FLOODFORECASTINGCENTRE

a working partnership between Environment Agency | Met Office

User Specification for the visualisation of the Surface Water Flooding Hazard Impact Model

1. Overview

Work Package 5 of the Surface Water Flooding Hazard Impact Model (SWF HIM) will deliver an 'end-to-end trial system'. This document sets out the Flood Forecasting Service's user specification for visualising the operationally useful components of the SWF HIM. It has been informed by the following reports:

Surface Water Flooding Component for NHP HIM: Phase 1 (CEH)

Surface Water Flooding: Hazard Impact Model Research (HSL)

Surface Water Flood Forecasting for urban communities (CEH, The James Hutton Institute, Met Office, SEPA)

The FFC users will continue to work closely with the developers to fine tune the requirements set out below during the development phase.

2. Visualisation: overarching principles

1. For the Phase 2 'end-to-end trial system', the SWF HIM visualisation for the FFC will be through the Met Office Visual Weather system although other systems (e.g. NFFS or the FFFS) may be also used in the future.
2. The coding for the 'end-to-end trial' system will be scalable and configurable to allow for future changes to a national scale and upgrades to the SWF HIM and its underlying datasets.
3. The domain for the Phase 2 'end-to-end trial' system will necessarily be restrained to the case study domains for the impact assessments whilst visualisation of rainfall and surface runoff can be at a national scale.
4. To be of efficient use to the operational hydrometeorologist, the SWF HIM visualisation must be presented in an 'easy to use and interpret' form.
5. The visualisation will allow the hydrometeorologist to view summarised data (in space and/or time) and some of the finer resolution underlying data.
6. Temporal scales of the finer resolution visualisation must be sufficiently small (e.g. 1 hour) to allow the operational hydrometeorologist to make effective judgements on the timings of the driving meteorological / hydrological events

and the timings of the impacts. Summarised data over longer timeframes will also be needed (e.g. whole forecast period).

7. Spatial scale will be county / unitary authority for visualisation of summarised data and 1km for visualisation of the underlying data.
8. The visualisation will be consistent with the emerging NHP Hazard Impact Framework.

3. SWF HIM Components to be visualised

The SWF HIM can be split into components that aid the visualisation specification. Fundamentally, there are the Hazard and Impact components and these can be further sub-divided into four themes:

Rainfall

Surface runoff

Risk Detailed (1km)

Risk Summary (county/unitary authority).

These four themes form the basis of what is to be visualised.

4. Summary of User Specification

The SWF HIM inputs and outputs will be visualised as 1km gridded data or as county/unitary authority aggregated summaries. Individual ensemble members will not be visualised with the exception of a county/unitary authority time series of maximum surface runoff.

There are two options for linking to the Updated Flood Maps for Surface Water (uFMfSW) and these options will influence which rainfall and surface runoff inputs and outputs from SWF HIM will be available to visualise in the ‘end-to-end trial’ system.

Option 1

Use Depth, Velocity and Hazard outputs for 9 rainfall scenarios

Option 2

Use the ‘maximum outputs’ and flood outline approach for 1 storm duration resulting in 3 scenarios.

The preferred option (based on scientific advice) is Option 1. However, due to resource constraints in the generation of the Impact Library, the Phase 2 project is expected to take Option 2

There are two fundamental driving data feeds:

1. NOWCAST ensembles

2. Short Range Ensembles (SREN)

The visualisation requirements will be duplicated for the NOWCAST and the Short Range Ensembles based models. This will be indicated in the following section 5 (User Specification) by NOWCAST and SREN for each requirement.

5. User Specification – Hazard (rainfall & runoff)

Rainfall: Option 1 (preferred Rainfall option)

Requirement 1 NOWCAST and SREN:

For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour critical storm duration thresholds (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Requirement 2 NOWCAST and SREN:

For each *county / unitary authority* using the pixel with maximum rainfall in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour critical storm duration thresholds (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Rainfall: Option 2 (a subset of Rainfall: Option 1)

Requirement 3 NOWCAST and SREN:

For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1* hour critical storm duration threshold (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time-steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Requirement 4 NOWCAST and SREN:

For each *county / unitary authority* using the pixel with maximum rainfall in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1* hour critical storm duration threshold (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Surface Runoff: Option 1 (preferred Surface Runoff option)

Requirement 5 NOWCAST and SREN:

For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour SWF HIM 1 km average surface runoff (uFMfSW ‘effective rainfall’) threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Requirement 6 NOWCAST and SREN:

For both the Nowcast and Short Range Ensemble feeds:

For each *county / unitary authority* using the pixel with maximum surface runoff in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour SWF HIM 1 km surface runoff (uFMfSW ‘effective rainfall’) threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Surface Runoff: Option 2 (a subset of Surface Runoff: Option 1)

Requirement 7 NOWCAST and SREN:

For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1* hour duration G2G 1 km surface runoff (uFMfSW ‘effective rainfall’) threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

Requirement 8 NOWCAST and SREN:

For each *county / unitary authority* using the pixel with maximum rainfall in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1* hour G2G 1 km surface runoff (uFMfSW ‘effective rainfall’) threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.

*Recommendation from Surface Water Flooding Component for NHP HIM: Phase 1 Report.

Surface Runoff Ensemble Member Time Series

Requirement 9 NOWCAST and SREN:

(Required with either Option 1 or Option 2)

Per county / unitary authority a surface runoff time series. Maximum (or quantile) 1* hour surface runoff accumulation in any grid cell within each county/unitary authority for each ensemble member for each time-step of the whole forecast T+1 to T+32. These time-series plots to include configurable 1 hour surface runoff accumulation

thresholds for each county / unitary authority (low (7 mm) and high (8.5 mm) can be used in the first instance).

*Recommendation from Surface Water Flooding Component for NHP HIM: Phase 1 Report.

5. User Specification – Impact / Risk Information

Detailed Impact (1km)

Requirement 10 (Time-Series) NOWCAST and SREN:

*1km **maximum** impact severity level as a summary of all four impact categories and across all ensembles. The severity level thresholds being minimum, minor, significant and severe.* 1 hour time-steps T+1 to T+32. Also future proofed to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).

Requirement 11 NOWCAST and SREN:

*1km **maximum** impact severity level individually for each of the four impact categories and across all ensembles. The severity level thresholds being minimum, minor, significant and severe.* 1 hour time-steps, T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32) for each impact category.

Requirements 10 & 11 will be displayed side-by-side for ease of comparison. Figure 1 shows a suggested layout (from HSL note) for displaying requirements 10 & 11 together in one map display.

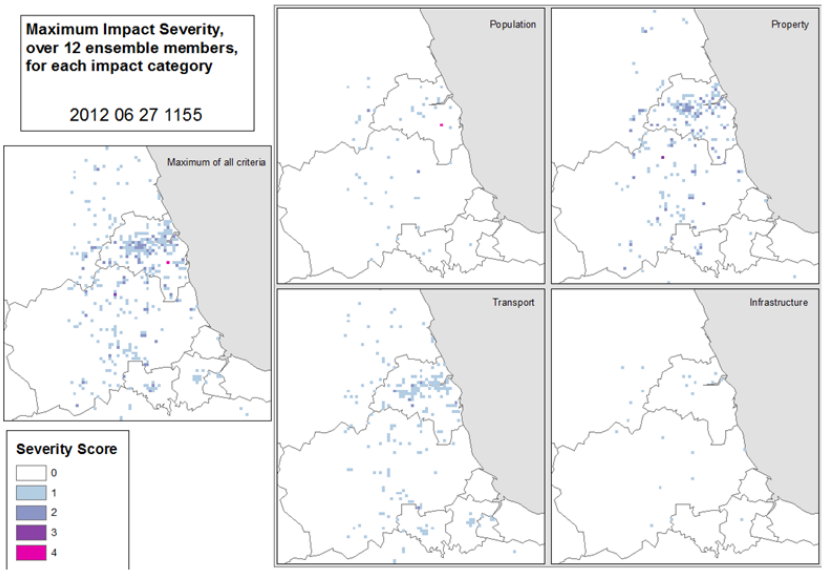


Figure 1: A general example of displaying requirements 10 & 11 side-by-side for ease of comparison.

Requirement 12 NOWCAST and SREN:

*1km **likelihood** of impact severity exceedance individually for each of the four impact categories and across all ensembles*. *The severity level thresholds being minimum, minor, significant and severe.* 1 hour time-steps, T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32) for each impact category.

Requirement 13 NOWCAST and SREN:

*1km **ensemble count** of impact severity exceedance as a summary of all four impact categories and across all ensembles*. *The severity level thresholds being minimum, minor, significant and severe.* 1 hour time-steps, T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).

County / Unitary Authority Risk Summaries

Requirement 14 NOWCAST and SREN:

After first applying the up-scaling of the 1 km impact severity exceedance (summary of all four impact categories – Requirement 10) data for each ensemble member to county / unitary authority scale using equation 3.1 from the HSL phase 1 report: Surface Water Flooding: Hazard Impact Model Research:

*At **county and unitary authority scale***, the ***risk*** summary based on a combined summary of each of the individual impact categories summarised over the ensemble members. 1 hour time-steps T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).

Requirement 15 NOWCAST and SREN:

By way of a call out graphic from the Requirement 14 map for each county / unitary authority:

A graphic for each county / unitary authority displaying the FFC Risk Matrix (4 x4 colour coded grid), with the number of ensemble members (expressed as a percentage of the total ensemble members) exceeding the four impact severity thresholds (minimal, minor, significant, severe) presented in the appropriate position on the matrix. 1 hour time-steps T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).

Based on the example in figure 2 below (taken from the HSL Phase 1 report), figure 3 shows an example of the call out graphic.

Impact					Overall
	Minimal	Minor	Significant	Severe	
No. of ensembles	6	8	8	2	24
Likelihood (%)	24/24x100= 100%	18/24x100= 75%	10/24x100= 41.7%	2/24x100= 8.3%	
Likelihood (matrix position)	High	High	Medium	Very Low	
Matrix Position	1x4	2/4	3x3	4x1	
Risk	Very Low	Low	Medium	Low	

Figure 2: example risk mapping case from HSL Phase 1 report.

High >60%	100%	75%		
Medium 40-60%			41.7%	
Low 20-40%				
Very Low <20%				8.3%
	Minimal	Minor	Significant	Severe

Figure 3: Example of Requirement 15 – call out risk information

6. User Specification for Gridded and Time Series Graphics – Visual Weather Map Editor

Note: The requirement numbers in this section do NOT correspond to those in the previous section.

All the following requirements apply to NOWCAST and SREN models.

Map Display:

Requirement 1

Map Title: Displayed in the top right-hand corner of the map window as viewed in VW Map Editor and to include ‘NOWCAST’ and ‘SREN’ as appropriate.

Requirement 2

Validity date and time of map (VT): Displayed along with the Map Title in the top right-hand corner of the map window as viewed in VW Map Editor.

Requirement 3

Data time (DT) of the driving rainfall forecast. Displayed in the top left-hand corner of the map window as viewed in VW Map Editor.

Requirement 4

Map Legend: Displayed in bottom right-hand corner of the map window as viewed in VW Map Editor.

Requirement 5

The base layer map on all visualisation products should be ‘OS Raster Map’ presented in a grey scale rather than colour to avoid confusion with the overlays.

Requirement 6

All maps to have a county / unitary authority layer, with the county name identified via a tooltip facility.

Requirement 7

Surface water flood risk layers for the Risk Summary (county and unitary authority) and Detailed Risk (1km) will be shown as green, yellow, amber and red as per the FFC Risk Matrix.

Requirement 8

Rainfall and runoff probability of exceedance layers will be presented in a clear probabilistic scale with 4 clearly distinguishable gradations of 0-19%, 20-39%, 40-59% and =>60%. Suggested colouring is 4 shades of contrasting blue to avoid potential confusion with risk colouring.

Layer Editor:

Requirement 9

All layers to be labelled with a clear but short description of the layer, using a consistent method between maps.

Time-Series Graphics: Visual Weather Map Editor

Tool Tip Graphic:

Requirement 10

A ‘pop-up’ tool-tip or ‘call-out’ that displays a time series graph (per county) with time on the horizontal axis and maximum 1 hour surface runoff on the vertical axis.

The horizontal axis will be graduated with one hour time-steps throughout the forecast period with each graduation being labelled with the date (dd-mm-yy) and time in the 24 hour clock format (hh:00).

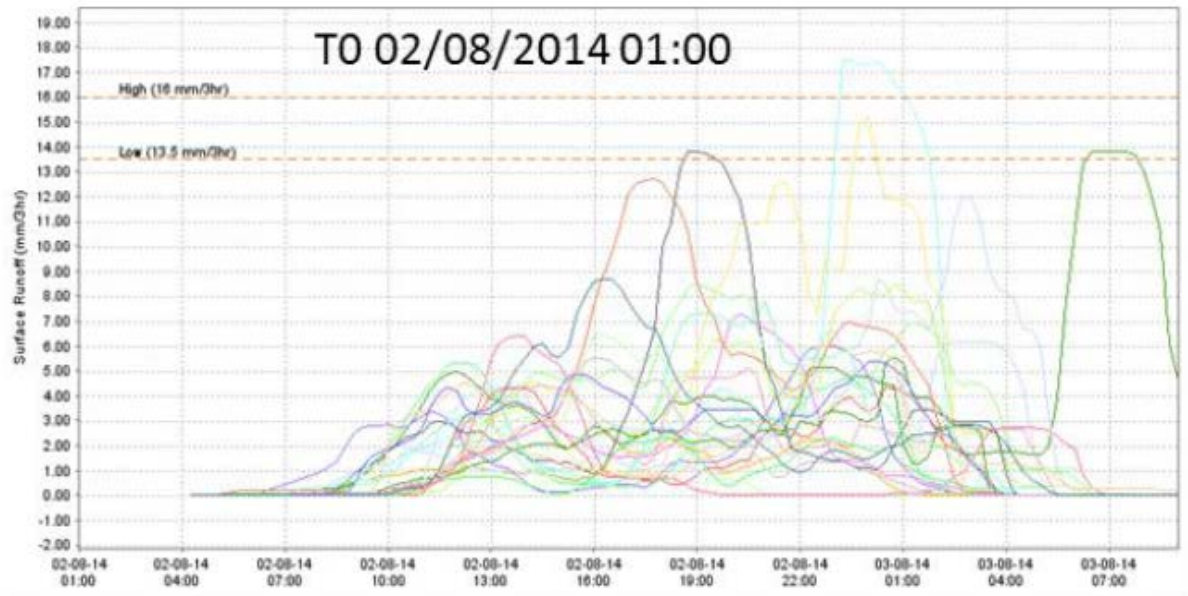
The vertical axis will be graduated in whole mm starting at 0.00 with a suitable upper threshold that will encompass any extreme values. The vertical axis will be labelled ‘Max 1 Hour Surface Runoff (mm).’

A time series of each individual member of the surface runoff ensembles (24 members) plotted in an easily distinguishable different colour per member.

The time series graph will be marked with the Data Time (DT) of the driving rainfall data run.

The graph will include the configurable 1 hour surface runoff accumulation thresholds (e.g. low (7 mm) and high (8.5 mm)). These thresholds could be different for each authority / county.

Figure 3 shows an example of a time-series plot courtesy of the CREW report: Surface water flood forecasting for urban communities. Please note, this is offered purely as an example and the detail (such as thresholds) and axis scales should not be taken literally.



Requirement 11

To view any combination of rainfall, surface runoff and impact maps side-by-side for the same Validity Time and be able to step through time sequences together.

Table 1. SWF HIM gridded and time series data visualisation requirements and summary of the number of Visual Weather maps and layers required for both the Nowcast and Short Range Ensemble forecasts.

Requirement	Description	Number of Visual Weather Maps	Number of Visual Weather layers	Notes
Requirement 1 Gridded Map	For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour critical storm duration thresholds (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	9	(30, 100, 1000 yr) by (1, 3, 6 hr). *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5*
Requirement 2 Gridded Map	For each *county / unitary authority* using the pixel with maximum rainfall in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour critical storm duration thresholds (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	9	(30, 100, 1000 yr) by (1, 3, 6 hr). *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5*
Requirement 3 Gridded Map	For each 1km pixel, the hourly probability of	1	3	(30, 100, 1000 yr) by (1 hr). *Surface Water*

	exceeding 30, 100, 1000 year 1* hour critical storm duration threshold (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time-steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.			*Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5*
Requirement 4 Gridded Map	For each *county / unitary authority* using the pixel with maximum rainfall in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1* hour critical storm duration threshold (FEH DDF rainfall on 5km grid used in uFMfSW design storm thresholds). Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	3	(30, 100, 1000 yr) by (1 hr) *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5 and Annex A*
Requirement 5 Gridded Map	For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour SWF HIM 1 km average surface runoff (uFMfSW 'effective rainfall') threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	9	(30, 100, 1000 yr) by (1, 3 and 6 hr). *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5 and Annex A*

Requirement 6 Gridded Map	For each *county / unitary authority* using the pixel with maximum surface runoff in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1, 3 and 6 hour SWF HIM 1 km surface runoff (uFMfSW 'effective rainfall') threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	9	(30, 100, 1000 yr) by (1, 3 and 6 hr). *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5 and Annex A*

Requirement 7 Gridded Map	For each 1km pixel, the hourly probability of exceeding 30, 100, 1000 year 1* hour duration G2G 1 km surface runoff (uFMfSW 'effective rainfall') threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	3	(30, 100, 1000 yr) by (1 hr) *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5 and Annex A*
Requirement 8 Gridded Map	For each *county / unitary authority* using the pixel with maximum rainfall in the first instance (a contingency for using other methods to be included, e.g. use of percentiles): the probability of exceeding 30, 100, 1000 year 1* hour G2G 1 km surface runoff (uFMfSW 'effective rainfall') threshold. Within each hour, a rolling window (15 minute time steps) samples data across the storm duration. Outputs are 1 hour time steps from T+[storm duration] to T+32.	1	3	(30, 100, 1000 yr) by (1 hr) *Surface Water Flooding Component for NHP HIM: Phase 1 (CEH) – Sections 4&5 and Annex A*
Requirement 9 Time Series	*Per county / unitary authority a surface runoff time series. Maximum (or quantile) 1* hour surface runoff accumulation in any grid cell within each county/unitary authority for each ensemble member for each time-step of the whole forecast T+1 to T+32. These time-series plots to include configurable 1 hour surface runoff accumulation*	N/A – available as a tool-tip call out from one of the other surface runoff maps if possible.	N/A	*Surface Water Flood Forecasting for urban communities – see Figure 14*

	thresholds for each county / unitary authority (low (7 mm) and high (8.5 mm) can be used in the first instance).			
Requirement 10 Gridded Map	*1km **maximum** impact severity level as a summary of all four impact categories and across all ensembles. The severity level thresholds being minimum, minor, significant and severe. 1 hour time-steps T+1 to T+32. Also future proofed to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).*	1	1	Requirements 10 & 11 will be displayed side-by-side for ease of comparison. Figure 1 shows a suggested layout (from HSL note) for displaying requirements 10 & 11 together in one map display.
Requirement 11 Gridded Map	*1km **maximum** impact severity level individually for each of the four impact categories and across all ensembles. The severity level thresholds being minimum, minor, significant and severe. 1 hour time-steps, T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32) for each impact category.*	1*	1*	Requirements 10 & 11 will be displayed side-by-side for ease of comparison. Figure 1 shows a suggested layout (from HSL note) for displaying requirements 10 & 11 together in one map display. *There are 5 impact themes but disruption to communities is a subset of damage to buildings
Requirement 12 Gridded Map	*1km **likelihood** of impact severity exceedance individually for each of the four impact categories and across all ensembles. The severity level thresholds being minimum, minor, significant and severe. 1 hour time-steps, T+1 to T+32. Also to*	1	4*	*There are 5 impact themes but disruption to communities is a subset of damage to buildings

	summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32) for each impact category.			
Requirement 13 Gridded Map	*1km **ensemble count** of impact severity exceedance as a summary of all four impact categories and across all ensembles. The severity level thresholds being minimum, minor, significant and severe. 1 hour time-steps, T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).*	1	4	*4 layers: Minimal, Minor, Significant, Severe*
Requirement 14 Gridded Map (connected to requirement 15).	*After first applying the up-scaling of the 1 km impact severity exceedance (summary of all four impact categories – requirement 10) data for each ensemble member to county / unitary authority scale using equation 3.1 from the HSL phase 1 report: Surface Water Flooding: Hazard Impact Model Research: At **county and unitary authority scale**, the **risk** summary based on a combined summary of each of the individual impact categories summarised over the ensemble members. 1 hour time-steps T+1 to T+32. Also to summarise other configurable periods. This*	1	1	*As per Section 3.6 in Surface Water Flooding: Hazard Impact Model Research (HSL).*

	configurable period initially being set to the whole period (T+1 to T+32).			
Requirement 15 Graphic: 'call out' risk matrix	*By way of a call out graphic from the Requirement 14 map for each county / unitary authority:* *A graphic for each county / unitary authority displaying the FFC Risk Matrix (4 x4 colour coded grid), with the number of ensemble members (expressed as a percentage of the total ensemble members) exceeding the four impact severity thresholds (minimal, minor, significant, severe) presented in the appropriate position on the matrix. 1 hour time-steps T+1 to T+32. Also to summarise other configurable periods. This configurable period initially being set to the whole period (T+1 to T+32).*	N/A	N/A	*A call out graphic accessed from Requirement 14 map.*

7. Impact Library: static data

Consideration should be given for the need of the FFC user to have a visualisation of the Impact Library static data. Although this is static data it will be high volume.

8. Future scalability and improvements

Phase 3 of the SWF HIM project will introduce a national (England & Wales) SWF HIM. This will introduce additional or extended requirements to the visualisation. The coding for the Phase 2 visualisation should be written to allow easy scaling for the following.

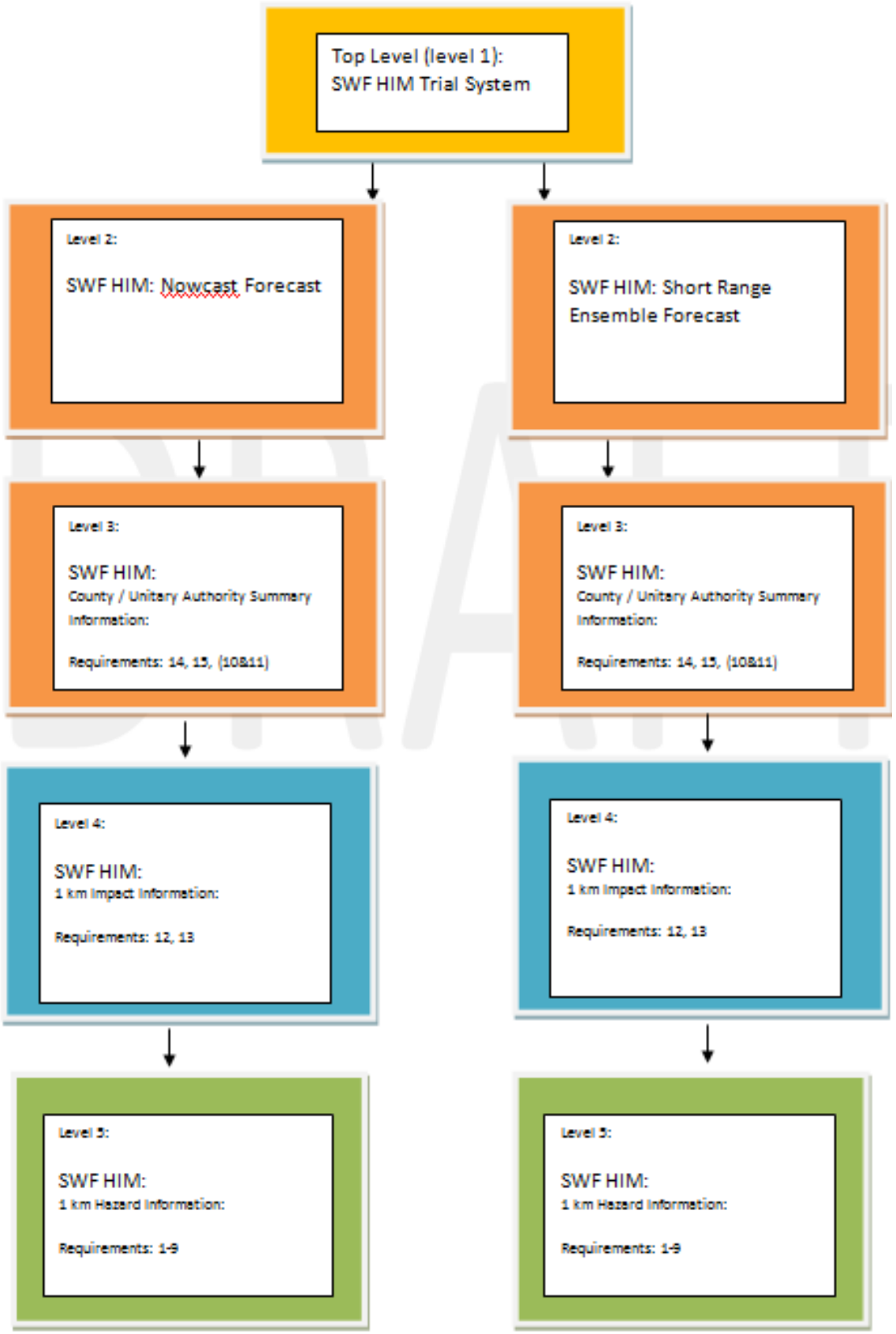
1. The domain will become the whole of England & Wales at 1 km resolution and a fundamental 15 minute time-step.
2. The downscaled 5 day MOGREPS-G project will provide a probabilistic forecast to day 5. This will require a day (24 hr Calendar Day) max risk summary map and extended frames to existing visualisation.
3. MOGREPS-UK will be extended to a useable T+48 hrs (actual T+54 hrs).
4. Larger ensemble sizes.

9. Functionality

The intention is to use the existing functionality of Visual Weather. However, consideration must be made to allow sufficient configurability to be able to deliver the following key functionality on other types of visualisation systems:

A key part of the functionality is to retain the valid time and location (zoom extent) when switching from map to map. This is to allow for ease of navigation through the map heirarchy.

10. Visual Weather File Structure for the SWF HIM Visualisation



11. Archiving and Retrieval

During the latter stages of the SWF HIM Phase 2 project and the subsequent trial of the end-to-end user system, there will be a requirement to archive and retrieve the output from the system. This is anticipated to be done on a case-by-case basis. As part of the end-to-end (WP5) plan, provision should be made for such archiving and retrieval methodology. A separate specification should be submitted for this, but it is anticipated the retrieval of archived SWF HIM end-to-end system output will viewed as per this document.