Supplementary Material

# Determination of Drainage Removal Rate Values

Drainage removal rate (DRR) values were determined using the approach detailed in van Leuwen et al., (2019) who cite Horrit et al., (2009), which was developed for large scale flood hazard mapping undertaken in the UK. The approach utilises modified version of the Rational Method and is set out in Equation 1 and Equation 2:

|  |  |  |
| --- | --- | --- |
|  |  | **Equation 1** |
|  |  | **Equation 2** |

The above equations account for the percentage runoff (); critical storm duration (); level of service of the drainage system (); and four parameters that describe the rainfall depth-duration-frequency curve (, , and ). This approach was used to determine the default DRR of 12 mm/hour for the UK. We calculated a DRR value of 8.6 mm/hour for urban areas based on a of 57%; and an assumed of 5 (i.e., 1-in-5 years). This calculated DRR value also incorporates an additional assumption that the drainage system in Addis Ababa will be blocked such that it operates at 50% of its hydraulic capacity. In non-urban areas we used a DRR value of 1.8 mm/hour based on a PR of 10%; and an assumed LoS of 1-in-2 years.

# Addition of River Channel Bathymetry to Global Digital Elevation Models

Channels are burned directly into the digital elevation models (DEMs) using a rectangular cross-sectional shape. We first estimate the bank full flow capacity of all channel reaches using a relationship between upstream drainage area and bank full discharge. RM peak flow predictions resulting from the 1-in-2 year rainfall event simulation were sampled alongside their upstream drainage areas for a range of channel sizes, and a relationship between discharge and upstream area derived using a power law with coefficient of determination of 0.994. Note we are adopting the widely used assumption that bank full discharge equals the median annual maximum flood, i.e., the flood with a 1-in-2 year return period (Williams, 1978; Bradbrook et al., 2004). Secondly, we determine channel reach widths from their bank full discharge using an hydraulic geometry relationship between bank full discharge and width (Leopold and Maddock, 1953; Moody and Troutman, 2002). Thirdly, we use Manning’s equation for uniform flow to calculate channel depth from discharge, width, longitudinal slope, and a Manning’s n hydraulic roughness coefficient.

# HEC-RAS Modelling Files Guidance Notes

1. Two HEC-RAS model projects are provided. ‘Akaki\_HECRAS\_model’ includes the return period event model runs for the reference model and each of the global dataset tests. ‘Akaki\_HECRAS\_model\_historical’ includes the historical event simulation used for validation.
2. All results files associated with the 5 m resolution DEM used in this study have been removed from the HEC-RAS projects, as it is not possible to provide this DEM.
3. Model results associated with the 5m resolution DEM have been provided separately to HEC-RAS projects, in the form of maximum depth grids. These results files are detailed in section 4.
4. The post-processed flood depth grids resulting from the MERIT and FABDEM test runs are computed in RAS Mapper using the version of the DEMS without the river channels added: ‘MERIT\_no\_channels\_Akaki’ and ‘FABDEM\_no\_channels\_Akaki’. This is to avoid issues with inaccuracies in the location of the burned in channels.
5. To run any of the included simulations, HEC-RAS Version 6.1 must be used so that restart files can be read.
6. The two downscaling methods provided in RAS Mapper (referred to as Water Surface Rendering Modes in HEC-RAS) are: (1) ‘Sloping (Cell Corners)’; and (2) ‘Sloping (Cell Corners + Face Centres) – Use Depth-Weighted Faces’. These are both available in version 6.4 of HEC-RAS.

# Geospatial Data Layers Guidance Notes

Layers provided are described in Supplementary Supplementary Table 1 below. All layers use the UTM zone 37N coordinate reference system.

Supplementary Table 1. Details of geospatial data layers provided.

| Geospatial data layer filename | Description  |
| --- | --- |
| RM\_5\_DSM1.tif | Reference model – maximum flood depth grid results; 1-in-5 year; downscaling method 1**1** |
| RM\_5\_DSM2.tif | Reference model – maximum flood depth grid results; 1-in-5 year; downscaling method 2 |
| RM\_100\_DSM1.tif | Reference model – maximum flood depth grid results; 1-in-100 year; downscaling method 1 |
| RM\_100\_DSM2.tif | Reference model – maximum flood depth grid results; 1-in-100 year; downscaling method 2 |
| PXR\_5\_DSM1.tif | Global ‘PXR’ rainfall dataset test – maximum flood depth grid results; 1-in-5 year; downscaling method 1 |
| PXR\_5\_DSM2.tif | Global ‘PXR’ rainfall dataset test – maximum flood depth grid results; 1-in-5 year; downscaling method 2 |
| PXR\_100\_DSM1.tif | Global ‘PXR’ rainfall dataset test – maximum flood depth grid results; 1-in-100 year; downscaling method 1 |
| PXR\_100\_DSM2.tif | Global ‘PXR’ rainfall dataset test – maximum flood depth grid results; 1-in-100 year; downscaling method 2 |
| 06SEP2017\_0700\_DSM1.tif | Historical event simulating flooding on 6 September 2017 – flood depth grid results at 7am UTC; downscaling method 1. |
| T37PDK\_20170906T073611\_B8B11B4\_ LandWater\_virtual\_clipped.tif | Sentinel 2 optical satellite image observing flooding on 6 September 2017. Bands 8, 11 and 4. |
| T37PDK\_20170906T073611\_MNDWI.shp | Flood extent extracted from the Sentinel 2 image. |
| Downscaling methods (1) and (2) are as described in note (6) of section 3 above. |

# Model Test Results: Flood Extents and Depths

Flood extent and depth results for each of the global dataset tests are summarized in **Supplementary Table 2** below. Statistics provided include total flooded area across the entire model domain, and the average peak flood depth value across the model domain.

**Supplementary Table 2.** Summary ofFlood Extent and Depth Results

|  | 1 in 5 | 1 in 100 |
| --- | --- | --- |
| Model Variant | Flooded area (km2) | Average peak flood depth (m) | Flooded area (km2) | Average peak flood depth (m) |
| Reference Model | 78.07 | 1.53 | 115.64 | 1.88 |
| FAB-DEM test | 89.04 | 0.86 | 136.47 | 1.21 |
| MERIT DEM test | 103.52 | 0.85 | 152.21 | 1.14 |
| Global rainfall data test | 105.05 | 1.77 | 143.92 | 2.21 |
| Fathom 2 | 93.80 | N/A1 | 288.00 | N/A1 |
| Comparative values not available because Fathom 2.0 data does not include depth information within permanent water bodies, unlike all other model variants. |

# References

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Leopold, L.B. and Maddock, T.J. 1953. *The Hydraulic Geometry of Stream Channels and Some Physiographic Implications* [Online]. Washington DC, USA. Available from: https://pubs.usgs.gov/publication/pp252.

van Leuwen, Z., Gill, E., Hunter, N. and Blazey, N. 2019. *Improving Surface Water Flood Mapping: Estimating Local Drainage Rates* [Online]. Bristol, UK: UK Environment Agency. Available from: https://assets.publishing.service.gov.uk/media/603660e18fa8f5480ff52477/Improving\_surface\_water\_flood\_mapping\_-\_estimating\_local\_drainage\_rates\_-\_report.pdf.

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