Case Study

PETROZUATA'S

Agar Multiphase Flow Meter

Heavy Oil Application

Luigi Bortolin - Petrozuata

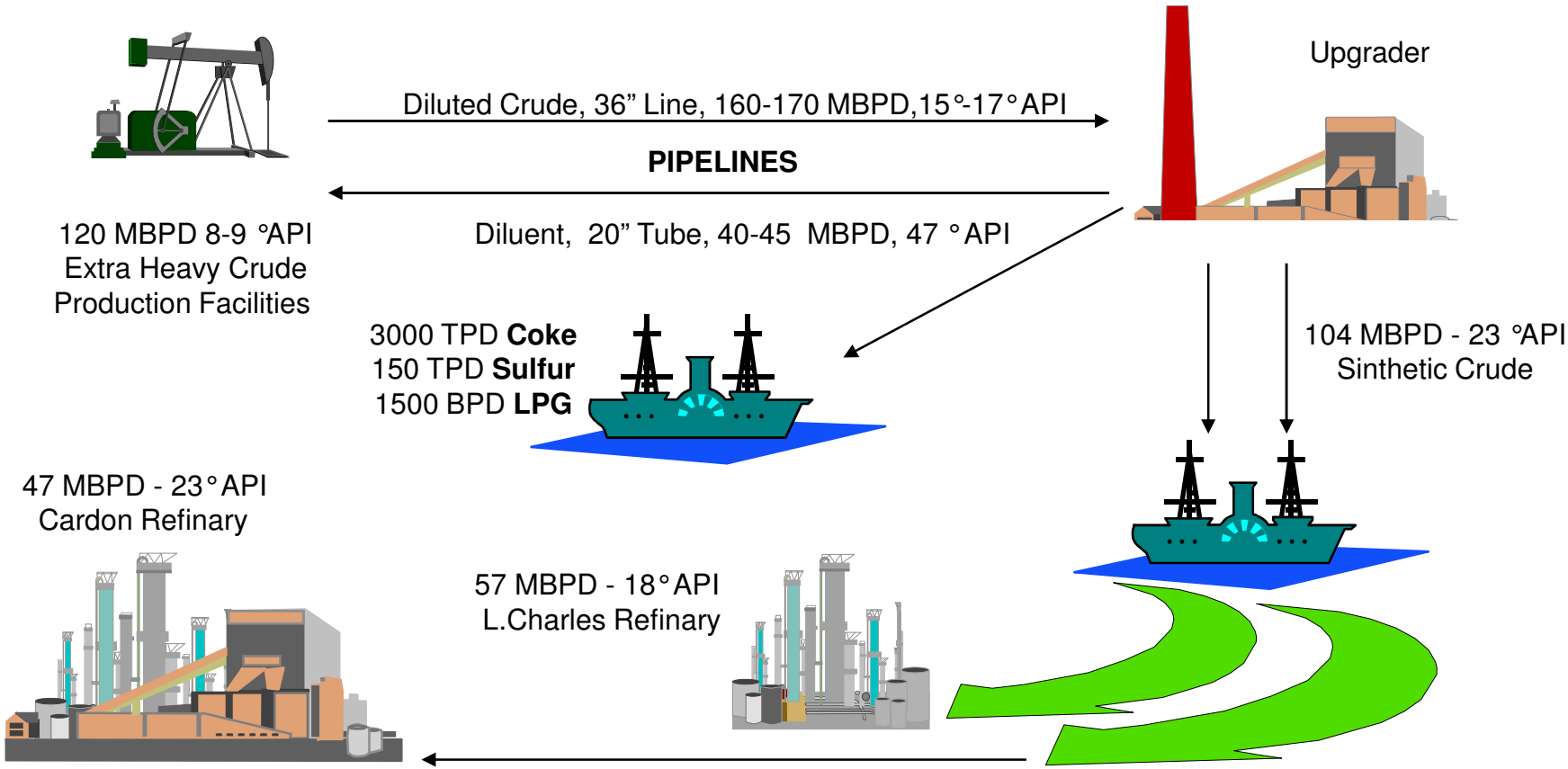
Parviz Mehdizadeh - Production Technology Inc.

Gordon Stobie - ConocoPhilips

AGAR CORPORATION
Process Measurement & Control Solutions

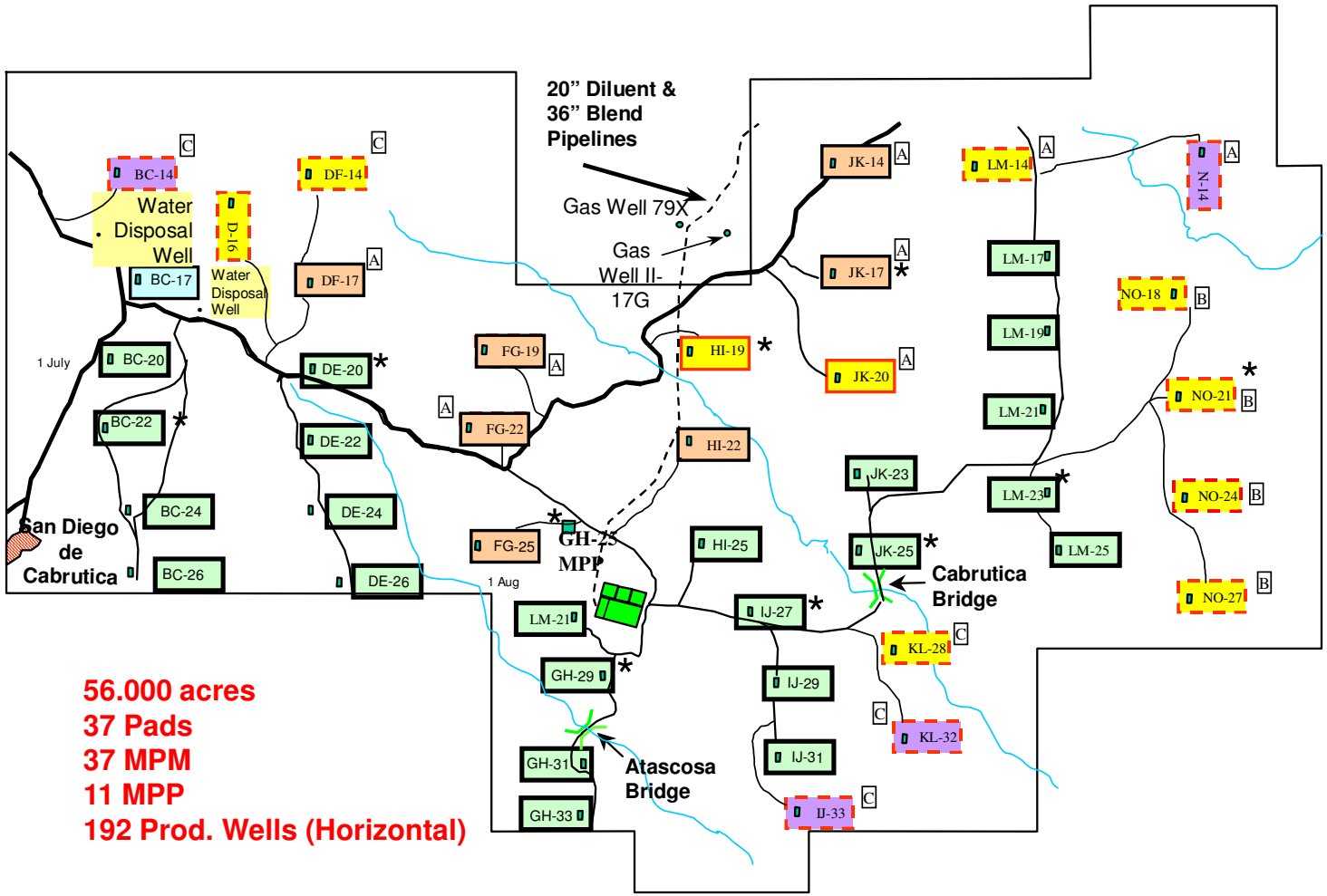
Petrozuata Development

Production - Pipeline transportation- Refining



Petrozuata Development

Field development showing extent of production area and well pads.



56.000 acres
37 Pads
37 MPM
11 MPP
192 Prod. Wells (Horizontal)

Petrozuata
Heavy and Extra Heavy Oil

Two of the major problems with metering, transporting and processing Heavy and Extra-Heavy Crude Oil are:

1. Viscosity effects
2. Emulsions
   - Gas-Oil (Foams)
   - Oil-Water (Viscosity variations)

MPFM Implementation & Testing Concerns

There were a number of concerns over the use of MPM's with Heavy Oil

1) Viscosity and viscosity variation effects
2) Temperature (original design with Thermal recovery)
3) Diluent (an option to 2 above)
4) Calibration frequency and procedures
5) High gas void fractions (GVF)
6) Effects of incomplete mixing
7) Field data capture and transmittal, particularly with downhole diluent injection

Vendor Selected: Agar

The primary key to the selection was the density variations expected in Petrozuata's application

Other reasons for selection

1. **No nuclear radioactive source**

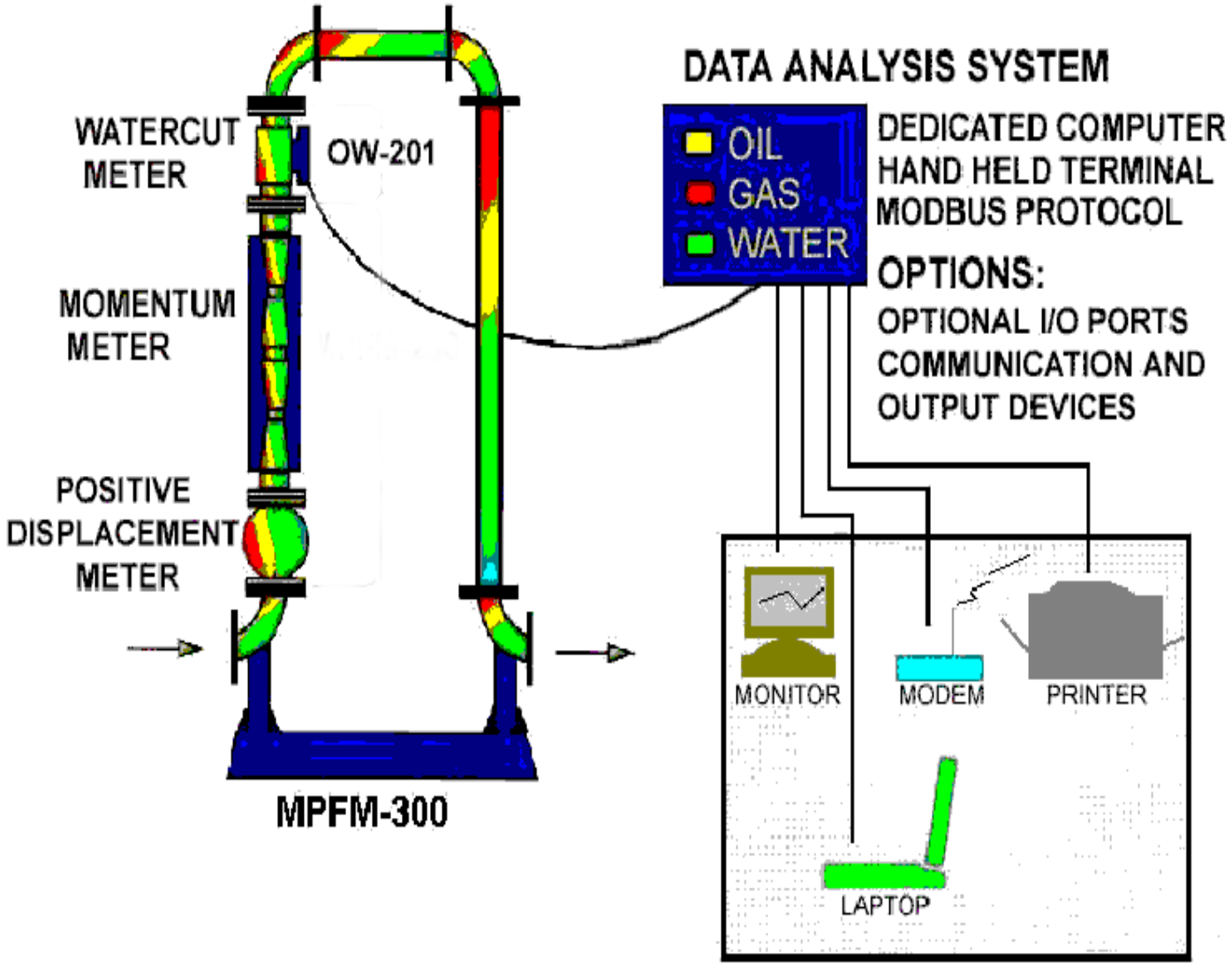
2. **PD meter was perceived to be able to handle the viscous flow regime**

3. **No knowledge of fluid properties was required**

4. **Worked well at both oil-continuous and water-continuous and in the cross over range** *(Microwave Water-cut)*

5. **Volumetric Meter Verification** (*measuring devices were capable of being checked against each other volumetrically).*

THE AGAR MPFM 300 SERIES



Testing Conclusions

Some basic conclusions from the MPM tests

The MPM selected uses a PD meter as the prime element for total volumetric measurement.
The volumetric measurement is un-affected by fluid properties such as density, WC, GVF & salinity, and relatively unaffected by viscosity.

It was felt that the PD meter gave a robust measurement in heavy viscous fluids.

Venturi measurements were felt to be overly affected by the density and the variable viscosity effects of the diluted crude.

Testing Conclusions, cont'd

The PD meter is perceived to provide an additional advantage.
This relates to the slip between the fluids. The fluids entering the PD meter generally travel at different velocities, but when leaving the PD meter, they appear, for a short time, to travel at the same velocity as they enter the dual Venturi. Thus the selected MPM would not need a slip model.

The microwave water cut monitor performed well in tests.
During the testing program there was thought that steam condensate if thermal operations were used, would impact the water salinity.

Design Well Rate Parameters

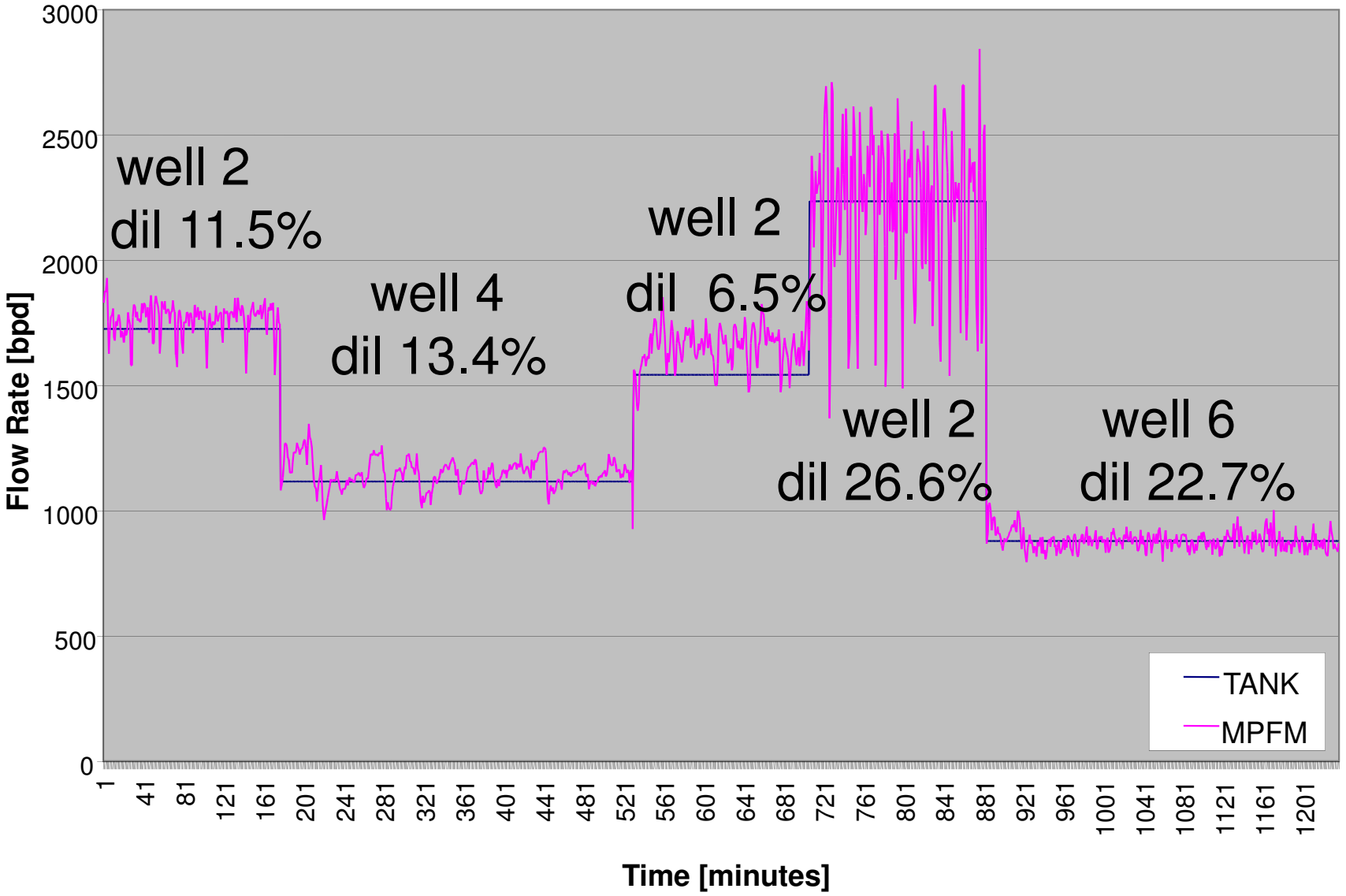
	Well Rate Ranges	
	Normal	Extreme
Blend (X-Heavy + Diluent)		
BPD/Well.....	500 - 2000	<100, > 3000
Watercut - %.....	0.5 - 2	5 - 20
Gas Oil Ratio -SCF/Bbl.....	100 - 200	300 - 1000

Extra-Heavy Crude @ 7-10° API

Diluent Properties @ 47° API Naptha

Blend – (Extra Heavy plus Diluent) @ 15-16° API

Comparison Between the MPM and Tank tests



Early Operating Experience
Key Learnings

- The Meter performed well when compared to the liquid tank tests. However field adjustments were required to extend the dynamic range of the meter at low flow rates.

Some electronic components exhibited early failures which could be explained (water ingress). Some component change outs required software updates which were not performed. Other failures were less explainable.

- A rigorous Preventive Maintenance and Training program was perceived to be the key to keep the meters operating properly…..these programs were put in place with the operator and vendor cooperation

MPM Testing

Volumetric Flow Test Verification

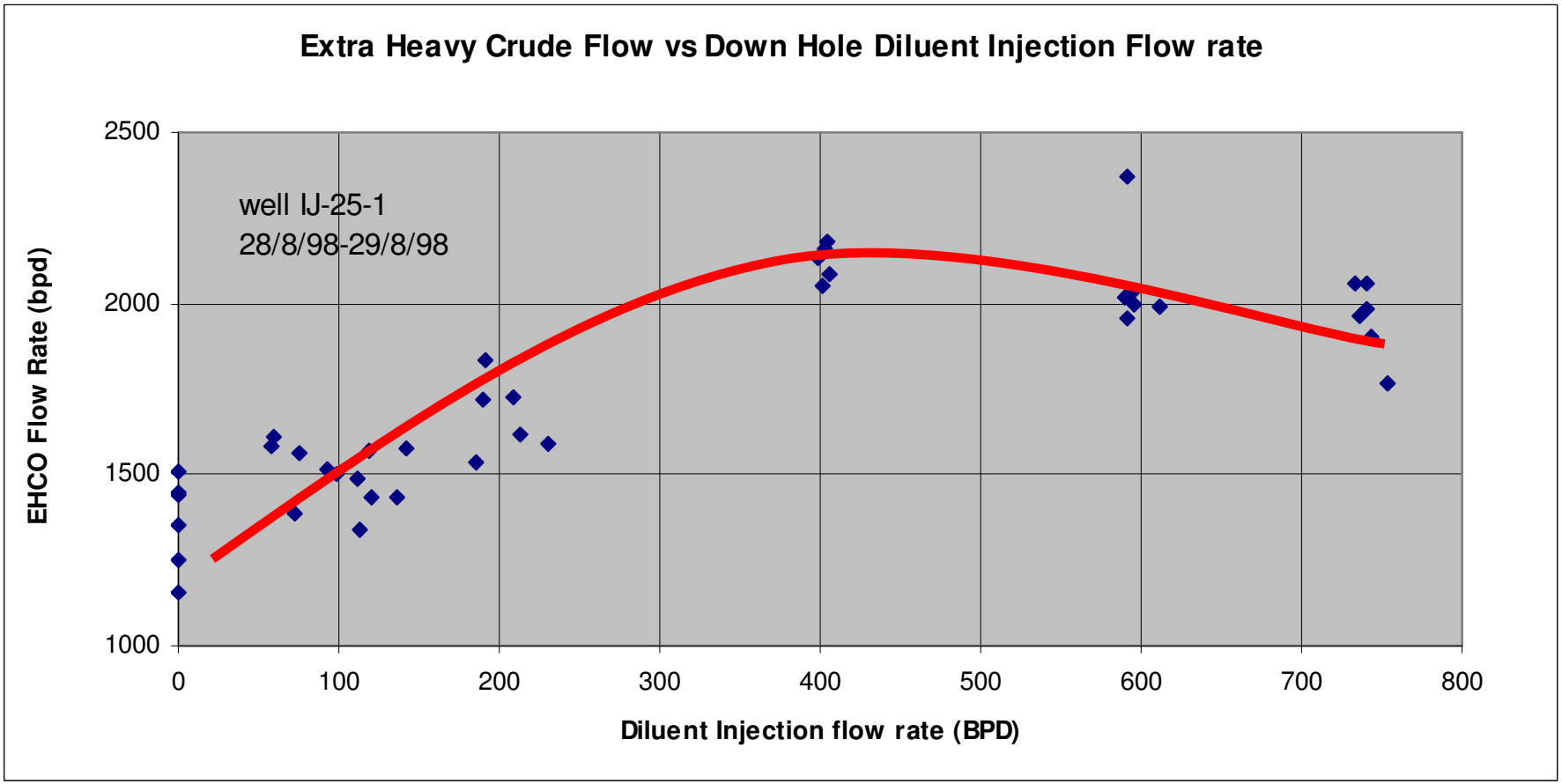
In addition to instrument calibrations there is a system test (SVT) to demonstrate the veracity of the MPM

1) This is a single phase flow test using the performance of the PD meter to act as a reference for the dual venturi

2) Since the same fluid is flowed through both meters, the outputs from the meters can be matched to the original factory calibration settings

3) In carrying out this test any failures in the Venturi or PD measurements can be identified

Well Flow Optimisation



Overall Assessment

- In an unconventional operation (ESP/PCP driven, diluent injected wells), the MPM's capability for accurate well testing compare well with conventional test separator.

- Use of Multiphase Technology (MPM & MPP) in this new oil field development has proved to be an economic and technically viable option compared to conventional systems. The savings have been tentatively put at 40% in Capital terms and 35% for OPEX

- Capital savings have been stated as about $35MM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