Improving Energy Efficiency on Irrigated Australian Cotton Farms – Energy Efficiency Information Grants

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Theme Leader – Irrigation and Water Management
National Centre for Engineering in Agriculture
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February 24, 2015

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This Activity received funding from the Department of Industry and Science.

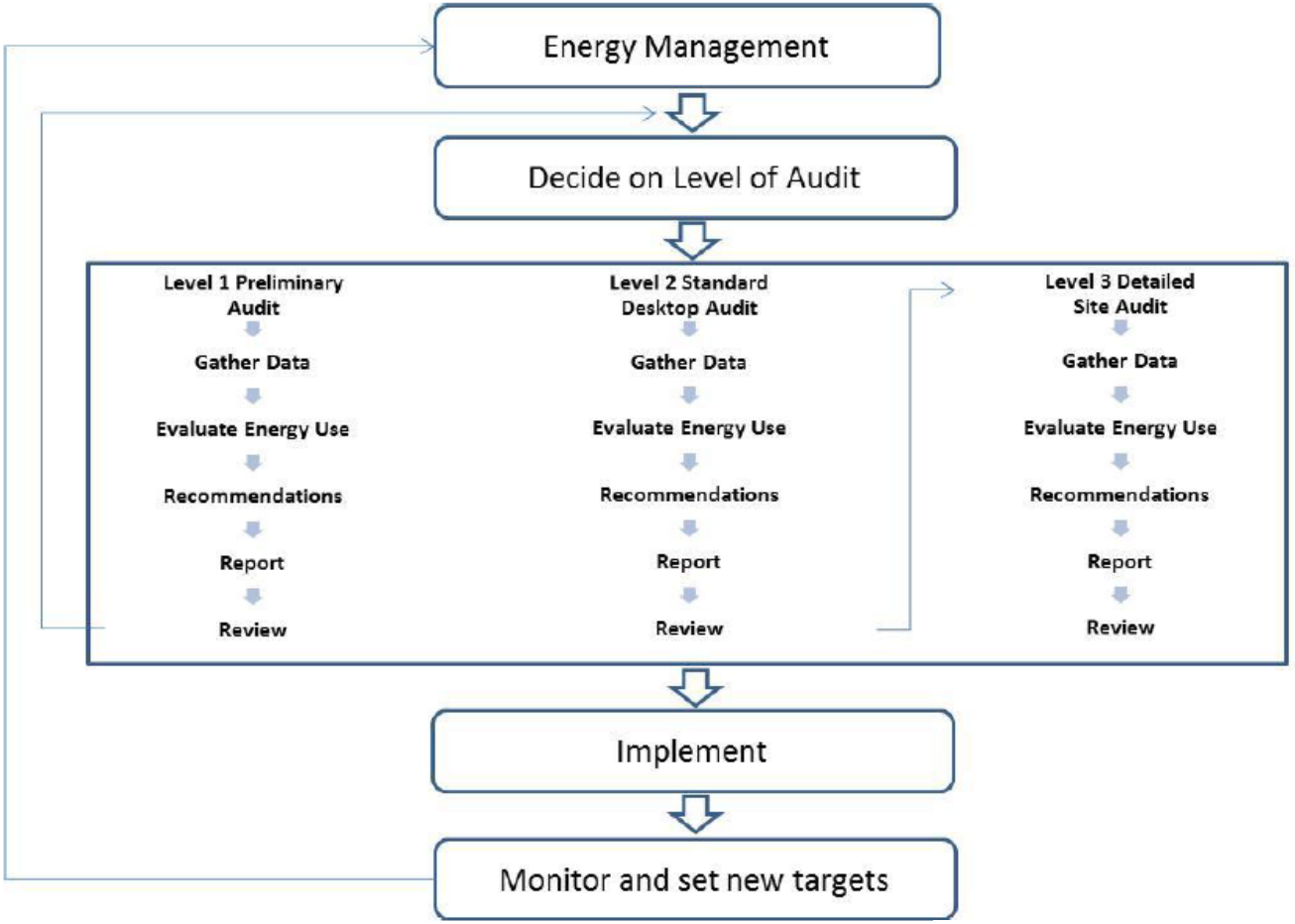
Why focus on Energy in Cotton?

- Cotton production is energy intensive – based on machinery, fertilizer & pesticide inputs
- Fastest growing input cost to cotton prod'n
- Energy consumed in visible & invisible forms
- thru electricity & diesel consumption
- solar energy input into plants for transpiration
- water supply cascading down from storages

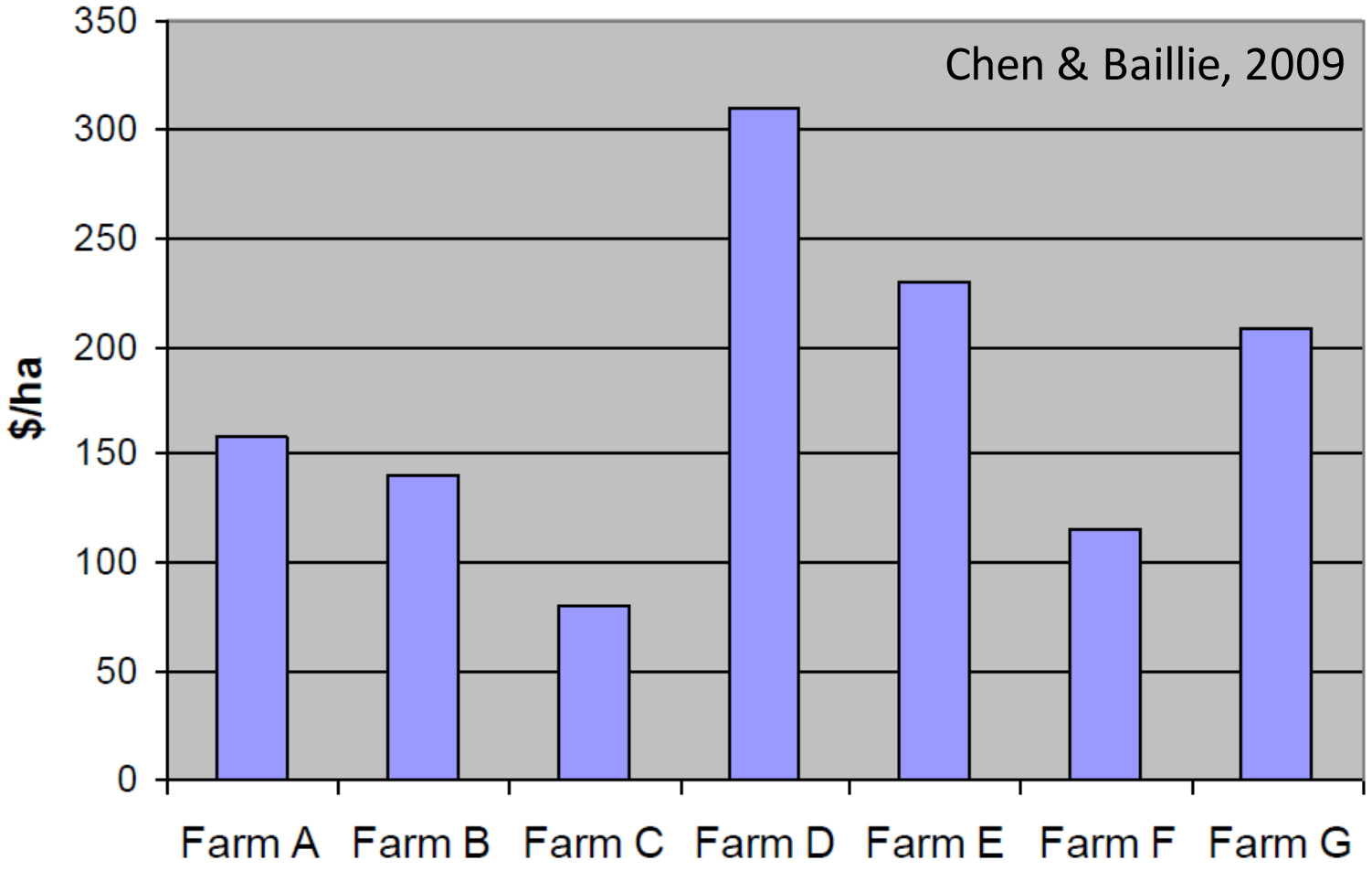
Why focus on Energy in Cotton?

- Reported energy input costs from $80/ha up to $310/ha by Chen & Baillie (2009) &
- Industry desire to understand GHG production
- Diesel use for Aust. Cotton prod'n from 120 to 180 Litres per hectare (range 95 to 365 L/ha)
- Converting to min. till – reduced costs 10%
- Up to 30% saving with focus on single operat'n

Energy Audit Process is valuable



Energy Costs on Cotton Farms 2009



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Why focus on irrigation energy?

	Fallow	Harvest	In Crop	Irrigation	Planting	Post Harvest
Farm A	15%	24%	8%	40%	4%	9%
Farm B	14%	27%	3%	39%	7%	10%
Farm C	4%	54%	21%	0%	5%	16%
Farm D	7%	14%	4%	70%	1%	3%
Farm E	5%	19%	4%	62%	2%	7%
Farm F	32%	38%	7%	9%	7%	7%
Farm G	12%	21%	4%	51%	4%	8%
All farm average	8%	20%	5%	57%	3%	7%

Irrigation - single biggest energy input to Aust. Cotton production

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Water is heavy – lots of energy to shift

- Water is very **HEAVY** material!!
- **Lots** of Energy needed to move & lift water
- Cotton evapotranspiration = 750 mm per seas.
- That is equal to 0.75 tonne per square metre
- That's 7.5 ML per ha up from plant & soil
- One ML per ha = 1000 tonnes of water per ha
- Cotton fields need at least 7500 tonnes per ha

Lots of Energy needed to shift water

- 7500t per ha is 180 B-double trucks per ha!!
- Each MegaLitre (ML) needs 9.81 MegaJoules (MJ) to lift up one metre of height
- To lift 1 ML up 1 metre, with pump, drive & diesel motor efficiencies of 80%, 95% & 35% you need 36.9 MJ per ML per metre of height
- Diesel holds 38.4 MJ per Litre – energy dense
- 7.2 L diesel pumps 7.5 ML up 1 metre

To save Energy do everything you can to reduce Water losses first

- Field use 7.5 ML/ha, lifted 5m = 36 L dies./ha
- If in-field irrigation efficiency is 70%, you need 10.7 ML/ha, lifted 5m = 51.4 L dies./ha
- If water distrib. & storage losses are 40%, you need to lift 17.8 ML/ha up 5m =85.7 L dies./ha
- Saving water in fields & storages saves Energy
- Evaluate irrig. performance & check dam loss

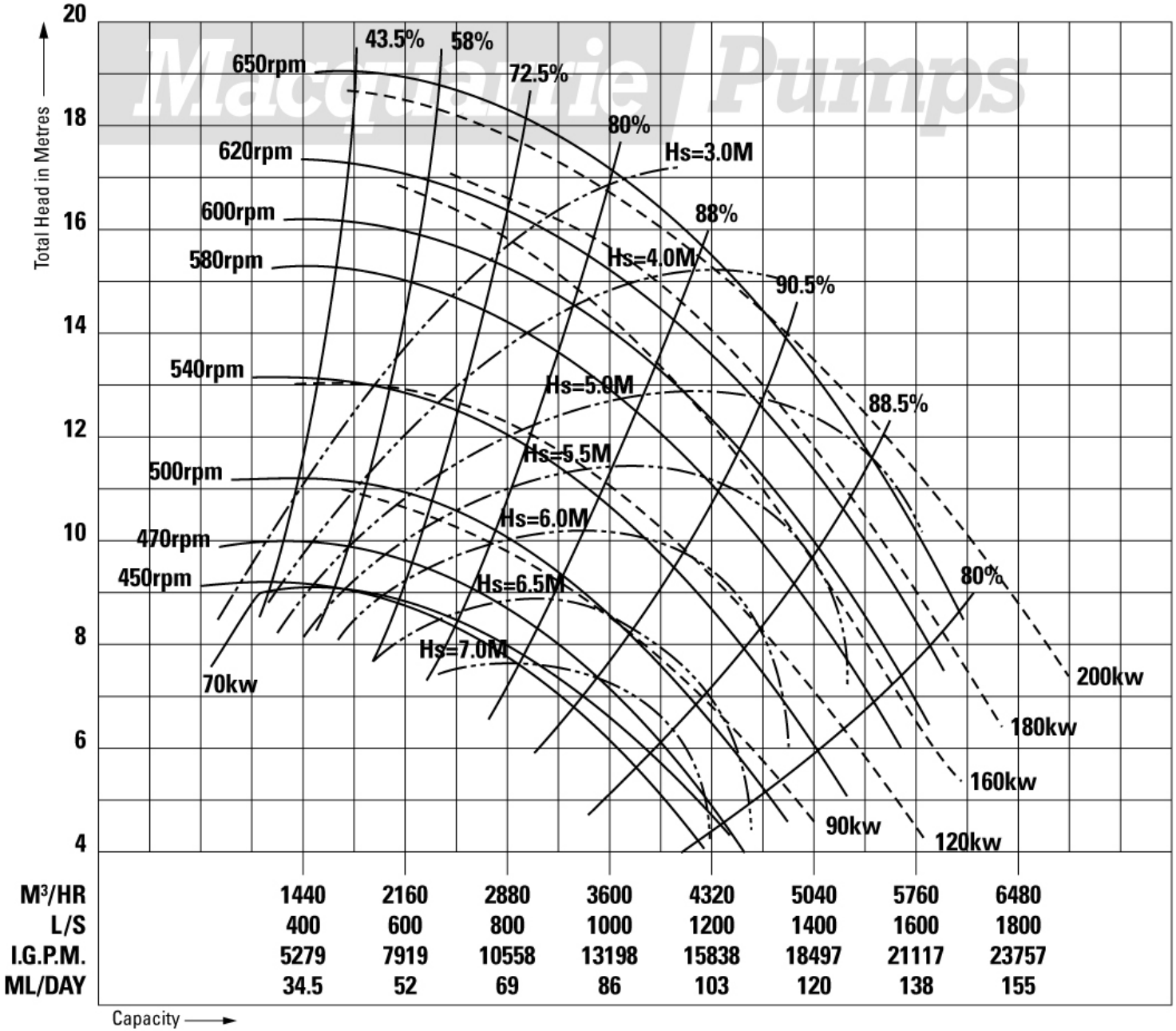
Focus on large mixed flow pumps

- More than 85% of water pumped on-farm in Aust. Cotton is with large mixed flow pumps
- In particular, the 26HBC-40 pump
- If half energy use in cotton is irrigation, then 40% energy use in cotton is through 26HBC-40
- Has been a focus of investigation in this work
- Used because cheap, robust & understood
- Understand performance with pump testing

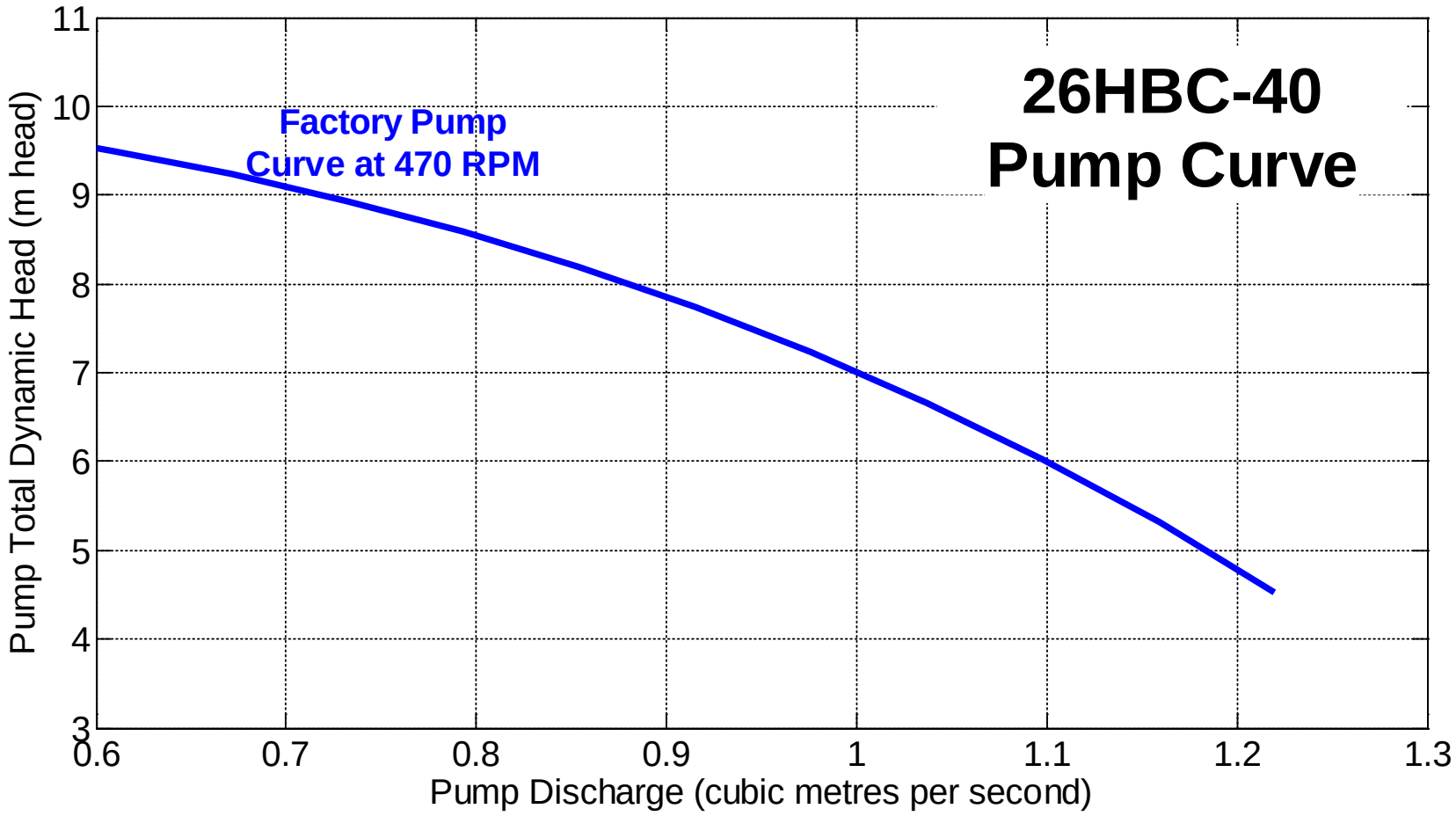
Investigating with pump tests

- Pump tests are completed on-farm with grower co-operation
- Total Dynamic Head of pump measured with gauges/manometers and flowmeters
- Pump/Eng. speed measured with RPM meter
- Discharge measured with Transit Time meter
- Dumpy level & staff to measure elevations

Suit: 26HB-40, 26HBC-40, 650HW-7 **Mixed Flow**



Factory Curve at 470 RPM – 26HBC40



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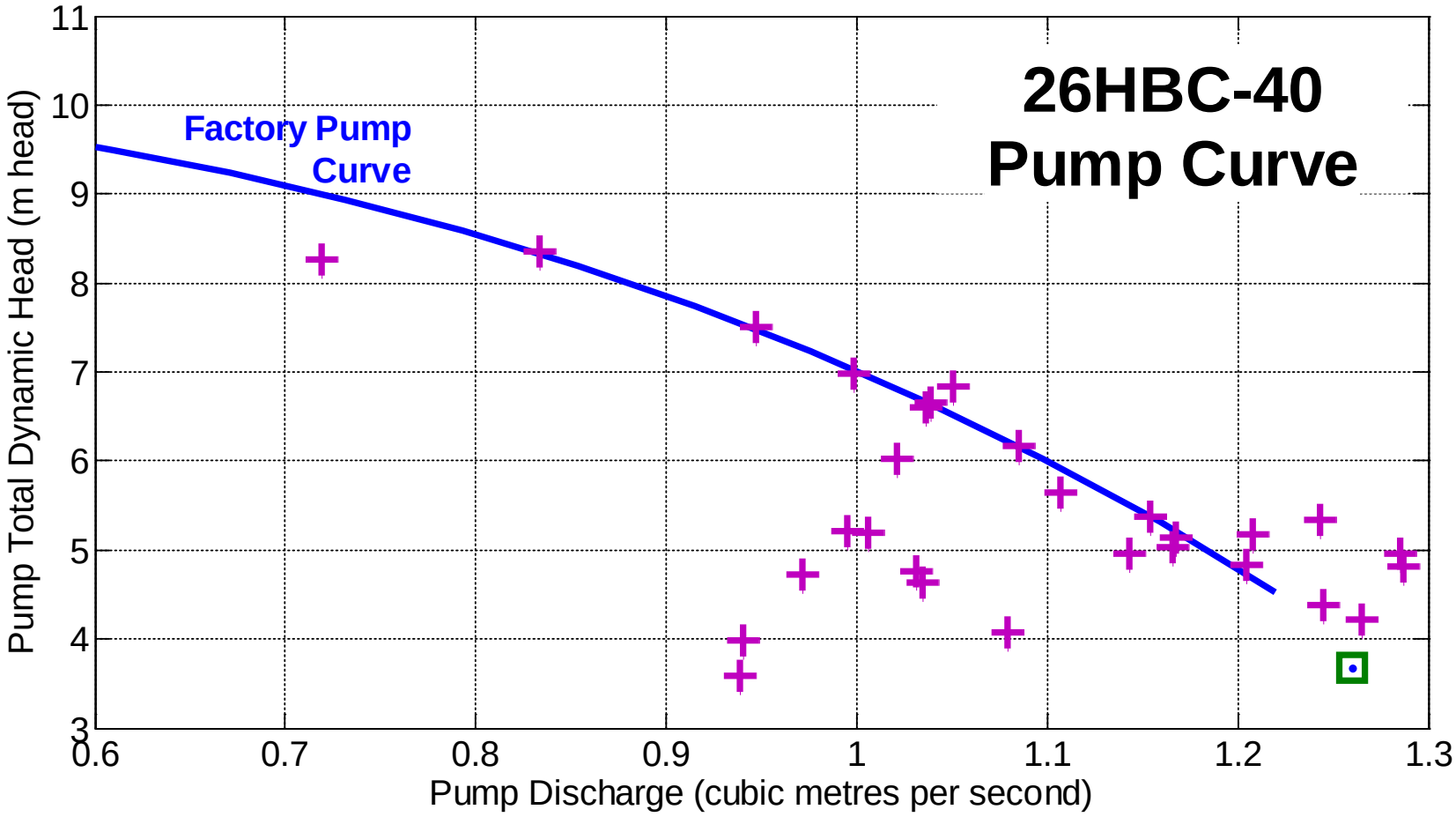
Homologized data 470 RPM – 26HBC40



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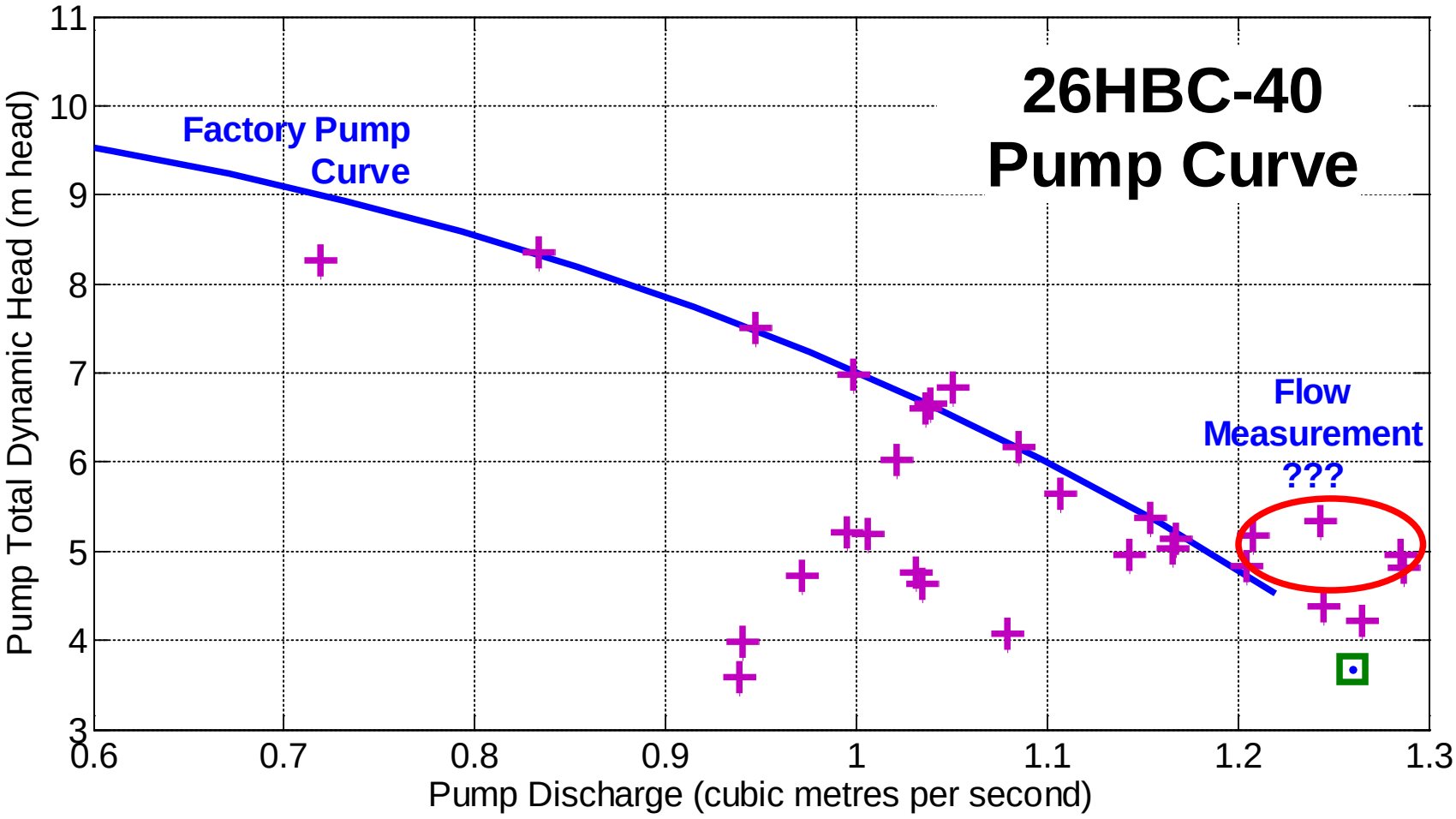

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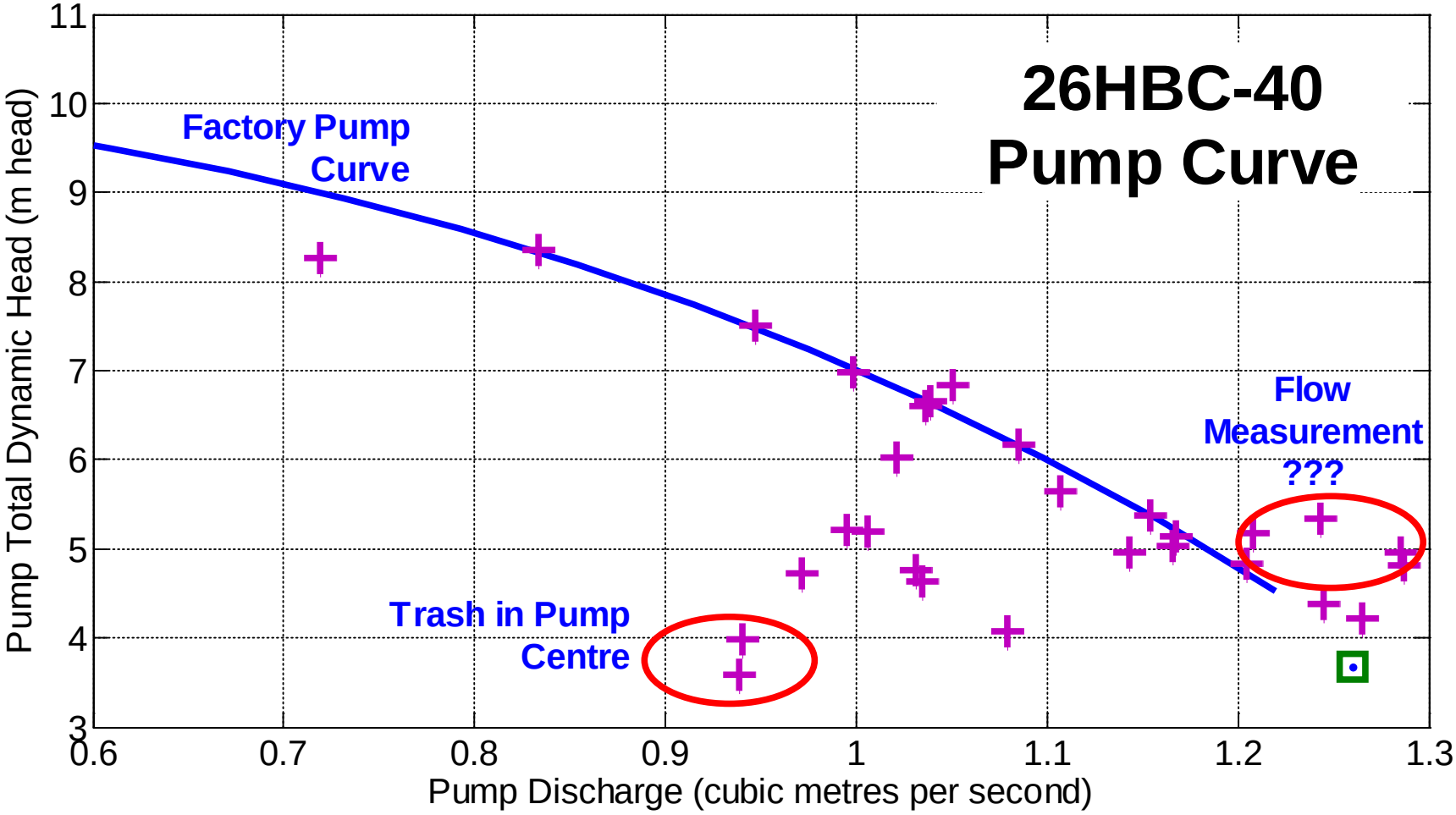

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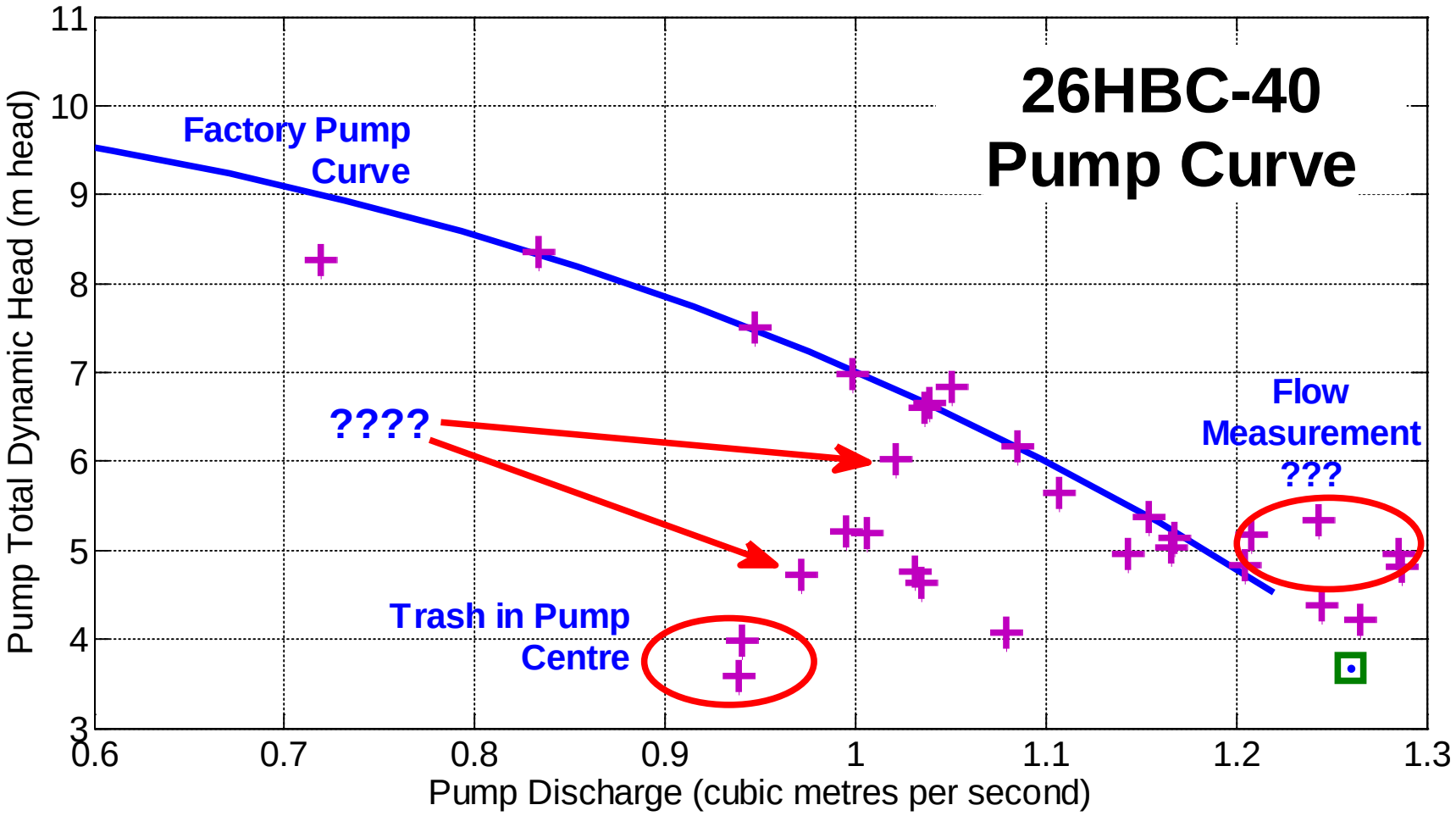
Bird’s nest of trash from eye of pump

Homologized data 470 RPM – 26HBC40



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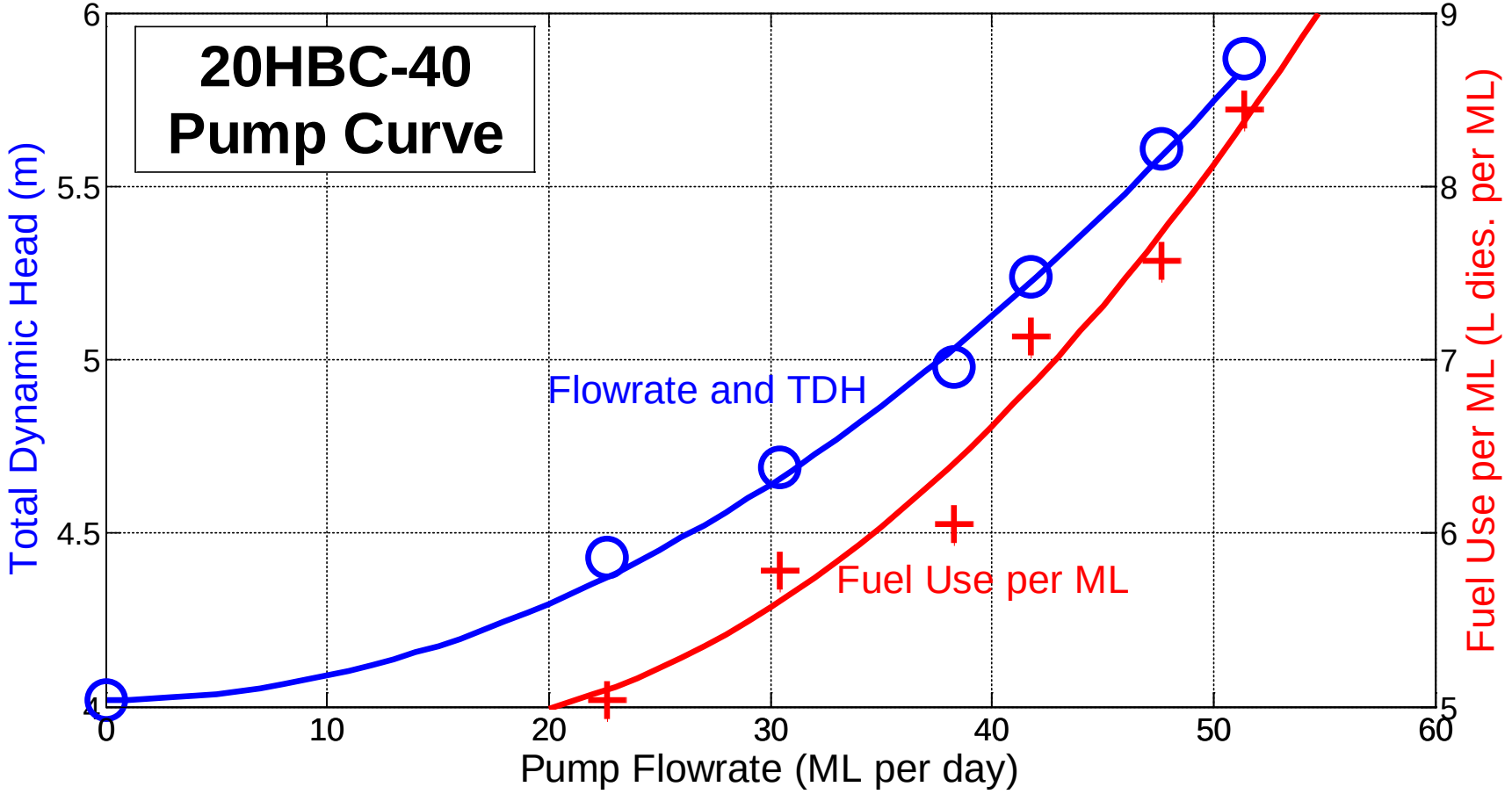
Water Flow and Fuel Use – 20HBC40



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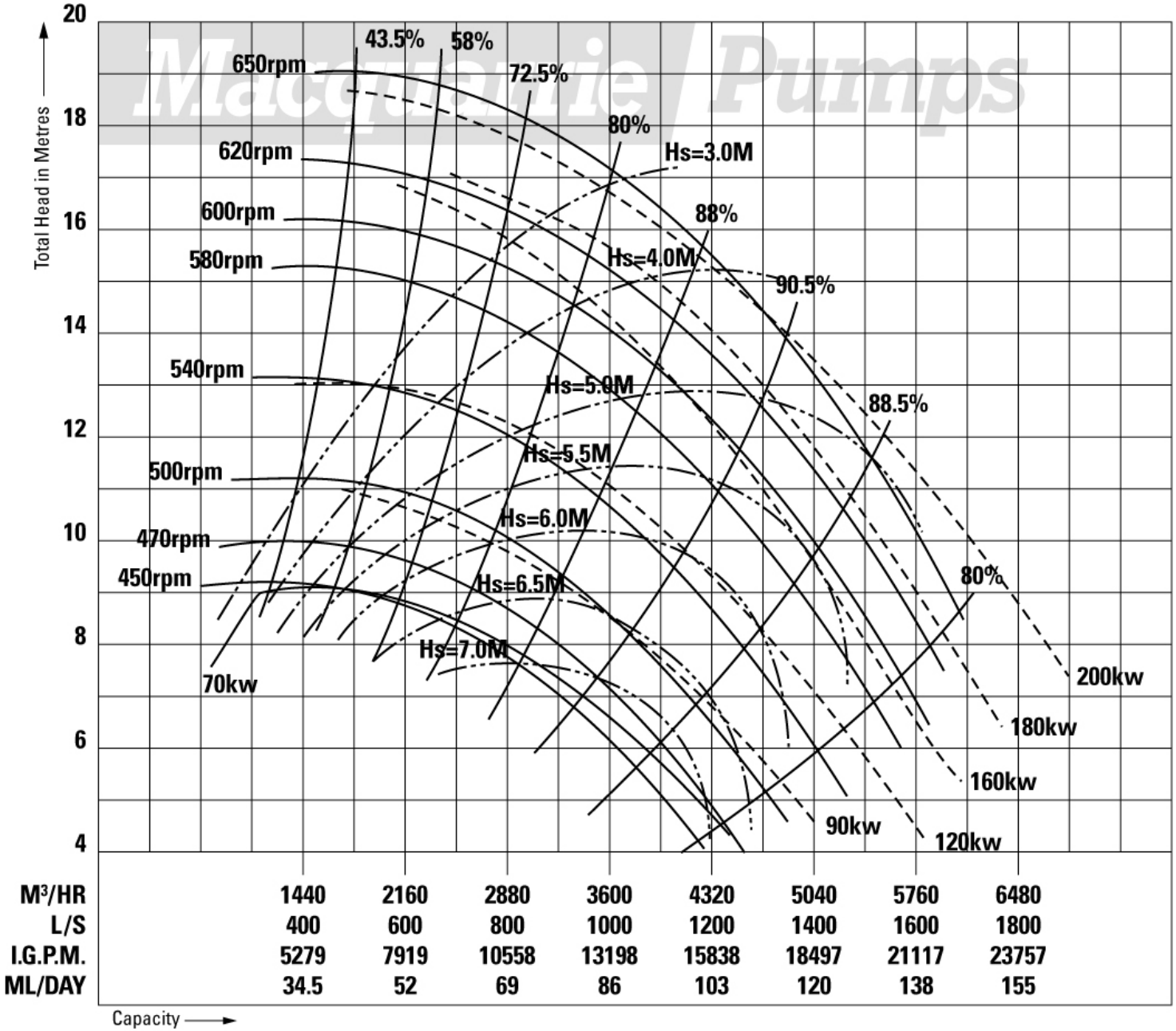
Suit: 26HB-40, 26HBC-40, 650HW-7 **Mixed Flow**



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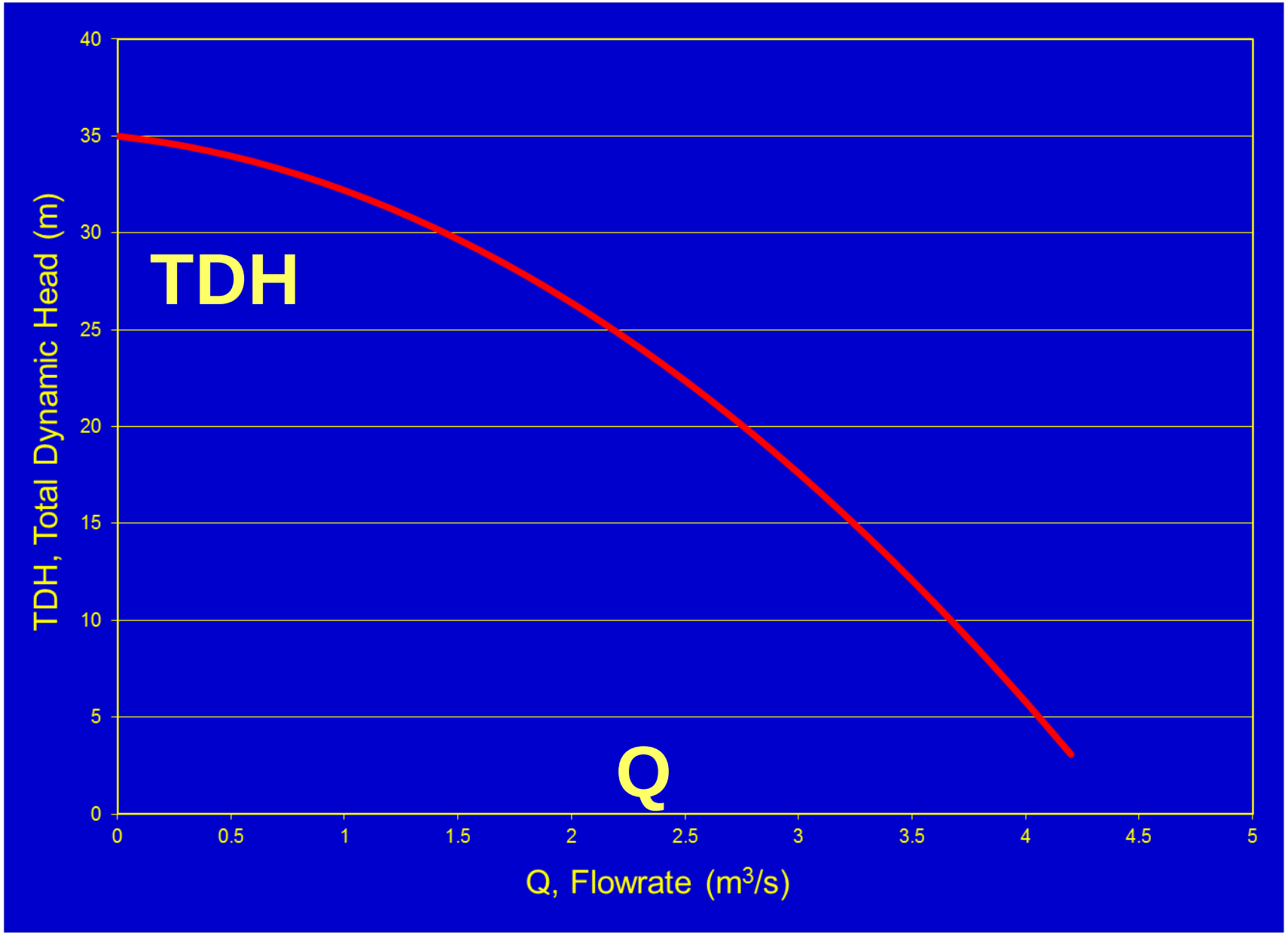
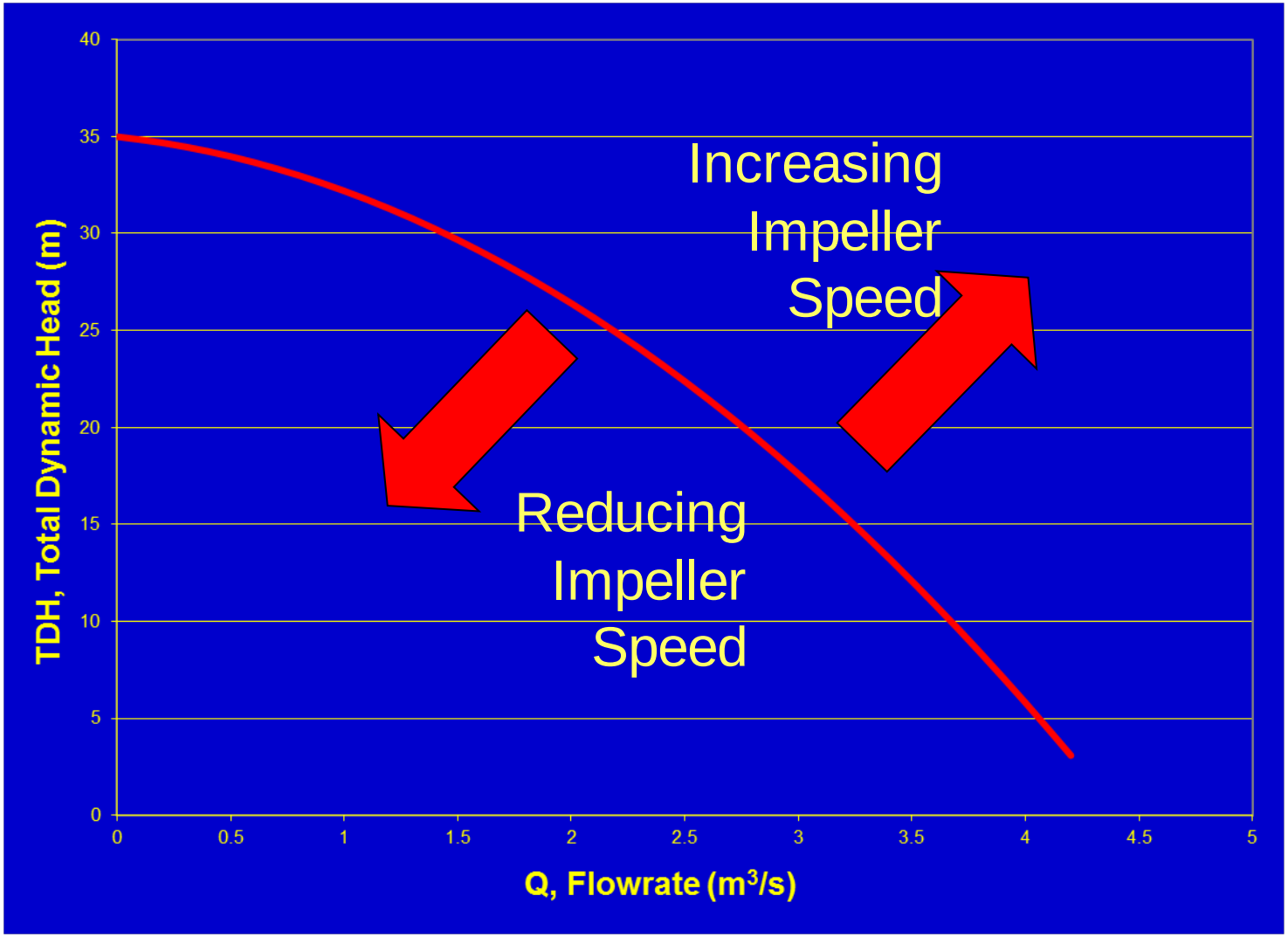
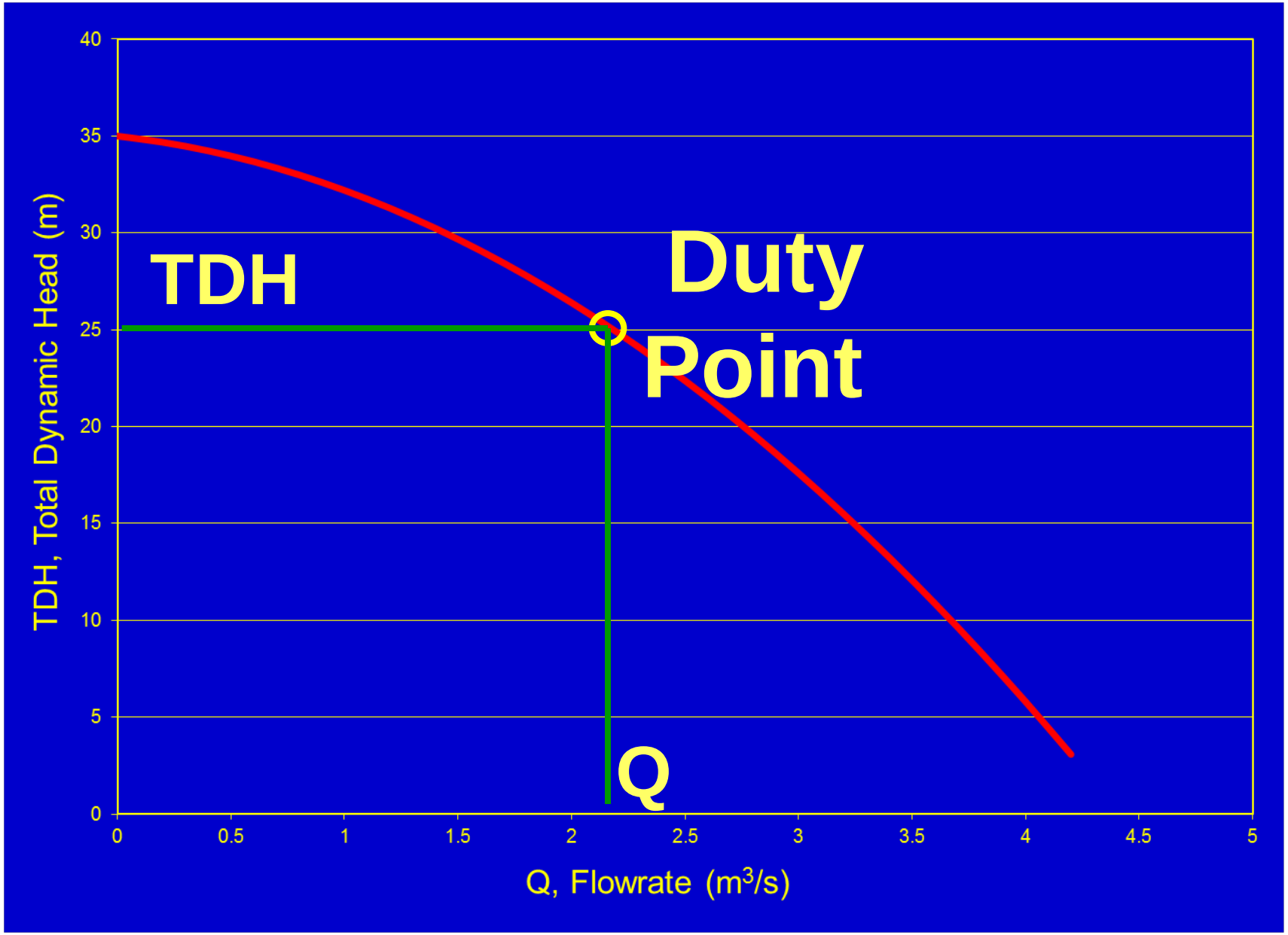
Pump Curve


TDH
Q
TDH, Total Dynamic Head (m)
Q, Flowrate (m3/s)
0
5
10
15
20
25
30
35
40
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Reducing & Increasing Speed

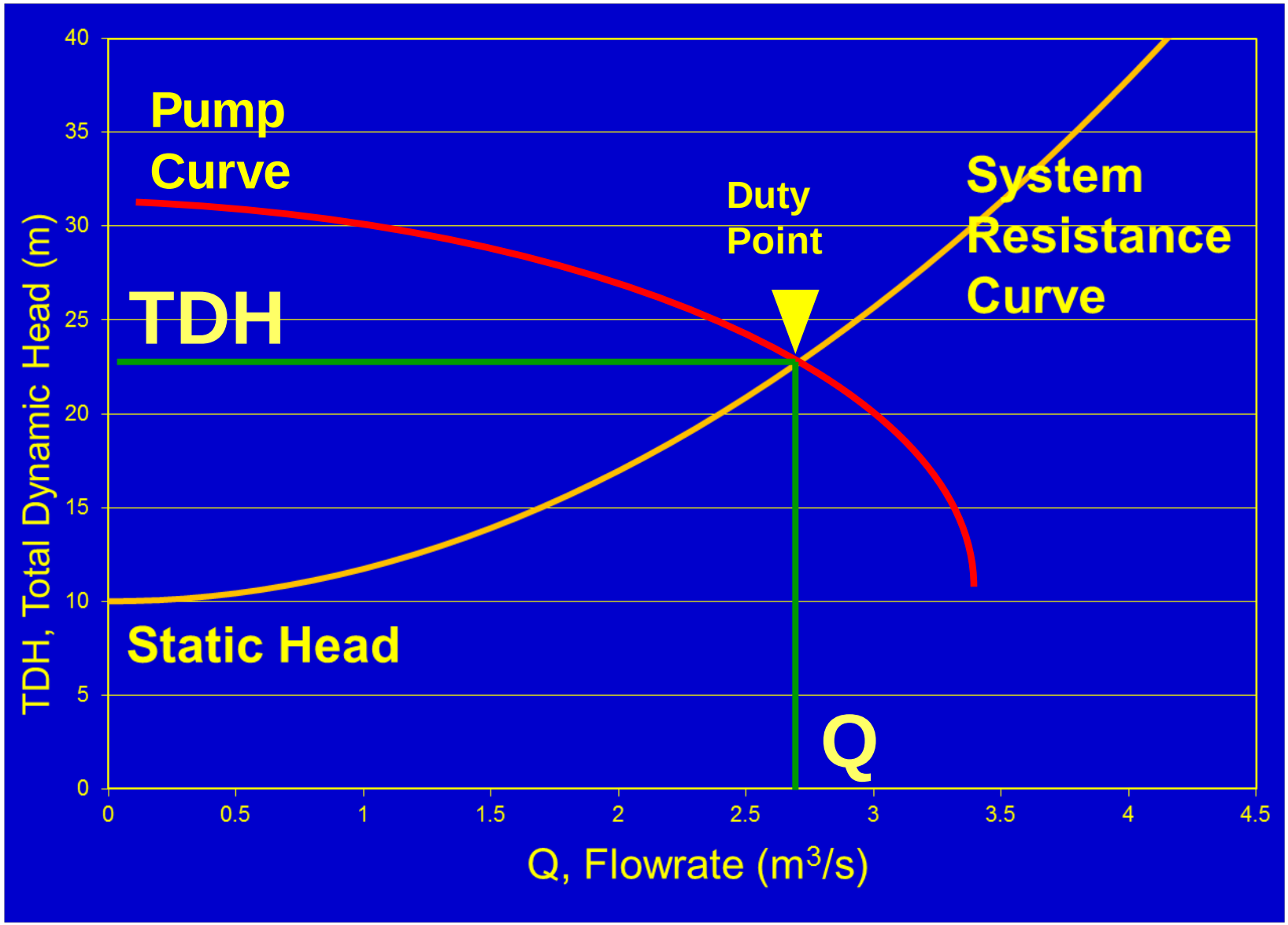


Pump Curve

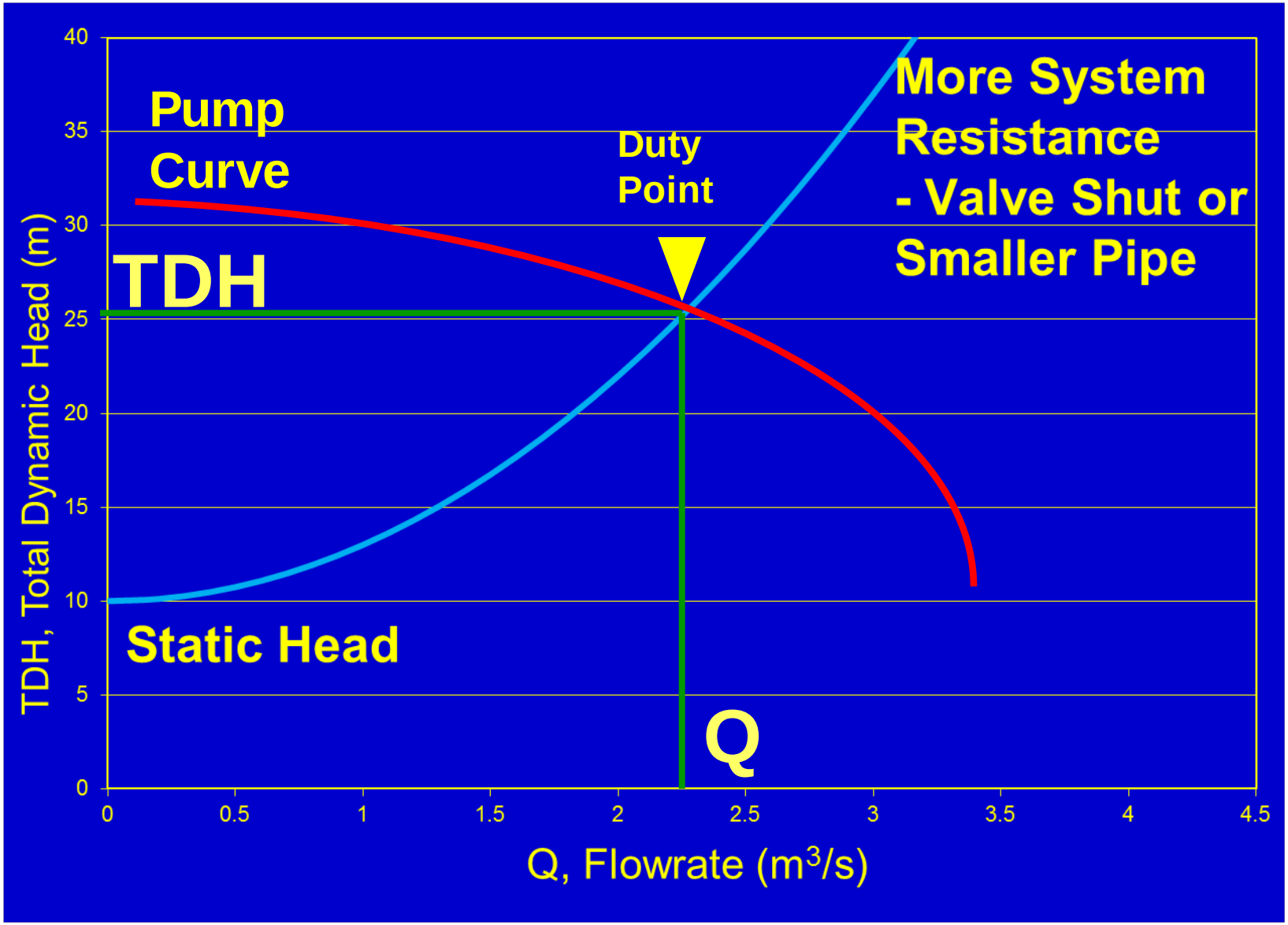

TDH
Duty
Point
Q
TDH, Total Dynamic Head (m)
Q, Flowrate (m3/s)
0
5
10
15
20
25
30
35
40
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Pump Total Dynamic Head & Energy Line

System Resistance and Pump Curve



Altering System Curve



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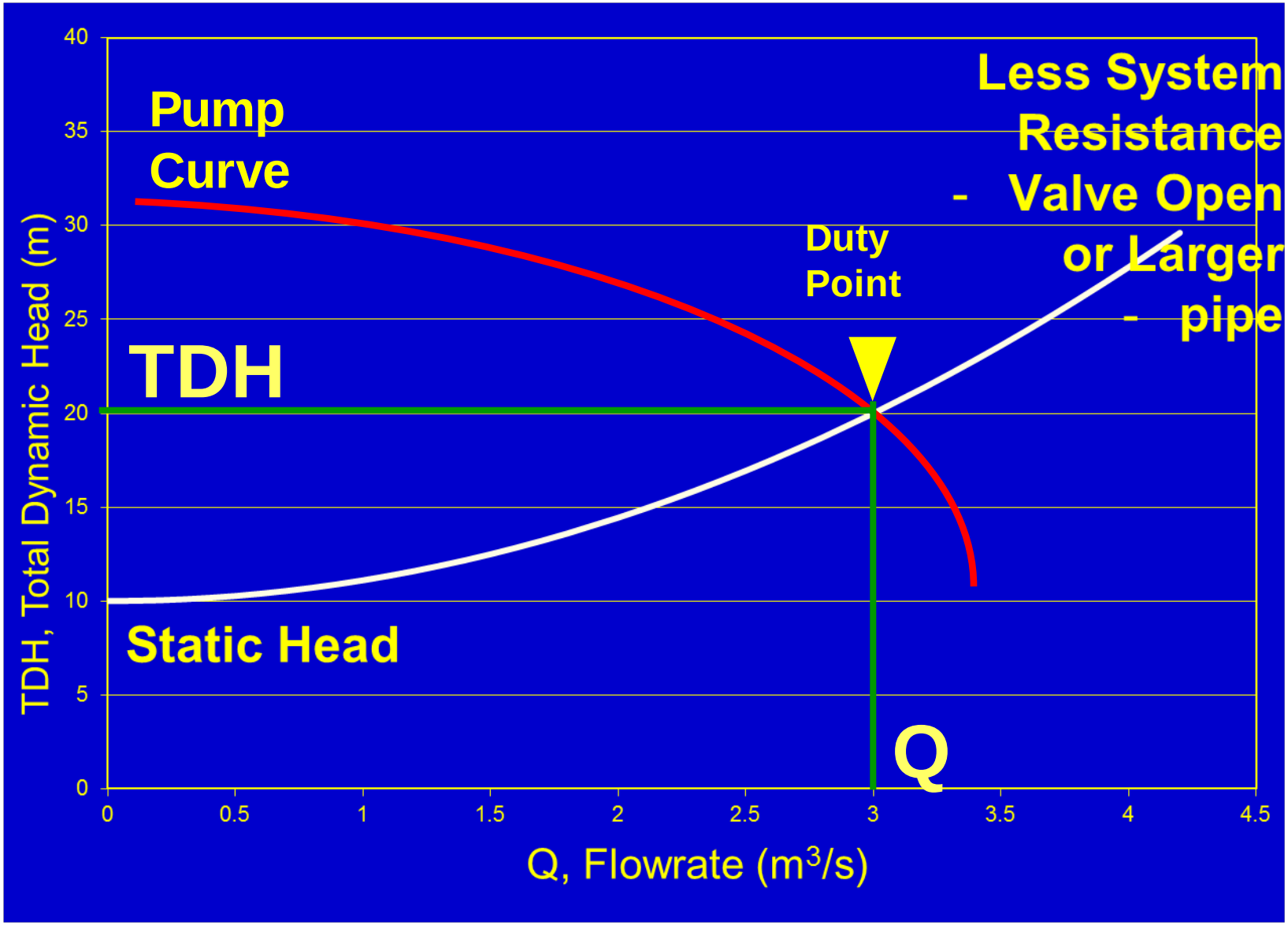
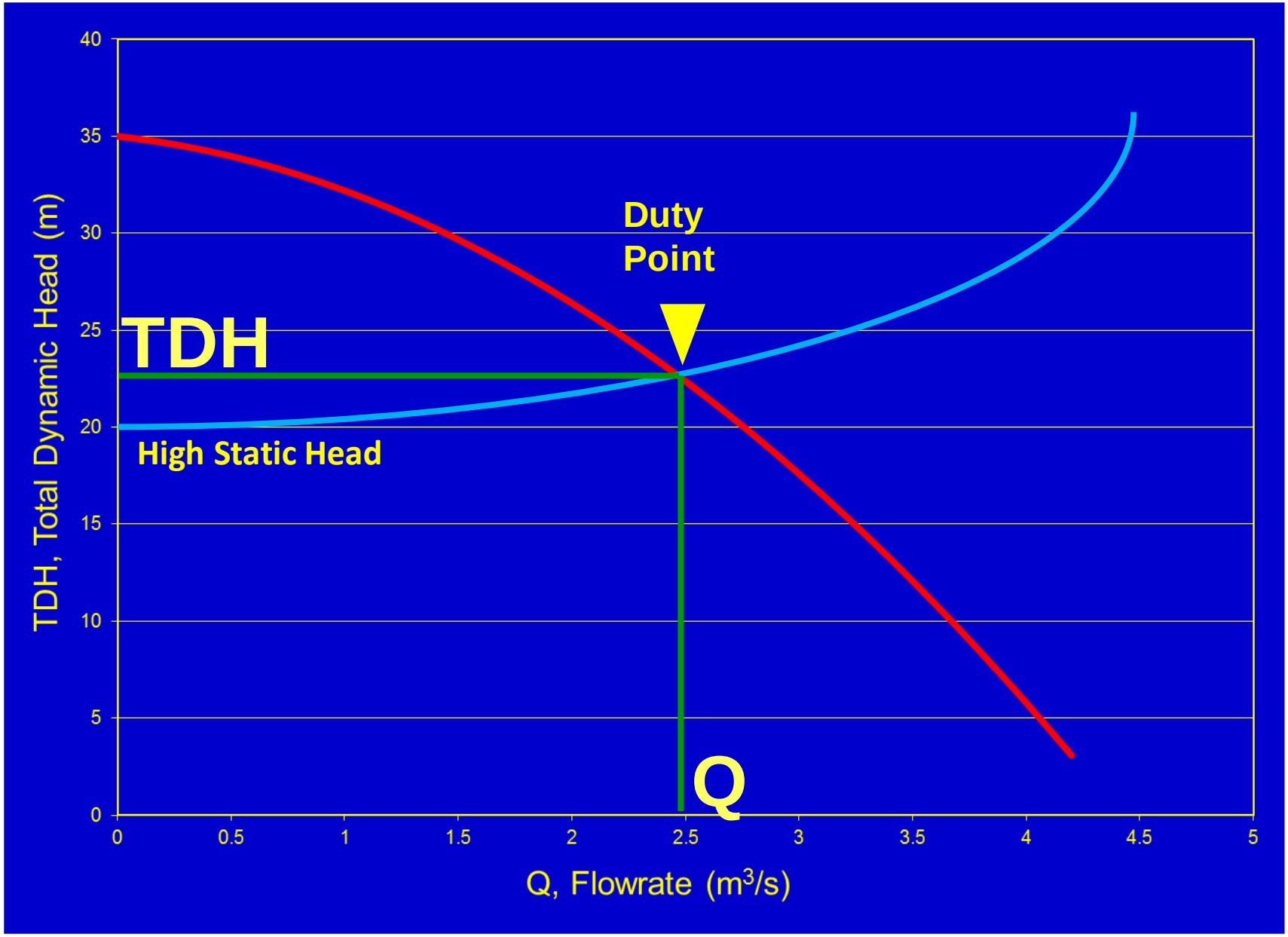
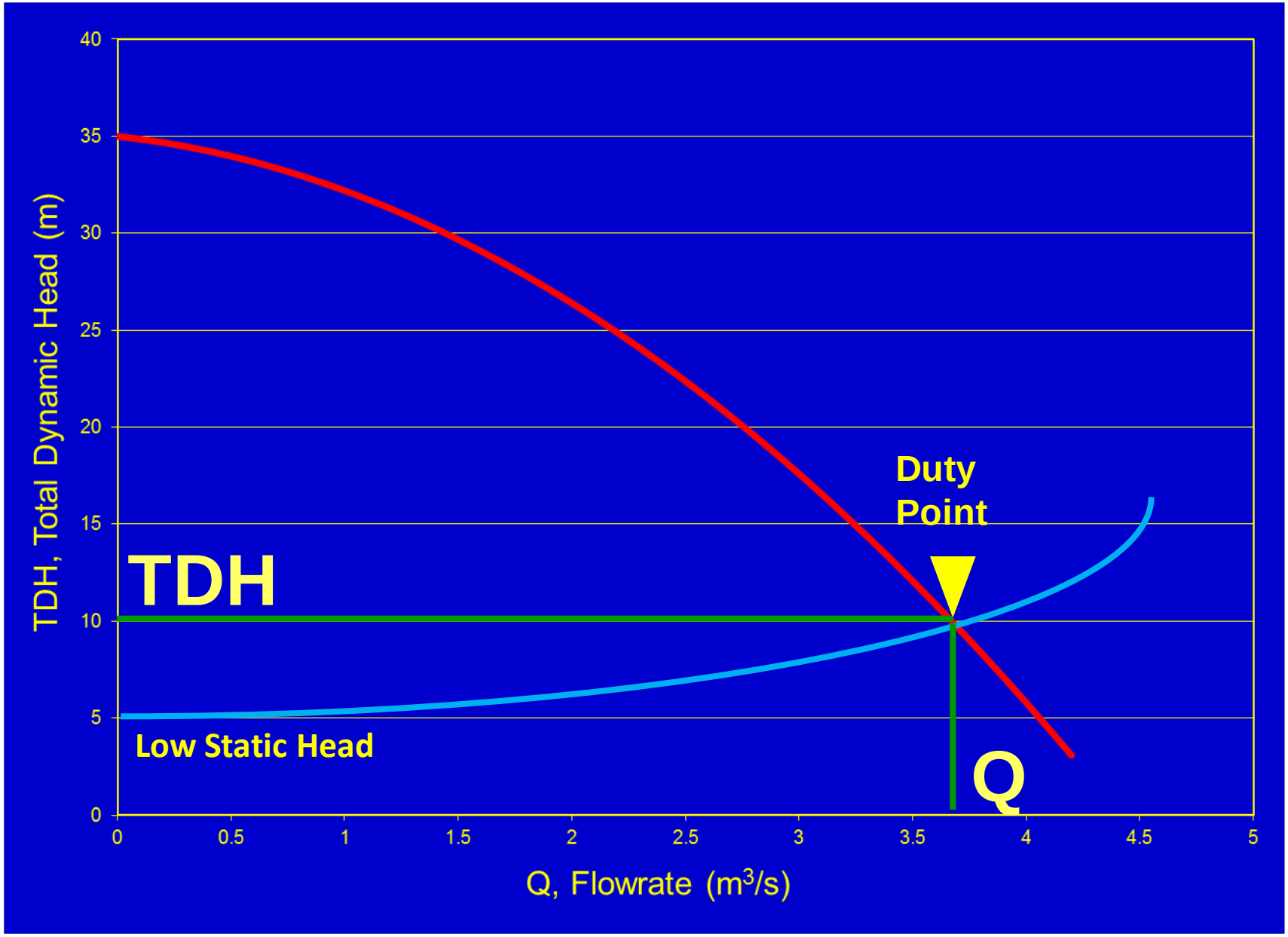


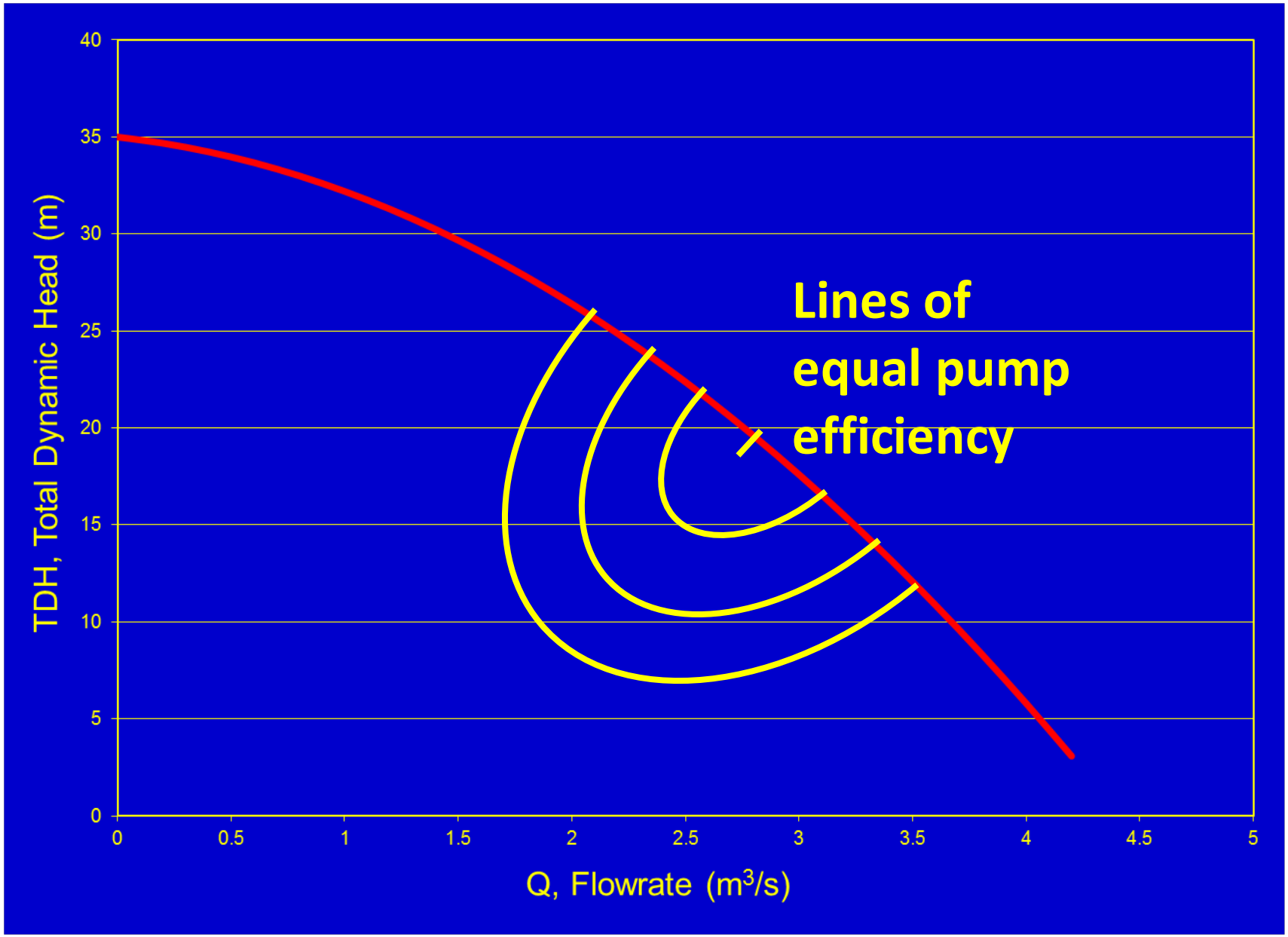
System Curve



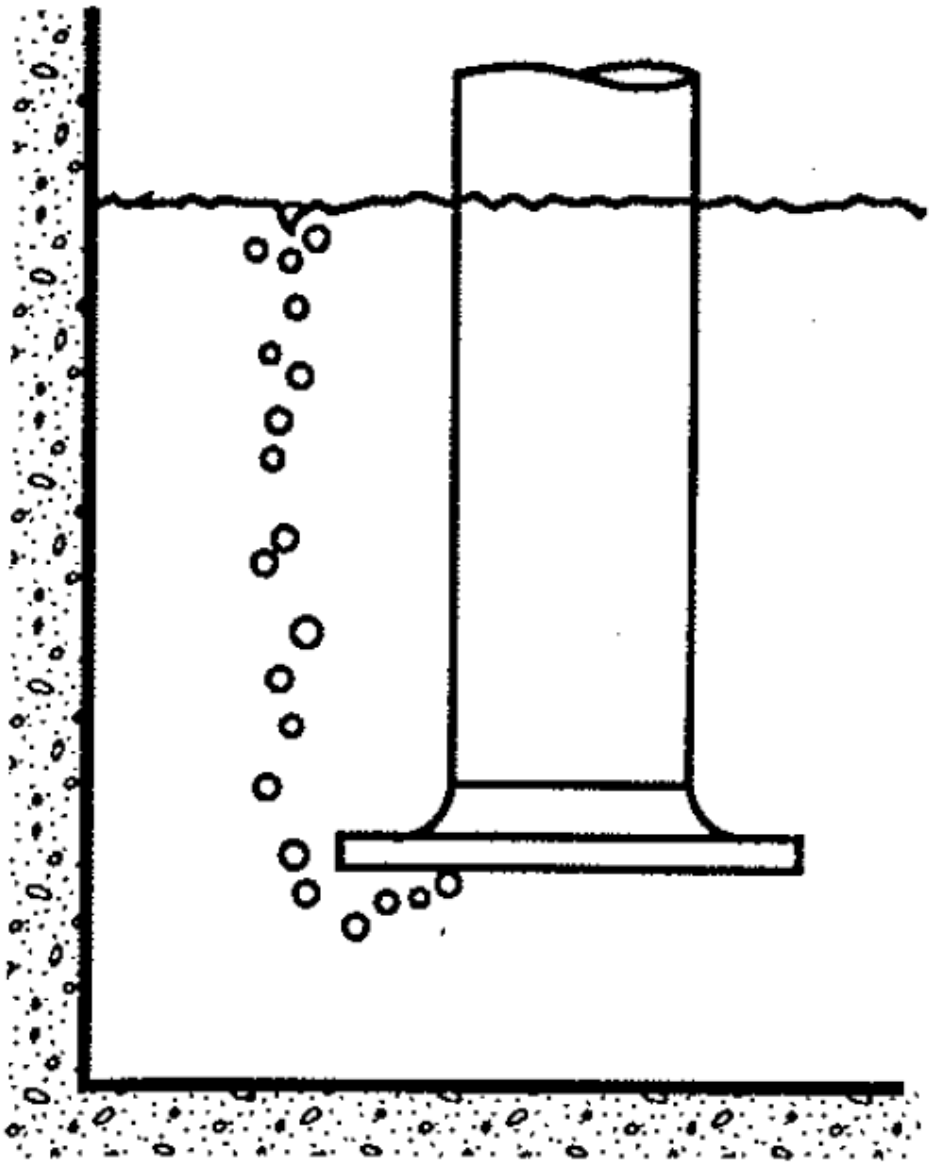
System Curve



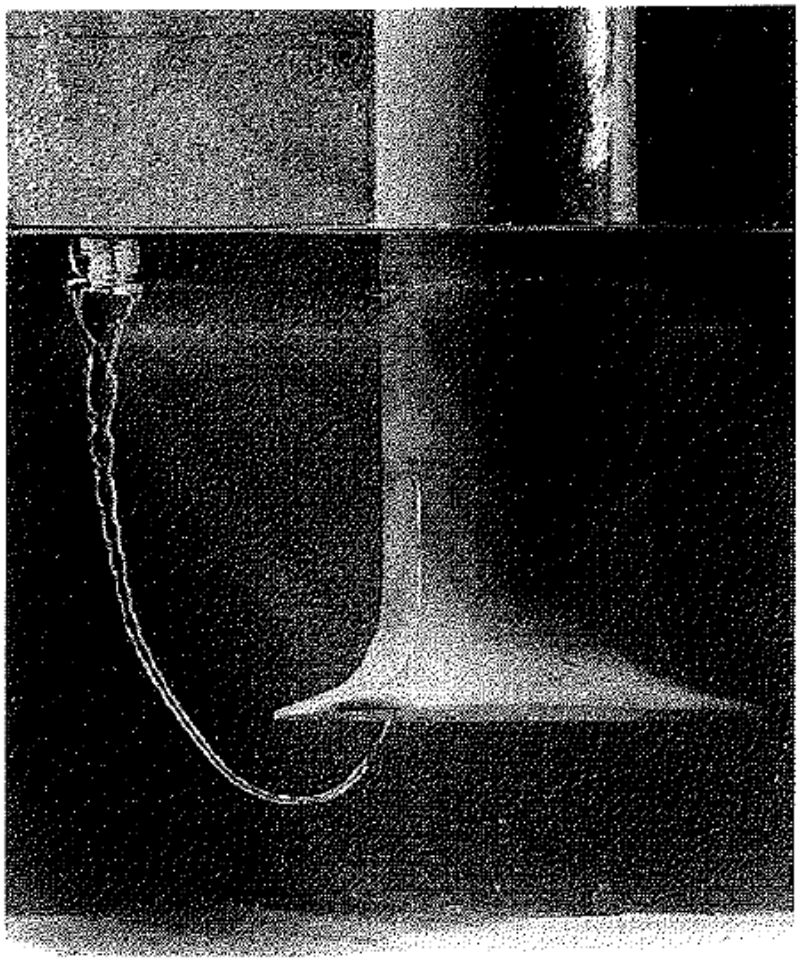
Pump Efficiency Curves

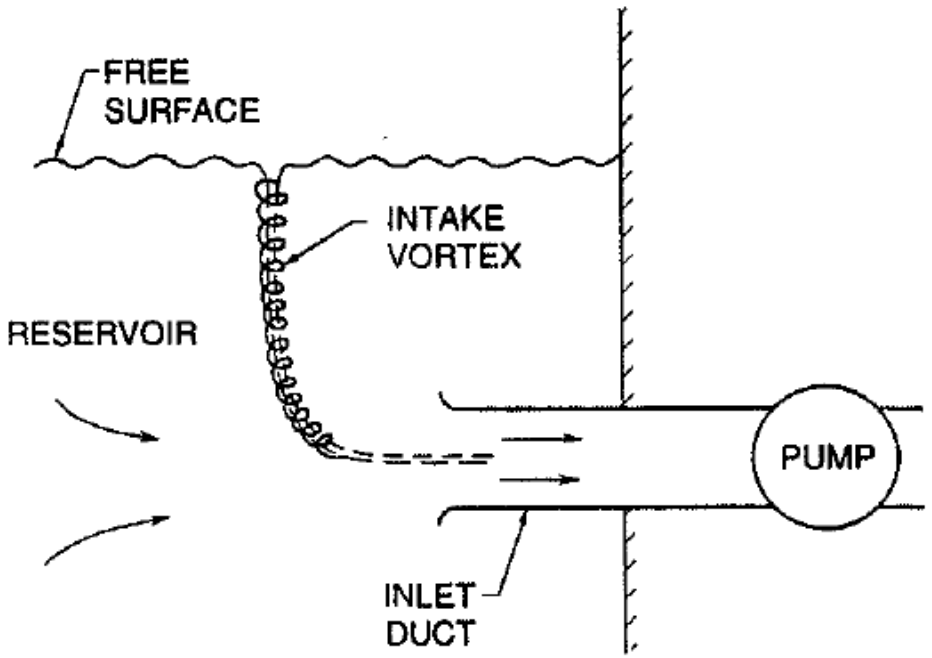


Vortex entrainment reduces performance

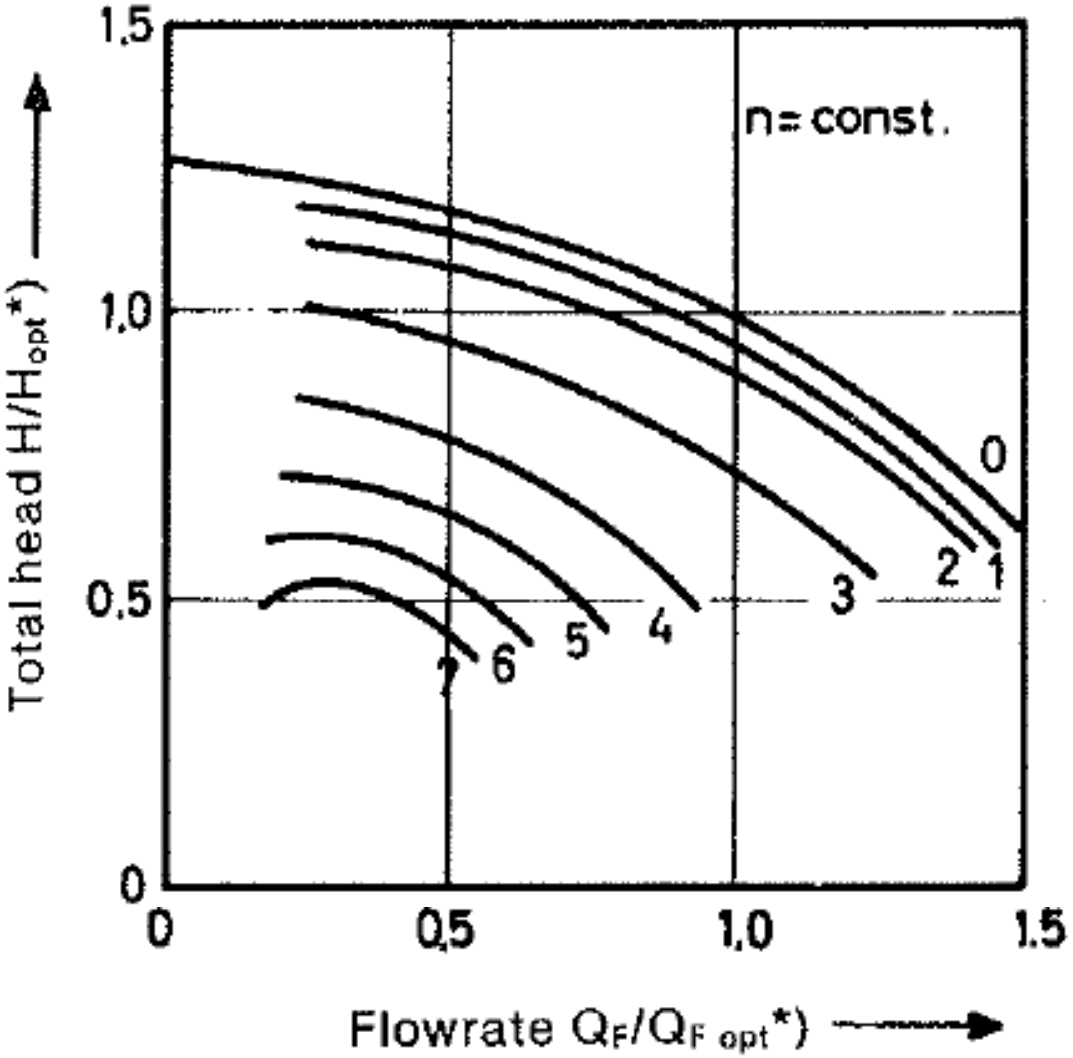


Fully developed vortices introduce air





Just a 2% gas entrainment reduces Total Dynamic Head by 10%



Vortex & trash into pump suction

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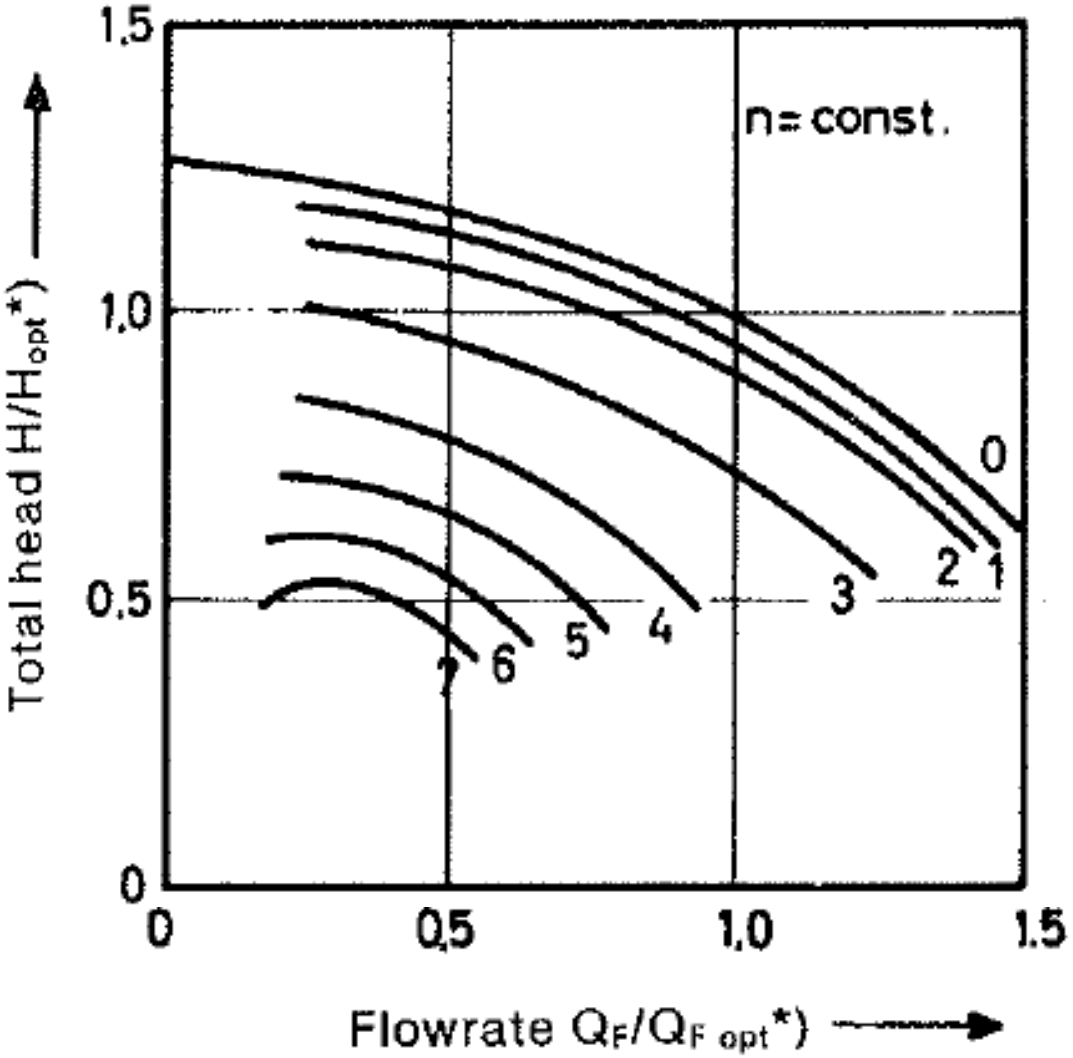
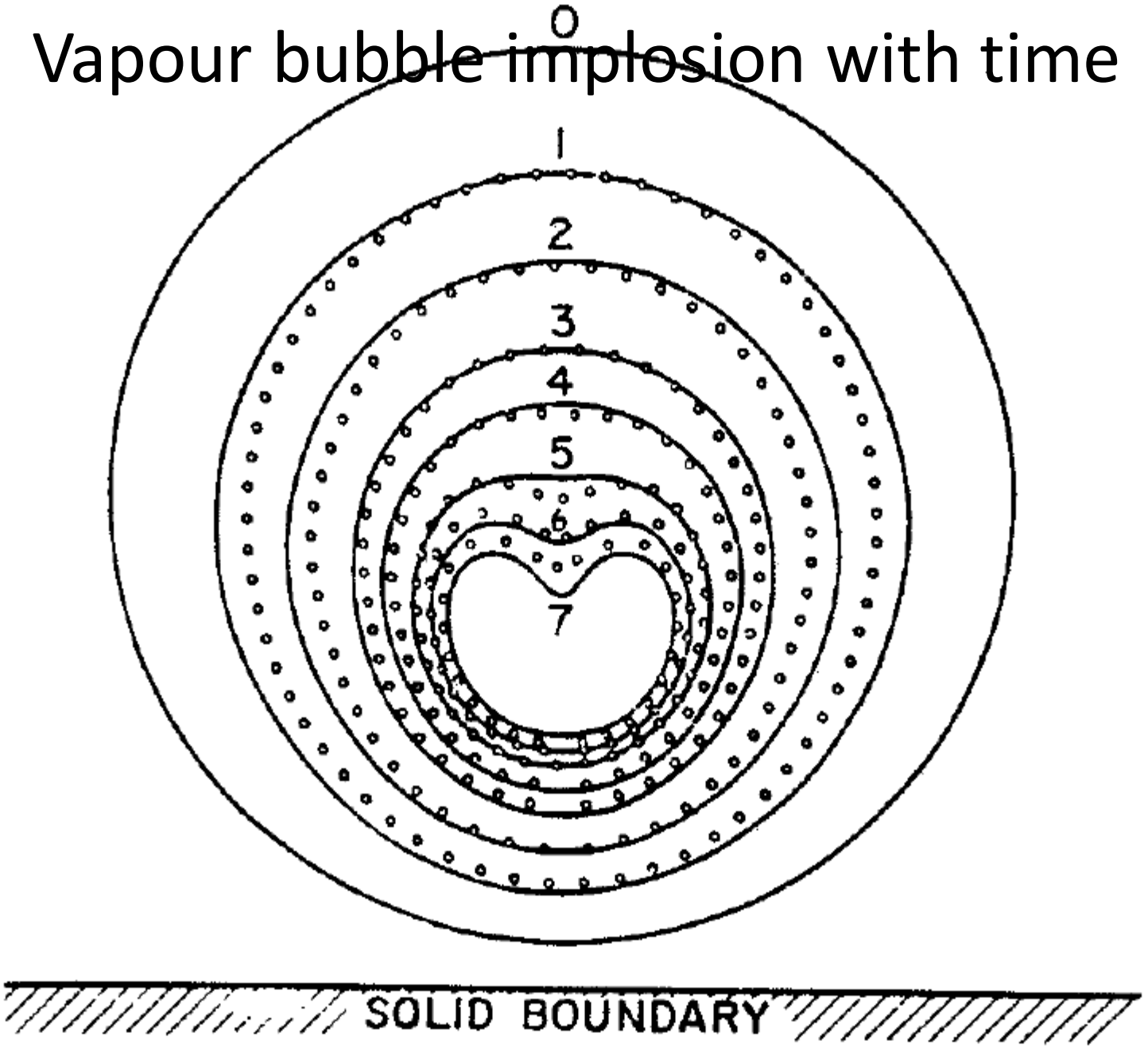


Photo of vortex into 26HBC-40

Cavitation damage

Vapour bubble implosion with time



Cavitation damage