OBSERVATIONS ON THE HYDROLOGY OF TWIGWORTH
Ian Cluckie

1. These notes are focused on aspects that affect the flood risk of Twigworth, a village of about 165 properties located outside Tewkesbury where recently a developer wished to construct, in the first instance, 725 new houses and the JCS may wish to allocate many more. Clearly, there is an issue of scale and location.

2. This area is Greenbelt and has been recognized as effectively water meadows since feudal times. It is essentially flat topography on fertile clay soils. It is directly adjacent to the flooded area mapped following the 2007 Flood. The proposed allocation site will be surrounded by fluvial flooding on 3 sides by any recurrence of a flood with the severity of 2007. Its choice for the development of extensive housing is unwise *and does not reflect the precautionary principle that is commonly adopted in modern flood design*.

3. A developer will not be required to live with the consequences of such an unwise development throughout the lifetime of a scheme with the majority of the risk and management being passed onto the future and existing Twigworth residents, the Water Company, the Highway Authority, the EA and TBC.

4. The responsibility of the JCS is to decide whether the inclusion of the potential allocation breaks the precautionary principle commonly employed when considering the Flood Risk aspects of a potential allocation.

5. Twigworth as a potential site suffers from extensive *Pluvial Flooding* and offers little prospect for the exploitation of infiltration in order to mitigate the impact of surface ponding and runoff. The SUDs (Sustainable Urban Drainage System) solution offered recently by a developer was based upon ground raising by over 600mm+ in order to lift the proposed housing above the expected flood zone, and storage ponds to be built alongside the Hatherley Brook in order to mitigate the surface runoff from the site and its impact downstream.

6. These *SUDs ponds* are intended to remain partially full at all times and reed beds will be used to oxidize the nutrient loading from the site. Little information has been provided in terms of the effectiveness of the proposed ponds, the impact of the first flush (where BOD levels can reach the strength of raw human sewage), or what impact the bypass runoff will have on the Hatherley Brook during an extreme flood? Developers should remember that the average daily temperature is also predicted to rise significantly (by +2 to +4 degrees centigrade on average) and the evaporation from open surface water ponds will therefore increase. Any new community will not necessarily welcome the variety of life that these ponds will support in this warmer future and the management task will be more onerous and expensive than is currently envisaged given the extensive algae blooms that

will occur in effectively still water situations or in the extreme case of a completely dry pond.

7. Almost no information was recently provided by a potential developer in relation to *Overland Flow* paths generated on the Twigworth site from direct pluvial runoff or adjacent (upslope) pluvial runoff from surrounding land. This aspect was commented on in detail in the TBC submission to a planning inquiry and the comments provided by the developer's consultant did not fully address this issue.

8. The Post-development "*Fluvial Flows"* in the Hatherley Brook have been estimated by a recent developer using a computer program call TUFLOW. This is a 1d commercially available hydraulic flow routing program and it will be dominated by the assumptions made regarding the channel hydraulic roughness and/or the channel blockage due to plant growth. Its ability to estimate the design flow depths will also be diminished by its inability to make a full allowance for culvert blockage as the Hatherley and Horsbere Brooks pass under the A38. This means that the forecast fluvial water levels will at best be highly uncertain estimates. This is a common difficulty in estimating post-development fluvial flows.

9. The modeling work carried out by a recent developer did not fully reflect the current changes introduced in terms of the recommended climate change allowances (and these are still crude estimates of the future impact of climate change and should be considered as at best tenuous and temporary). The current recommendations are that a 70% increase be introduced when attempting to model future fluvial flows whilst making due allowance for the impact of climate change.

10. The modeling of the design storms also generally fails to recognize the nature of future flood producing storms and the likelihood that *Mesoscale Convective Complex Systems (MCS)* will dominate future extreme floods. These are large frontal storms with significant embedded convective cells. This inherent uncertainty should encourage the choice of development sites further away from known flood-prone areas that is in keeping with the precautionary principle.

11. An MCS event would have very high rainfall rates often greatly in excess of the maximum infiltration capacity of the soil. This would "armor and seal" the ground surface through the impact of large raindrops in clay catchments and generate overland flow even when there is storage potential available in the soil. The likely occurrence of overland flow would therefore be considerable and the management of such flow would become important.

12. The use of the MIcrodrainage Software by a recent developer has raised issues in terms of the choice of the *Standard Percentage Runoff Coefficient (SPR).* This is often hard coded into software as a fixed choice of 0.47 for a category 4 Soil (clay). This means that all the rainfall-runoff calculations assume that only 47% of the rainfall will convert to runoff. The revision of

the Institute of Hydrology document IH124 (written in 1994 and embedded into the version of Microdrainage used by the developers consultant) was an update of the original FEH/FSR (published in 1975). This followed some years of negative criticism of the original Flood Studies Report. Continuing criticism eventually led to the revision ReFH2 that was introduced in 2016. This effectively allows for an SPR of 0.7 (i.e. 70%) that many still consider unreasonable for clay soils in extreme rainfall? Special treatment of Scottish storms was introduced by SEPA and reflected in ReFH2. Indeed, the USA EPA revised American practice to allow 100% runoff from clay (and highly urbanized) catchments. With this knowledge, recent calculations carried out by a potential developer are likely to underrepresent the storm runoff by a factor of 2. This will have a serious impact on the computed fluvial flood levels and any consequent SUDs storage design.

13. It is now a common requirement in the mitigation of Overland Flow to introduce tree belts in order to help mitigate the problem of surface water causing overland flow and encourage increased levels of infiltration in even a clay soil. It is unfortunate that a recent developer or indeed the JCS have not considered such a sustainable solution in the context of the Twigworth site. However, their introduction would reduce the area of proposed housing on this site with obvious economic consequences.

Professor Ian David Cluckie, FREng, Acad.CAE, FRSA

Emeritus Professor of Engineering
Zienkiewicz Center for Computational Engineering, Swansea University
Fellow of the Royal Academy of Engineering
Academician of the Chinese Academy of Engineering

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