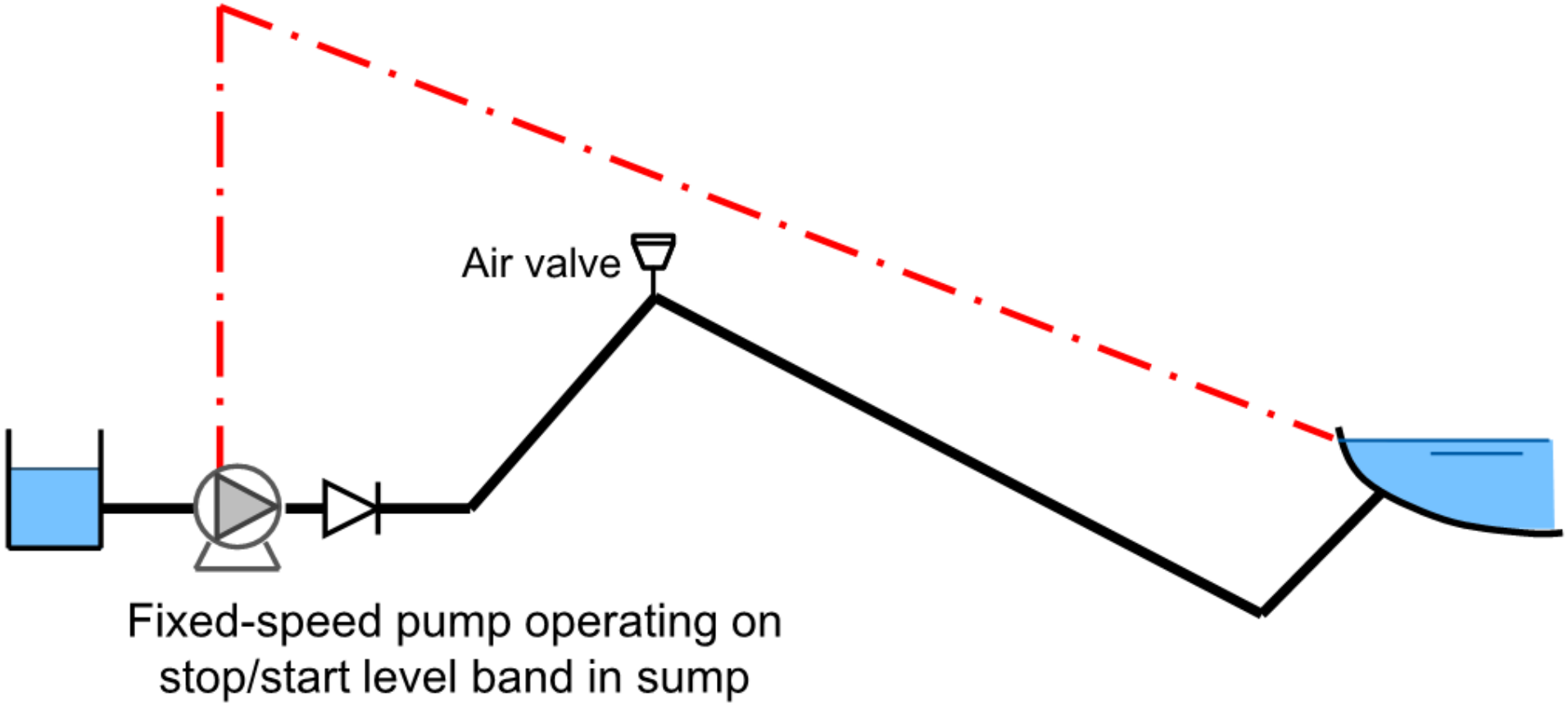
Meadowhead & Stevenston – Kilmarnock Pumping Station



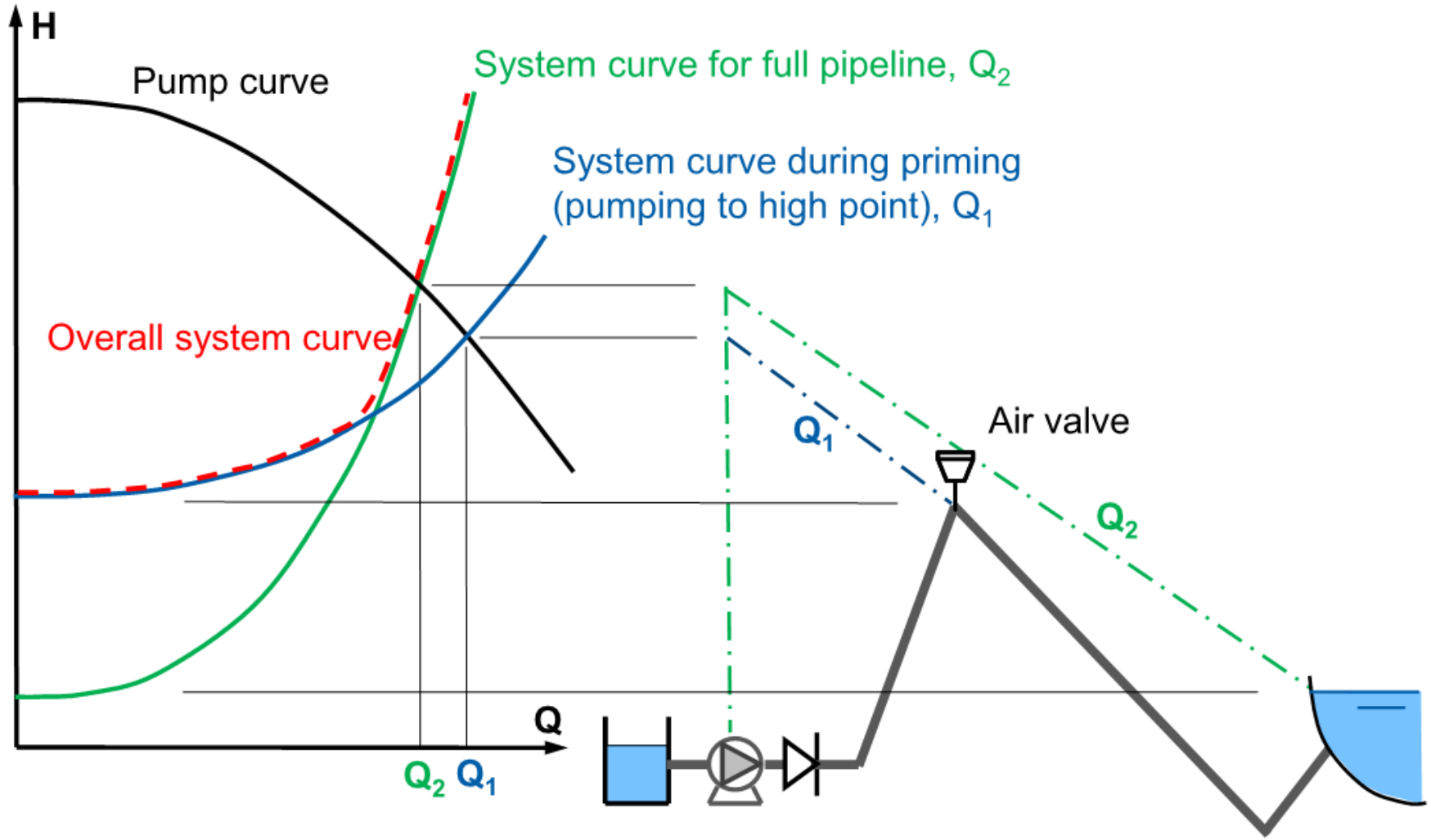
Glencorse WTW Sludge Main



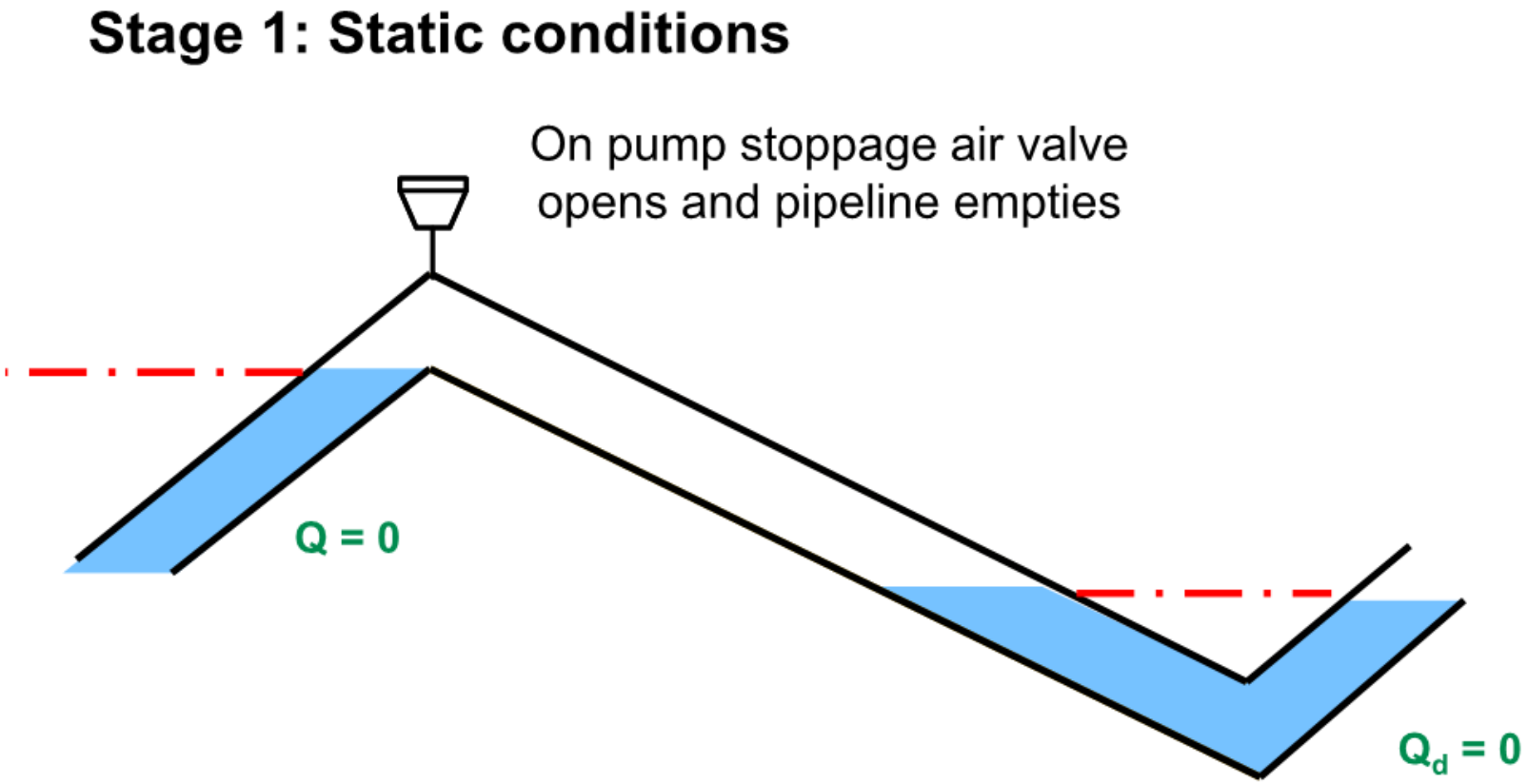
Undulating pipeline with highpoint



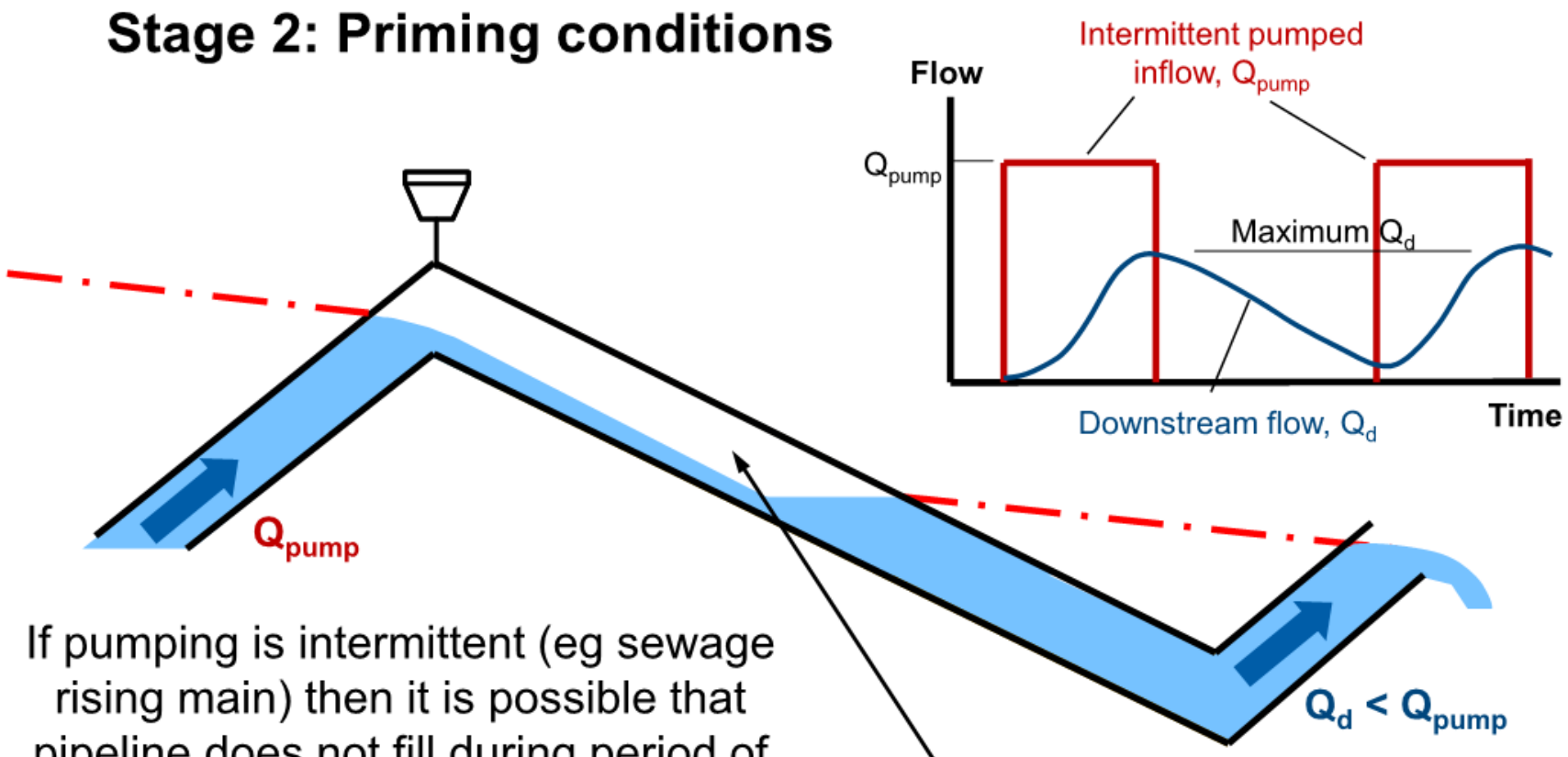
Undulating pipeline with highpoint



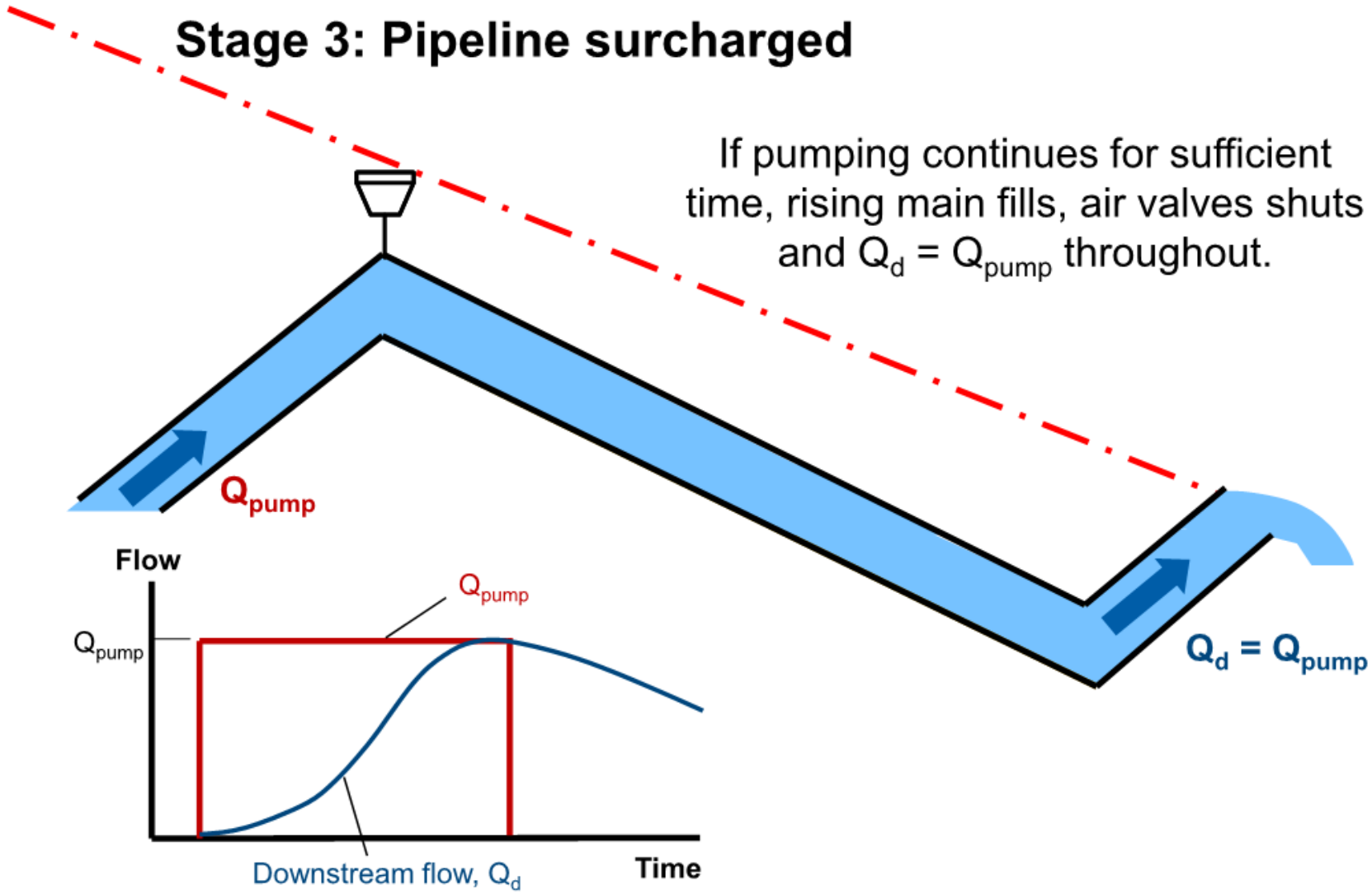
Undulating pipeline with highpoint



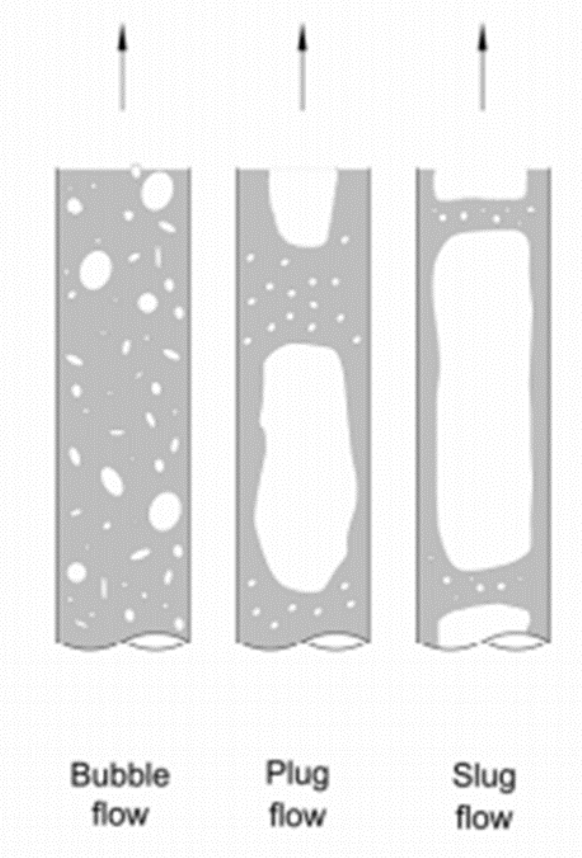
Undulating pipeline with highpoint



Undulating pipeline with highpoint



Air management



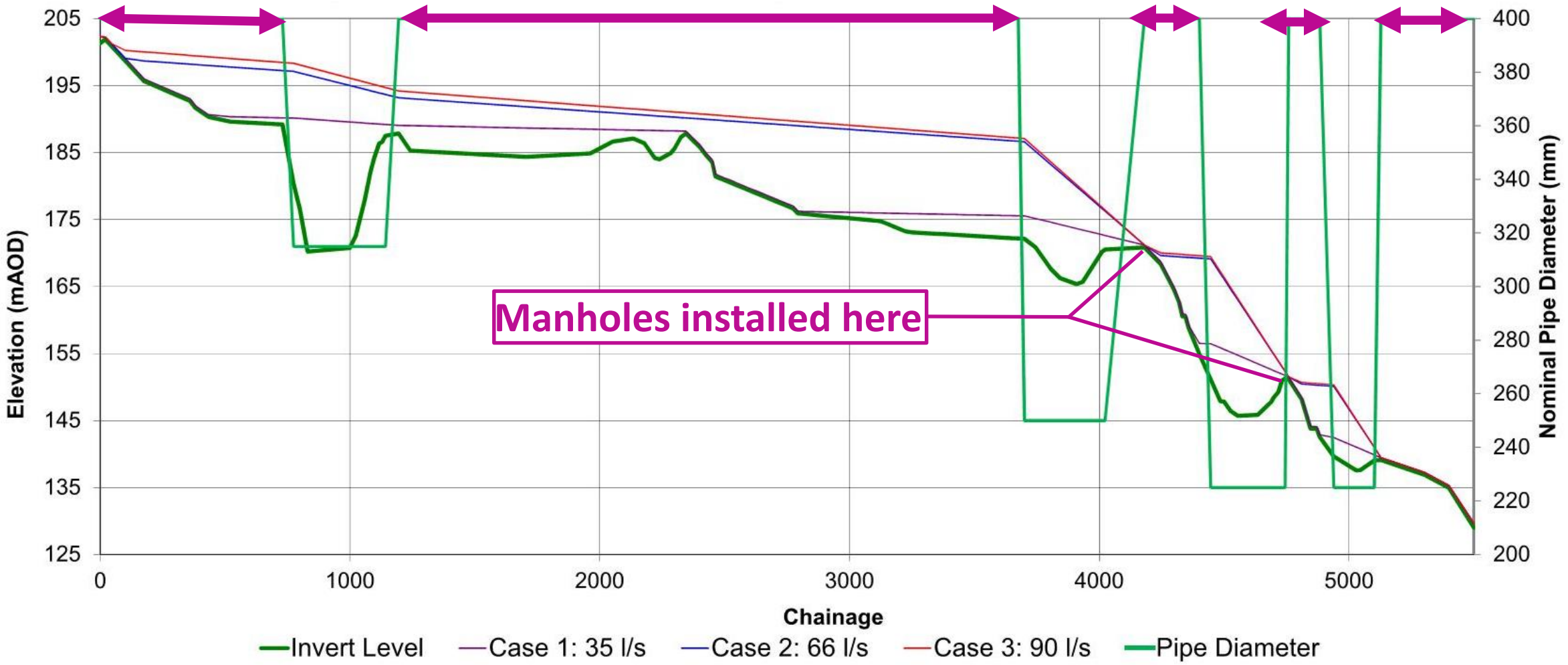
HR Wallingford. (2005). *Air problems in pipelines: A design manual.* Wallingford: HR Wallingford Ltd.

As air/water flow patterns differ depending on the pipe slope, distinctions are therefore usually made between flow patterns in vertical, sloping and horizontal pipeline flows.

Vertical flow patterns, which are generally more axisymmetric when compared with horizontal flows, can be described as follows (see Figure 4.1):

- *Bubble flow* – the air is distributed in the water as spherical or spherical cap bubbles which are small with respect to conduit diameter. This flow pattern occurs when a relatively small quantity of air is mixed with a moderate flow of water.
- *Plug flow* – occurs as the air flow increases. The transition from bubble flow to plug flow occurs when the bubble diameter is about one-half the conduit diameter.
- *Slug flow* – as the air flow increases further, a regular train of very large bubbles occurs. Each of these slug bubbles occupies almost the whole pipe cross section except for a thin liquid layer on the wall and their length is several times the pipe diameter.

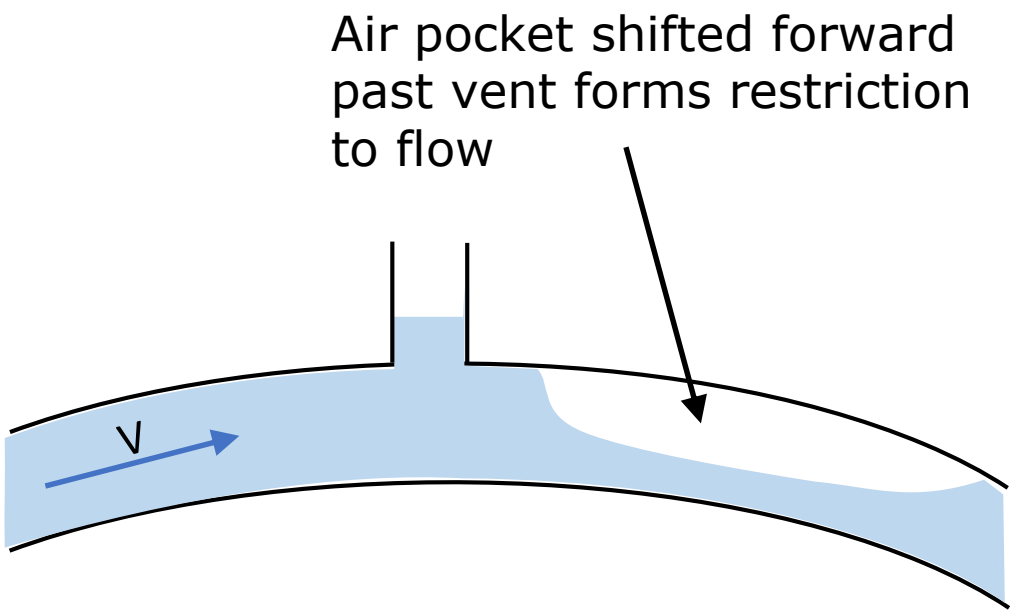
Glencorse WTW Sludge Main



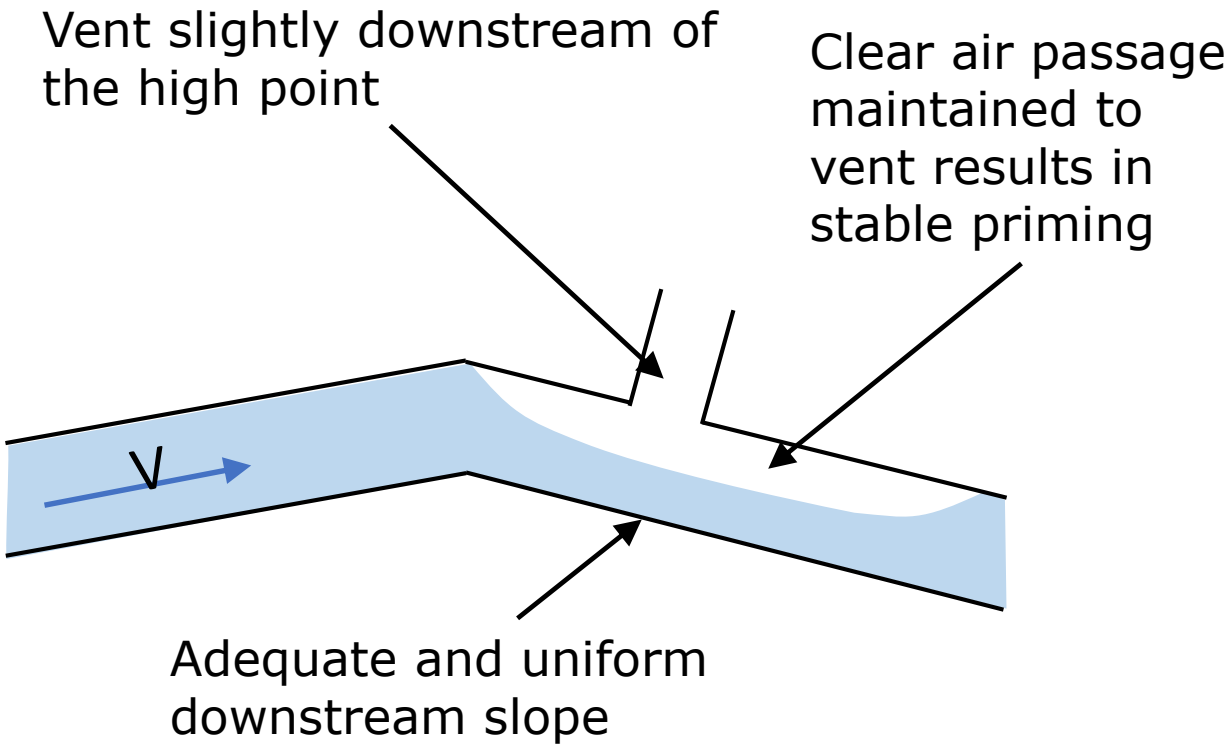
Diameter in gravity sections allows for part full flow and manage air more effectively

Air management

Convex Profile

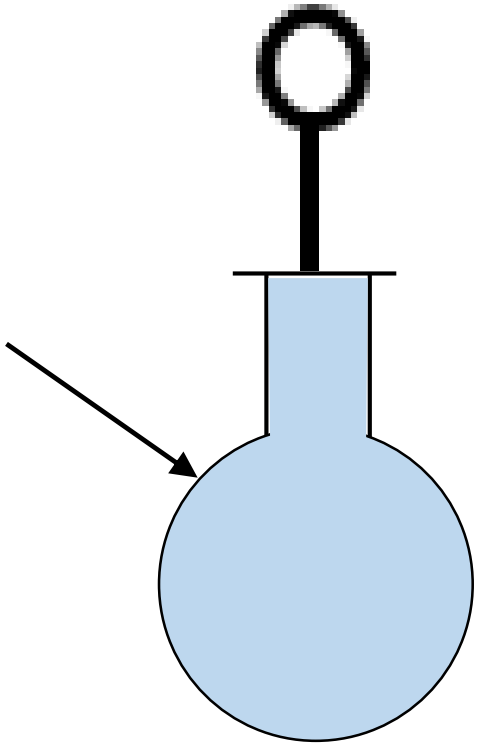


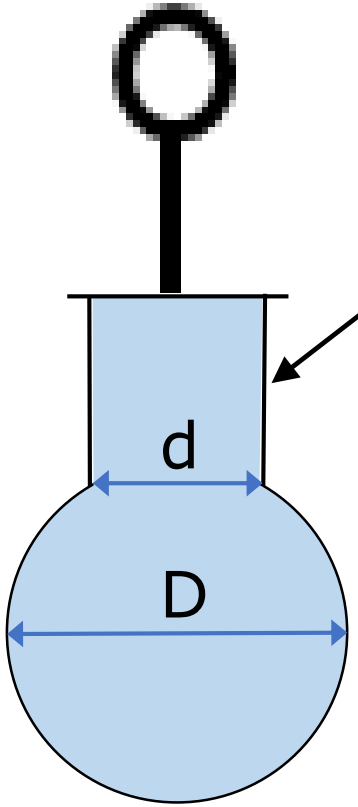
Angular Profile



Air management

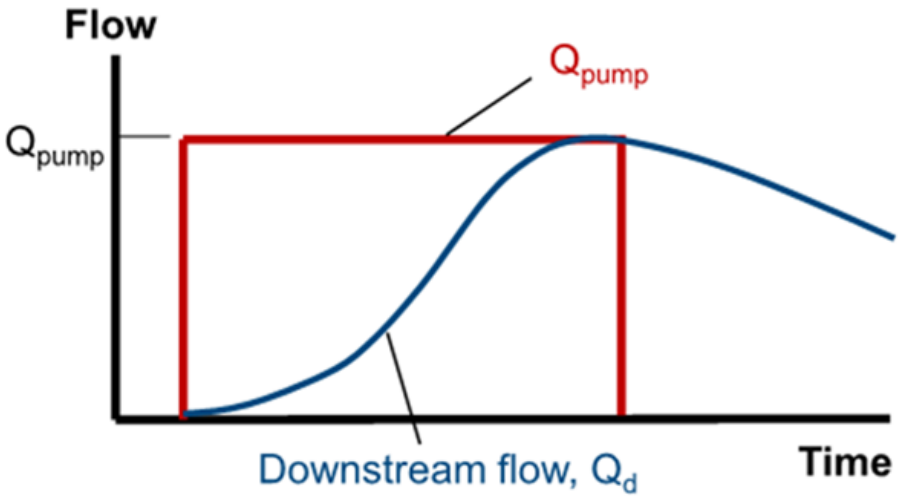
Tee too small – inefficient capturing of air





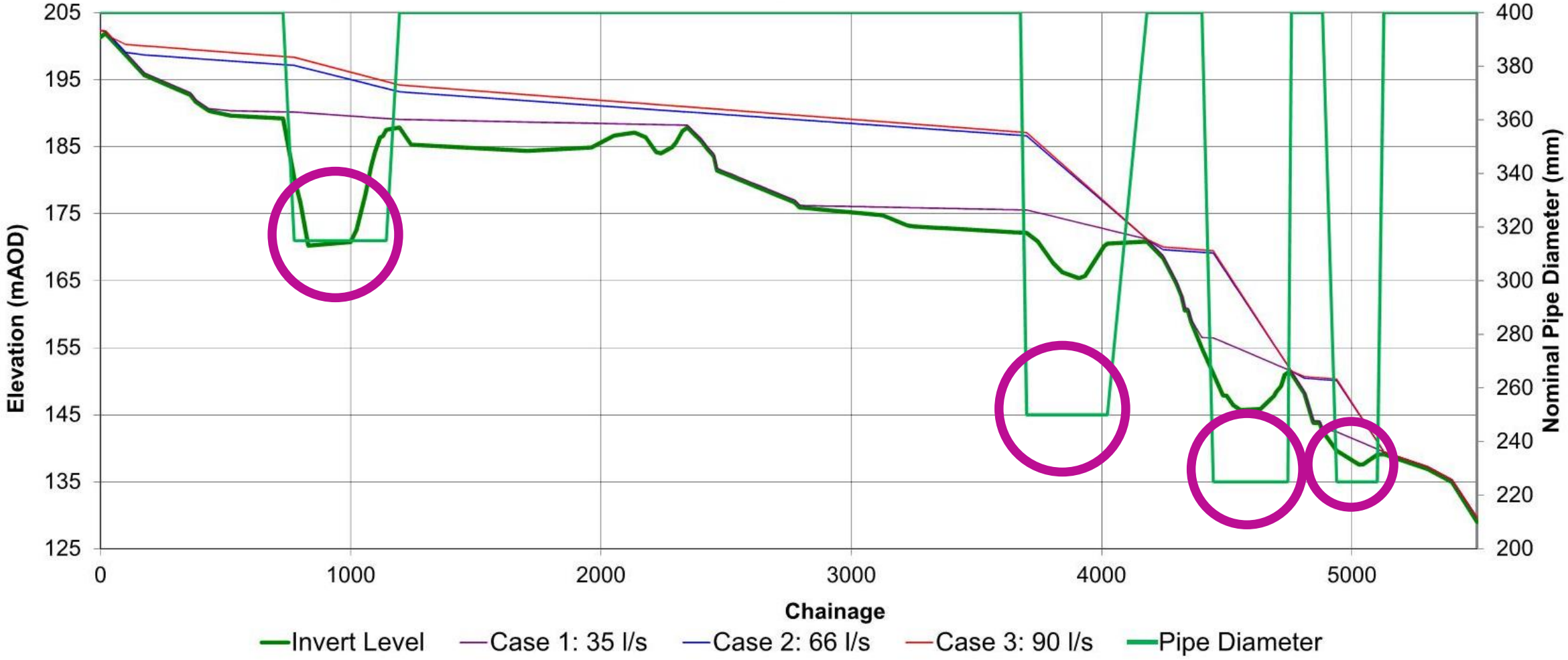
Larger Tee - d > 0.5D promotes efficient capturing of air

Low velocity and sediment



- If maximum flow in inverted siphon section less than pumped flow then velocities also lower.
- If drainage or sewage pumping system, then there may be problems with meeting criteria on self-cleansing velocities.
- If so potential problems of siltation and eventual blockage of pipe.

Glencorse WTW Sludge Main



Self cleansing velocity – sediment transport

			Case	1				2				3			
D/s head	129.66	mAOD	Q (l/s) =	35				66				90			
ks	3	mm	ks (mm) =	3				3				0.6			
kin viscosity	1.14E-06	m/s2	Kin Visc	1.14E-06				1.14E-06				1.14E-06			
Sludge factor	1.1		Sludge fac	1.1				1.1				1			

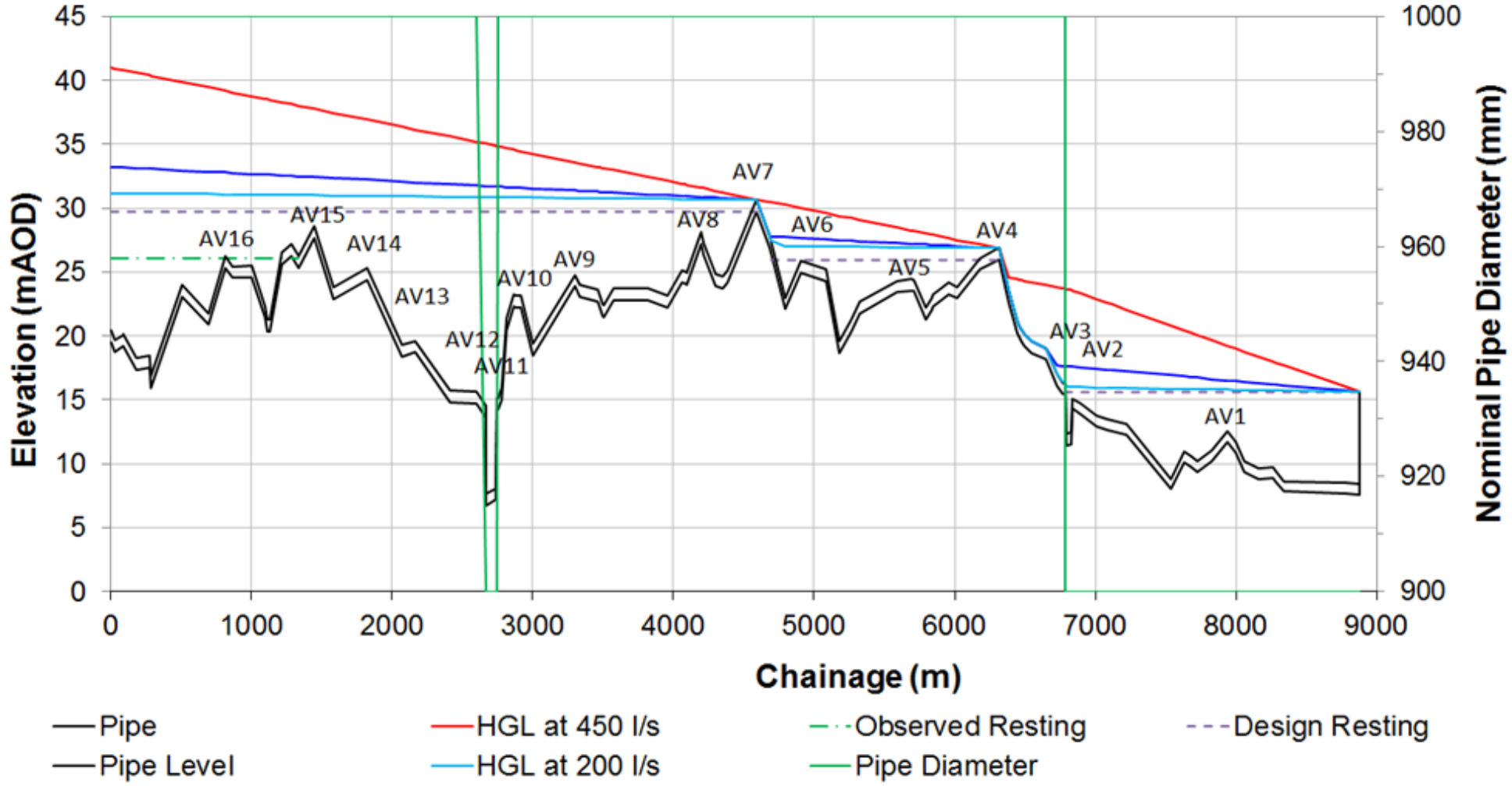
Pipe options

OD (mm)	SDR	ID (mm)	ID (m)	2/3 depth (m)	Vel (full) (m/s)	max s, v= 0.75	s (2/3 dia) (1:…)	V (2/3 dia) (m/s)	Vel (full) (m/s)	max s, v= 0.75	s (2/3 dia) (1:…)	V (2/3 dia) (m/s)	Vel (full) (m/s)	max s, v= 0.75	s (2/3 dia) (1:…)	V (2/3 dia) (m/s)
400	17	352.9	0.3529	0.2353	0.358	297	821	0.505	0.675	398	233	0.953	0.920	353	212	1.299
355	21	321.2	0.3212	0.2141	0.432	296	499	0.610	0.815	231	142	1.150	1.111	216	130	1.568
355	17	313.2	0.3132	0.2088	0.454	295	437	0.641	0.856	202	124	1.209	1.168	190	114	1.649
315	17	277.9	0.2779	0.1853	0.577	283	232	0.815	1.088	107	66	1.536	1.483	102	61	2.095
280	17	247.1	0.2471	0.1647	0.730	234	124	1.031	1.377	57	35	1.944	1.877	55	33	2.651
250	17	220.6	0.2206	0.1471	0.916	110	68	1.293	1.727	31	19	2.439	2.355	30	18	3.325
225	17	198.5	0.1985	0.1324	1.131	63	39	1.596	2.132	18	11	3.011	2.907	17	11	4.105

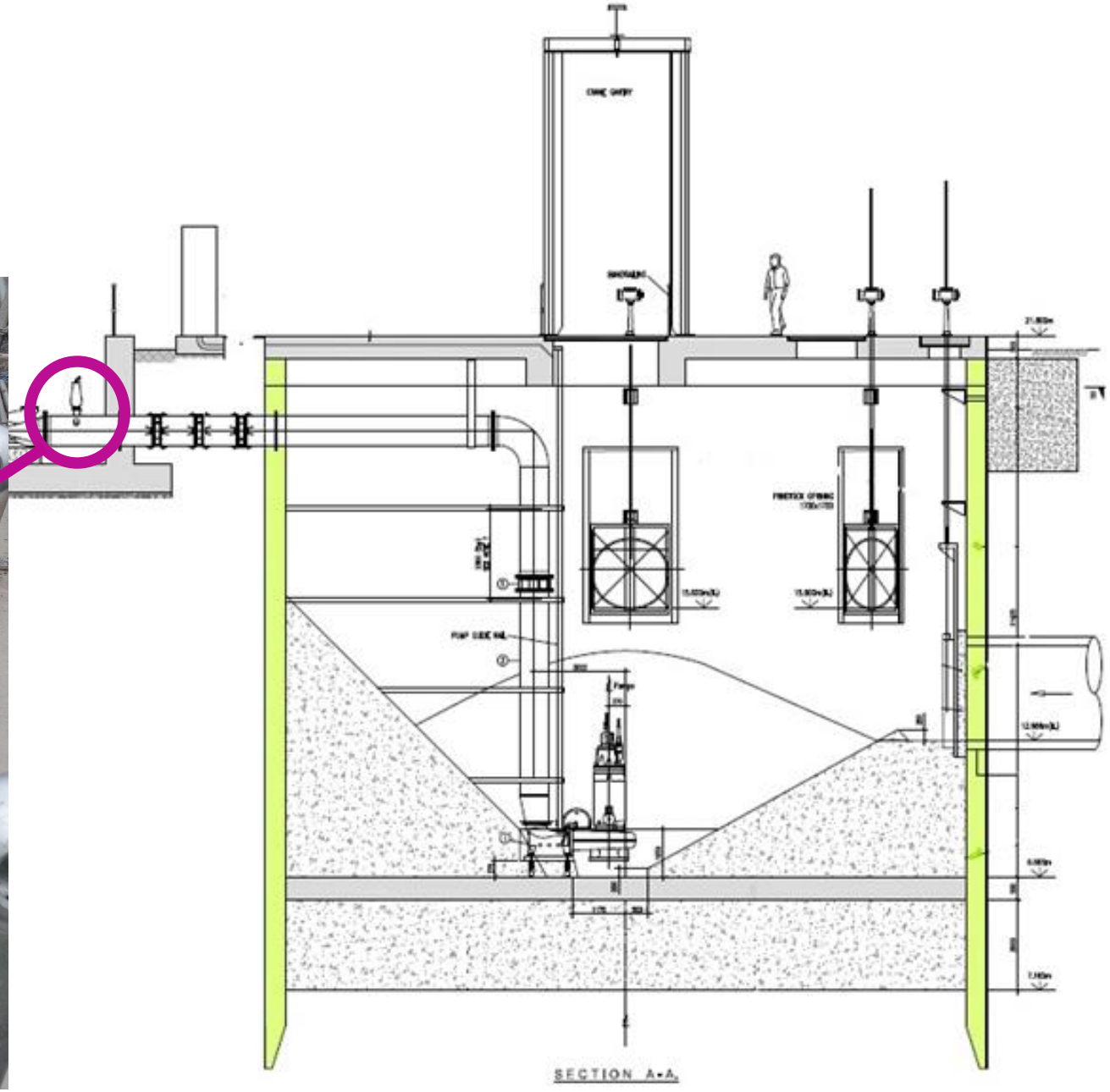
Unstable flow conditions

- Inlet capacity is variable, eg due to gulping, upstream level too near soffit
- … exacerbated by flow plunging onto inlet
- Insufficient size of pump discharge chambers, after pump stoppage, water level oscillates, maximum level can be higher than steady state level
- Priming instabilities

Meadowhead & Stevenston



Meadowhead & Stevenston



BUILDING A WORLD OF DIFFERENCE

19 September 2019

Tom Scott

+64 27 277 9160
ScottT@bv.com

Langford Sue

+61 3 9272 1563
Langford.Sue@beca.com

BUILDING A WORLD OF DIFFERENCE®

Beca

BLACK & VEATCH