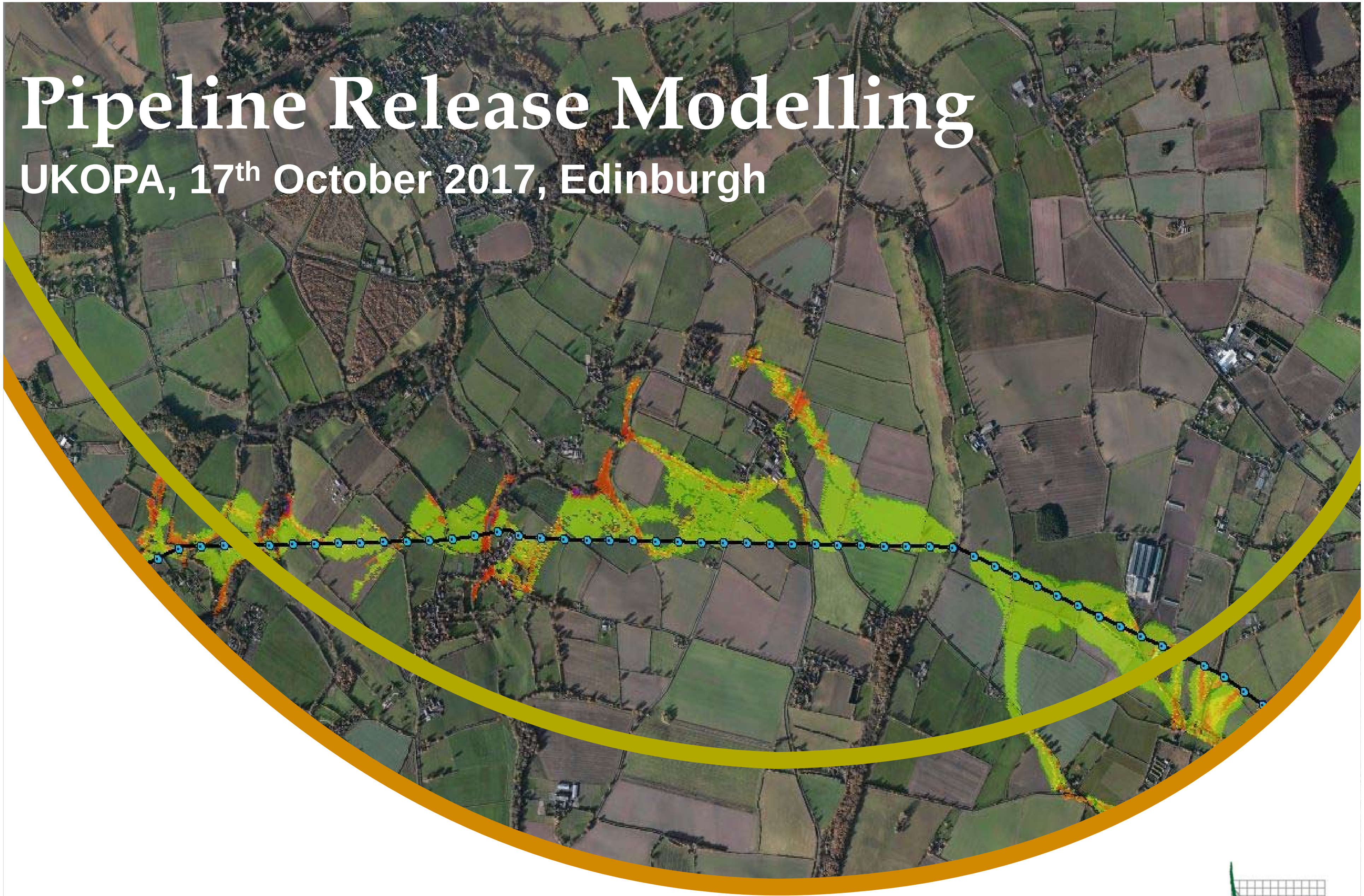
Pipeline Release Modelling

UKOPA, 17th October 2017, Edinburgh



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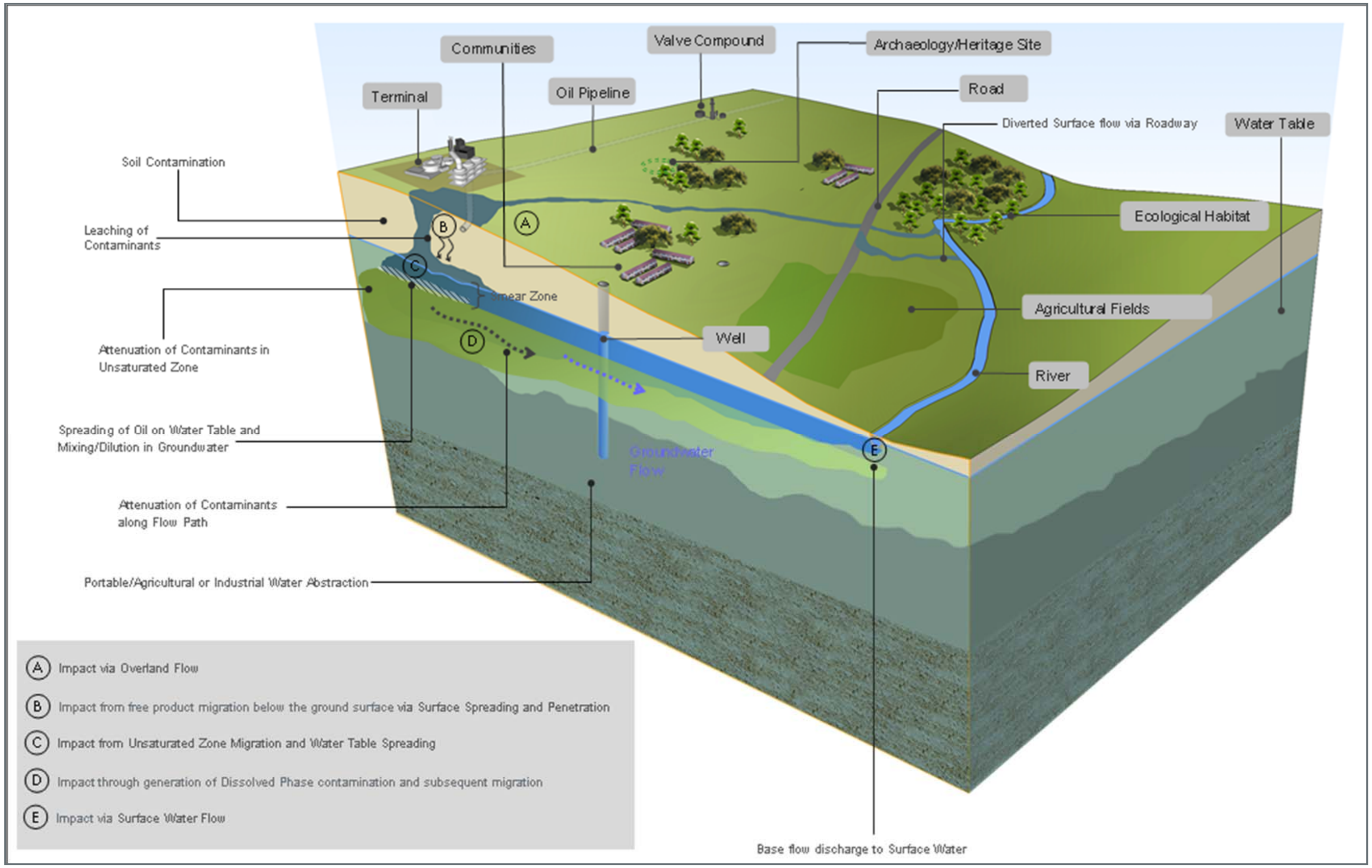
Contents

This technical annex comprises the following key elements:

Oil Spill Modelling Conceptual Site Model

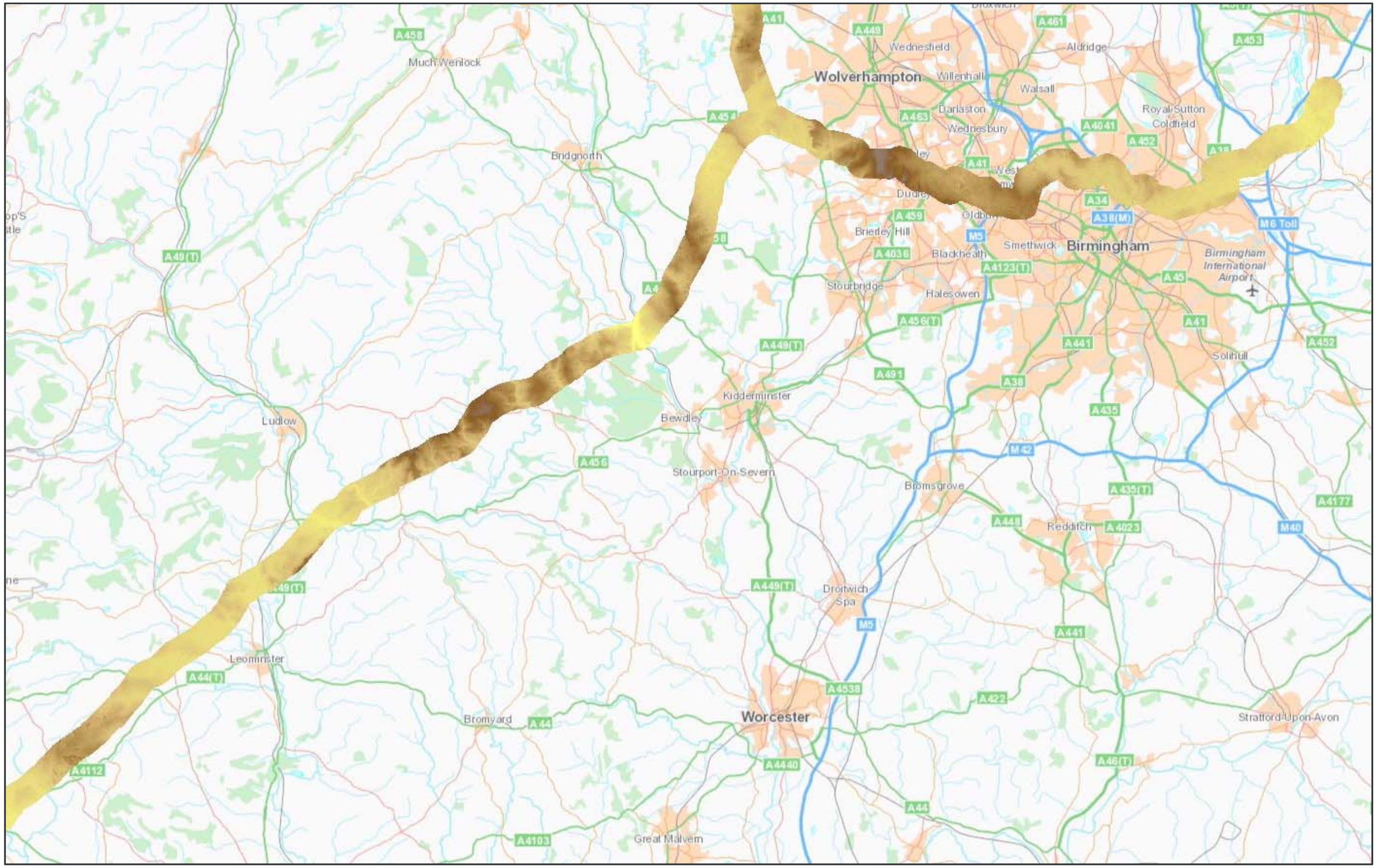
- The potential pathways from a spill along a pipeline route and the associated infrastructure include overland flow, direct entry to surface waters or via groundwater towards sensitive receptors (see figure). This report focuses on overland flow.



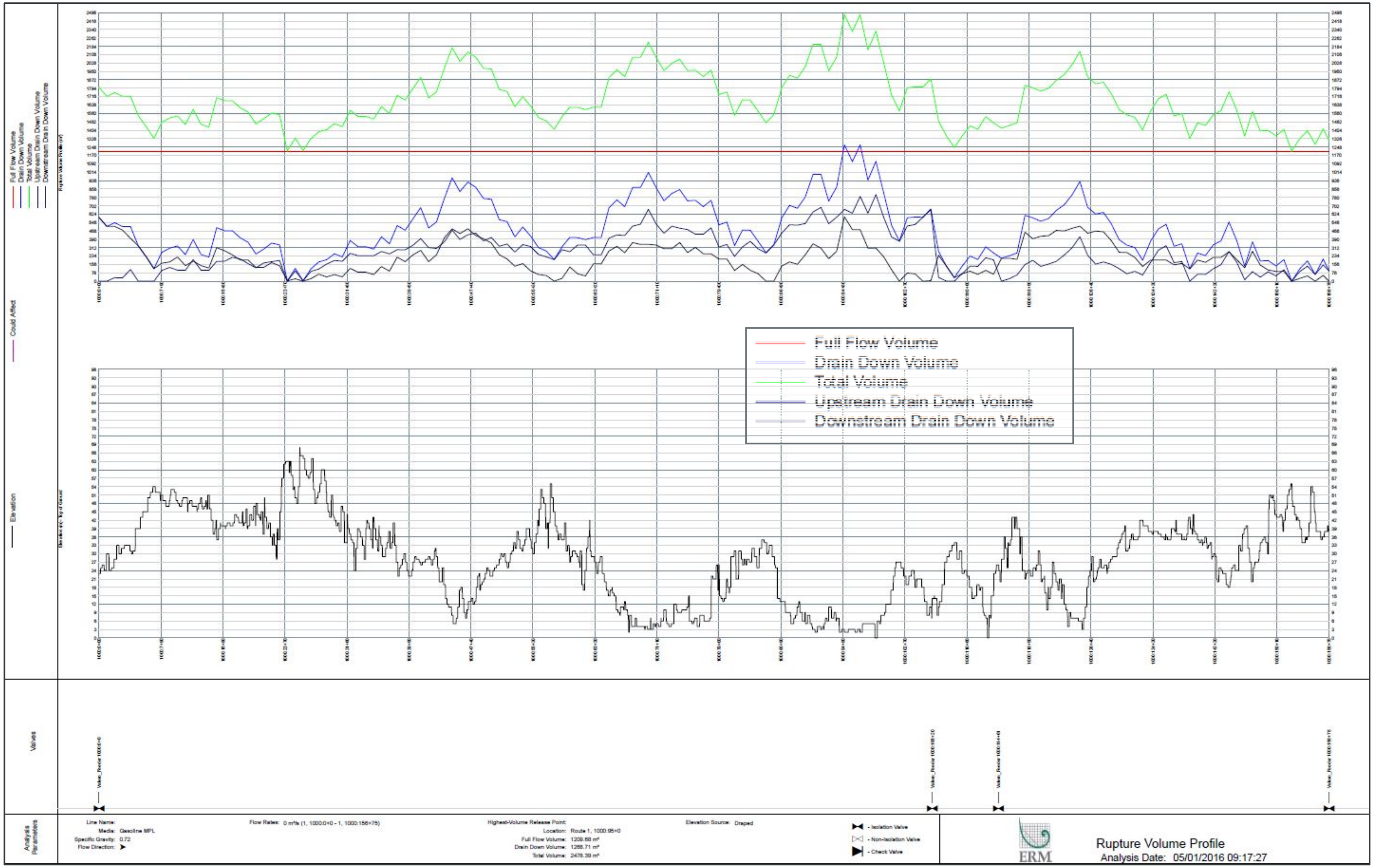
Pipeline Release Input Data Requirements

- Input data required for pipeline overland flow modelling includes:
  - Pipeline physical parameters and route information.
  - Product type physical parameters.
  - Potential spill locations.
  - Potential reasonable release volumes and release rates for various scenarios (3 x scenarios are typically used for Pipeline Modelling).
  - Potential reasonable response times for the three separate scenarios.
  - Appropriate Digital Elevation Model (DEM) or Digital Surface Model (DSM).

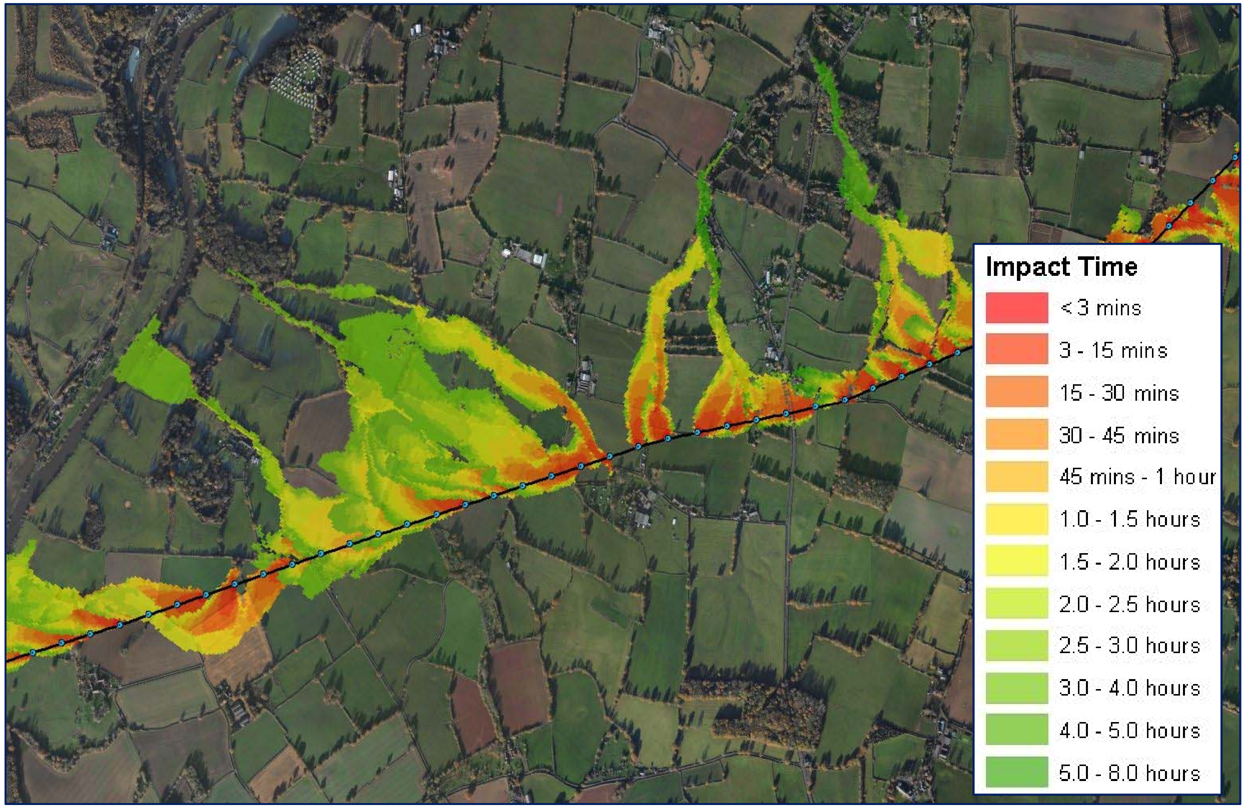
DSM – 1 km wide corridor along Pipeline



Full Bore Scenario Flow Results – 16″ Line



Example Output – Spill Plumes, Impact Time



- The simulated extent of spilled product can be shown by time to impact (built up out of grid cells equivalent to the resolution of the DSM, e.g. ~4m x 4m).
- In some areas the product is simulated to flow for the full 8 hours of the simulation (green colours left) while in others, the spill from an individual release point does not continue flowing for 8 hours. The difference is due to DSM topography and influence from surface water to different release volumes.

Surface Flow Models - Enhanced Visualisation

Key Elements

Tank overtops bund wall at low point
Spill extends off site rapidly and engulfs neighbouring road

Access limited from west as a result of the spill and current location for assembly no longer appropriate.

Spill simulated to extend into dock where dock gates are likely to help with containment and recovery.

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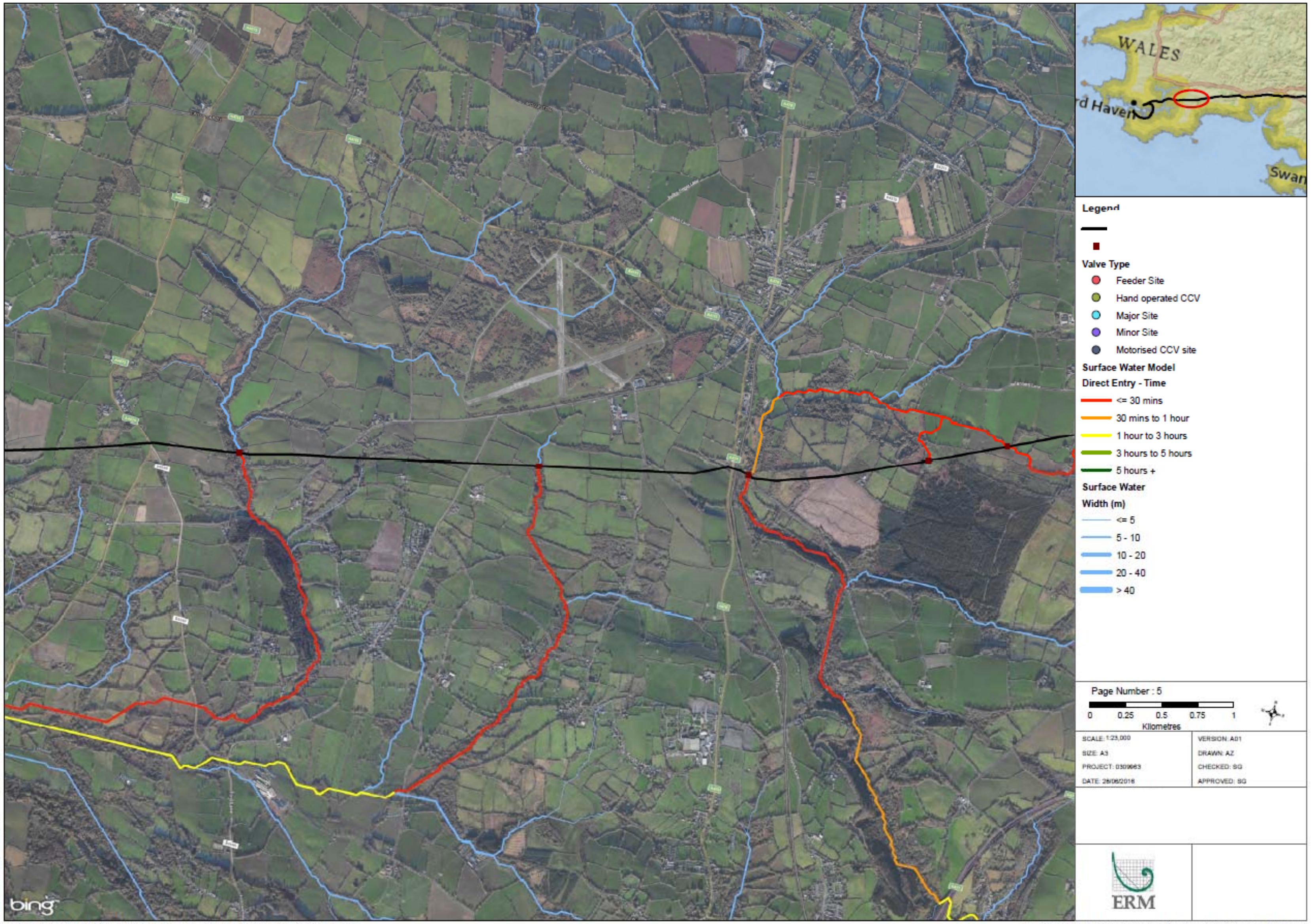
Surface Water – Product Migration with Network Analyst



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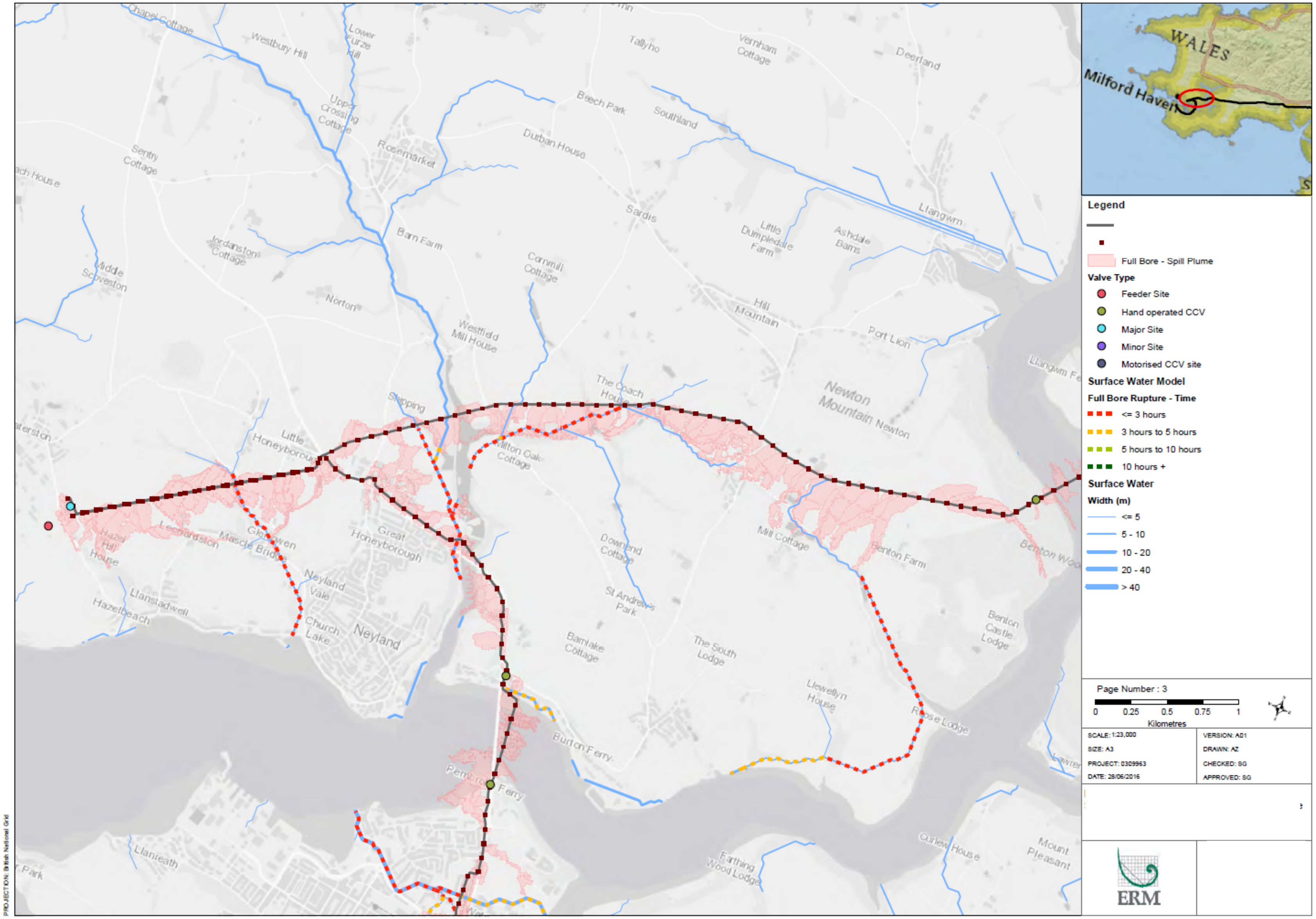
Surface Water – Product Migration after Overland Flow



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Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, Increment P Corp.

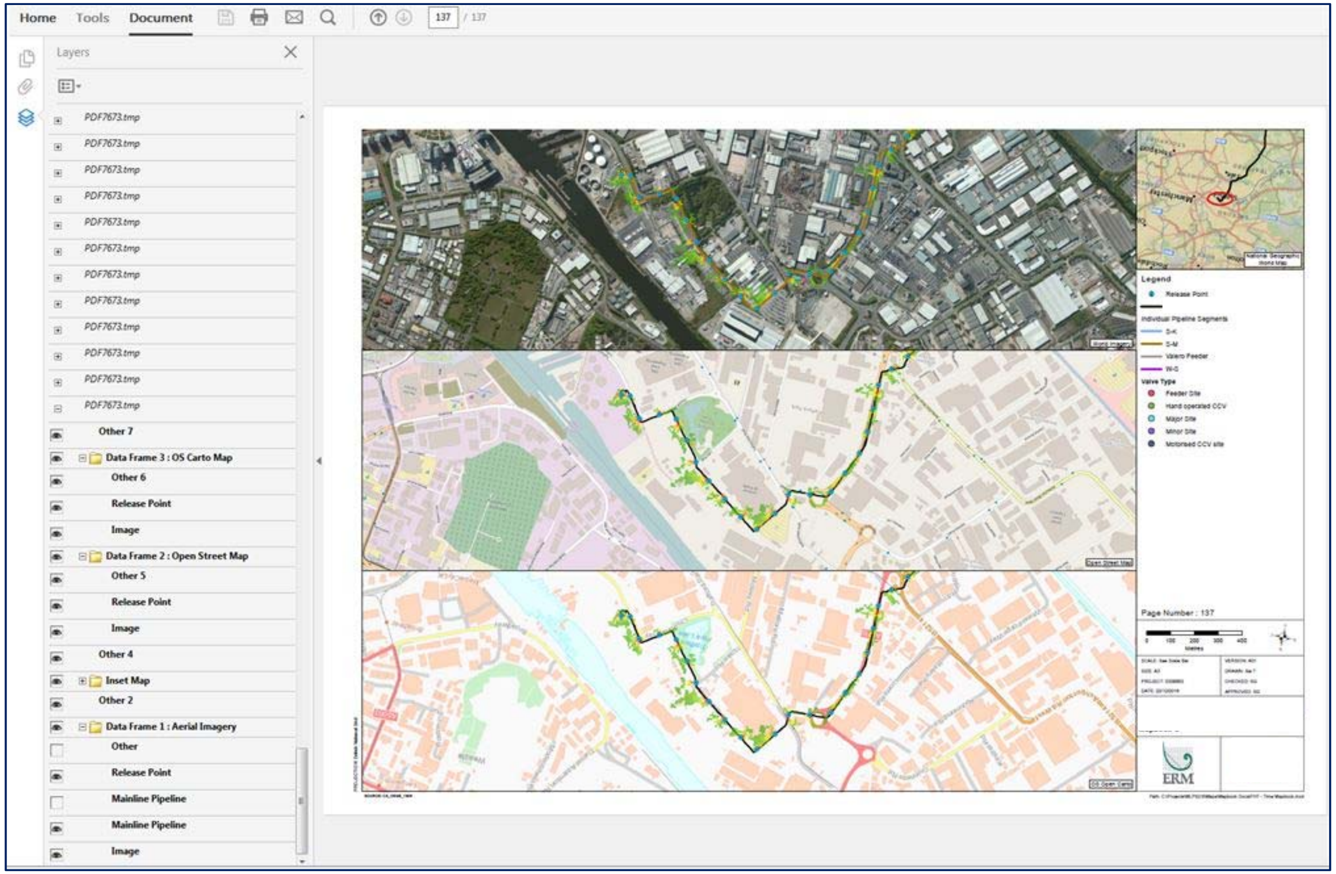
Path: C:\3_Temp\WorkingGISProjectFolders\MLP\MAPS\Full Bore Rupture - Surface Water Modelling.mxd

Pipeline Map Catalogues

- The results from the modelling have been incorporated into a group of map catalogues to show the simulated releases displayed by final volume and impact time for the different scenarios.

Interactive Layering

- The mapbooks also allow the user to switch on and off certain layers such as the basemapping, release points and pipelines.

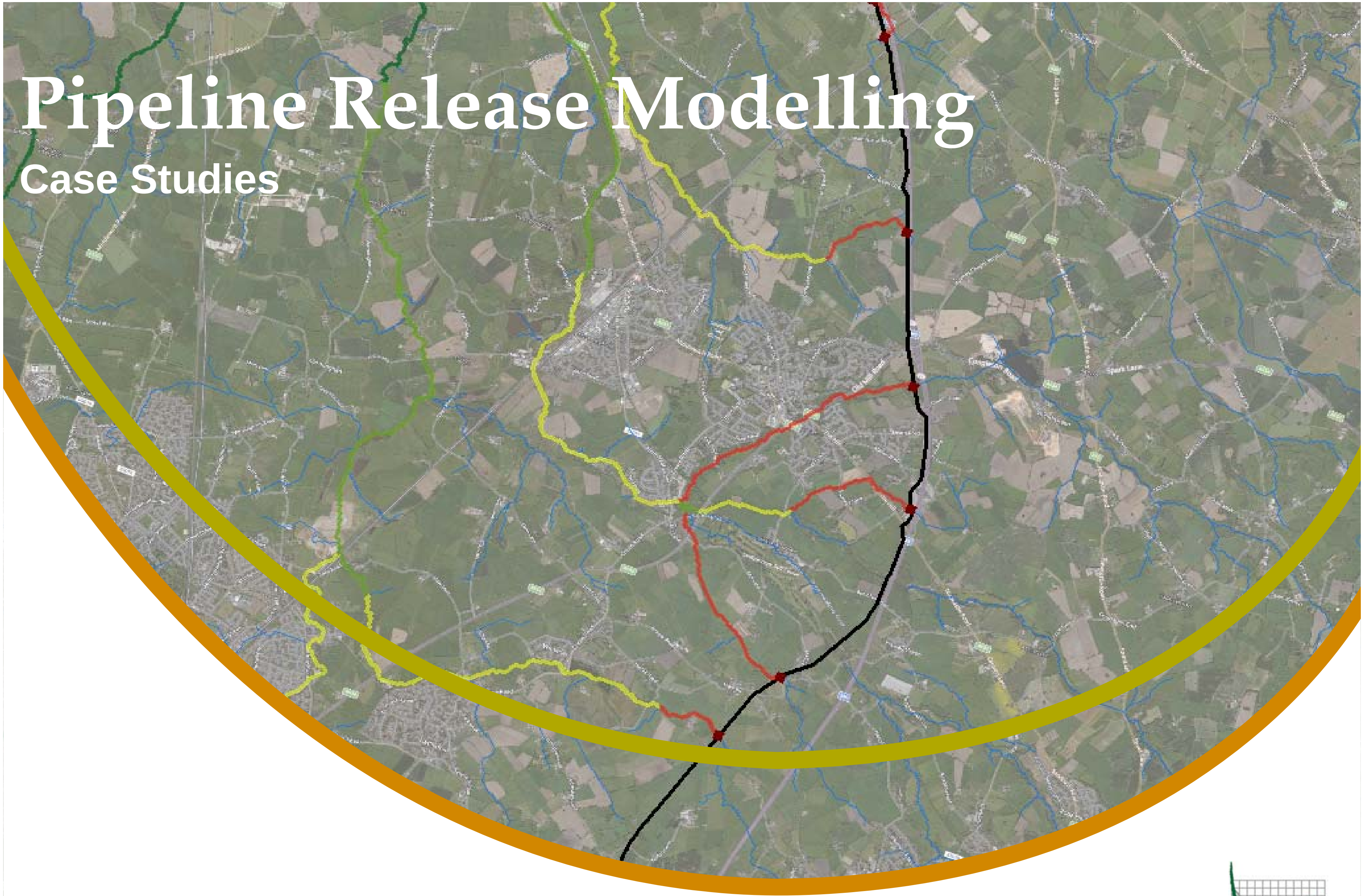


- Each mapbook page has a corresponding dropdown list which contains the 4 insets, with their associated layers. This allows multiple scenarios to be presented on each page.

- Each page uses several different mapping sources, as each displays different sets of pertinent data.

Pipeline Release Modelling

Case Studies



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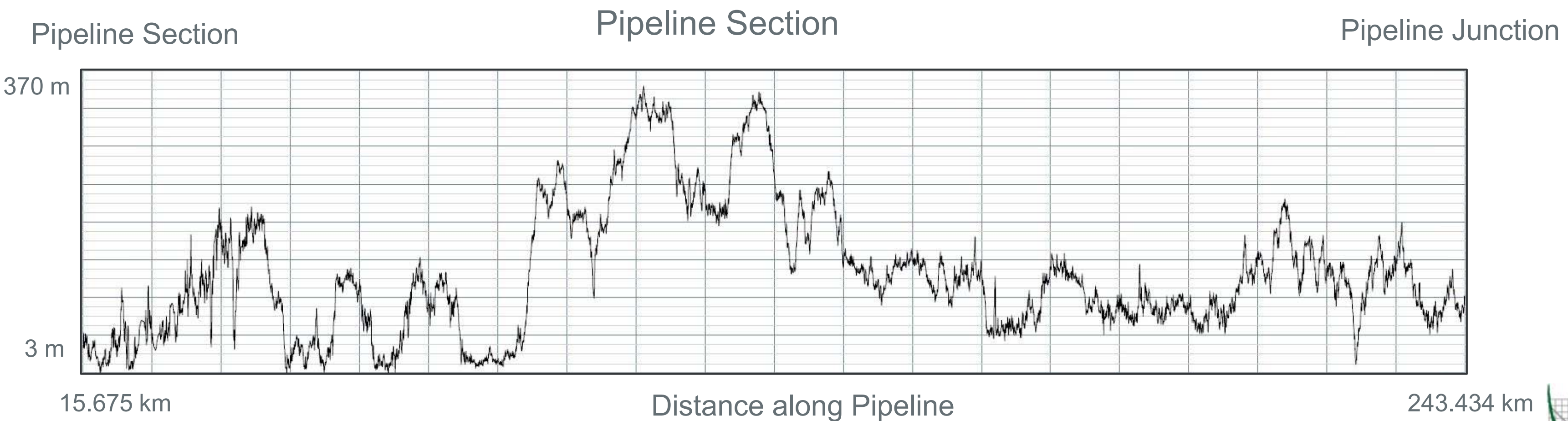
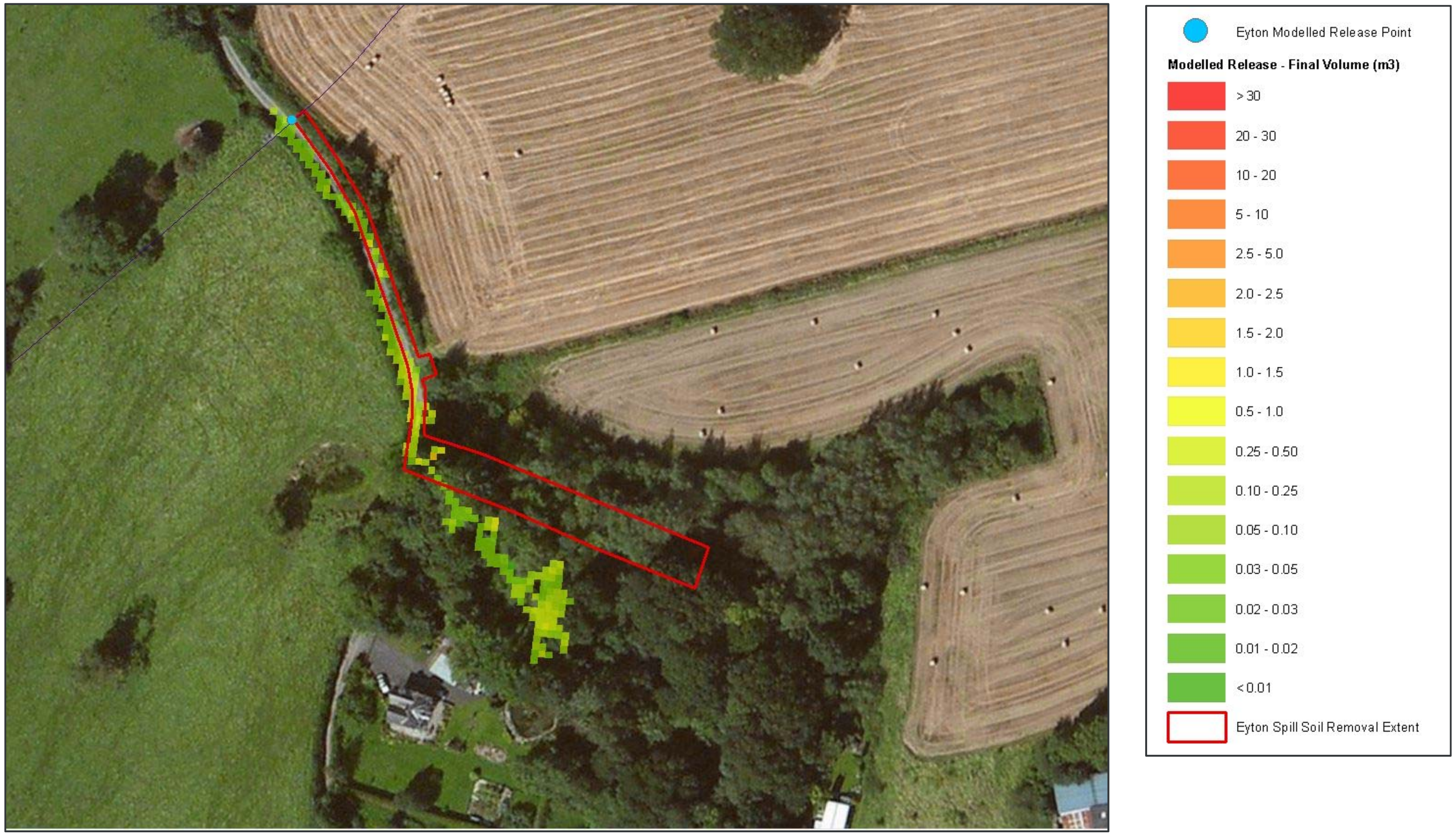
Pipeline Parameters

- The pipeline is buried along the majority of the route with the exception of some above ground elements at the Main Pumping Stations covering a distance of c. 400km
- The pipeline sections have a number of isolation valves (comprised a mixture of motorised CCV sites and hand-operated valves) which are positioned at key locations along the pipeline route. These include gathering stations, booster stations, valves at areas of elevation change, areas of higher population density and near major watercourses.
- The pipeline carries a mixture of finished products for end-user distribution operator owned terminals.
- The pipeline network is comprised of 16” and 12” diameter pipework.
- There is an elevation change of approximately 370m along the route.



Model Validation 2 – Failed Illegal Hot Tap

- The figures below shows the results of the simulated release from a failed hot tap scenario using a 2 m resolution DSM, along with the soil removal plan extent put in place in response to the actual release event which occurred.
- The modelled release and actual release match reasonably well, until the release reaches the trees which seem to mask the location of the ditch/stream the actual release followed.



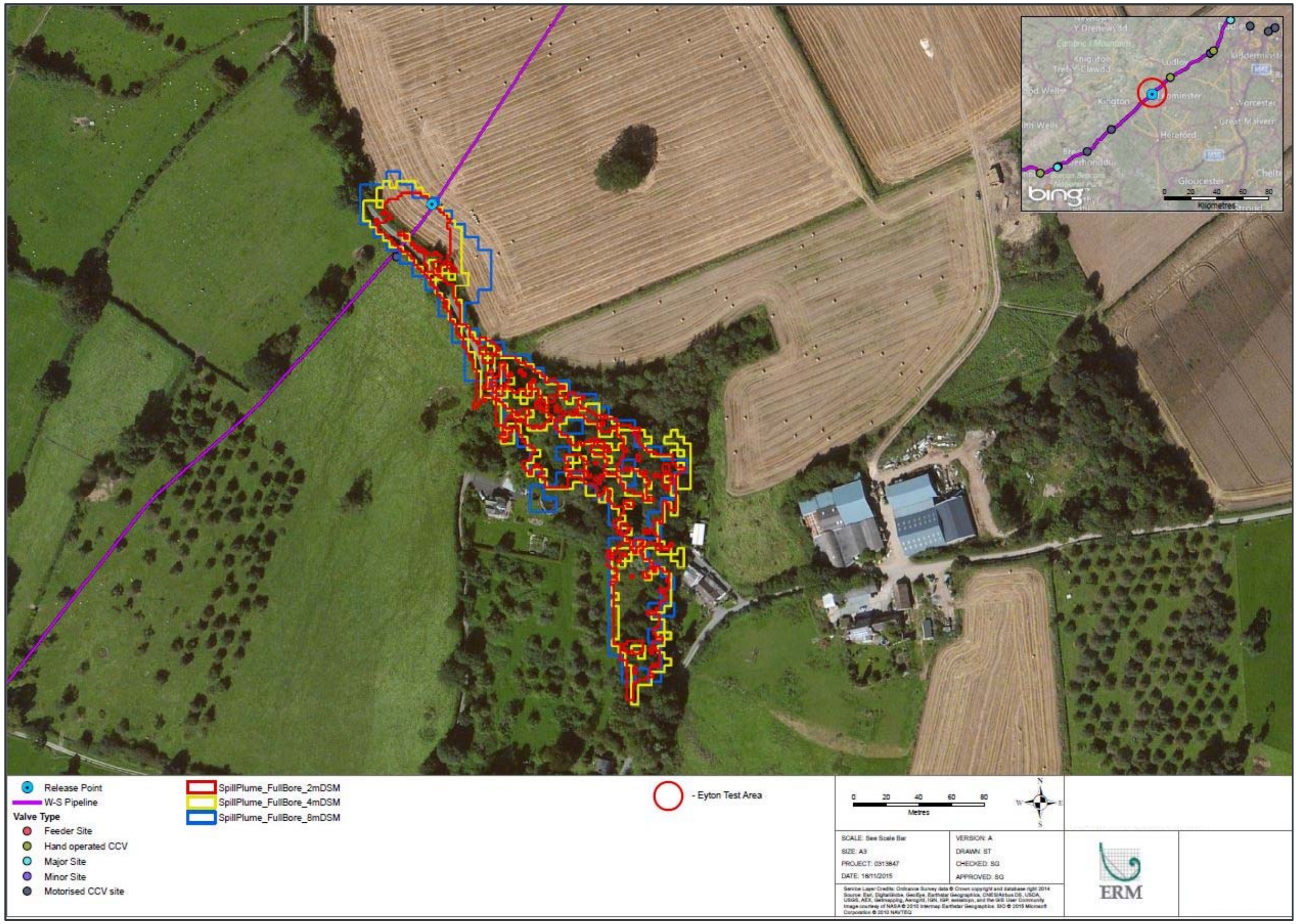
Hypothetical Event Scenarios

Scenario Description	Rationale / comment	Gasoline spill rate (m3/h)	Gasoline spill rate (m3/s)	Gasoline flow rate (m3/h)	Decline profile desc. (conservative case)	Simulation Time
Full bore rupture *Mitigation:* • *Close valves. Response within 5 minutes, motorised valves closed within 15 minute, hand operated valves within 3 hours*	Worst credible case	650	1.81E-01	650	Fast decline	8
Failed hot tap 12mm hole in pipe *Mitigation:* • *Close valves. Response within 12 hours, 24 hours or 3 days*	For planning purposes	1.3	3.61E-04	650	No draindown	72
Weeping clamp / long term failure *Mitigation:* • *Close valves. Response within 14 days*	For planning purposes	0.1	2.778E-05	650	No draindown	336

- The scenarios selected for analysis provide a range of total volume losses which enable comparisons between worst case and most likely release scenarios in terms of risk frequency.
- In addition to 'worst case' rupture scenario more likely scenarios were also modelled – such as the effect of deliberate damage (fuel theft) or slow leaks (failed clamps or fatigue crack, etc.).
- To provide coverage along the pipeline route, releases were simulated at points positioned at a 100 m spacing. The total number of these release points modelled = **4087 points**.

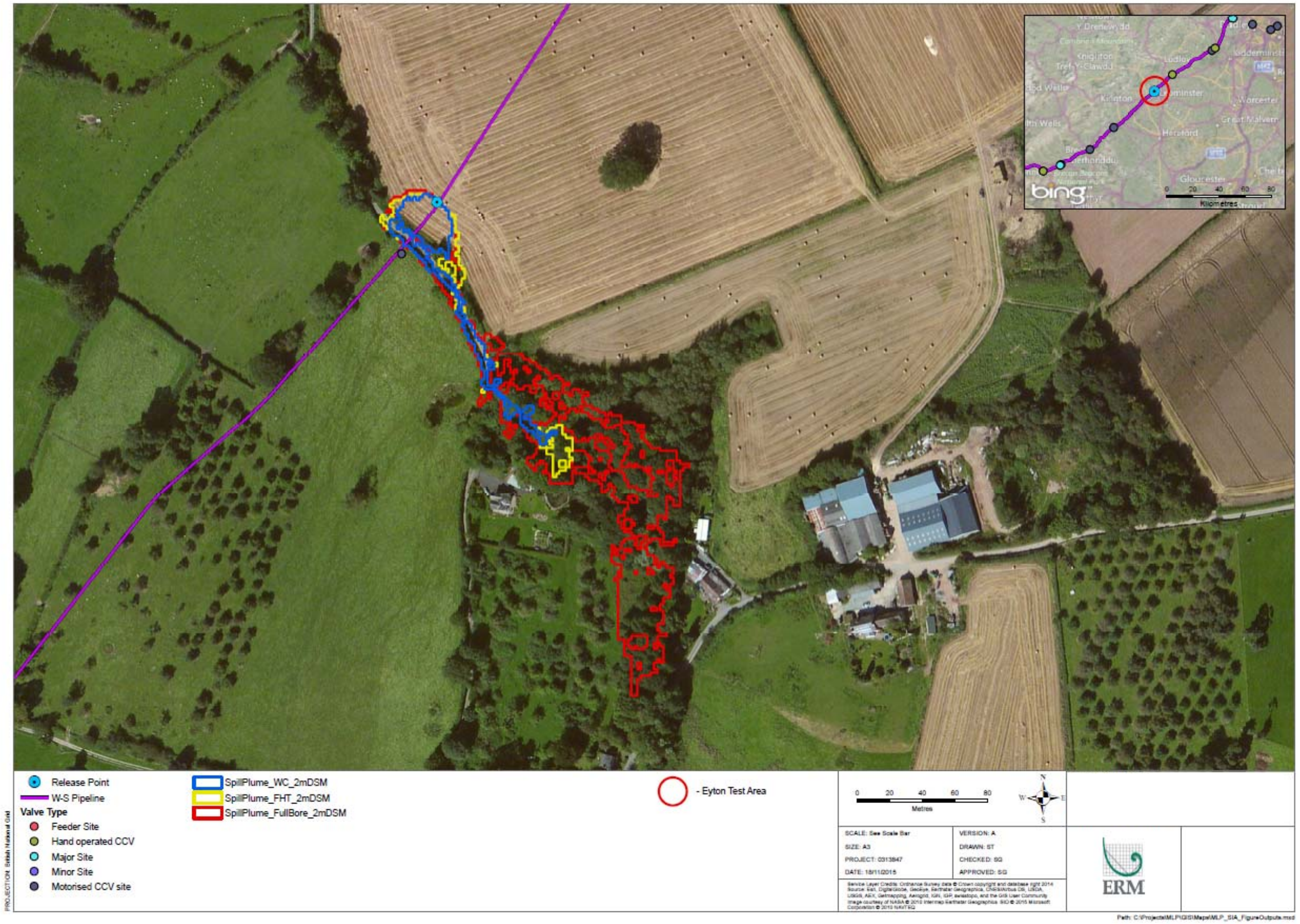
Model Validation 1 – DSM Resolutions

- The figure below shows the simulated full-bore rupture release scenarios from a single release point using 2 m, 4 m and 8 m resolution DSM data.
- All three release extents are shown to be similar, which suggests that the use of a coarser 8 m resolution DSM for the modelling is unlikely to significantly compromise result accuracy.



Model Validation 2 – Spill Scenarios

- The figure below shows the simulated weeping clamp, failed hot tap and full bore release scenarios.
- All three release extents are shown to be similar, which suggests that the use of a coarser 8 m resolution DSM for the modelling is unlikely to significantly compromise result accuracy.



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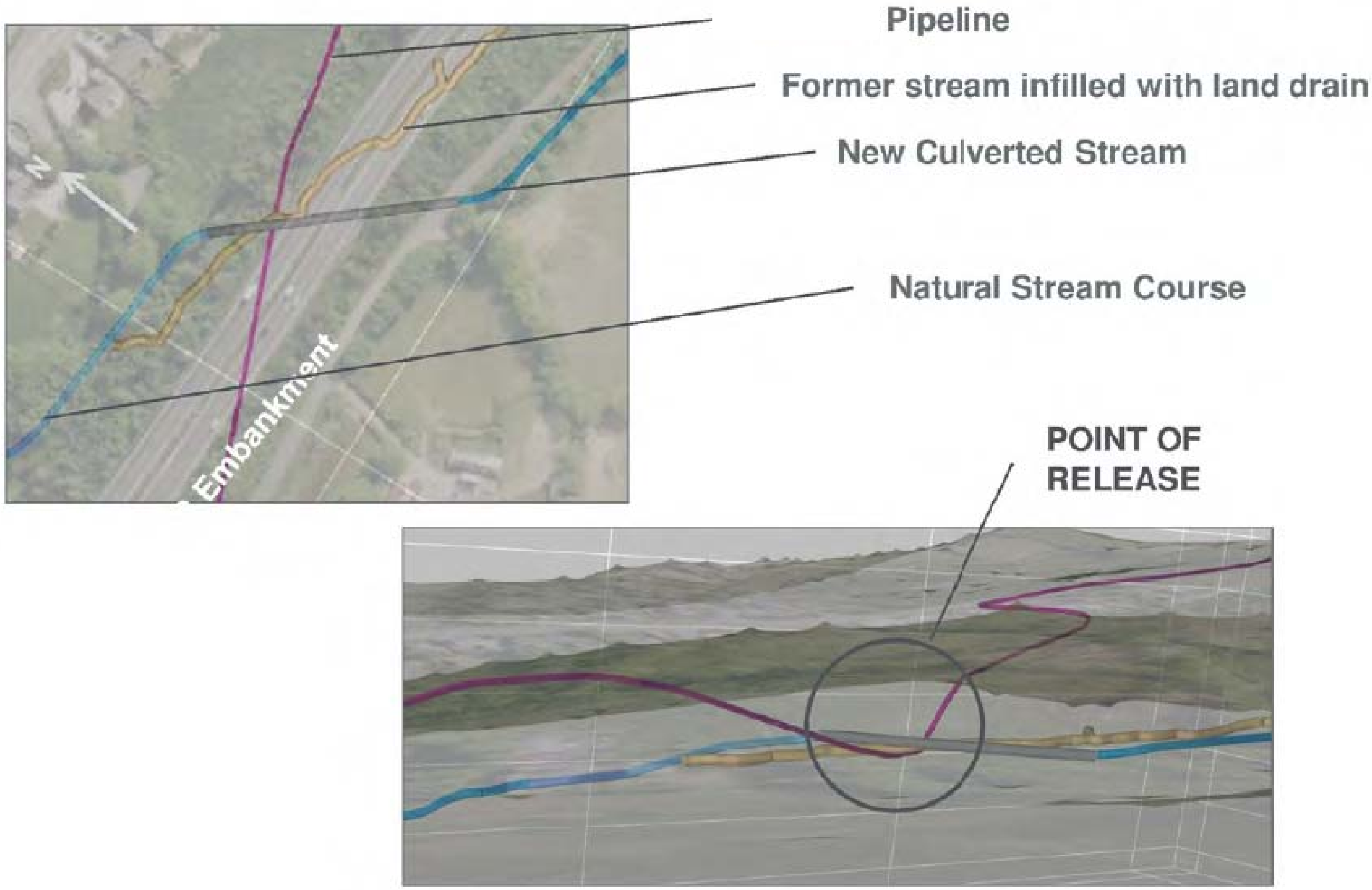
Third Party Impact

Time 0 mins: loss of pressure, automatic valves closed.

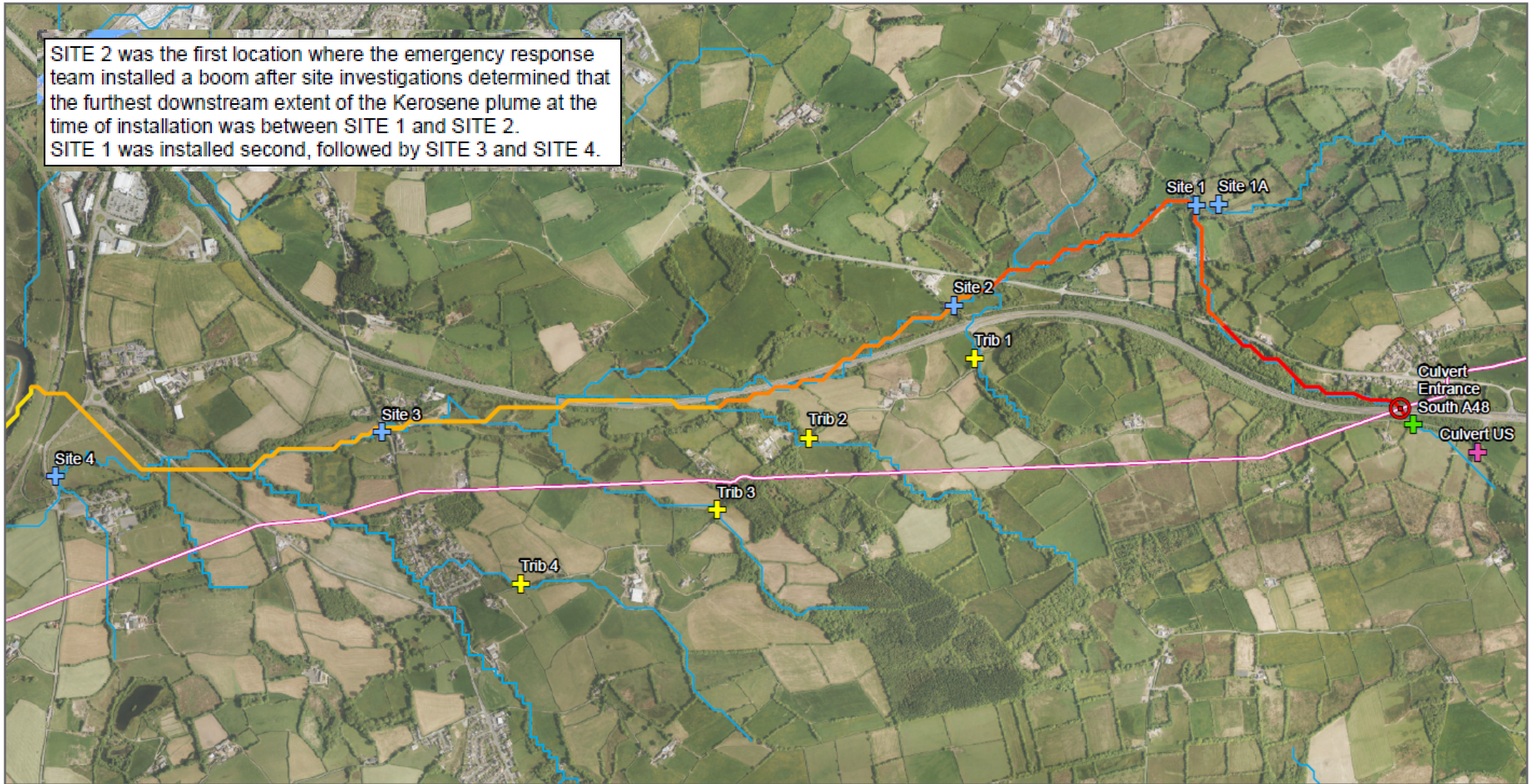
Time 30 mins: first signs of contamination entering stream.

Time: 1 hour hydrocarbon pooling in stream observed.

Time 2 hours: Booms installed based on spill plan estimates of velocity of product in surface waters.



Third Party Impact – Initial Response



Release Location
Culvert
Recovery Site
Surface Water
Trib
Mainline Pipe Route
Surface Waters

To End Point (cumulative seconds)
< 10 mins
10 - 20 mins
20 - 30 mins
30 - 60 mins
1 - 2 hours

0 100 200 300 400 500
Metres
N

SCALE: See Scale Bar	VERSION: A01
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PROJECT: UKOPA Presentation	CHECKED: SG
DATE: 26/09/2017	APPROVED: SG

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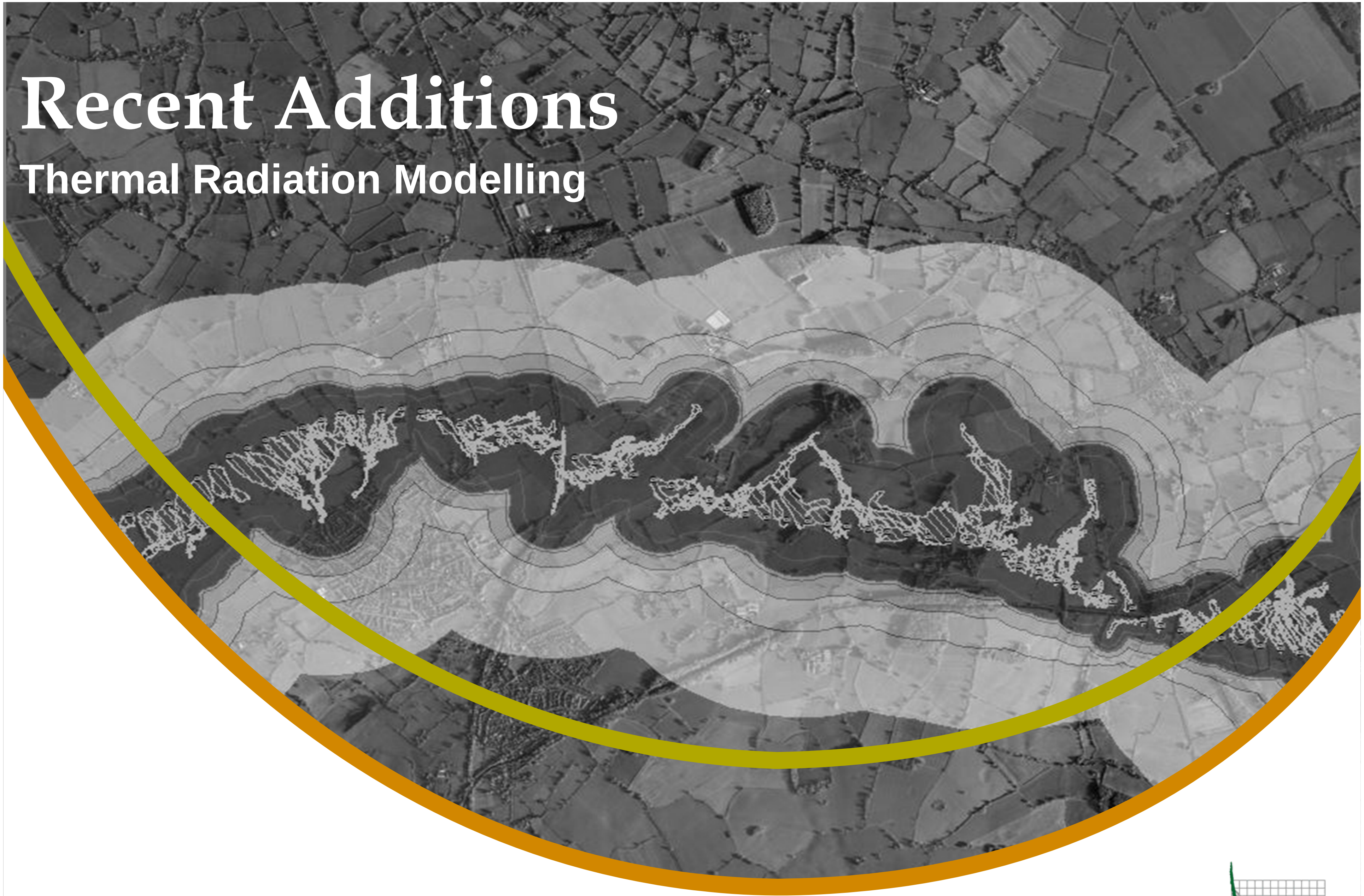
PROJECTION: British National Grid

Recovery Operations


- Four recovery sites were established. Site 2 first followed by Sites 1, 1A, 3 and 4.
- No product was ever reported to have got passed recovery site 2.
- Booming sites were identified based on product flow predictions from the model and crews were dispatched to several locations to provide multiple booming locations, to give redundancy. Product flow direction and flow time estimations helped identify sites and prioritise order in which booms were deployed.
- Recovery operations operated intensively for approximately 3 weeks recovering approximately 95% of the spill volume.

Recent Additions

Thermal Radiation Modelling



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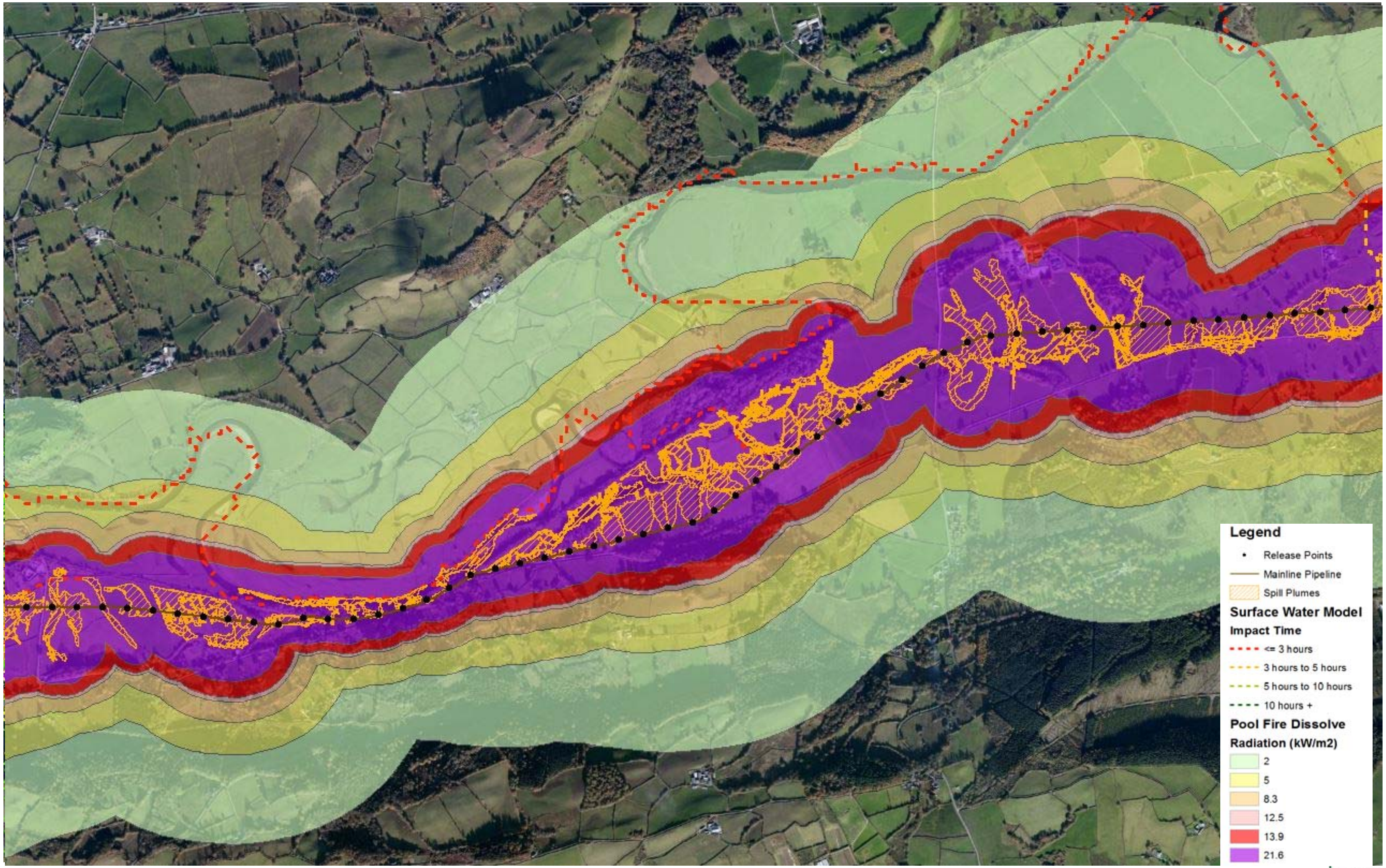
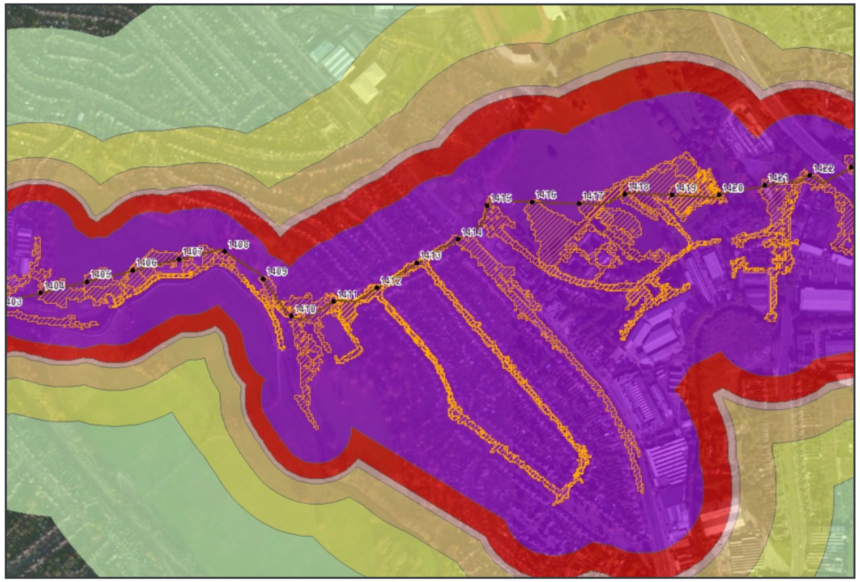
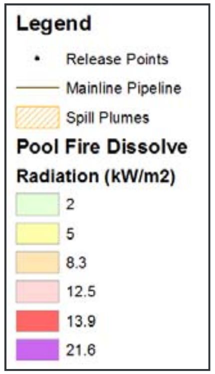
Thermal Radiation Modelling

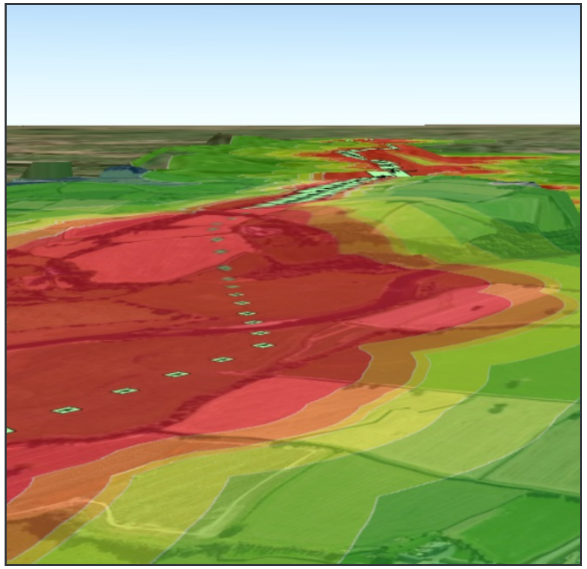


Web Viewer Content Examples

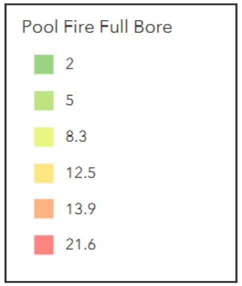


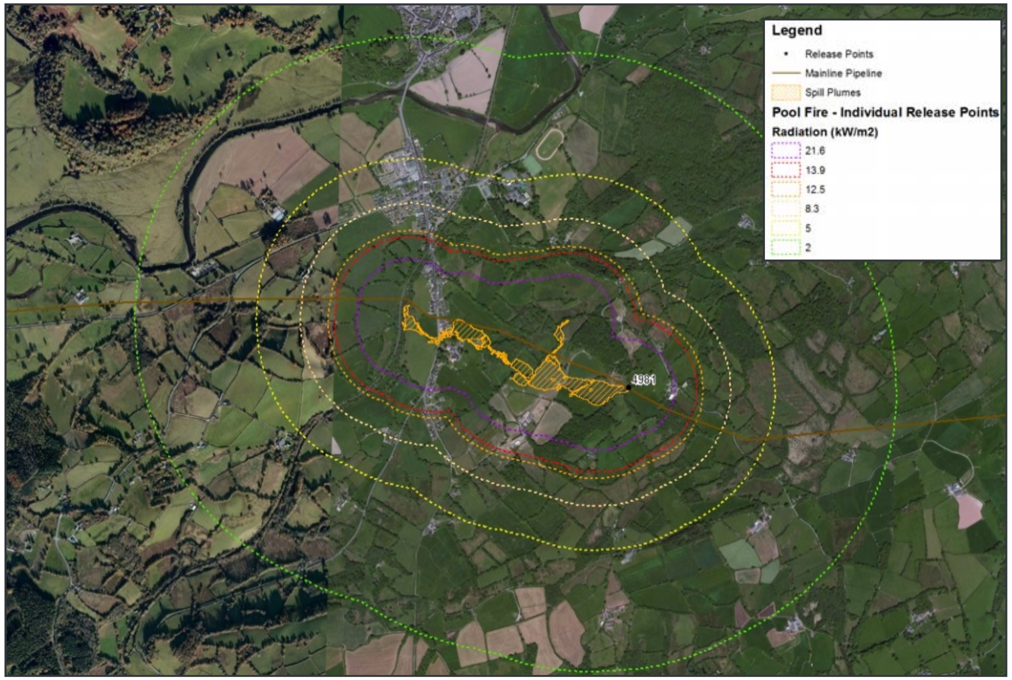


Thermal radiation extents dissolved allowing for the radiation extents to be displayed for all simulated spill plumes along the pipeline.



The thermal radiation extents can viewed over a 3d surface draped which has aerial imagery draped over it.





Individual release point spill plume and thermal radiation extents displayed. Any release point(s) can be isolated and viewed individually (or in groupings).

Further Information

For further details on pipeline release modelling and other environmental support services please contact:

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