NEW COST EFFECTIVE WATER INJECTION SYSTEM FOR MARINE DIESEL ENGINES

By Dr. Anatoly Mezheritsky, P.Eng.
M.A.Turbo/Engine Ltd

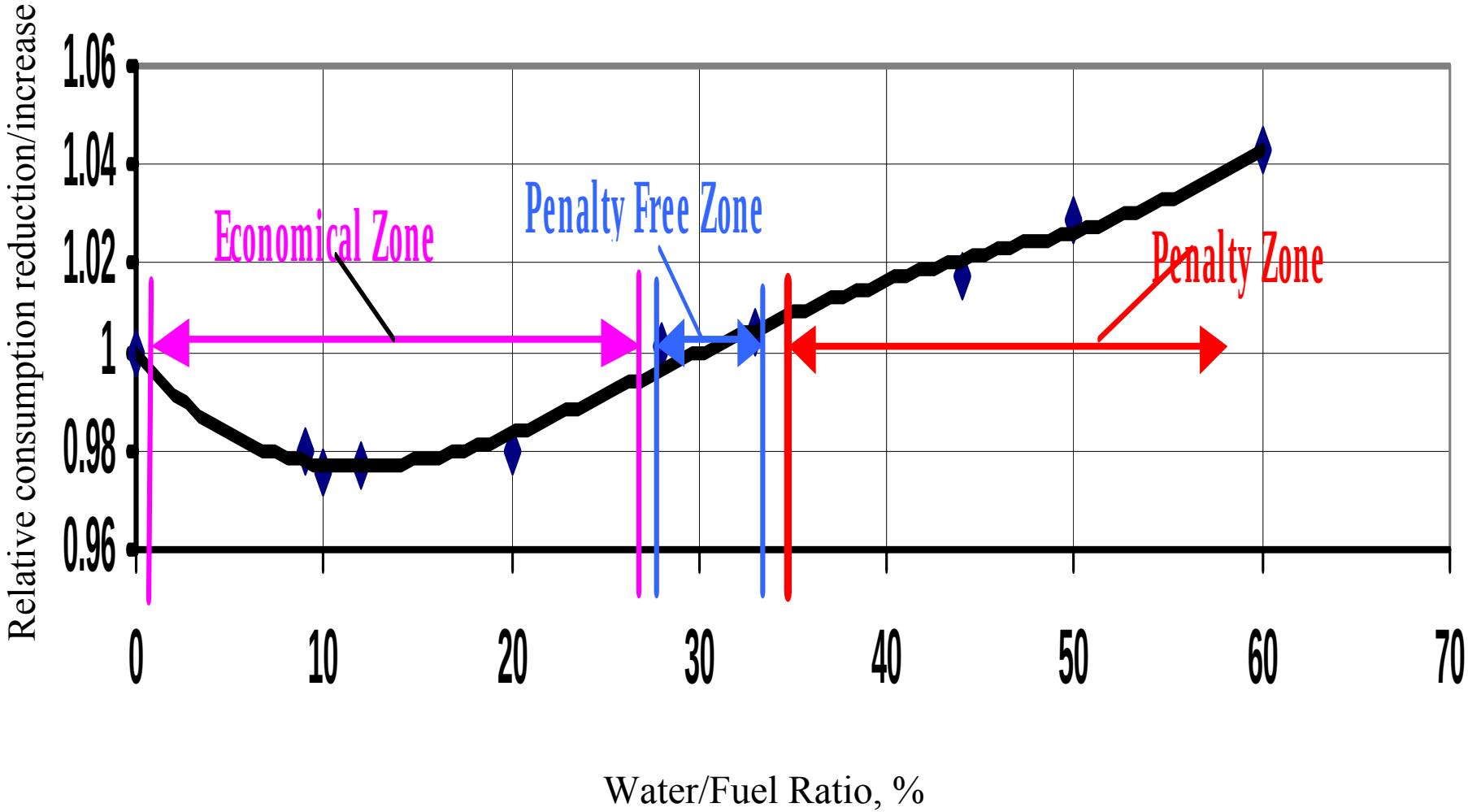
Vancouver, BC

Ship emissions are considered by the USA and other countries authorities as a major global problem that rivals land-based air pollution sources of nitrogen oxides (NOx) and acid-rain causing sulphur.

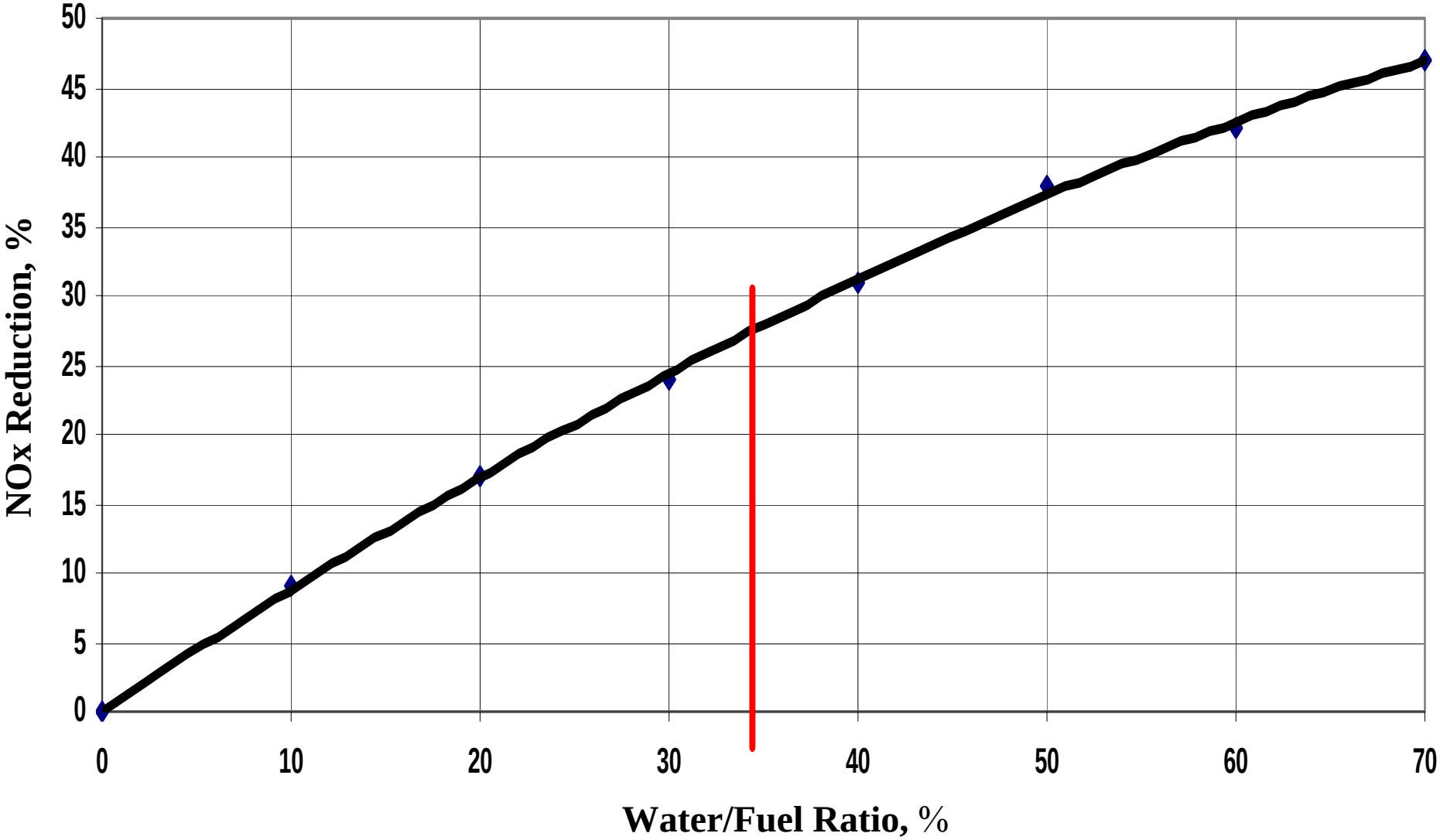
Therefore, each year Governments and Local Regulators raise the bar for emission compliance a little higher.

EPA has recently enforced NOx regulations proposed by IMO for new vessels build under American flag.

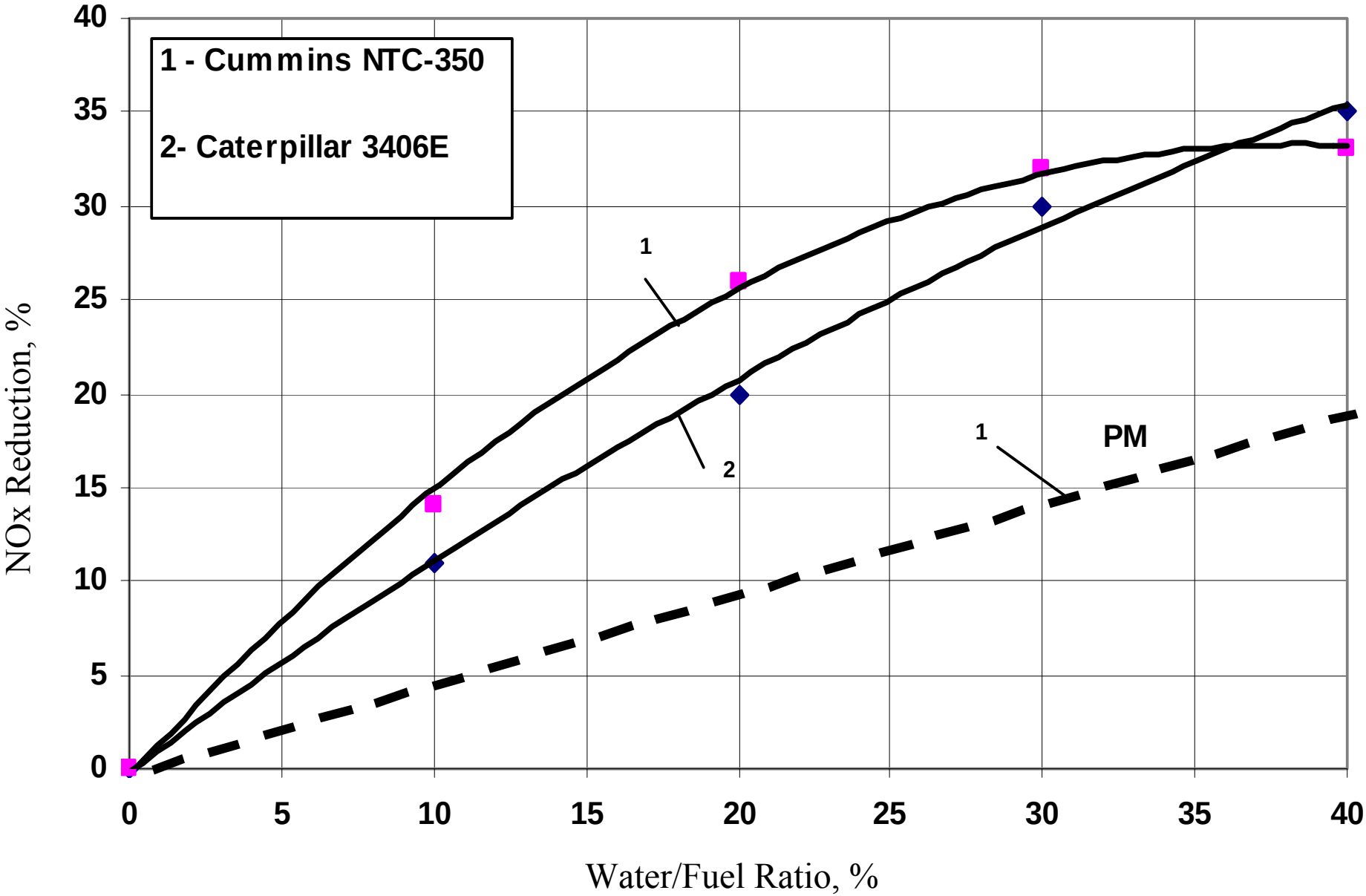
Relationship between Water/Fuel Ratio and relative specific fuel consumption



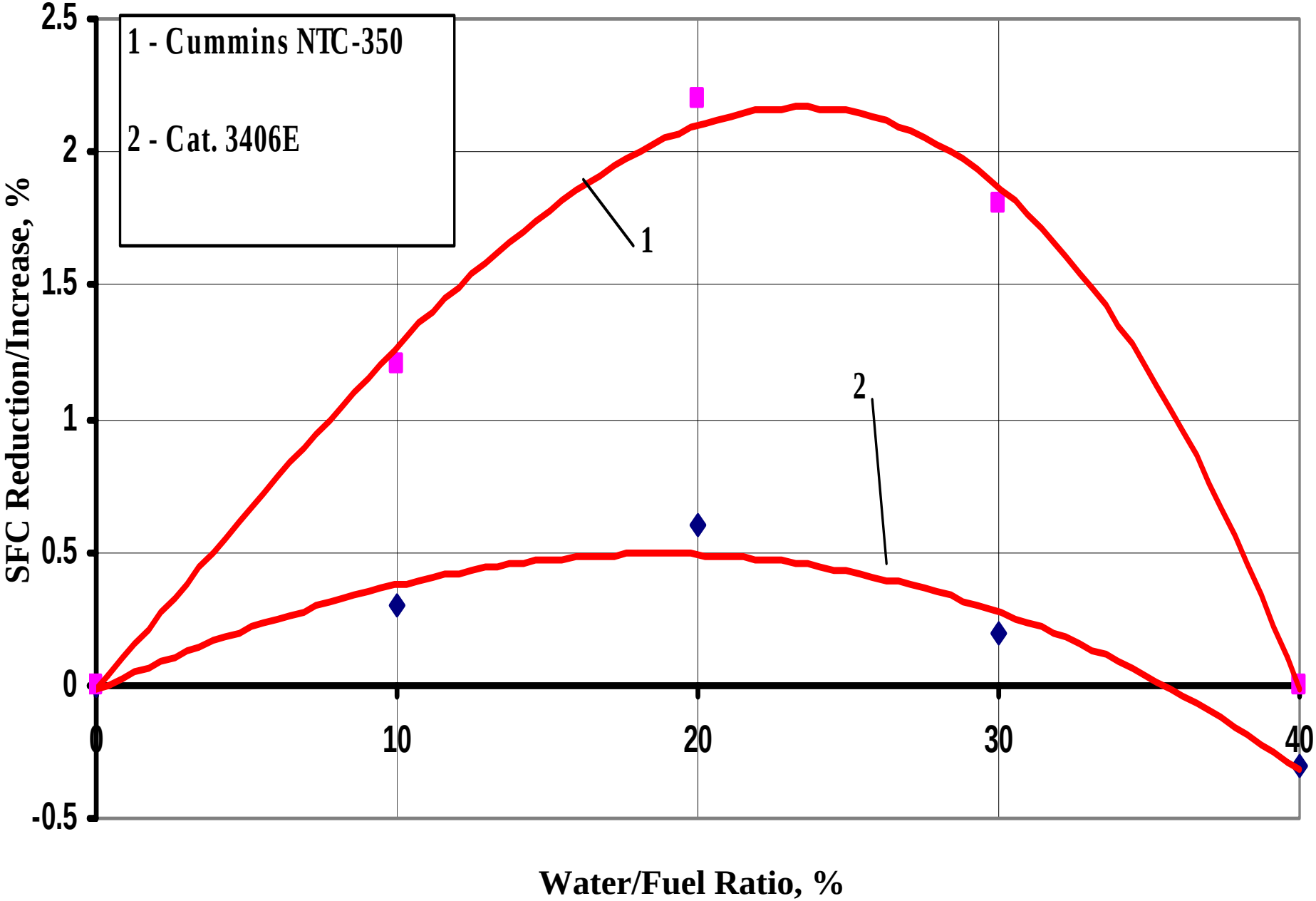
Theoretical Effect of Water Injection on NOx Formation



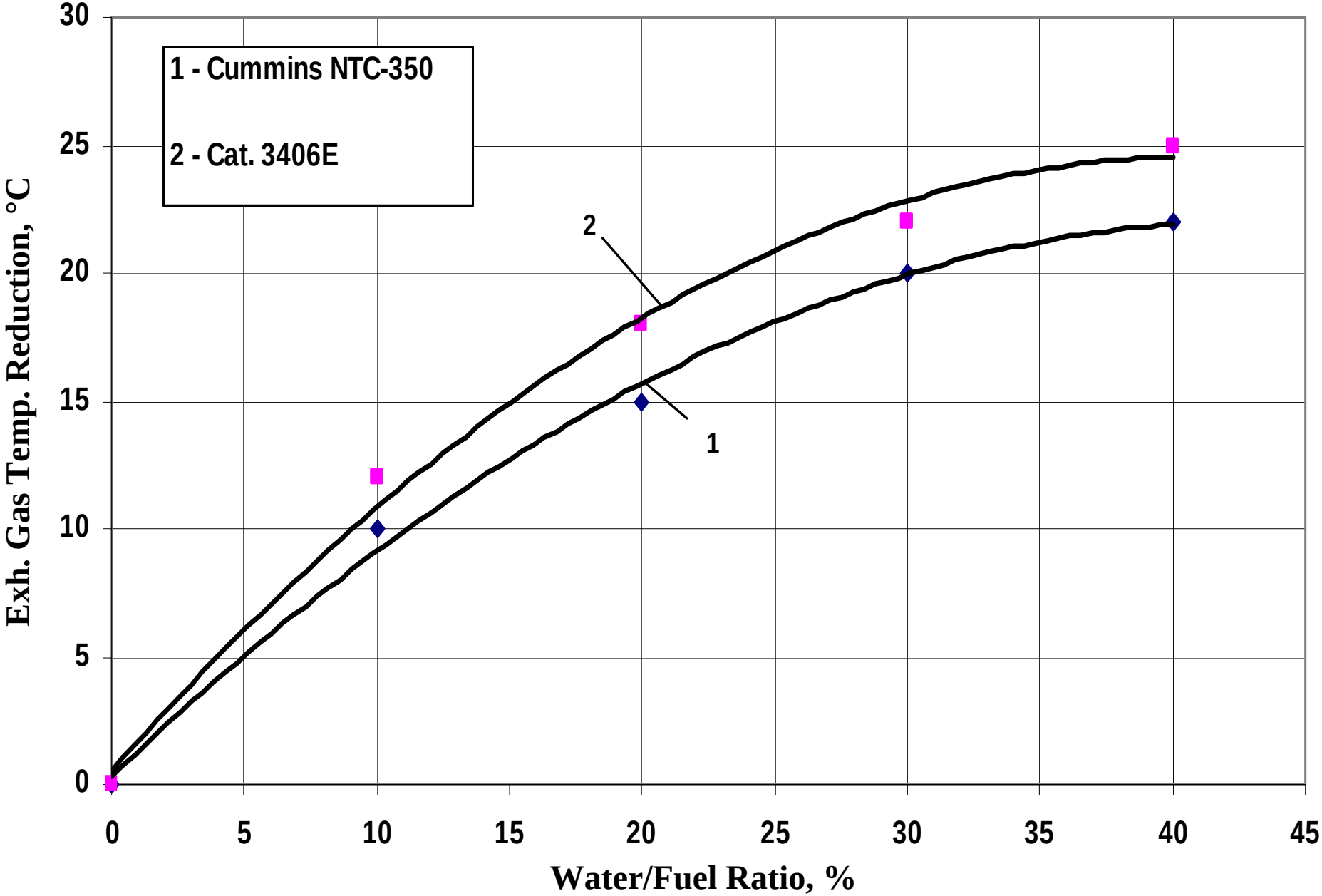
Influence of Water Injection on NOx and PM Emissions



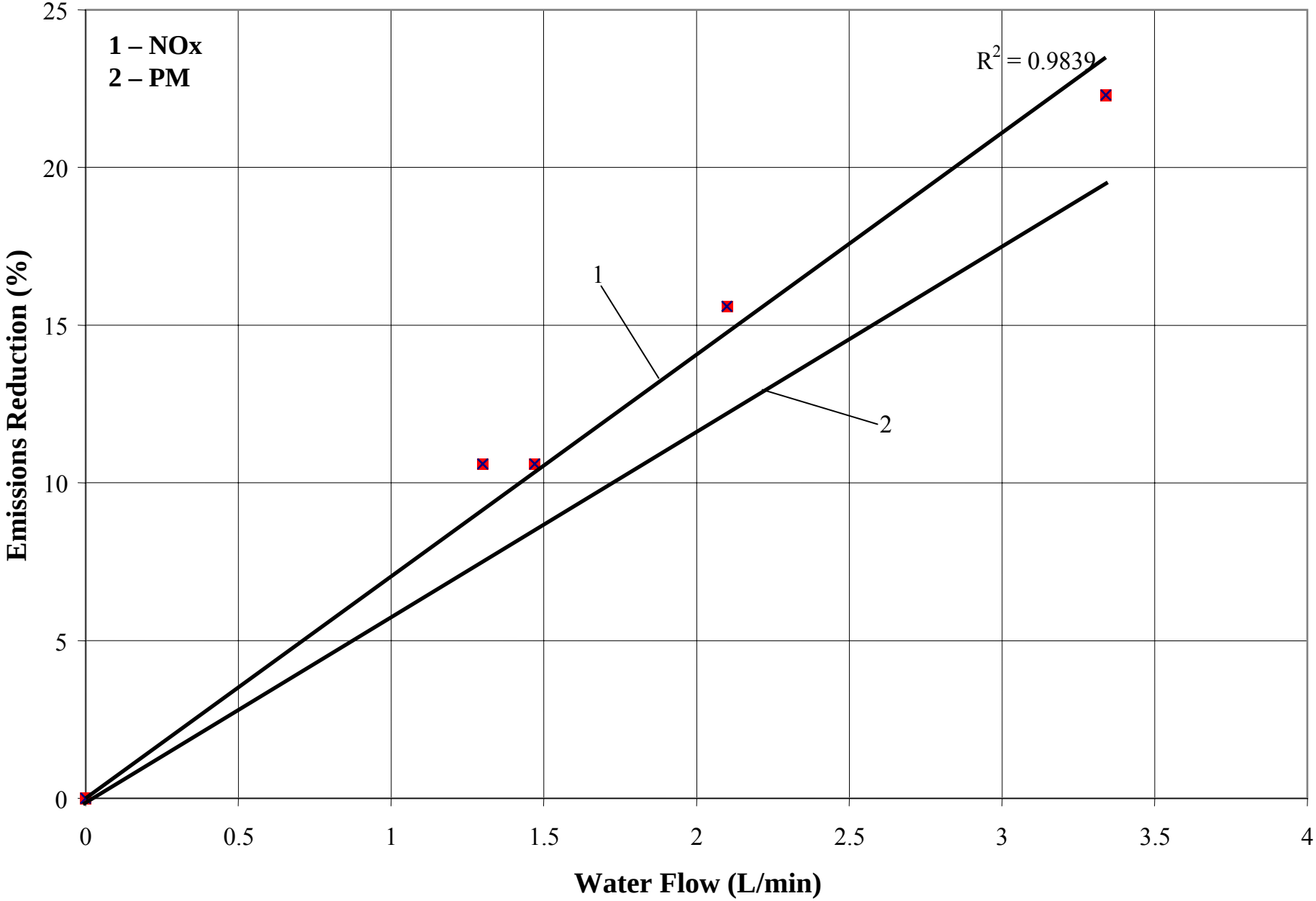
Influence of Water Injection on Specific Fuel Consumption



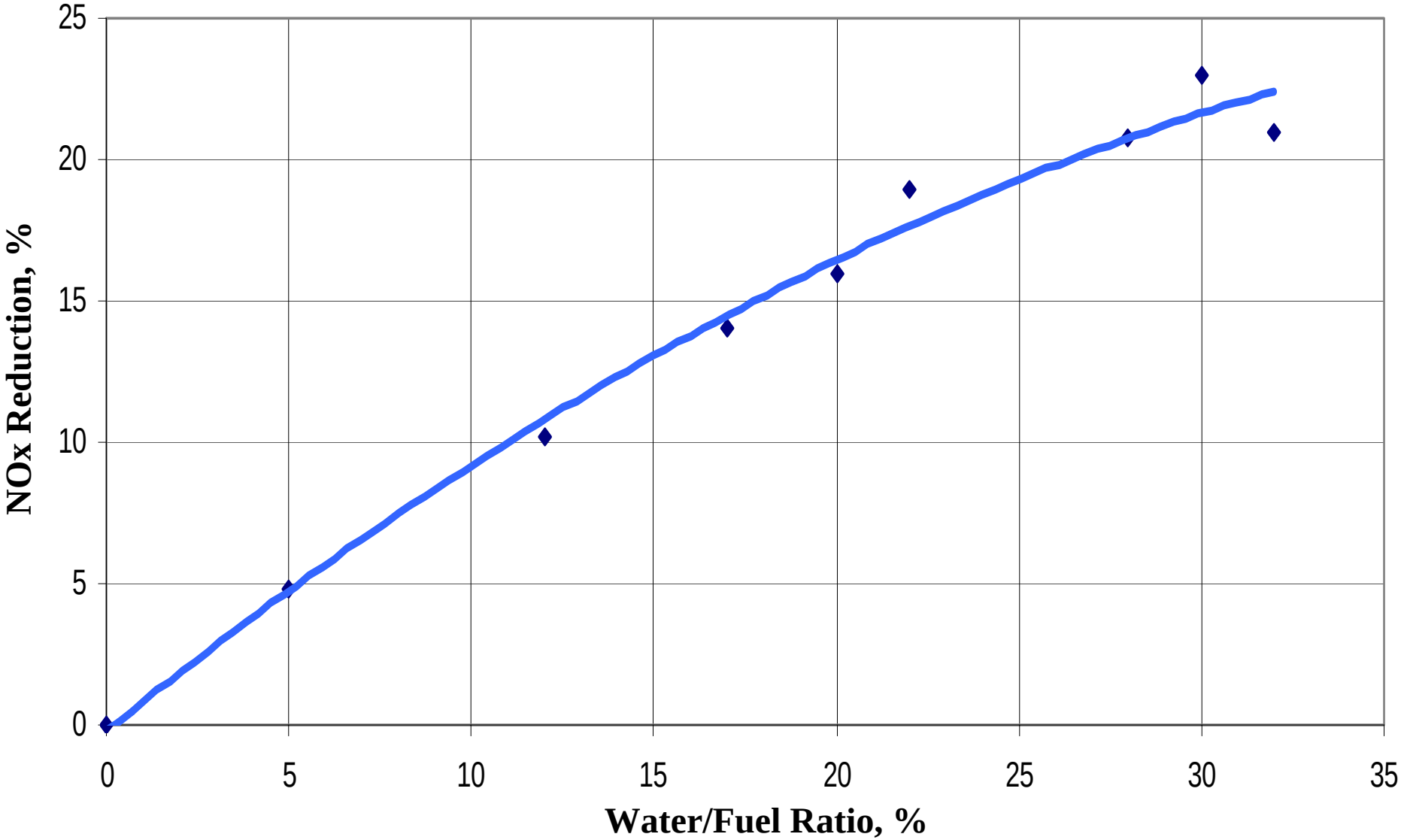
Influence of Water Injection on Exhaust Gas Temperature



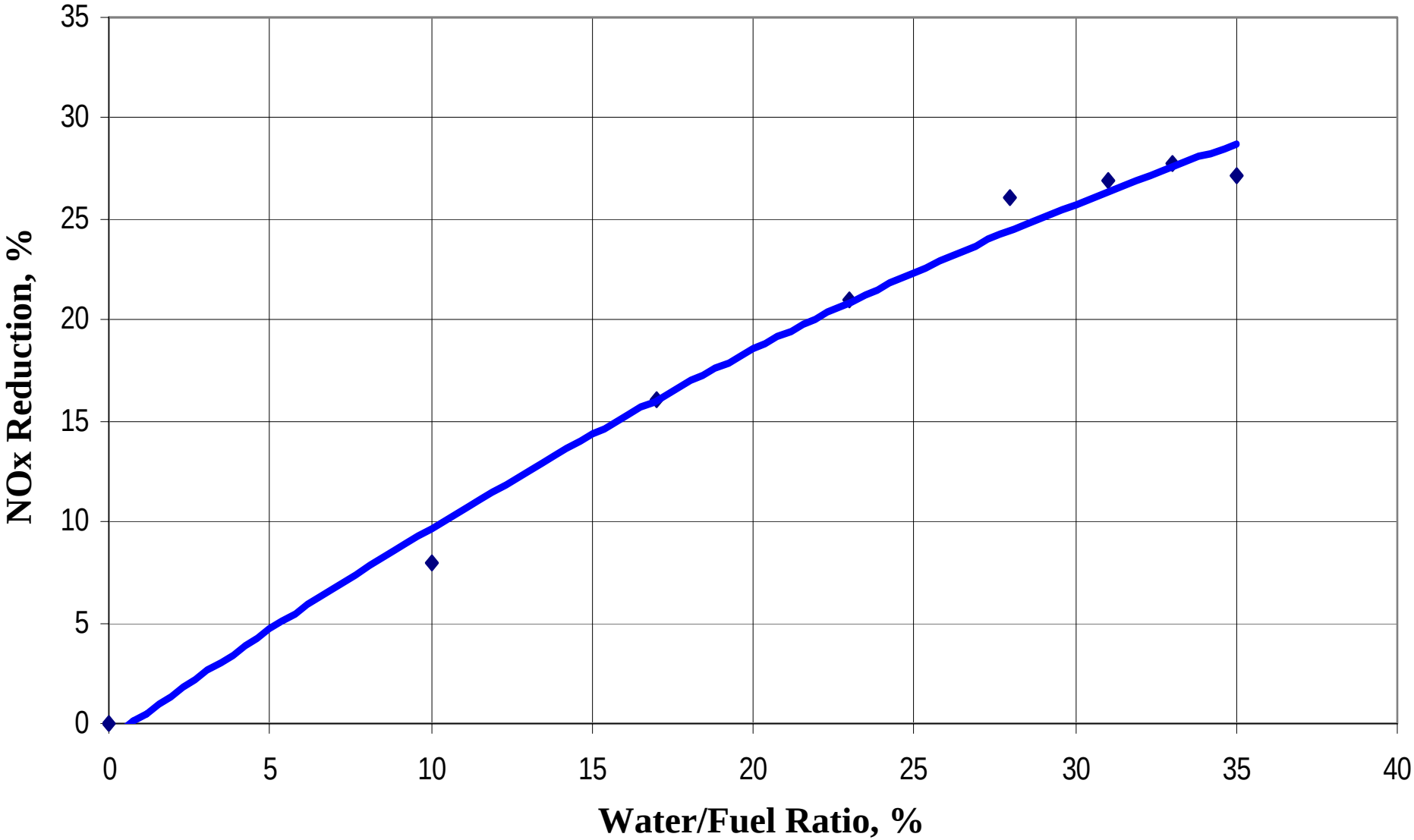
Emission Reduction on the Ferry of New Westminster



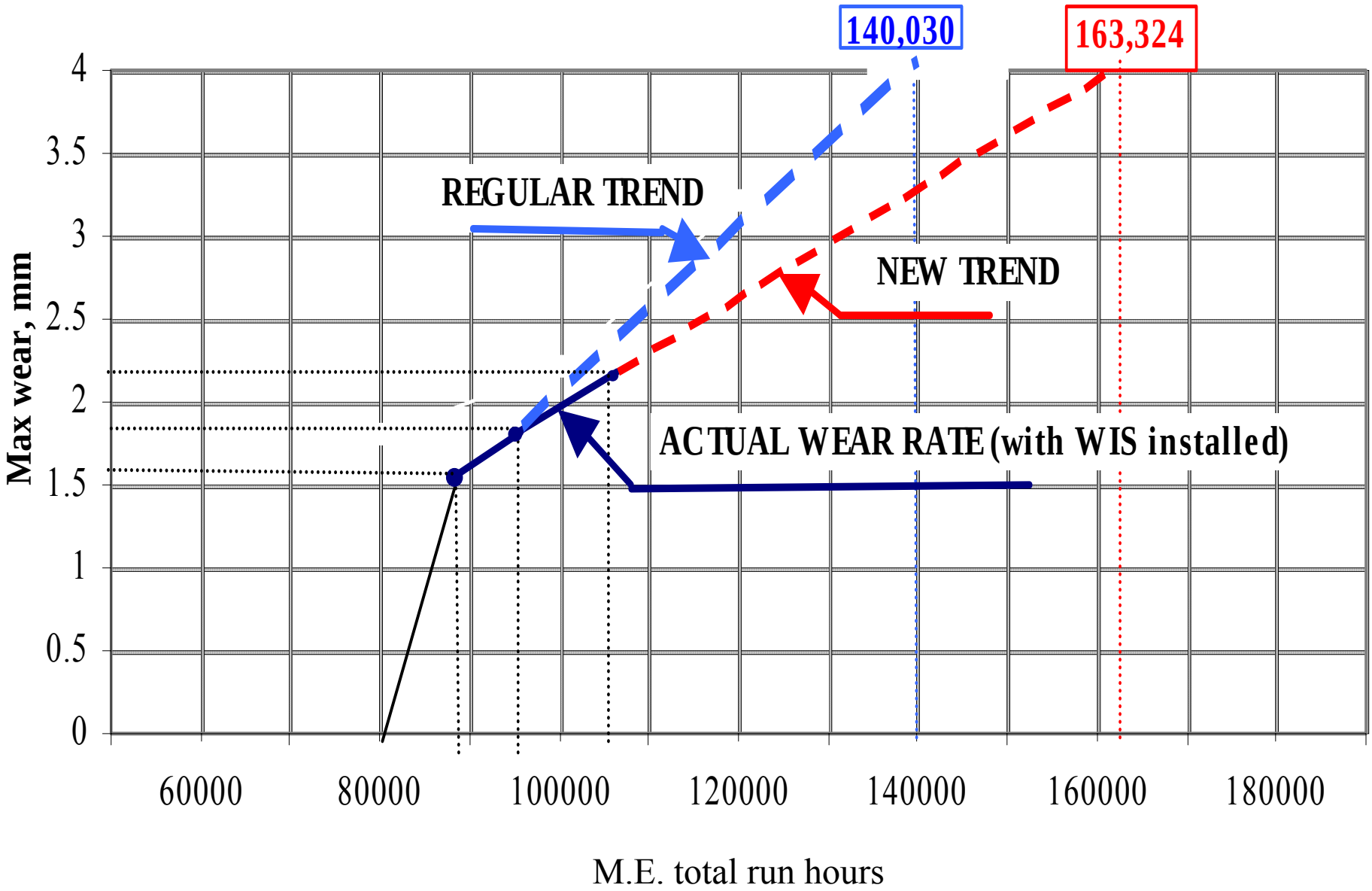
NOx Reduction versus WFR
(Bebedouro, main engine)



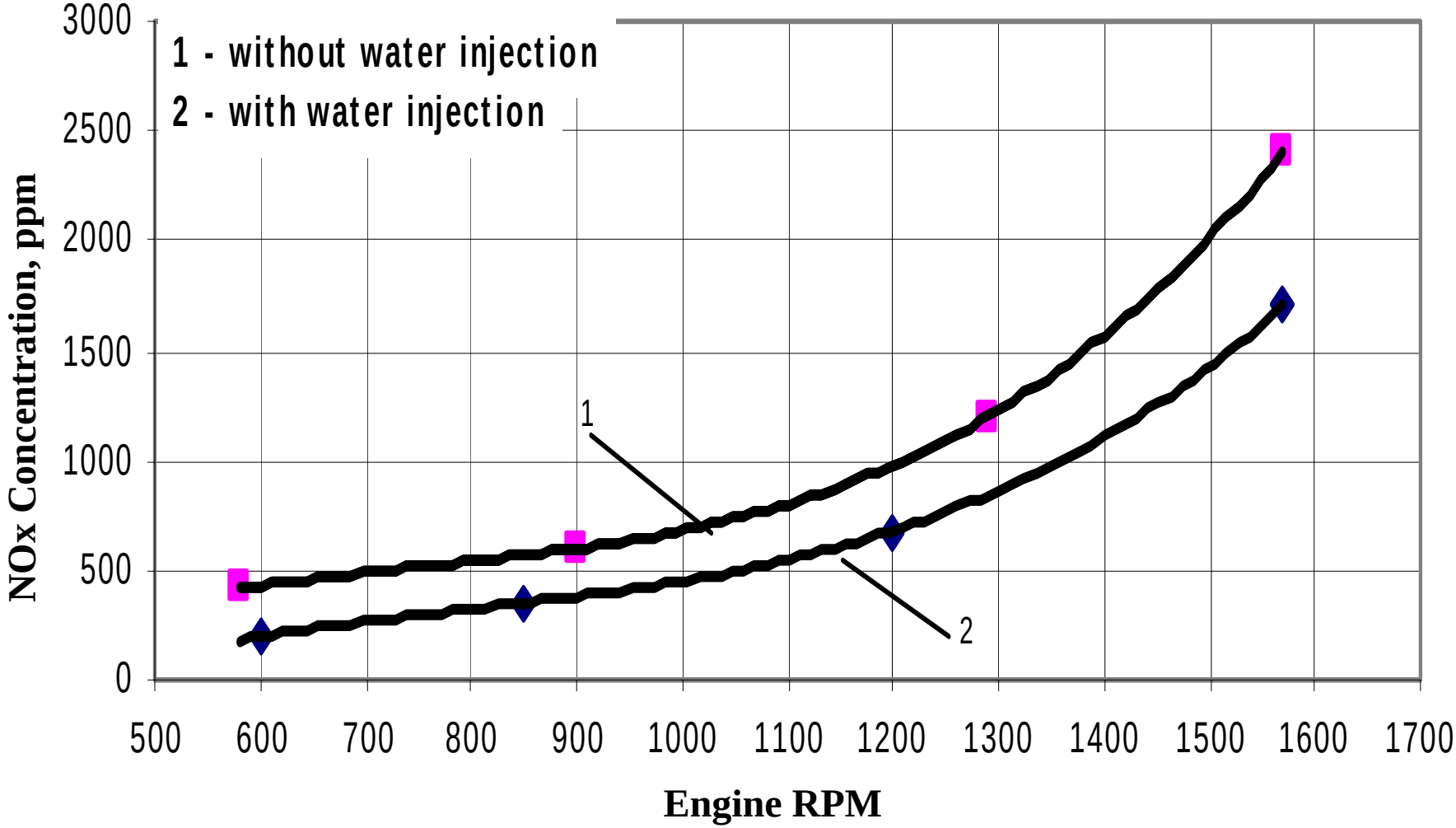
NOx Reduction versus WFR
(Bebedouro, auxiliary Wartsila engine)



M/V BEBEDOURO



Influence of Water Injection on NOx Emissions
Detroit naturally aspirated engine, ferry Oski



Influence of water injection on NOx and fuel consumption; ferry New Westminster, 3508 Caterpillar auxiliary engine

Load, kW	REDUCTION, %		Water/Fuel Ratio, %
	Fuel consumption	NOx Emission	
200	3.26	27.05	30.13
210	3.12	26.01	29.29
220	3.17	25.80	28.46
230	3.26	25.50	27.96
250	3.39	25.00	26.83

Algoma Central Marine engines retrofitted with WIS

Vessel	Engine					
	Main			Auxiliary		
	Type	Power, HP	RPM	Type	Power, HP	RPM
Peter R. Cresswell	MAK 6M552	4,800	500	Cat D399	1,000	1,200
Algosoo	10PC2V MK2	5,350	500			
Algocape	Sulzer 6RD76	9,600	119			

Notes:

1.Peter R Cresswell and Algosoo are equipped with two main engines, while Algocape has one main engine.

2.Algosoo has three auxiliary engines. WIS was retrofitted to all engines.

Algoma Central Marine engines test results

Vessel	Engine	Weighted NOx, g/kW-hr		IMO/EPA standard g/kW-h	WFR %
		Without water	With water		
Algocape	**Sulzer 6RD76**	**17.7 (+)**	**16.2 (-)**	***17.0***	**9.7**
Algosoo	**Pielstick 10PC2V**				
	STBD	**14.2 (+)**	**12.7 (-)**	***13.5***	**10.0**
	PORT	**14.2 (+)**	**2.8 (-)**	***13.5***	**10.0**
	Cat. D399	**8.4 (-)**	**8.10 (-)**	***10.9***	**3.2**
Peter R. Cresswell	**MAK 6M552**				
	STBD	**13.6 (+)**	**12.6 (-)**	***13.0***	**8.4**
	PORT	**13.7 (+)**	**12.4 (-)**	***13.0***	**10.2**

Notes: (+) means results are above IMO/EPA standards;
(-) means results are below IMO/EPA standards

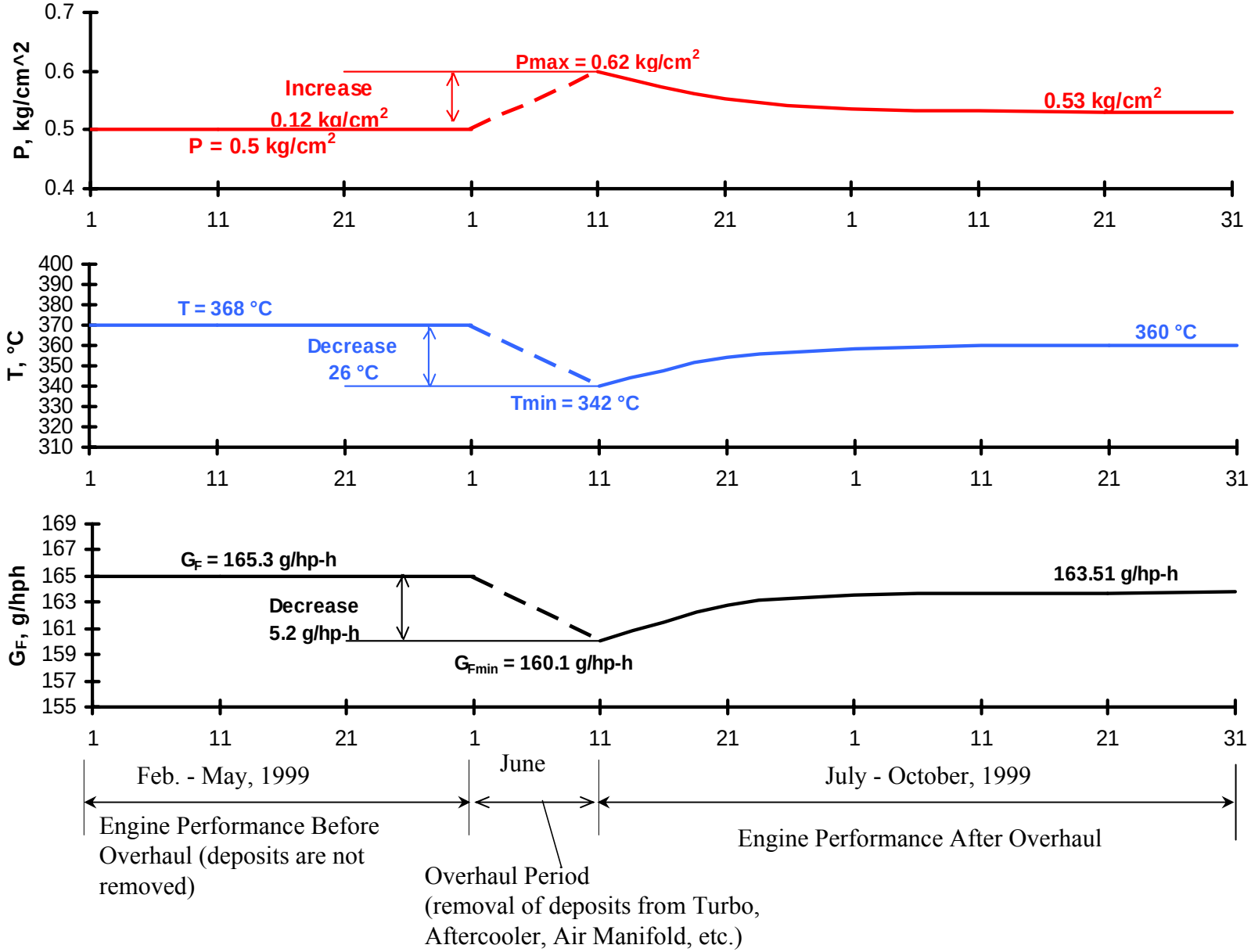
Decrease in turbocharger efficiency by 1 per cent results in the following (under constant engine power):

Supercharged air pressure decreases by 1-2%;

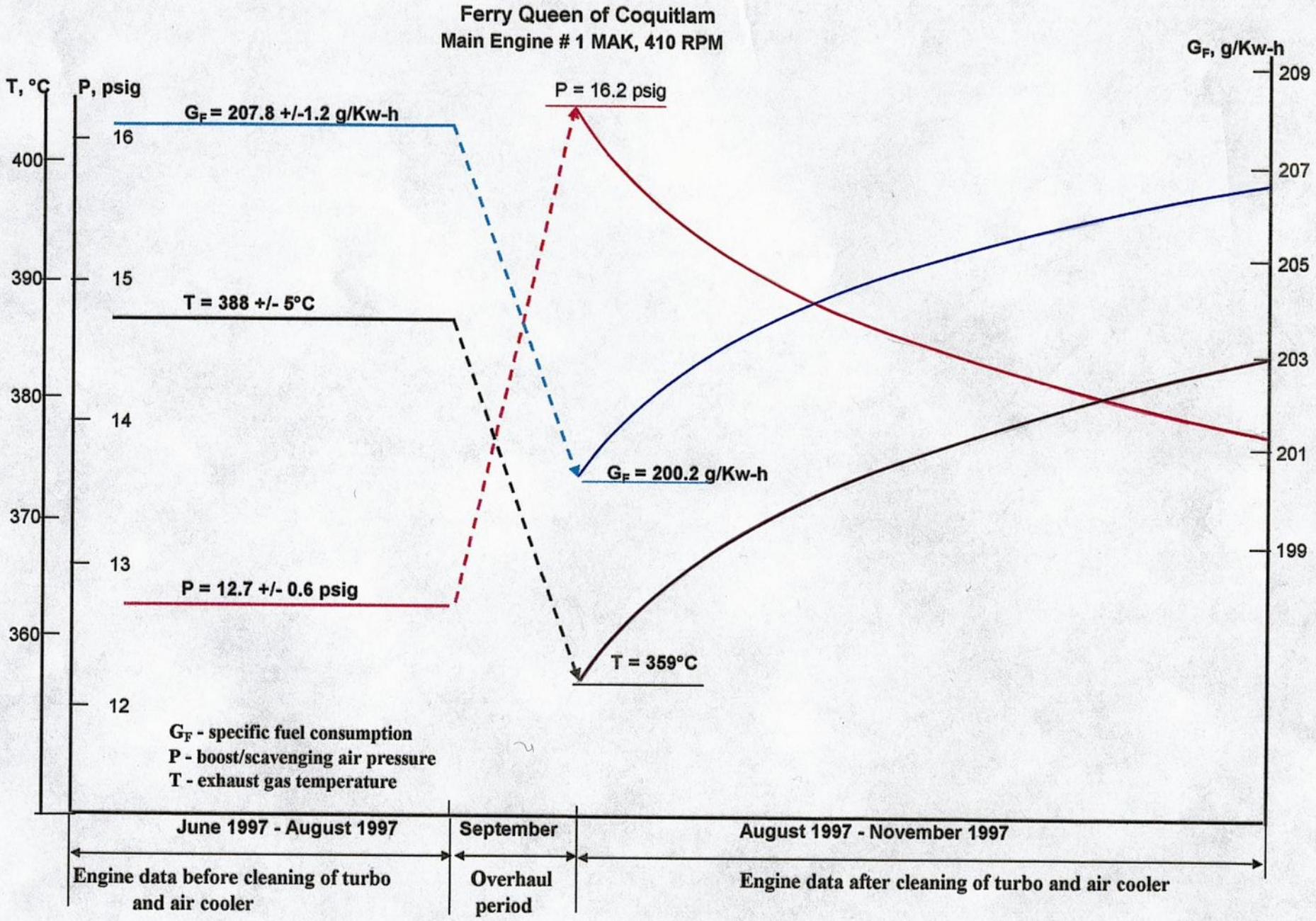
Exhaust gas temperature increases by 30-5%;

Exhaust gas emissions increases by 0.5-1.0%;

Specific fuel consumption increases by 0.2- 0.4%



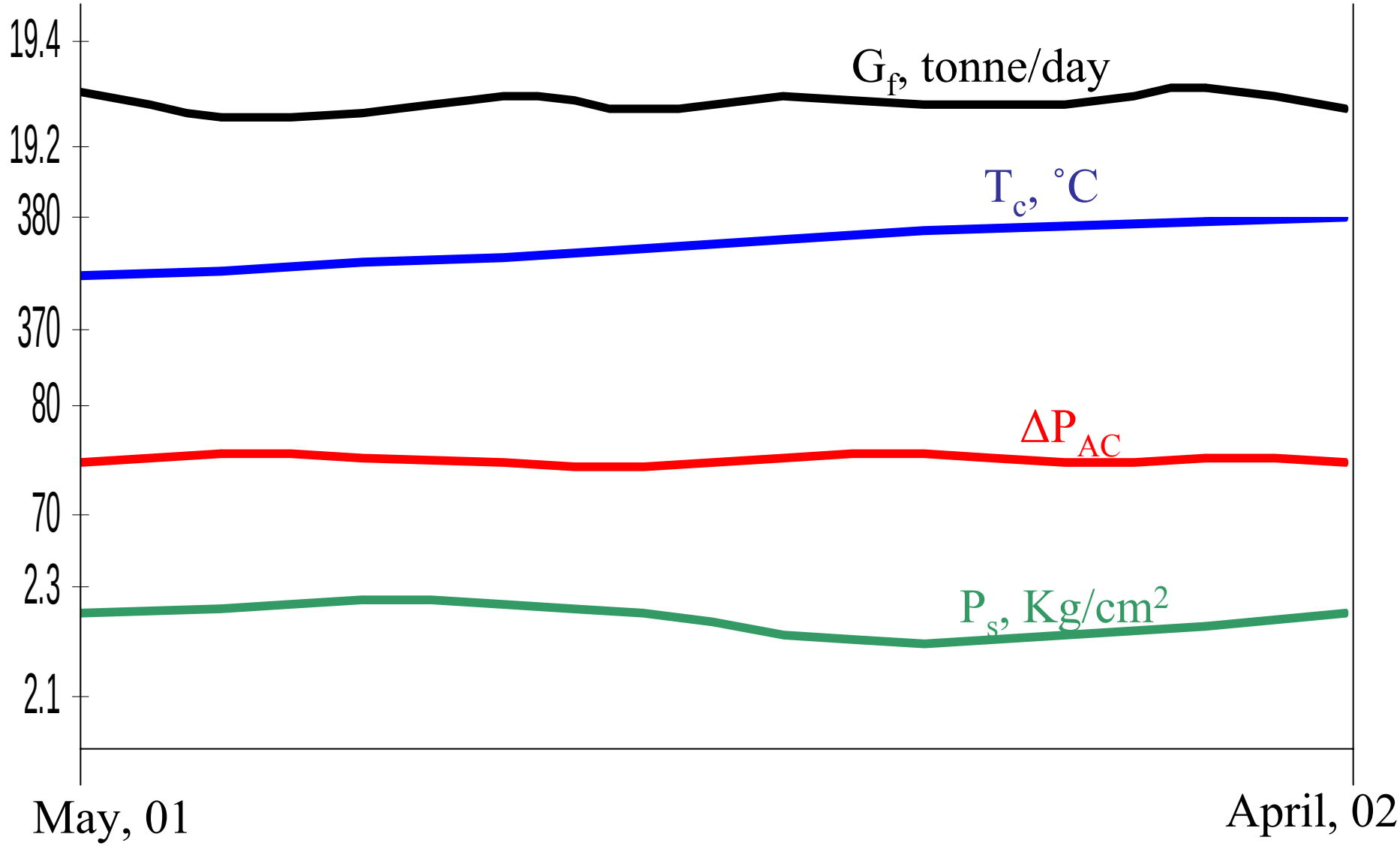
Auxiliary Engine Yanmar 6GL-DT



Relationship between engine parameters and time of operation without cleaning of turbos & air coolers

M/V Bebedouro.

Main Engine Sulzer 4RTA58



Calculation of simple pay-back period for ferry *Queen of New Westminster*

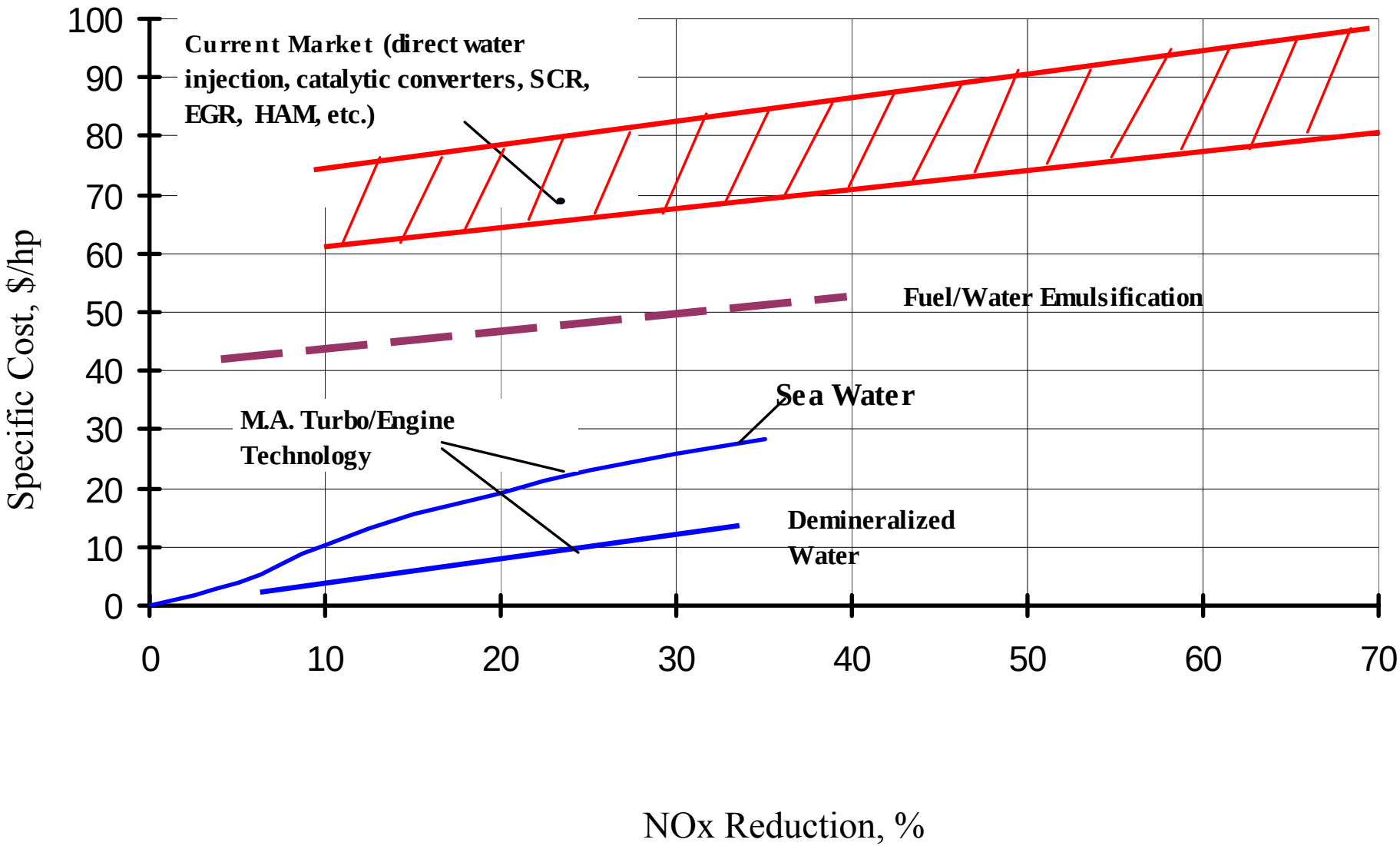
Savings due to WIS operation

Total operational main engines power - 16,000HP
Average fuel consumption for main engines – 6,640t/year @ $460/tonne.
Cost of fuel for main engines $3,054,400/year
Savings for main engines due to WIS (1.4%, based on ERMD test results) - $42,760/year
Average fuel consumption for three auxiliary engines – 600t/year @ 460/tonne
Savings for auxiliary engines due to WIS– $5,500/year
Total fuel savings - $48,200/year
Spare parts savings due to reduced exhaust gas temperature (estimated) - $6,000/year
Reduction of maintenance cost due to clean air coolers, manifolds, etc. (estimated) - $7,000/year
Total savings - $61,200/year

Expenditures

CWI System cost including installation (for four main and three auxiliary engines) - $90,000
Cost of water supply- $2,500/year (BC Ferries data)
Spare cartridges - $ 1,200/year
Total expenditures - $93,700
Simple back period: 93,700/61,200 = 1.5 year =18 months

Specific Cost of Different NOx Control Technologies



Benefits of Water Injection Technology

- Increased efficiency of the combustion process and reduced fuel consumption up to 5%
- Exhaust gases temperature reduction up to 25°C
- Reduced formation of NOx up to 30% and smoke emission up to 20%
- Reduction in peak combustion temperature
- Minimized thermal stresses on the engine components
- Prevention of carbon buildup on the cylinder walls, turbochargers, air coolers, suction valves, scavenging manifolds, etc.
- Increased overhaul period
- Reduced maintenance cost up to 25%