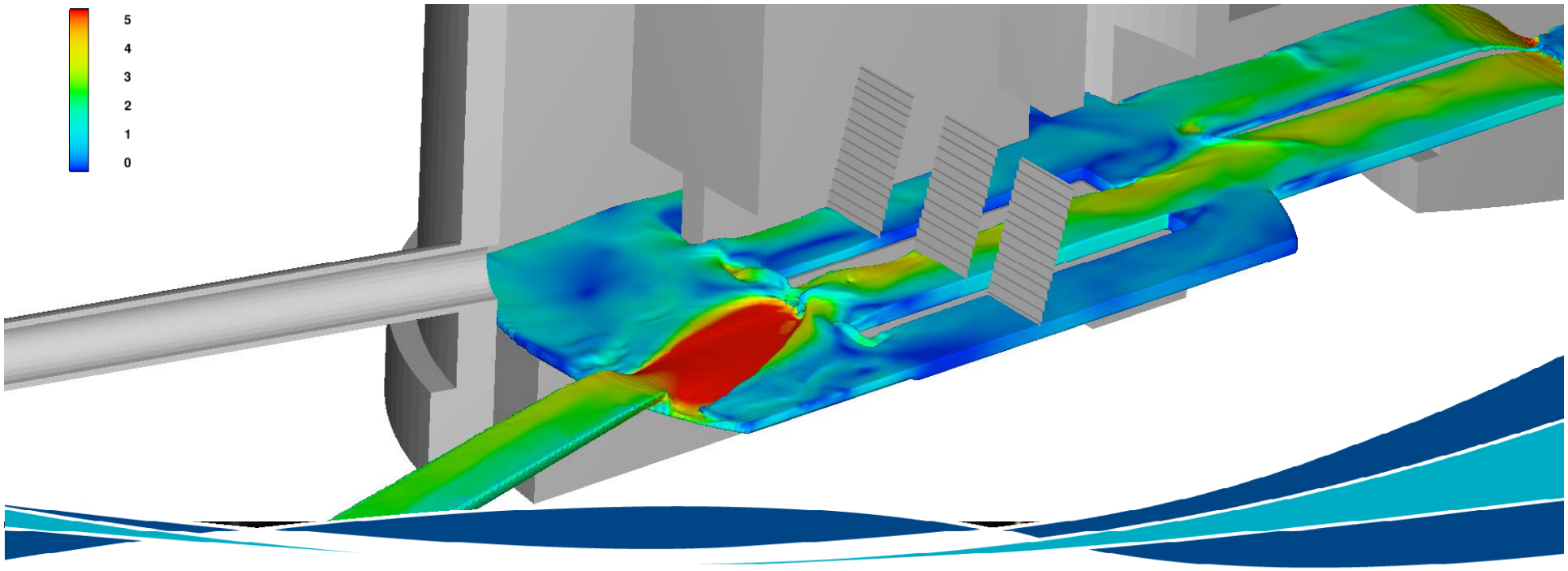

Balancing the flow – Optimisation of the Malad IPS Screen Chamber using CFD

John Chesterton and Sarah Jones

Mott MacDonald

Mumbai Sewage Disposal Project: Stage II Priority Works

Rapid expansion of Mumbai

- 7 million people out of 16 million not connected to mains sewerage
- Raw effluent flows into Mumbai's numerous creeks
- Sewage collected only partially treated before discharge
- During monsoon downpours capacity is overwhelmed
- Creeks and coastal waters highly polluted - little or no marine life

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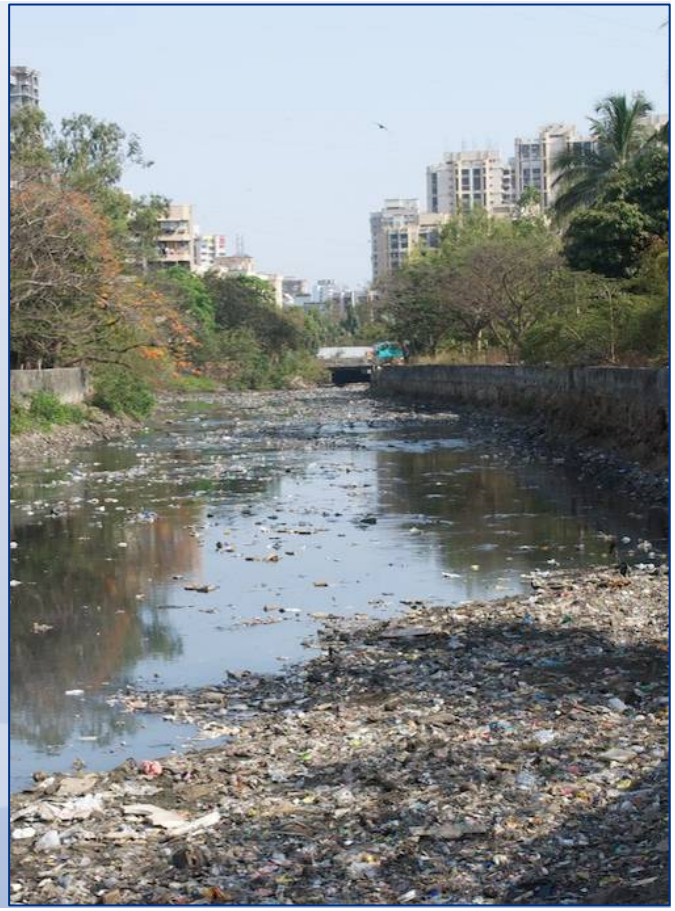
Mumbai Master Plan Objectives

Overall project objective

- Provide 100% collection of wastewater
- Provide a healthier and improved environment for people of Mumbai
- Improve the quality & reliability of wastewater collection, treatment & disposal to minimise the impact on the environment

Stage II Priority Works

- HK$8 billion capital project
- Capacity - 2025 predicted flows:
- Dry weather 3.3 Mm^3/d, Monsoon 6.6 Mm^3/d
- 2.8-fold increase over flows currently treated



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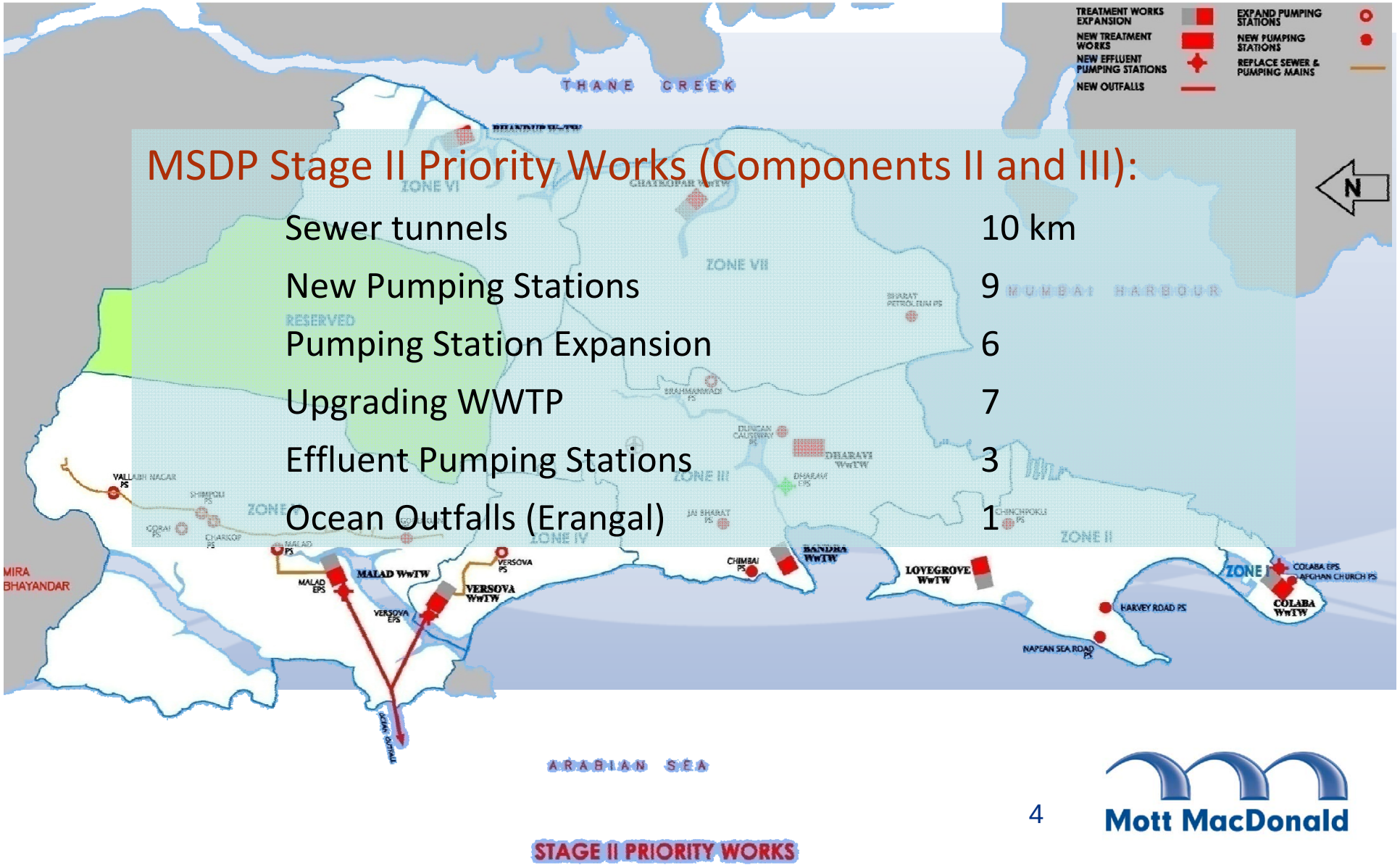
MSDP Priority Works



MSDP Stage II Priority Works (Components II and III):

Sewer tunnels	10 km
New Pumping Stations	9
Pumping Station Expansion	6
Upgrading WWTP	7
Effluent Pumping Stations	3
Ocean Outfalls (Erangal)	1

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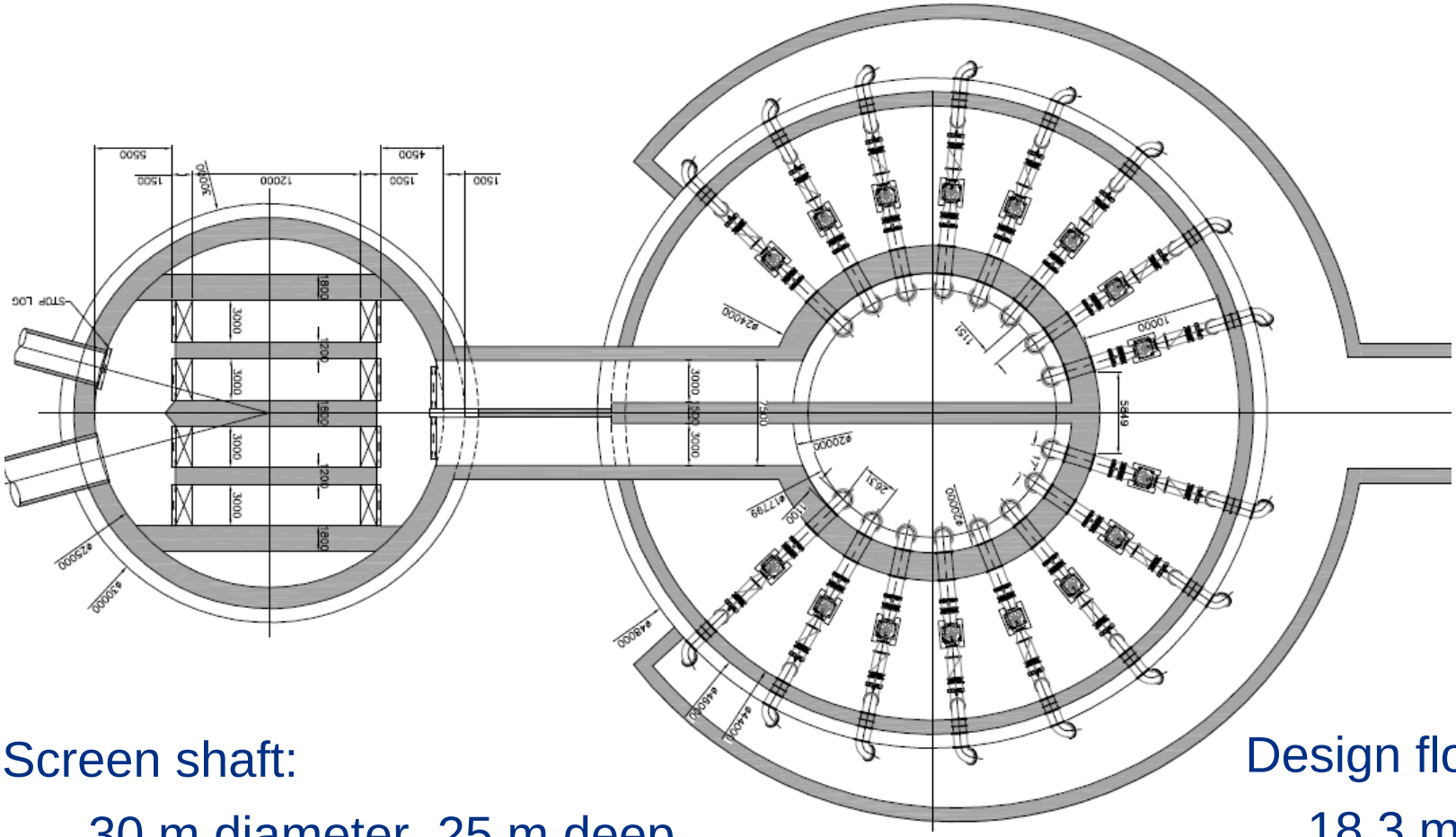
Malad Influent Pumping Station Layout



Screen shaft:

30 m diameter, 25 m deep

Design flow:

18.3 m^3/s

Incoming sewers:

3.2 m and 2.2 m diameter

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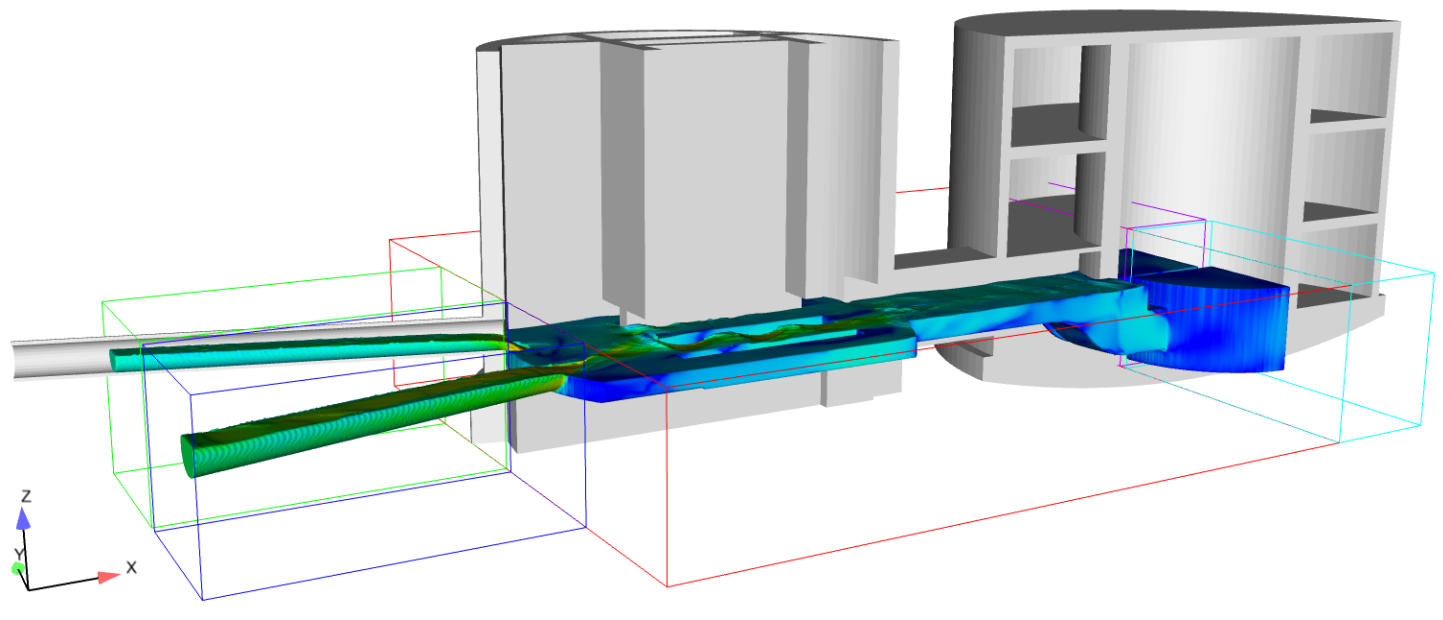
Objectives of CFD Modelling

- To confirm that the screen chamber shaft diameter was adequate
- To confirm whether the acceptance criteria could be met with baffling or whether incoming tunnel realignment required
  - Flow per screen to be within ± 33% of mean flow
  - Mean velocity across screen < 1.2 m/s
- To give confidence to the designers that the final design was feasible
- Minimise risk to cost and program due to unforeseen issues

Screen Chamber Model



- CFD solver FLOW-3D (transient, VOF, RNG k-ε)
- Mesh structured grid, mesh size 100 mm
- Bar screens inclined 2D baffles with head loss from Kirschmer's formula

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Modelled Cases

Flow case	3.2m Tunnel (m^3/s)	2.2m Tunnel (m^3/s)	Wet well level (m)
Pass Forward Flow (PFF)	13.7	4.6	9.82
Peak Dry Weather Flow (PDWF)	8.7	2.9	9.22
Average Dry Weather Flow (ADWF)	6.7	2.3	8.62
Pass Forward Flow (PFF)	13.7	-	9.52
Peak Dry Weather Flow (PDWF)	8.7	-	9.19
Average Dry Weather Flow (ADWF)	6.7	-	8.32

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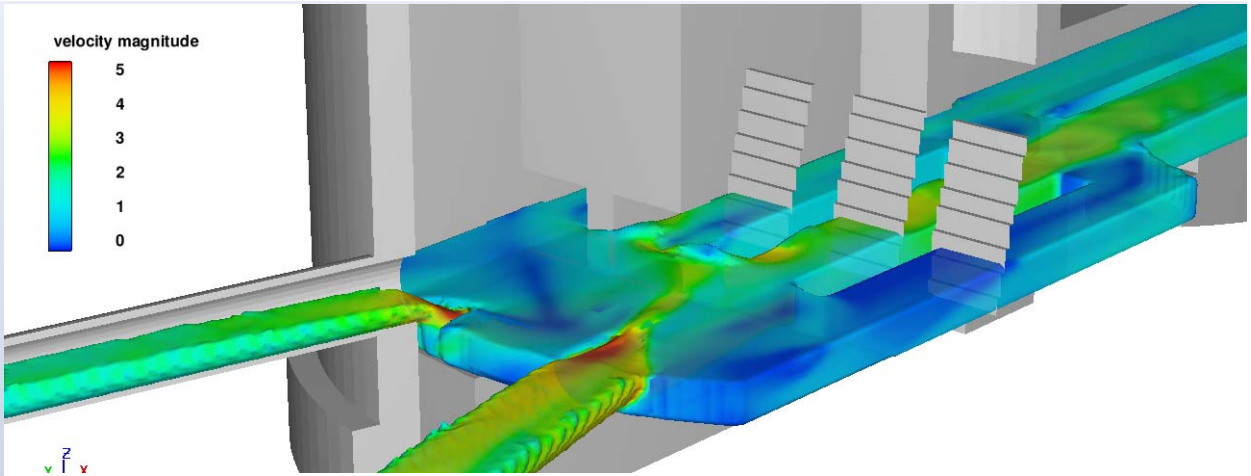
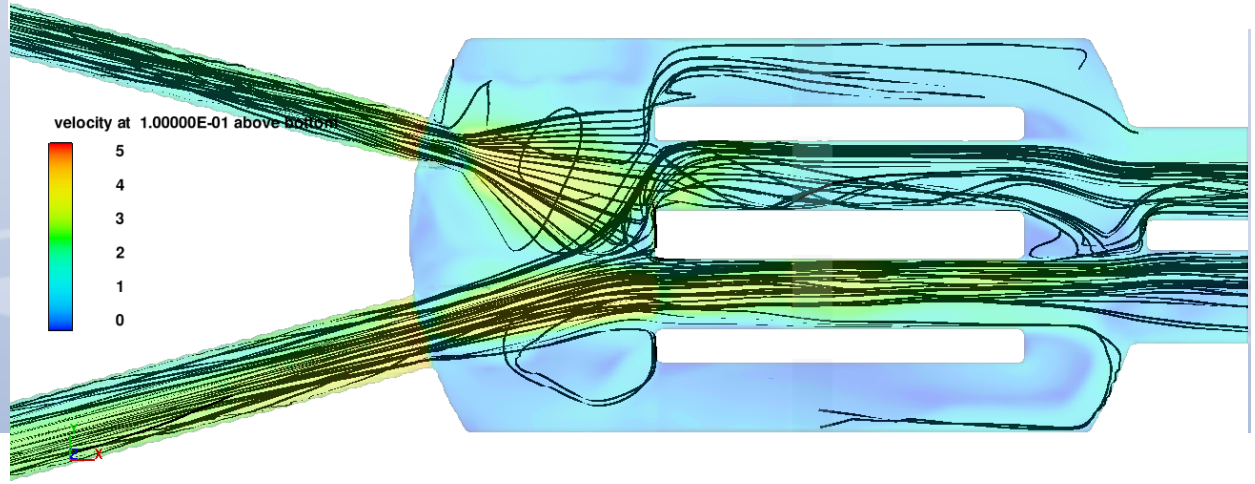
Initial Layout Results – No Baffles

Flow biased to centre channels

- Failed acceptance criteria
- Flows through screens > ±130% of mean
- Maximum mean velocity through screens 2.4 m/s





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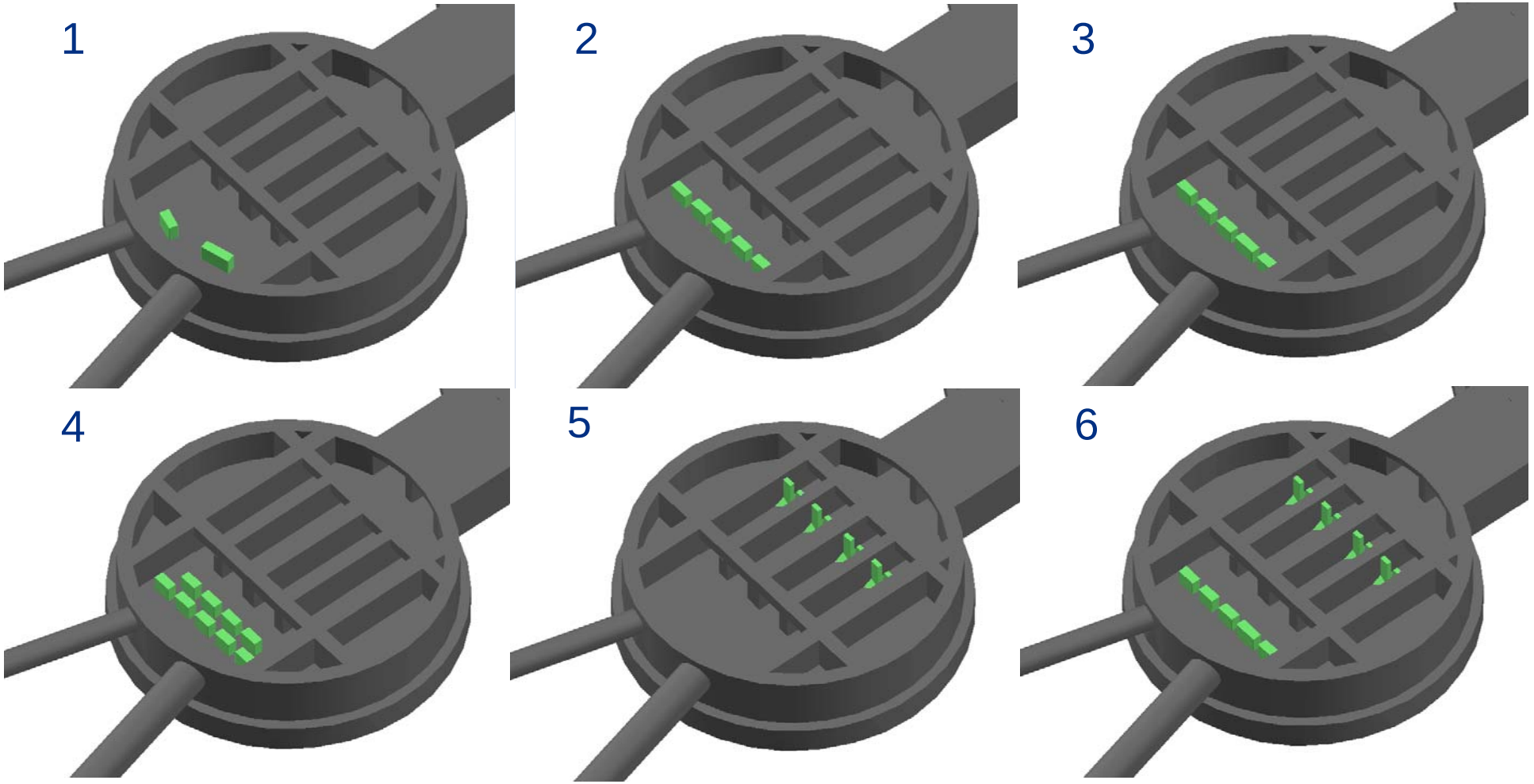
Baffle Arrangements Tested



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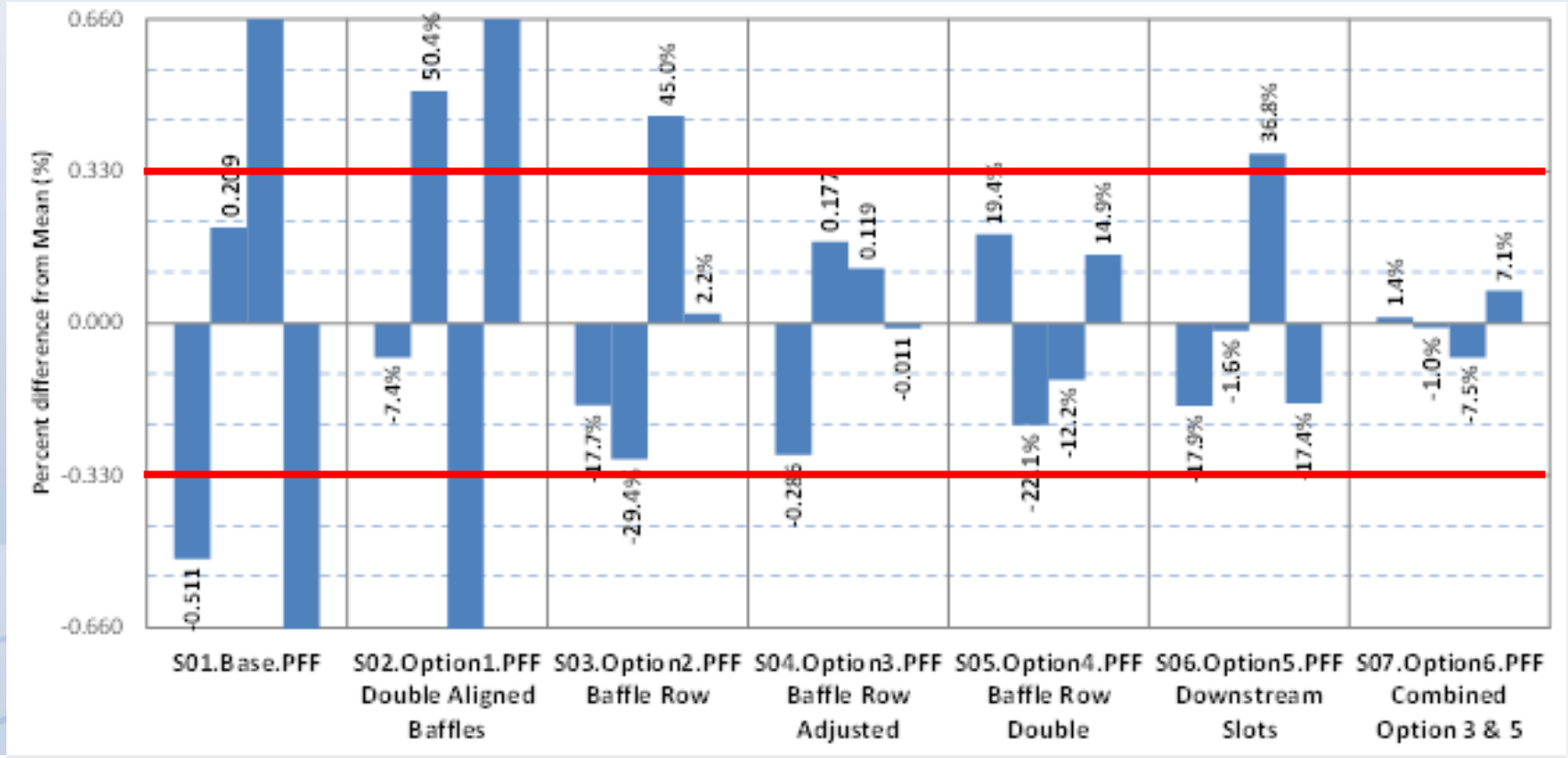
Comparison of Results at PFF

Flow criterion (% difference from mean) through the 4 screens



Pass/Fail ✗ ✗ ✗ ✓ ✓ ✗ ✓

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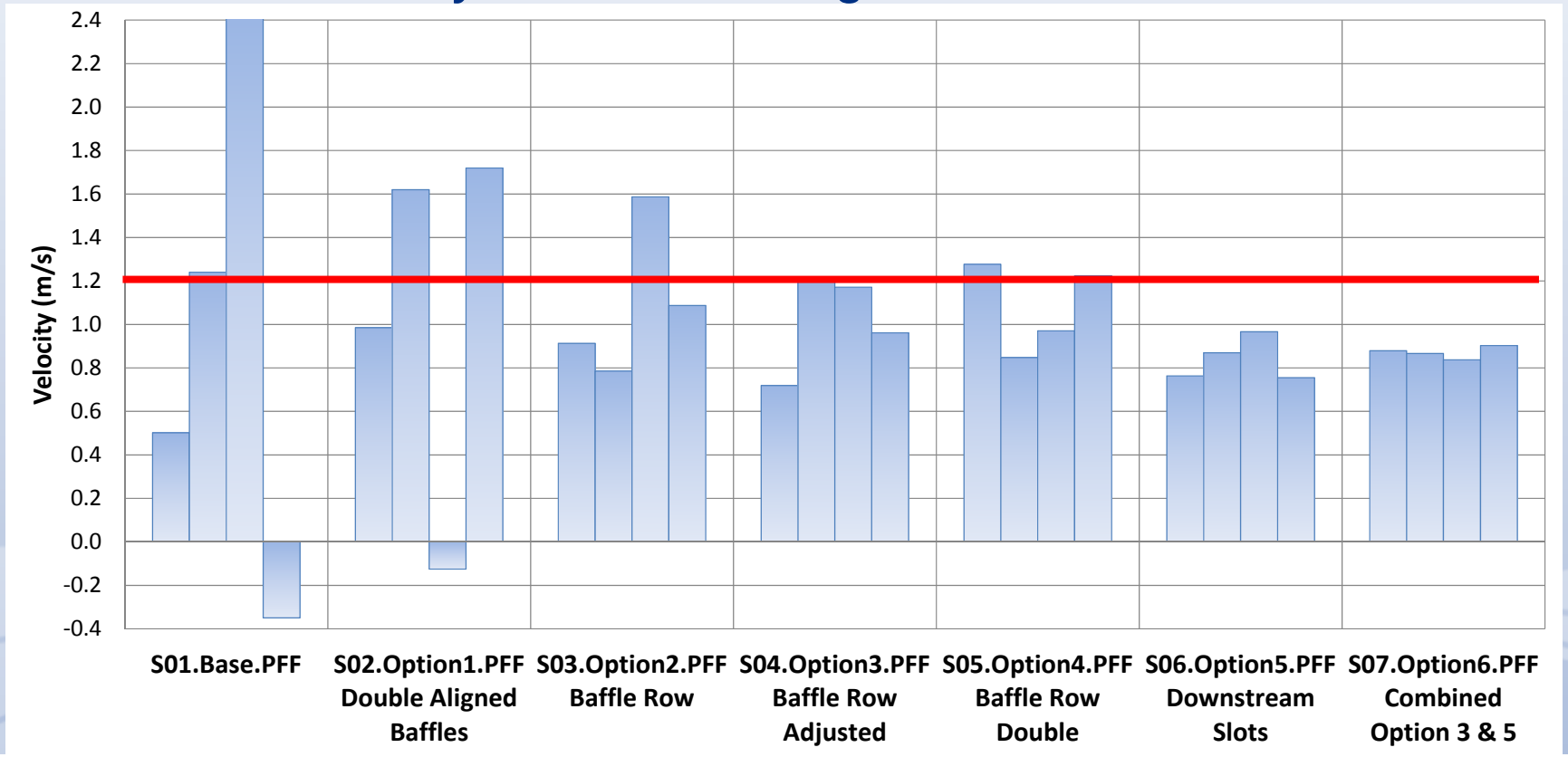
Comparison of Results at PFF

Velocity criterion through the 4 screens



Pass/Fail	✗	✗	✗	✓	✗	✓	✓

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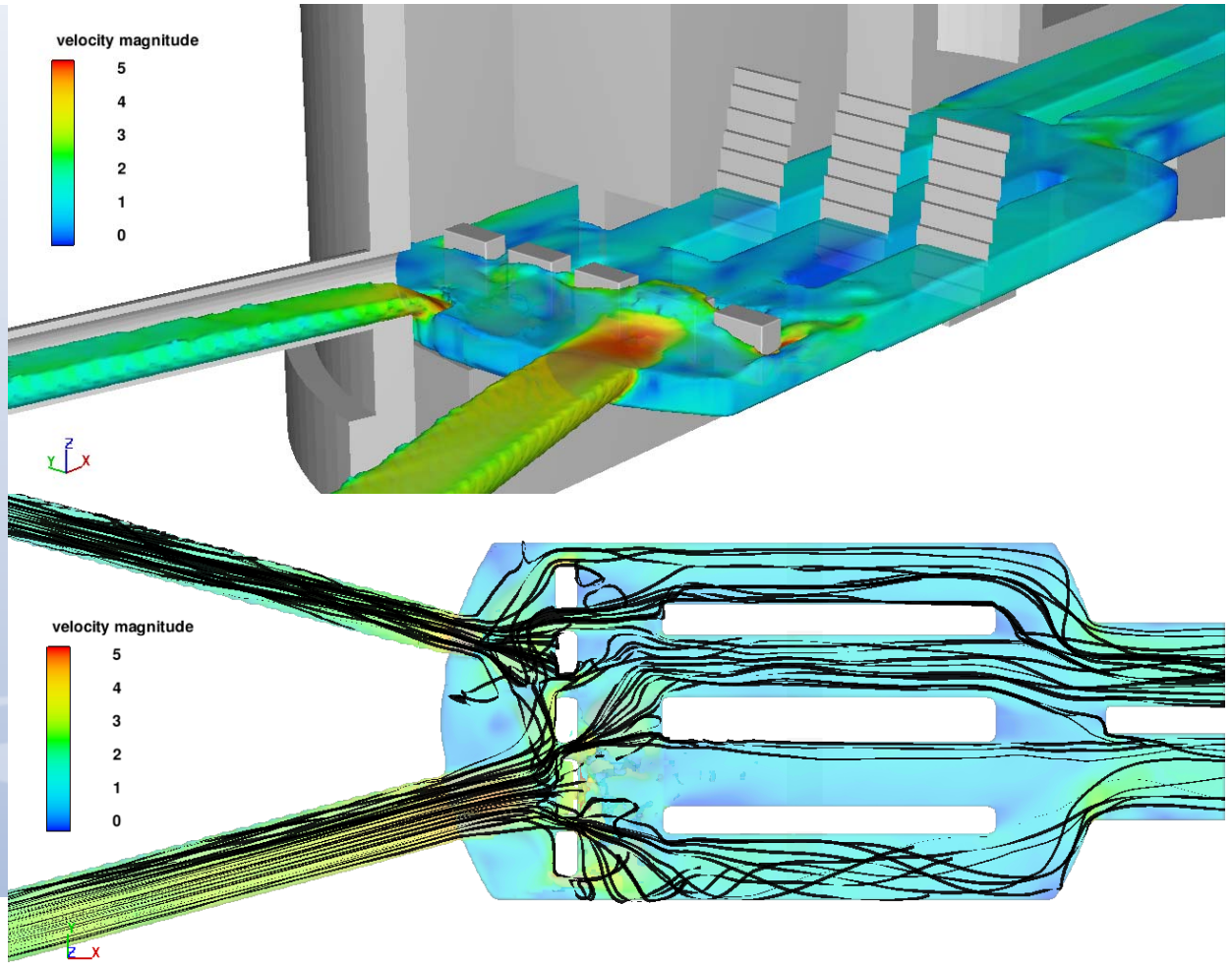
Results for Final Baffle Arrangement

Flow distributed across all channels

- Passed acceptance criteria at all flows
- Flows through screens < ±33% of mean
- Maximum mean velocity through screens < 1.2 m/s



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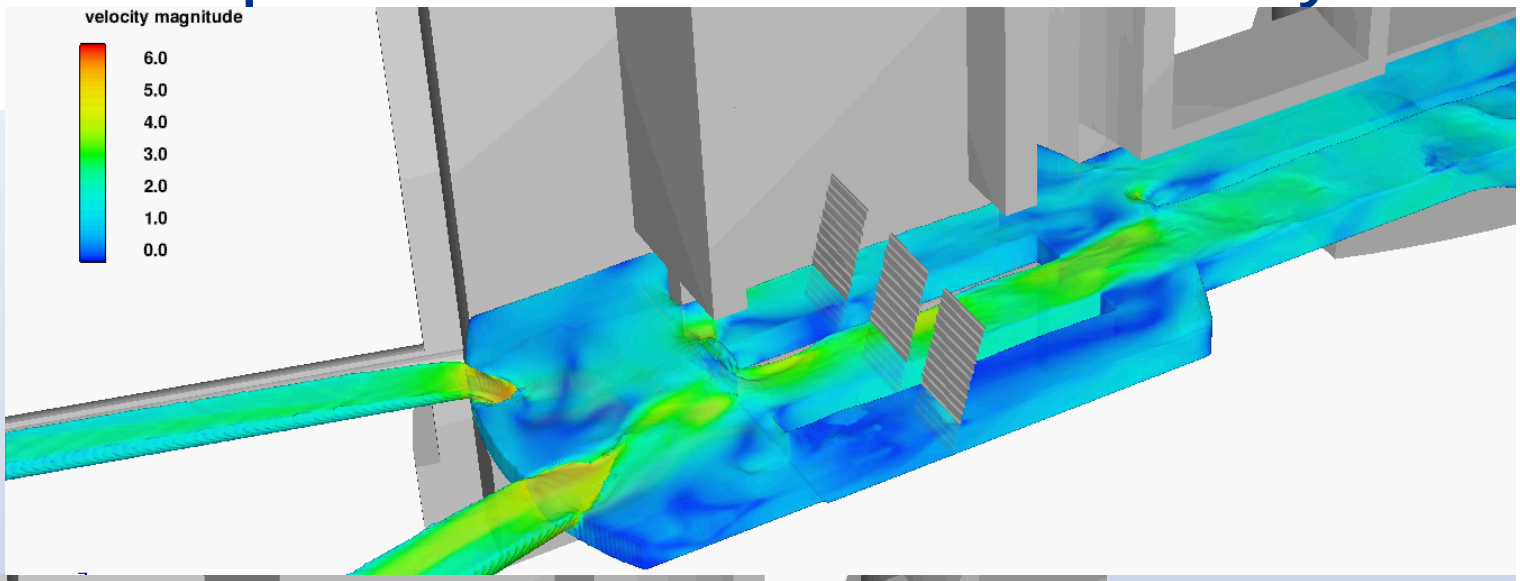
Conclusions

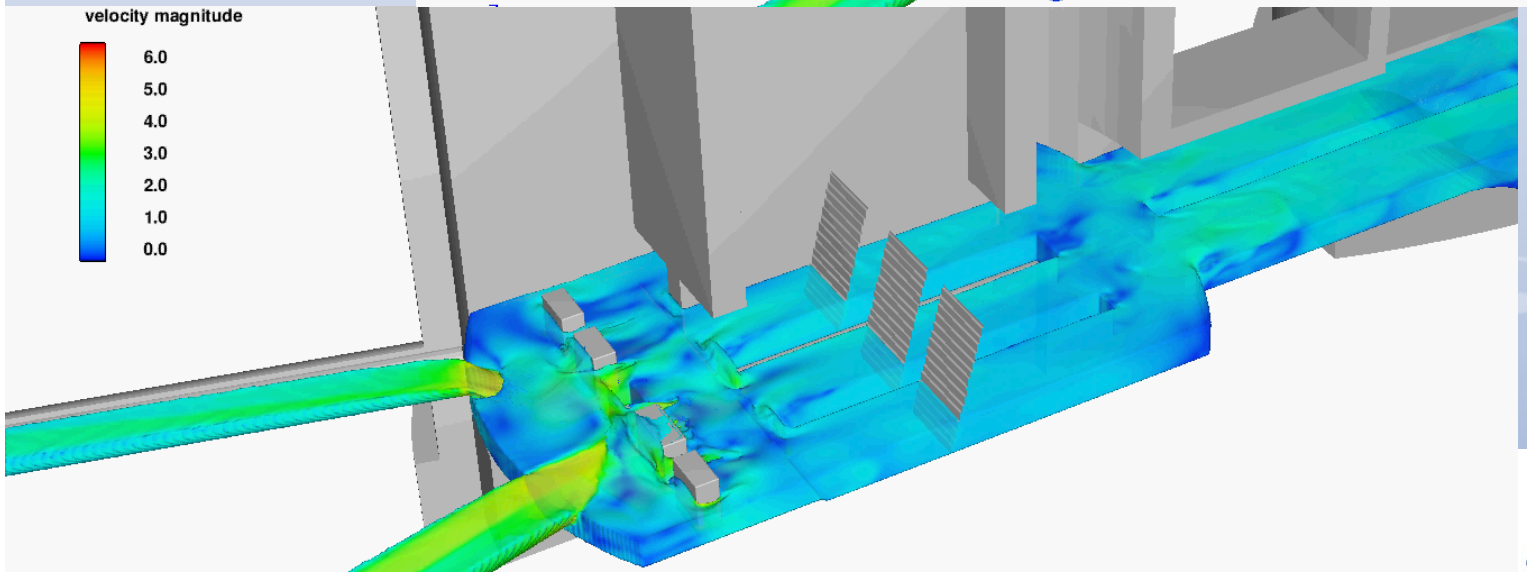
Value of CFD analysis

- Mitigated the risk to cost and programme at early design stage by demonstrating the problems and modelling potential solutions
- Confirmed no need to increase shaft diameter above 30 m or to alter approach tunnel alignments
- Demonstrated that baffling was required
  - Showed various baffle arrangements can pass acceptance criteria
  - Simple baffle arrangement selected for tender design
  - Can be refined at detailed design stage with further CFD or physical modelling (to include the wet well)

Comparison of Initial and Final Layout

Initial >





< Final

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