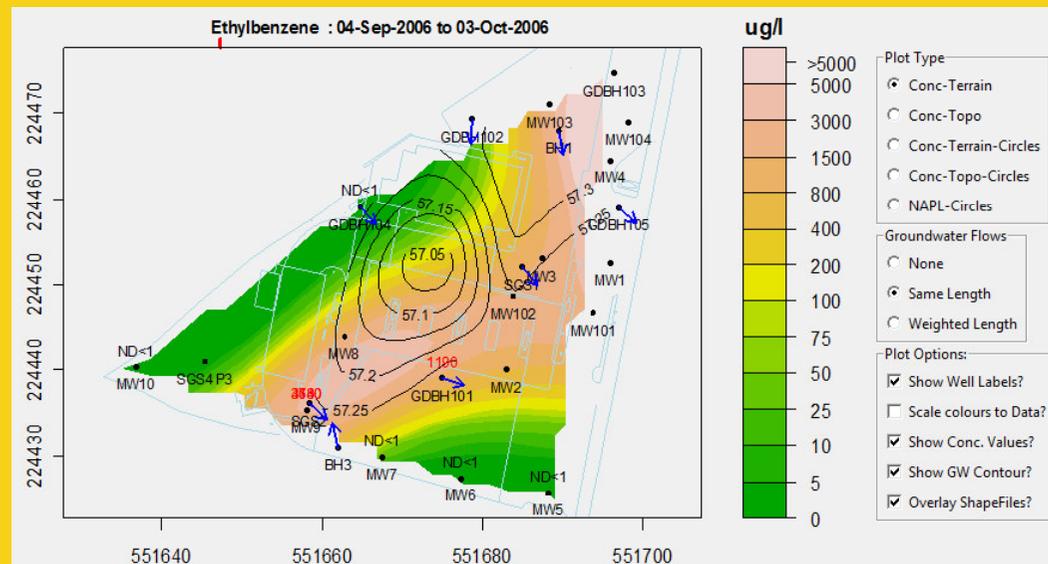




GWSDAT

Ground Water Spatio Temporal Analysis Tool.



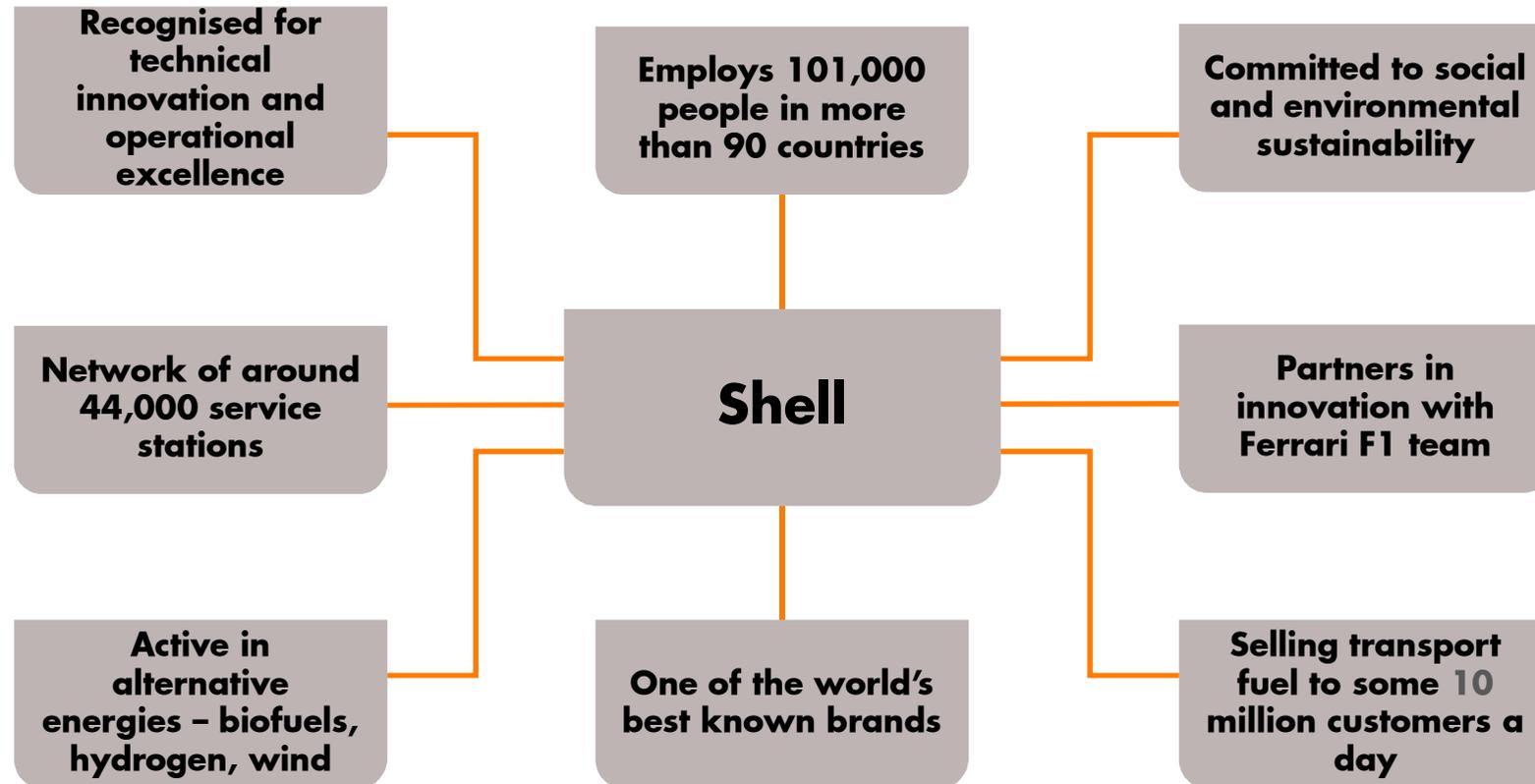
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DEFINITIONS AND CAUTIONARY NOTE

- **Reserves:** Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves for all 2009 and 2010 data, and includes both SEC proved oil and gas reserves and SEC proven mining reserves for 2008 data.
- **Resources:** Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves or SEC proven mining reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.
- **Organic:** Our use of the term Organic includes SEC proved oil and gas reserves and SEC proven mining reserves (for 2008) excluding changes resulting from acquisitions, divestments and year-average pricing impact.
- To facilitate a better understanding of underlying business performance, the financial results are also presented on an estimated current cost of supplies (CCS) basis as applied for the Oil Products and Chemicals segment earnings. Earnings on an estimated current cost of supplies basis provides useful information concerning the effect of changes in the cost of supplies on Royal Dutch Shell’s results of operations and is a measure to manage the performance of the Oil Products and Chemicals segments but is not a measure of financial performance under IFRS.
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ABOUT SHELL



About the Statistics and Chemometrics Team

- Team consists of 17 people working in three countries:
 - UK (Chester), NL (Amsterdam & The Hague), US (Houston)
- Inter-disciplinary:
 - Majority of team are trained Statisticians but others have “seen the light” and come to statistics from other areas (Physics, Material Science and Chemical Engineer).
- The team provides statistical consulting services to all areas of Shell. We have a wide and diverse portfolio of projects.

Project Background

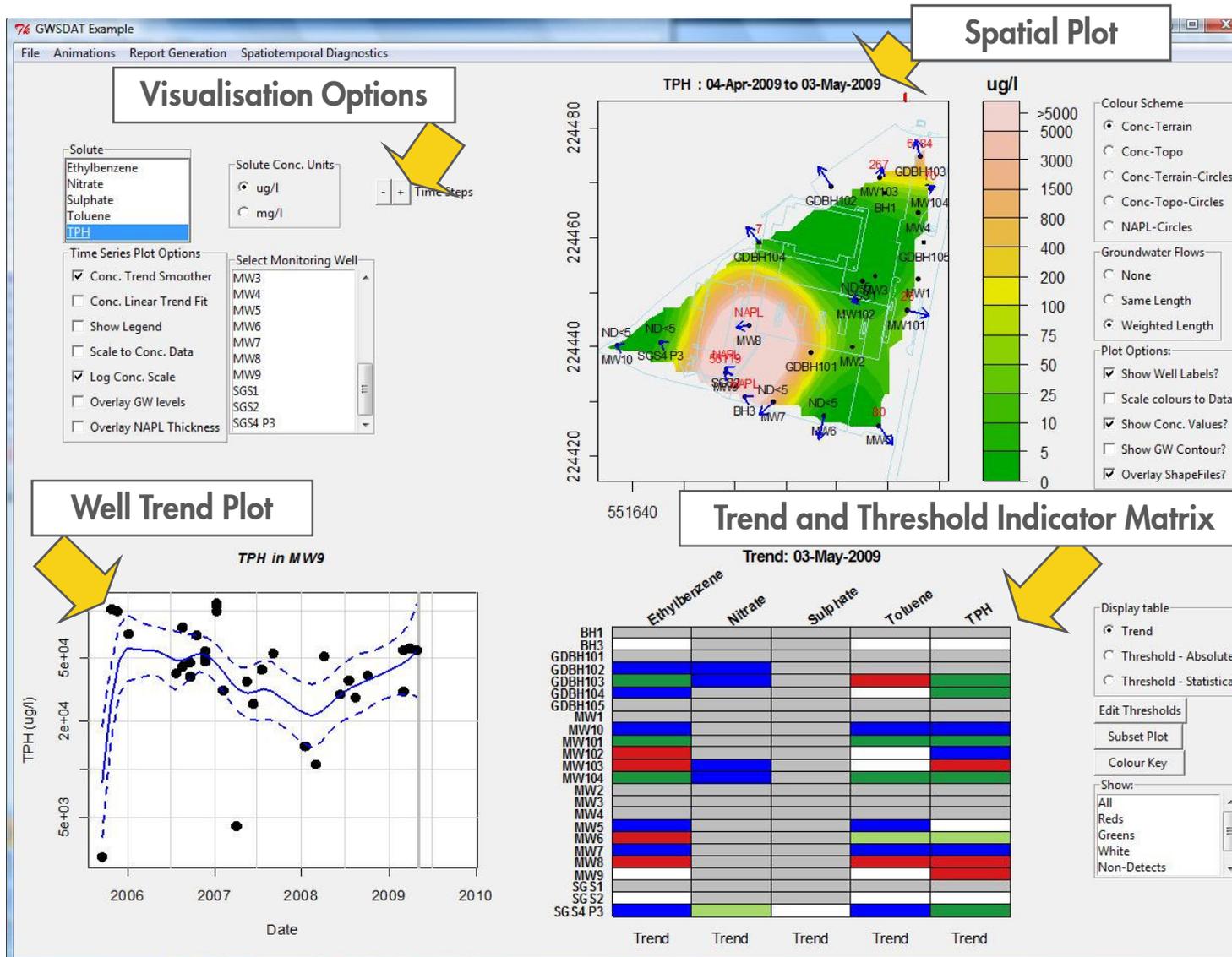
- **Problem:** External environmental consultants collecting huge quantities of groundwater monitoring data but no standardized way to objectively report, analyze and make inference.
- **Consequence:** Poor analysis of data results in lost opportunities for closeout of groundwater monitoring, early leak detection and avoiding unnecessary remediation work.
- **Solution:** Using R, we developed **GWSDAT** (GroundWater Spatio-Temporal Data Analysis Tool) a user-friendly geostatistical software application for the analysis and visualisation of trends in environmental (groundwater) monitoring data.

GWSDAT Data Input

GWSDAT (GroundWater Spatio-Temporal Data Analysis Tool)
Author: Wayne.W.Jones@Shell.com Version: 1.2

Historical Monitoring Data						Well Coordinates				GIS ShapeFiles
WellName	Constituent	SampleDate	Result	Units	Flags	WellName	XCoord	YCoord	Aquifer	Filenames (*.shp)
SGS5 P1	Nitrate	05/11/2009	54.59	mg/l	E-acc	BH1	551689.43	224468.03		C:\GWSDAT_v1.2\GIS Files\GWSDATex2.shp
SGS5 P2	Nitrate	05/11/2009	67.93	mg/l		BH2	551679.43	224426.03		
SGS5 P1	Sulphate	05/11/2009	99	mg/l	E-acc	BH3	551661.93	224430.99		
SGS5 P2	Sulphate	05/11/2009	61	mg/l		GDBH101	551674.93	224439.03		
GDBH102	Ethylbenzene	03/11/2009	ND<1	ug/l		GDBH102	551678.76	224469.31		
GDBH104	Ethylbenzene	03/11/2009	ND<1	ug/l		GDBH103	551696.31	224474.70		
GDBH104	Toluene	03/11/2009	ND<1	ug/l		GDBH103A	551696.31	224474.90		
GDBH104	TPH	03/11/2009	36	ug/l		GDBH104	551664.76	224459.11		
MW10	Ethylbenzene	03/11/2009	ND<1	ug/l		GDBH105	551696.93	224459.03		
MW10	Toluene	03/11/2009	ND<1	ug/l		MW1	551695.93	224452.53		
MW10	TPH	03/11/2009	ND<5	ug/l		MW10	551636.84	224440.36		
MW103	Ethylbenzene	03/11/2009	9	ug/l		MW101	551693.78	224446.68		
MW103	Toluene	03/11/2009	6	ug/l		MW102	551683.81	224448.57		
MW103	TPH	03/11/2009	162	ug/l		MW103	551688.30	224470.95		
MW6	Ethylbenzene	03/11/2009	ND<1	ug/l		MW104	551698.19	224468.99		
MW6	Toluene	03/11/2009	ND<1	ug/l		MW2	551682.93	224440.03		
MW6	TPH	03/11/2009	ND<5	ug/l		MW3	551687.43	224453.03		
SGS4 P1	Ethylbenzene	03/11/2009	ND<1	ug/l		MW4	551695.93	224464.53		
SGS4 P1	Toluene	03/11/2009	ND<1	ug/l		MW5	551688.24	224425.70		
SGS4 P1	TPH	03/11/2009	ND<5	ug/l		MW6	551677.34	224427.38		
SGS4 P3	Ethylbenzene	03/11/2009	ND<1	ug/l		MW7	551667.54	224429.89		
SGS4 P3	Toluene	03/11/2009	ND<1	ug/l		MW8	551662.76	224443.96		
SGS4 P3	TPH	03/11/2009	6	ug/l		MW9	551658.17	224435.39		
SGS3 P1	Nitrate	02/11/2009	57.12	mg/L		SGS1	551684.93	224452.03		
SGS3 P2	Nitrate	02/11/2009	62.21	mg/l		SGS2	551658.40	224436.14		
SGS3 P3	Nitrate	02/11/2009	65.18	mg/l		SGS3 P1	551664.47	224454.61	A	
SGS4 P1	Nitrate	02/11/2009	88.6	mg/l		SGS3 P2	551664.47	224454.61	A	
SGS4 P3	Nitrate	02/11/2009	3.55	mg/l		SGS3 P3	551664.47	224454.61	A	
MW102	Toluene	02/11/2009	ND<1	ug/l		SGS4 P1	551645.46	224440.97	A	
MW102	TPH	02/11/2009	ND<5	ug/l		SGS4 P3	551645.46	224440.97		
MW7	Toluene	02/11/2009	ND<1	ug/l		SGS5 P1	551714.21	224453.87	A	
MW7	TPH	02/11/2009	ND<5	ug/l		SGS5 P2	551714.21	224453.87	A	
SGS3 P1	Toluene	02/11/2009	ND<1	ug/l						
SGS3 P1	TPH	02/11/2009	ND<5	ug/l						
SGS3 P2	Toluene	02/11/2009	ND<1	ug/l						
SGS3 P2	TPH	02/11/2009	ND<5	ug/l						
SGS3 P3	Toluene	02/11/2009	ND<1	ug/l						

GWSDAT User Interface



GWSDAT R Software Architecture

- GWSDAT to Microsoft products for a user friendly application entry point (e.g. Excel, PowerPoint, Word) and automatic report generation (R packages: **RExcel and rcom**).
- Graphical User Interface (R packages: **tcltk and rpanel**).
- Time series trend detection (R packages: **sm, Kendall and zoo**).
- Methods for visualising and handling Spatial data (R packages **deldir, sp, splancs and maptools**).
- Spatiotemporal smoothing and animations (R packages **svm in e1071, animation**).
- Jointly sponsored PhD student with Prof Adrian Bowman and Dr Ludger Evers at Glasgow University Statistics Department to research spatiotemporal modelling of environmental groundwater data.

GWSDAT Business Benefits

- GWSDAT adds value (cost savings and reduction in environmental liabilities) through improved risk-based decision making and response include:
 - Early identification of new sources of contamination, increasing trends and off-site migration.
 - Evaluation of groundwater monitoring trends over time and space.
 - Nonparametric statistical and uncertainty analyses to assess highly variable groundwater data.
 - Reduction in the number of sites in long-term monitoring or active remediation through simple, visual demonstrations of groundwater data and trends.
 - More efficient evaluation and reporting of groundwater monitoring trends via simple, standardised plots and tables created at the 'click of a mouse'.

Q&A

