



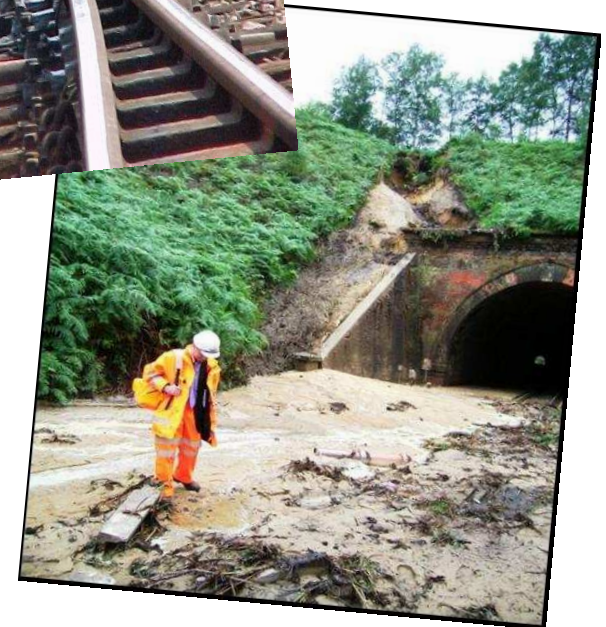
CLIMATE CHANGE ADAPTATION
Vulnerability Mapping

John Dora, Principal Engineer

Vulnerability Mapping

Two approaches described:

1. Track buckle risk management and impact on performance
 - Based on climate modelling, historic delay data and standards
2. Earthwork and water risk
 - Based on digital mapping tools



Track Buckle Risks to Performance

- Track buckle risk management and impact on performance
- Network Rail Standards give thresholds:
 - Actions are taken at Critical Rail Temperatures (CRTs)
 - These include the deployment of heat watchmen who monitor rail temperature, to the imposition of speed restrictions to reduce the risk of derailment
- Tables specify the criteria – next slide
 - Track Engineers advised three representative criteria

Track Buckle Risks to Performance

Track condition	CRT (W)	CRT (30/60) = CRT (W) +	CRT (20) = CRT (W) +	Period for which CRT shall apply
Undisturbed, fully ballasted and consolidated	SFT ⁽¹⁾ + 32	5	10	Permanently
Re-railed only (no other disturbance or deficiency)	SFT + 32	5	10	Permanently
No ballast shoulder: level with sleeper top (no other disturbance or deficiency)	SFT + 27	5	8	Until shoulder is restored
Tamped/lined with slues/lifts up to 25mm	SFT + 22	4	7	3 days
Tamped/lined with slues/lifts > 25mm	SFT + 20*	3	6	5 days
Mechanised stoneblown	SFT + 20	3	6	5 days
Tamped or stoneblown S&C	SFT + 20	3	6	7 days
Measured shovel packed/hand-held stoneblown	SFT +17	3	5	3 days
3 Consecutive sleepers voided at 15mm or more	SFT + 17	3	5	Until packed and stable
Ballast generally full between sleepers and on shoulders, but not consolidated (8 beds or more)	SFT + 15*	3	5	tonnage dependent
Ballast generally full between sleepers and on shoulders, but not consolidated (less than 8 beds)	SFT + 15	3	5	5 days
3 or more consecutive slurried beds, where ballast is not compacted against the sleeper ends	SFT + 10	3	5	Until packed and stable
Severe shortage of ballast between sleepers and/or part sleeper ends exposed, extending 8 beds or more	SFT + 10	N/A (apply 20 ESR at SFT +13)	3	Until fully ballasted, then 5 days

Track Buckle Risks to Performance

The main actions are designated as follows:

- CRT(W): a Watchman will be in place to monitor the length of track concerned
- CRT(30/60): a 30/60mph speed restriction shall be applied
- CRT(20): a 20mph speed restriction shall be applied
- The rail temperatures at which these actions are taken depend on the nature and condition of the track

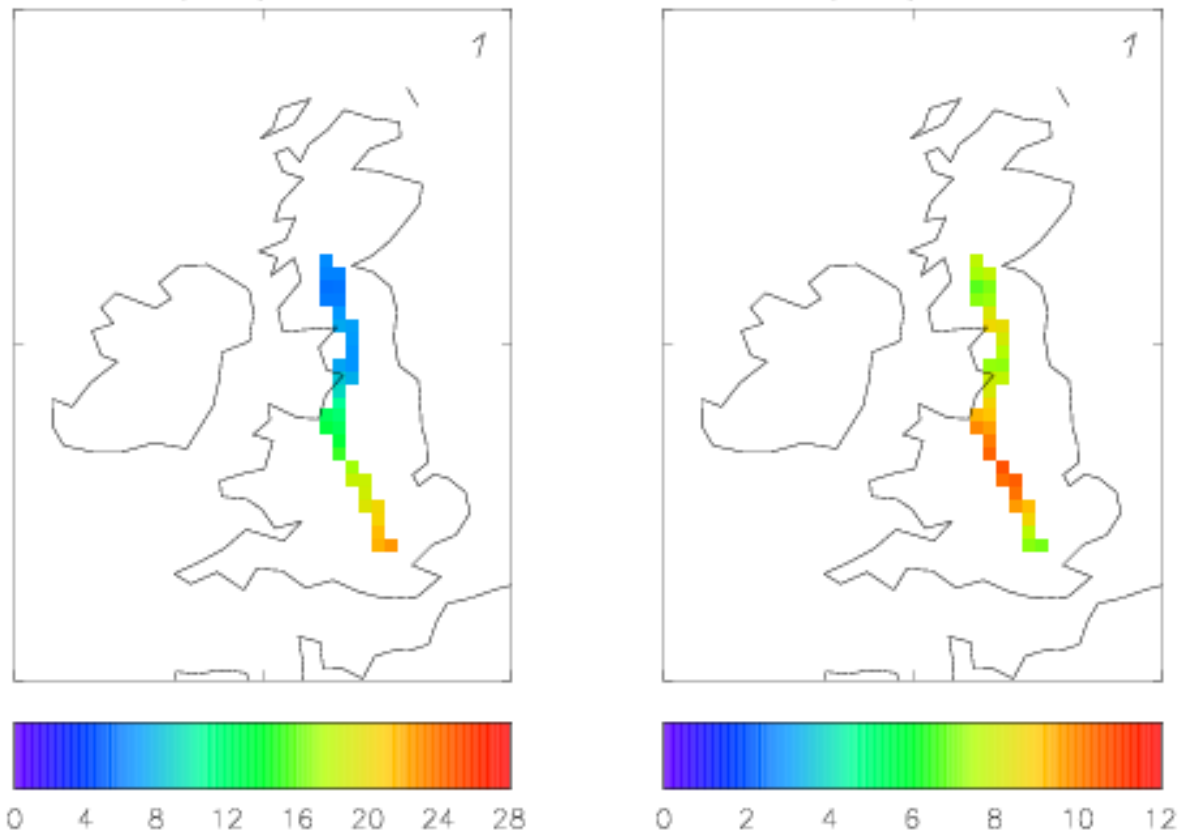
Track Buckle Risks Methodology

- Convert Rail temperature to Air temperature
 - Hunt, 1994 gives the relationship between air (T_{air}) and rail (T_{rail}) temperature ($^{\circ}\text{C}$) as follows:

$$T_{\text{air}} = 2/3 T_{\text{rail}}$$

- Correct bias using observed data
- Establish frequency of days exceeding T_{air} for 2020s, 2030s, 2040s via Climate Models
- Use historic delay data on West Coast Main Line to identify where the greatest increases will be
- Calculate change for future decades

Track Buckle Results - Example

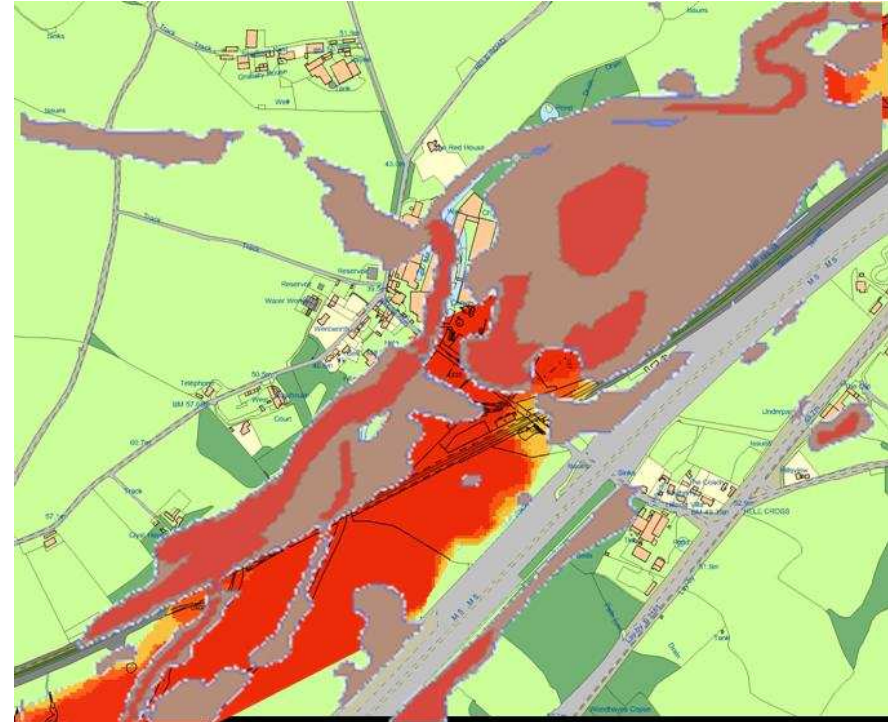


This report uses source data which is freely available from UKCP09 (c) Crown Copyright 2009. The UK Climate Projections (UKCP09) have been made available under licence from the Department for Environment, Food and Rural Affairs (Defra) and the Department of Climate Change (DECC) using data developed by the Met Office, UK Climate Impacts Programme, British Atmospheric Data Centre, Newcastle University, University of East Anglia, Environment Agency, Tyndall Centre and Proudman Oceanographic Laboratory.

Ensemble mean number of days heat watchmen are required, for 3 consecutive slurred beds in the present day (left) and change into the future (right). The uncertainty in these results is currently being assessed.

Water Risk on Earthworks

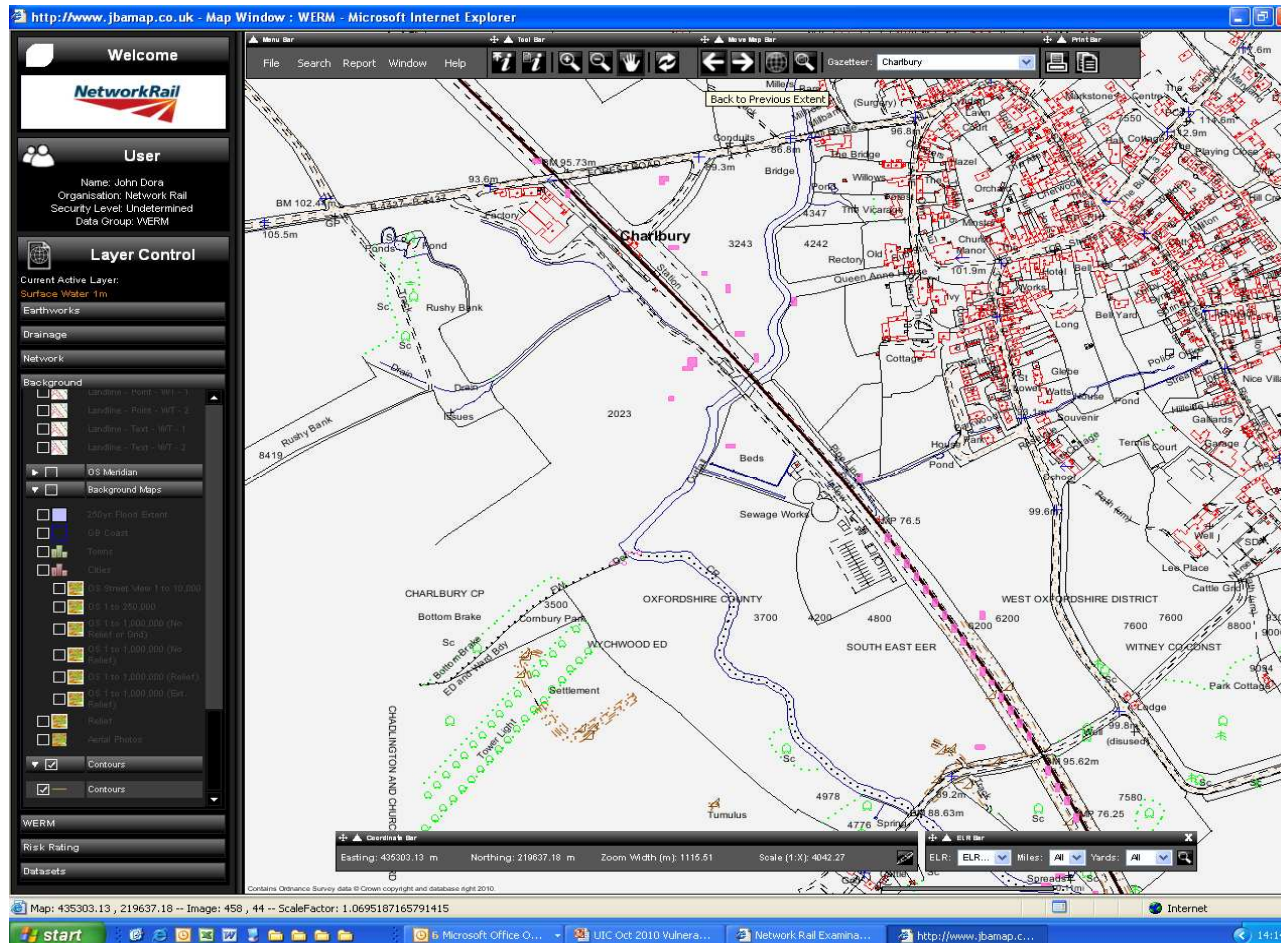
- Makes use of digital elevation and terrain modelling
- 100m swath across whole network – detailed elevation data
- Coarse data outside this swath



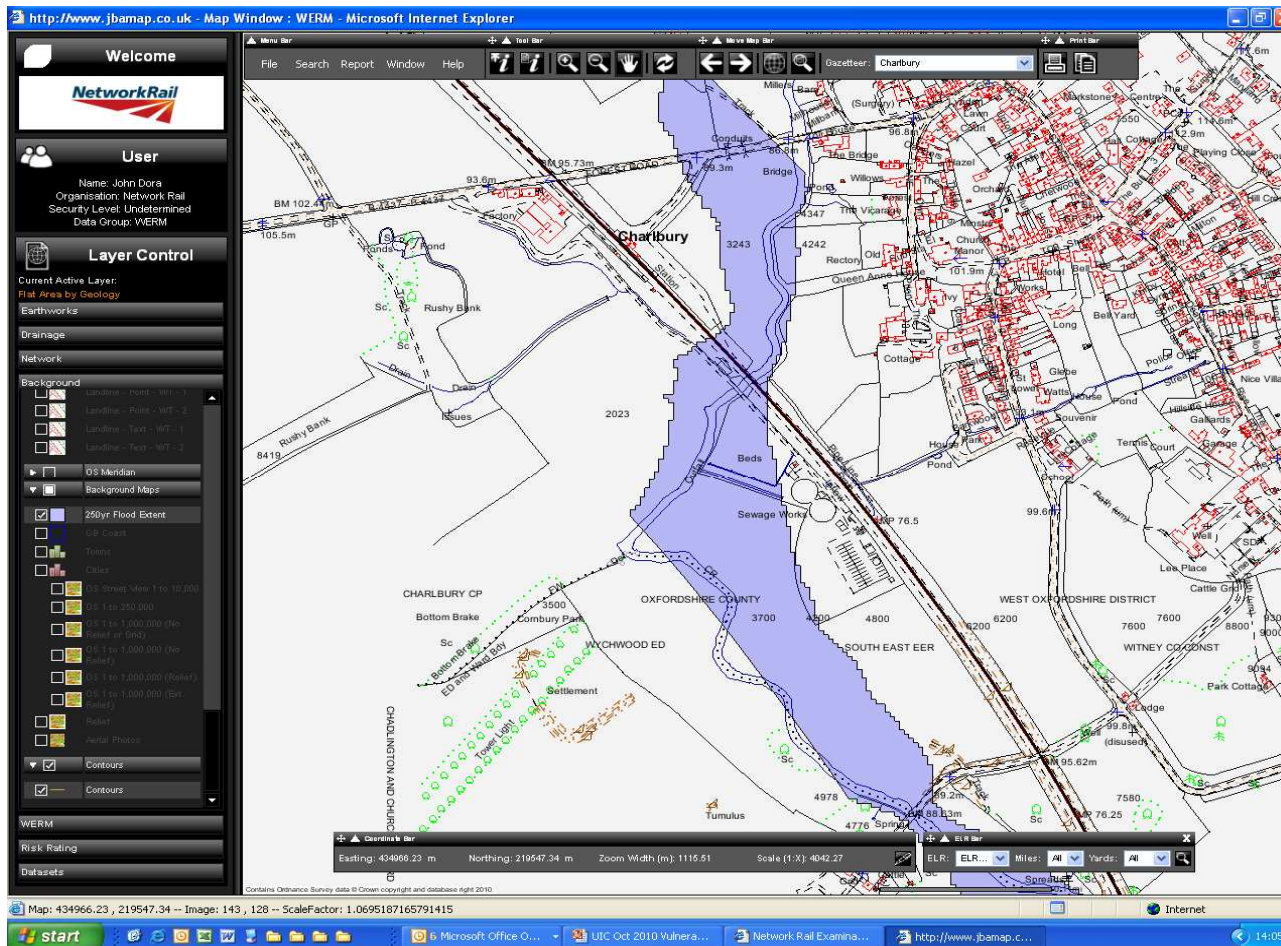
Water Risk on Earthworks

- Surface water flood risk and fluvial flood risk from Environment Agency-developed tools
- Geology from British Geological Survey
- Slope towards/ away from railway at 2m cross sections
- Risks categorised numerically:
 - water concentration + geology + height

Initial map



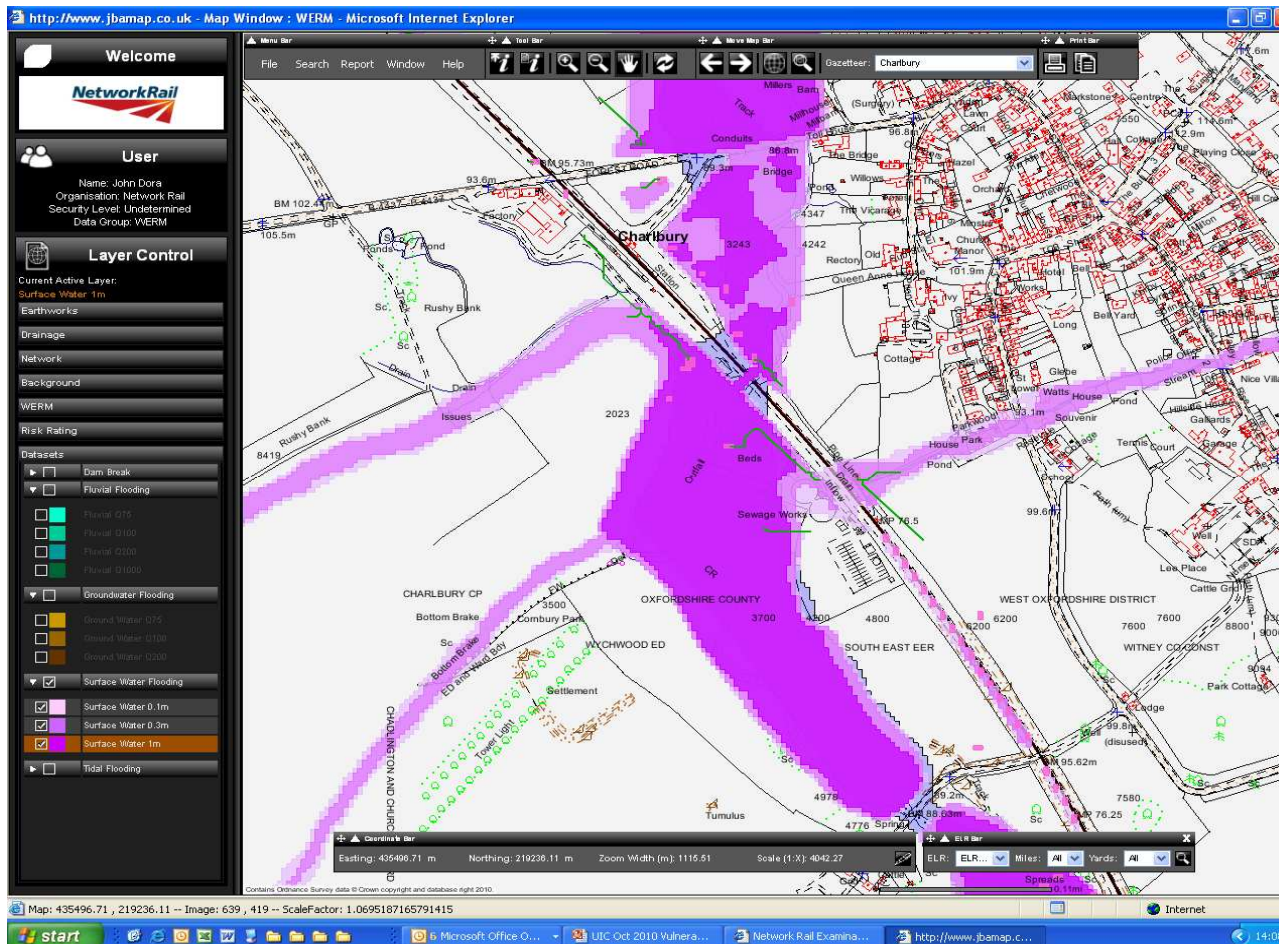
Add 250 year floodplain



Add surface water flow routes

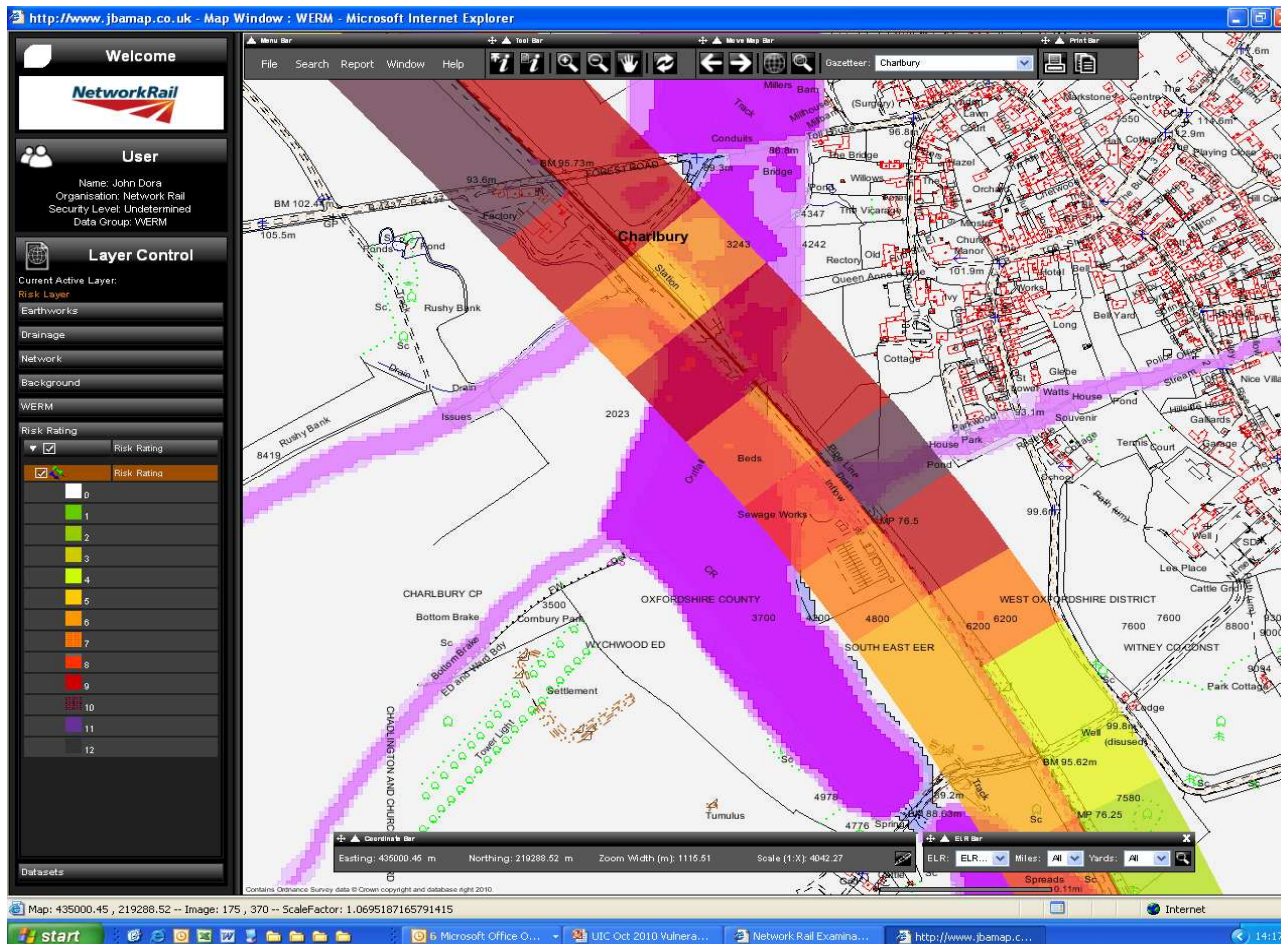
The screenshot displays a web-based GIS application interface. At the top, a browser window title reads "http://www.jbamap.co.uk - Map Window : WERM - Microsoft Internet Explorer". The main map area shows a detailed view of Charbury, Oxfordshire, with a river and surrounding urban areas. The map is overlaid with various layers, including "Flow Route" (indicated by green lines) and "Flow Area" (indicated by blue shaded regions). A "Layer Control" panel on the left side of the map allows users to toggle different layers on and off. The "User" section on the left identifies the user as John Dora, an employee of Network Rail. The "Welcome" message is also visible. The bottom of the window shows a Windows taskbar with the time 14:07 and several open applications, including Microsoft Office and Network Rail Examina... The map interface includes a menu bar, a toolbar, and a status bar at the bottom with coordinates and scale information.

Add sinks and surface water depths



Numerical
risk
categories
applied

Process data into viewable risk bands



Data can be analysed

The screenshot displays a web-based GIS application interface. On the left, a sidebar contains a 'Welcome' message with the NetworkRail logo, a 'User' section for John Dora, and a 'Layer Control' panel with various map layers like 'Risk Layer', 'Earthworks', and 'Drainage'. The main map area shows a geographic area with colored overlays representing risk levels. A 'Report By Data' dialog box is open in the center, allowing for data filtering. The dialog includes search criteria for 'Risk Layer', 'ELR', 'Start Mileage', and 'End Mileage'. A 'View Fields' section at the bottom of the dialog lists 'ELR', 'Start Mileage', and 'End Mileage'. The background map shows a street grid and various landmarks, with a scale bar at the bottom indicating 4042.27 meters. A vertical bar on the right side of the map is labeled 'Year 4'.

Export into spreadsheets

Not just pretty pictures!

The screenshot shows a web browser window displaying a risk map of a railway area. The map is color-coded by risk level, with a legend on the left side of the interface. A 'Report By Data' dialog box is open in the foreground, allowing users to search for specific data points based on criteria like 'ELR', 'Start Mileage', and 'End Mileage'. The dialog box includes fields for search criteria, logical operators (AND), and a 'View Fields' section to select which data points to export to a spreadsheet.

Report By Data

Search Table: Risk Layer

Search Field (1): ELR

Search Value (1): = O/WV

AND

Search Field (2): Start Mileage

Search Value (2): = 76

AND

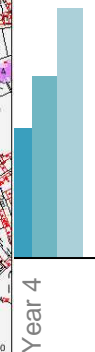
Search Field (3): End Mileage

Search Value (3): = 77

Exact Match: Yes

View Fields: (1-5) | (4-6)

ELR
Start Mileage
End Mileage



...Spreadsheet..

The screenshot displays a web-based GIS application interface. On the left, a 'Layer Control' panel shows various layers including 'Risk Rating' and 'Risk Rating' with a legend. The main map area shows a risk assessment map with color-coded zones (red, orange, yellow, green, purple) overlaid on a street map. A search results window is open, displaying a table of data.

Row	Risk Score	ELR	Start Mileage	End Mileage
2	0	OWWW	116.143	116.154
3	0	OWWW	120.154	120.185
4	0	OWWW	120.154	120.185
5	0	OWWW	120.154	120.185
6	0	OWWW	120.154	120.185
7	1	OWWW	93.121	93.132
8	1	OWWW	93.132	93.143
9	1	OWWW	93.154	93.165
10	1	OWWW	93.154	93.165
11	1	OWWW	97.132	97.143
12	1	OWWW	98	98.011
13	1	OWWW	99.11	99.121
14	1	OWWW	99.121	99.132
15	1	OWWW	125.044	125.055
16	1	OWWW	127.066	127.077
17	1	OWWW	129.121	129.132
18	1	OWWW	129.185	130
19	2	OWWW	147.154	147.165
20	2	OWWW	85.011	85.022
21	2	OWWW	113.033	113.044
22	2	OWWW	116.132	116.143
23	3	OWWW	76.011	76.022
24	3	OWWW	76.033	76.044
25	3	OWWW	77.033	77.044
26	3	OWWW	77.088	77.099
27	3	OWWW	77.088	77.099
28	3	OWWW	77.154	77.165
29	3	OWWW	78	78.011
30	3	OWWW	78.022	78.033
31	3	OWWW	79.066	79.077
32	3	OWWW	79.066	79.077
33	3	OWWW	79.077	79.088
34	3	OWWW	81	81.011
35	3	OWWW	81.011	81.022
36	3	OWWW	83.165	84
37	3	OWWW	93.077	93.088
38	3	OWWW	93.154	93.165
39	3	OWWW	96	96.011
40	3	OWWW	96	96.011
41	3	OWWW	96	96.011
42	3	OWWW	96	96.011
43	3	OWWW	96	96.011

Conclusions

- There are different ways to approach modelling
- Many tools have been developed to manage current risks
- Use these tools, data and science to build knowledge...
- Think System Resilience
 - Think Engineering Solutions
 - Think Priorities
 - Think Early Benefits in improved Reliability