Proposed Housing & Church Development, Kerry Road, Abermule, Powys

Flooding Consequences Assessment

Report 20316

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QUALITY MANAGEMENT REPORT

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EXECUTIVE SUMMARY

- The Applicant is seeking planning permission for the construction of a new church with a separate residential development of four dwellings, with access road and parking areas, on a predominantly greenfield site located on the eastern side of Abermule, Powys.

- The site area within the application red line boundary is 2.5 ha and includes the stretch of the B4368 that forms the southern boundary.

- The site is located on the left bank of the R. Mule, a tributary of the Severn.

- Impermeable surfaces (i.e. B4368) currently account for 7% of the site area. The proposed development will create impermeable surfaces covering 0.42 ha, increasing the impermeable proportion to 24% of the total site area.

- Current Natural Resources Wales flood maps confirm that only the extreme north-eastern margin of the site, closest to the R. Mule, lies within the 1% (100-year) and 0.1% (1000-year) flood plain.

- However, there will be <u>no development within the flood plain</u>. Proposed finished floor levels for the church and housing units ensure ample freeboard above the extreme 0.1% flood level, in compliance with TAN 15 guidelines.

- There will be <u>no risk to life</u>. The site access is roughly 3.0 m above the 0.1% flood level and there is safe access/egress via the B4368 leading to higher ground to the south.

- There will be <u>no impediment or diversion of floodwaters</u>, or loss of <u>flood plain storage</u>, that will increase flood risk beyond the development. The proposed development will have <u>no impact on fluvial or coastal morphology</u>.

- Flood risk is limited to the potential impacts beyond the development of increased surface runoff resulting from creating impermeable surfaces on what is currently a predominantly greenfield site.

- On-site percolation tests confirm the potential for effective infiltration of surface runoff.

- Potential sustainable drainage (SuDS) measures include:
    - dedicated rain butts and soakaways for the church and housing units;
    - additional storage adjacent to the church to accommodate excess roof runoff to provide a source for grey-water recycling;
    - grass swales and/or infiltration strips alongside access roads and edges of parking areas;
    - part-permeable parking areas.

- Sample calculations indicate that with such measures in place, it will be possible to restrict post development runoff rates and volumes to existing greenfield rates for a 30-year design storm event, with no flooding within the development plots. Some internal inundation (eg temporary flooding of parking areas) for more extreme events can be tolerated.

- Further investigations and consultation with the local Drainage Authority will be required prior to final design of the SuDS system for the development.

EXECUTIVE SUMMARY

CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

The Applicant is seeking planning permission for the construction of a new church with a separate hosing development of four residential dwellings on a predominantly greenfield site just to the east of Abermule, Powys. The site is on the left bank of the R. Mule that flows into the Severn at Abermule some 550 m further downstream. The proposed development is not within the current Natural Resources Wales (NRW) flood plain and is not at risk of direct fluvial flooding. However, the development will create impermeable surfaces on what is currently a predominantly greenfield site and NRW stipulated the need for a flooding consequences assessment (FCA) following guidelines given in Technical Advice Note 15 (TAN 15)[1], primarily to assess impacts of the proposed development on flooding risk elsewhere.

Two previous FCA's for the proposed development site were produced by David Floyd, Consultant Hydrologist / Water Resources Engineer (the Consultant). The first, submitted in February 2011[2], included proposed residential development (8 dwellings) on land adjacent to the church plot. The second, submitted in July 2012[3], incorporated minor changes to the proposed church plans but excluded any residential development.

A revised planning application is being prepared by Hughes Architects on behalf of the Applicant, incorporating further changes to the proposed church plans and re-introducing residential development, limited to four dwellings. According to TAN 15, the church and residential dwellings are classified as 'highly vulnerable development'. NRW requires that the revised planning application is accompanied by an updated FCA that incorporates changes in development proposals and also takes into account latest NRW flood maps.

This report presents the FCA for the proposed housing and church development. It follows guidelines presented in TAN 15, with particular emphasis on 'technical requirements for assessing flooding consequences' in Appendix 1, Section E. Key issues that need to be addressed by the FCA are:

- Confirm, based on the best information currently available, that the proposed development is not at risk of flooding during the 1% annual exceedance probability (AEP) flood (100-year), making allowance for potential future increases in flood peaks resulting from global warming (Q_{100+CC}).
- Confirm, based on the best information currently available, that the proposed development is not at risk of flooding during the 0.1% AEP (1000-year) flood (Q_{1000}).
- Evaluate consequences of the site being flooded in relation to risk to life.
- Evaluate the risk of impediment/diversion of floodwaters and /or potential loss of flood plain storage.
- Assess potential impacts of the proposed development on flooding risk beyond the development through increased surface runoff.
- Demonstrate that appropriate mitigation measures can restrict future surface runoff to existing greenfield runoff rates.

1.2 STRUCTURE OF REPORT

The FCA is presented in the following sections:

- Section 2 describes the existing site characteristics.
- Section 3 presents the development proposals.
- Section 4 assesses the flooding risk associated with the proposed development, together with potential mitigation and management measures to minimise impacts of the development.
- Section 5 addresses, step-by-step, technical requirements for undertaking a flooding consequences assessment as laid down in Appendix 1 of TAN 15 with associated findings of the FCA, cross referenced to relevant sections of this report.

Figures and Plates are included separately after the main report text.

Annex A contains details of percolation tests carried out in March 2010 to assess the viability of soakaways or other sustainable drainage (SuDS) measures that may be implemented.

2 SITE CHARACTERISTICS

2.1 PLOT LOCATION AND EXISTING DEVELOPMENT

The development site for the proposed construction of housing and a new church is located to the east of Abermule at approximate NGR SO 165 945, between the B4368 (Kerry Road) and the R. Mule, a tributary of the Severn (Figure 1).

The **plot** is defined as the proposed development area mostly located between the disused railway embankment and the B4368 (Kerry Road), as shown in Figure 2. The plot covers an area of 1.84 ha consisting of the housing plot (0.40 ha) to the west and church plot (1.44 ha) to the east. The disused railway embankment separates the plot from the left bank flood plain of the R. Mule, forming a *de facto* flood defence.

The plot is currently greenfield grassland. Housing and church plots are separated by a post and wire fence and a temporary access track leading off the B4368 (Plates 1-4).

The **site**, as defined by the 'red line' for the current planning application, incorporates additional areas external to the plot, including the B4368 to the south and residual grass and wooded areas to the north (see §3 and Figure 6). The total site area is 2.5 ha.

2.2 TOPOGRAPHY

A topographic ground survey of the plot was carried on behalf of the Applicant in May 2008[4]. The survey was updated in December 2009[5] to give spot levels and contours (0.25 m interval) across the plot. Ground surveys were confined to the area within the plot boundary and did not extend across the R. Mule flood plain. They were therefore supplemented by the purchase of LiDAR (aerial survey) data from the Environment Agency (EA), in the form of a single 'tile' (SO1694), flown on 10 May 2006 at 2.00 m horizontal resolution. Filtered (DTM) LiDAR data were processed using MapInfo Professional[6] and Vertical Mapper[7] software to produce contours and cross sections across the plot and the R. Mule flood plain.

Site and external contours are shown in Figure 3 with representative cross sections plotted in Figure 4. The housing plot (Section A) falls from 98.5 mAOD at the B4368, sloping steadily north-westwards towards the R. Mule with a minimum elevation of about 95.0 mAOD at the north-west boundary. Minimum ground levels within the plot are at least 3.0 m above the R. Mule bed level. The church plot is relatively flat with most of the plot lying between 99.0 mAOD and 97.5 mAOD, with minimum ground levels some 3.5 to 4.0 m above the R. Mule bed level and a wide strip of land between the northern plot boundary and the R. Mule flood plain (Figure 4 Sections B, C). The extensive flood plain and rising ground between the river and the development plot are evident in Plates 5 to 7.

In the north-east corner below 98.0 mAOD, bounded by the R. Mule, ground levels fall rapidly towards the river and a narrow strip inside the plot boundary lies within the flood plain (Figure 4, Section D). The flood plain on the right bank is restricted by rapidly rising ground.

Ground elevation at the existing (and future) access to the plot from the B4368 (Plate 4) is 98.5 mAOD, more than 6.0 m above the R. Mule bed level.

2.3 SUPERFICIAL GEOLOGY

Sustainable urban drainage (SuDS) measures will form a major component of mitigation against flood risk within and beyond the proposed development resulting from the introduction of impermeable surfaces on what is currently a predominantly greenfield site. The potential for soakaways and other SUDS measures will depend largely on the soil characteristics and underlying superficial geology.

A map showing the superficial geology in the Abermule area is reproduced in Figure 5[8]. Most of the development site is underlain by alluvial fan deposits, a mixture of clay and silt. The extreme north-east corner of the site is underlain by alluvium comprising mixed clay, silt, sand and gravel.

The nature of these deposits suggests good potential for infiltration of surface runoff from the future development. This was tested further by a series of percolation tests carried out in March 2010, described in Annex A and §4.4.3.

3 PROPOSED DEVELOPMENT

The red line site boundary, covering a total area of 2.5 ha, is shown in Figure 6. The proposed development includes the housing plot on 0.40 ha to the west and the church plot on 1.20 ha (internal) to the east, with shared access from the B4368. Future development proposals, including location of the church and housing units, access roads, parking areas and residual soft landscaping, are shown in Figure 7.

The proposed housing development lies within the area designated for residential development in the UDP. Existing ground levels at Units A and B (3 bed bungalows each 110 m^2 footprint), closest to the R. Mule, are approximately 95.5 and 96.5 mAOD respectively. Finished floor levels (FFL) will be at least 500 mm above existing ground levels, nominally 96.3 mAOD, some 1300 mm above the extreme 0.1% (Q_{1000}) flood level at this point as plotted in Figure 4 (Section A). A central access carriageway will separate these units from Units C and D (4 bed detached houses each 87 m^2 footprint) adjacent to the B4368 where the existing ground level is 97.5 to 98.0 mAOD. Nominal FFL for these units is 97.5 mAOD, 2500 mm above the extreme 0.1% (Q_{1000}) flood level at this point (Figure 4, Section A). Each housing unit will have dedicated parking areas (3 spaces each) and soft landscaped gardens.

The proposed church development (footprint 900 m^2 inclusive of canopy area) will be located on higher ground away from the river with a FFL of 98.31 mAOD, some 4.0 m above the R. Mule bed level and 1600 mm above extreme 0.1% (Q_{1000}) flood levels (Figure 4, Section C). There will be 74 parking spaces and an intermediate access road. Nine of the parking spaces will be built on a grasscrete base. Non-developed land will be grassed with newly-planted trees around the plot boundary.

There will be no development within 7 m of the R. Mule, preserving the minimum wayleave required by NRW for maintenance purposes.

Under existing conditions the only impermeable area is formed by the B4368 along the southern site boundary. The 120 m stretch of road running westwards from the western boundary of the housing plot opposite Court Close to the railway is included within the red line boundary, but any surface runoff from this stretch will drain directly northwards and will have no impact on runoff from the development plot. This area (720 m^2) was excluded from surface runoff calculations and for the purposes of the FCA, the gross site area is 24,280 m^2 (2.428 ha).

Table 1 gives a breakdown of permeable and impermeable areas within the site for existing and post-development conditions. Under existing conditions impermeable areas account for 7% of the church plot and 6% of the housing plot. With the proposed future development, impermeable areas will increase to 22% for the church plot and 33% for the housing plot, 24% for the combined area.

Existing and Future Development Areas (sq.m) — Table 1

EXISTING		CHURCH	HOUSING	TOTAL
IMPERMEABLE	B4368 (external)	1320	360[A]	1680[A]
	% impermeable	7%	6%	7%
PERMEABLE	Permeable (internal)	12000	4000	16000
	Residual (external)	5280	1320	6600
TOTAL		**18600**	**5680**	**24280**

FUTURE		CHURCH	HOUSING	TOTAL
IMPERMEABLE	B4368 (external)	1320	360[A]	1680[A]
	Buildings	900	394	1294
	Block paving	625	140	765
	Road & asphalt parking (internal)	1153	956	2109
	Walling	29	0	29
	Site Impermeable	**2710**	**1490**	**4200**
	Total Impermeable	**4030**	**1850**	**5880**
	% impermeable	22%	33%	24%
PERMEABLE	Permeable block paving	750	370	1120
	Ecogrid grassed	800	0	800
	Soft landscaping (internal)	7740	2140	9880
	Residual (external)	5280	1320	6600
	Total Permeable	14570	3830	18400
TOTAL		**18600**	**5680**	**24280**

[A] *excludes 120 m stretch of B4368 leading west from housing plot (720 sq.m)*

4 FLOOD RISK, MITIGATION AND MANAGEMENT

4.1 GENERAL

The prime potential direct source of flooding of the proposed development plot is overbank flooding from the R. Mule, draining from the Kerry Hills with a significant catchment area of 49 km^2 to the Severn confluence. Flooding from the Severn could present a secondary threat, either directly, or indirectly through floodwater backing up the R. Mule when levels in the Severn are high. The R. Mule has a free outfall at its confluence with the Severn (Plate 8). There are no hydraulic structures along the watercourse adjacent to the development plot. However, the R. Mule passes through two bridges downstream of the plot carrying the railway and the B4368, that could constrict flow and cause backing up of floodwater past the development.

There are no formal flood defences along the R. Mule. However, the disused railway embankment that forms the northern boundary of the plot does provide an effective *de facto* defence.

In terms of flooding history, NRW has no records of flooding of the development plot from fluvial, groundwater or pluvial sources.

4.2 NATURAL RESOURCES WALES FLOOD ZONES

The current (July 2016) NRW flood map adjacent to the development site is reproduced in Figure 8, showing the modelled 1% (Flood Zone 3, Q_{100}) and 0.1% (Flood Zone 2, Q_{1000}) flood limits. The housing plot is entirely flood-free. The north-eastern segment of the church plot, where ground levels fall rapidly to the R. Mule left bank, lies within the flood plain but it does not extend to the proposed church building or associated development infrastructure.

Downstream of the site towards the railway the flood plain broadens out, influenced by flood levels in the Severn and possibly backwater effects from restricted bridge openings. The B4368 running south from the plot remains dry, providing safe access/egress even for the extreme 0.1% (Q_{1000}) flood event.

All elements of the proposed development are entirely beyond extreme (0.1%, Q_{1000}) flood limits.

4.3 FLOOD RISK WITHIN THE DEVELOPMENT

There will be no development within the flood plain. Issues of flooding depth, rate of rise of floodwater and flow velocity are therefore not material to this FCA. There is no risk to life. The church will be occupied for limited periods and there will be no night-time occupancy. The site access from the B4368 is more than 3.0 m above the extreme flood level and there is a dry evacuation route to the south. Nevertheless, as an added precaution, the Applicant will undertake to register with, and act upon, the EA Floodline Warnings Direct service.

4.4 FLOOD RISK BEYOND THE DEVELOPMENT

Since the development is not within the flood plain, there will be no impediment or diversion of floodwaters, or loss of flood plain storage, that could increase flood risk beyond the development. The proposed development will have no impact on fluvial or coastal morphology.

The main issue is therefore the impact of increased surface runoff resulting from the introduction of impermeable surfaces on what is currently a predominantly greenfield site. Potential SuDS mitigation measures will inevitably focus on infiltration of surplus runoff.

4.4.1 On-Site Infiltration Potential

The potential for on-site infiltration was assessed by percolation tests carried out on both the housing plot and the church plot on 4 March 2010, described in Annex A. Results were encouraging, indicating percolation values (V_P) comfortably within the range required for effective source control infiltration, especially on higher ground towards the B4368 where infiltration rates in excess of 1.0 lit/sec/m^2 (footprint) are indicated.

It is beyond the scope of this FCA to produce designs for appropriate mitigation (SUDS) measures. However, a preliminary assessment has been made on the premise that post-development peak runoff rates and volumes exiting the site boundary will not exceed existing rates, and no flooding within the development plots will occur for a 30-year design storm event. This is precautionary since, for example, soakaways for individual residential properties are typically designed to handle a design 10-year storm. For the more extreme 100-year (+climate) event, some internal inundation (eg temporary flooding of parking areas) could be tolerated, but runoff beyond the development should be kept to a minimum level to be agreed with the local Drainage Authority.

4.4.2 Existing Vs Post-Development Runoff

An example analysis was carried out to give an indication of the magnitude of peak post-development runoff rates and volumes in comparison with existing rates, summarised in Table 2. Plot features (drainage path lengths and slopes) were obtained from LiDAR data with existing and future impermeable areas abstracted from Table 1.

Design storm characteristics were abstracted from the FEH CD-ROM[9] based on depth-duration-frequency curves applicable to Abermule. For this example, a short duration (1.3 hours) high intensity storm was applied, for return periods of 30 years (Q_{30}) and 100 years (increased by 30% to allow for future increases in storm intensity resulting from climate change, Q_{100+CC}). Winter and summer design storm profiles based on a 6-minute time increment are plotted in Figure 9. Design storm totals and peak intensity are as follows:

Event	Storm Total (mm)	Peak Intensity (mm/hr)
Winter Q30	18	35
Winter Q100+CC	33	64
Summer Q30	28	77
Summer Q100+CC	51	140

Peak runoff rates and volumes were computed using a simple HEC-HMS[10] model. Storm losses and residual runoff are based on the weighted curve number (CN) approach. Drier antecedent conditions in the summer were accounted for by adopting a higher initial abstraction loss (5 mm). Results are summarised in Table 2. Surface runoff hydrographs for the church and housing plots, for existing and future conditions, are compared in Figure 10. Runoff rates are higher than computed in previous studies due to the inclusion, within the red line boundary, of the B4368 on the southern boundary and additional grassed/wooded areas.

The required capacity for SuDS measures is represented by the difference between existing and post-development runoff rates and volumes. It is evident that summer events, with higher storm totals and peak intensities, are more critical.

Existing and Future Surface Runoff **Table 2**

WINTER	Area	Q 30		Q 100+CC	
	ha	Peak lit/sec	Vol m3	Peak lit/sec	Vol m3
Church-EX	1.86	28	57	78	155
Church-FUT	1.86	48	102	110	227
DIFF		20	45	32	72
Housing-EX	0.57	8	17	23	46
Housing-FUT	0.57	19	41	41	86
DIFF		11	24	18	40
Total-EX	2.43	36	74	101	200
Total-FUT	2.43	67	143	151	313
DIFF		31	69	50	113
SUMMER	**Area**	**Q 30**		**Q 100+CC**	
	ha	Peak lit/sec	Vol m3	Peak lit/sec	Vol m3
Church-EX	1.86	60	104	175	295
Church-FUT	1.86	94	171	227	401
DIFF		34	67	52	106
Housing-EX	0.57	17	30	52	88
Housing-FUT	0.57	36	67	81	146
DIFF		19	37	29	58
Total-EX	2.43	77	134	227	384
Total-FUT	2.43	130	239	308	547
DIFF		53	105	81	163

4.4.3 Potential SuDS Measures

It is assumed that no flooding within the site shall be permitted for the $\mathbf{Q_{30}}$ event. For the church plot peak infiltration requirement is 34 lit/sec. The church building (900 m^2) makes up 33% of the plot impermeable area, hence peak roof runoff of 11 lit/sec is indicated. For the housing plot peak infiltration requirement is 19 lit/sec. Housing units (394 m^2) make up 26% of the plot impermeable area, hence combined peak roof runoff of 4 lit/sec is indicated (1 lit/sec per unit). It is proposed that rain butts be fitted to all down pipes on the church and housing units. These will provide moderate storage and be a source for watering garden areas, thereby contributing to recycling and water resource conservation.

On-site percolation tests indicated good potential for infiltration. Dedicated soakaways will be dimensioned to provide sufficient capacity to store/infiltrate surplus roof runoff. There may also be scope to include storage facilities, possibly an underground tank, adjacent to the church to provide a source for grey-water recycling.

Runoff from remaining impervious surfaces (driveways, parking areas and access roads) could be drained to lateral drainage features in the form of shallow grass swales and/or more formal infiltration strips. There is ample space to provide the necessary infiltration footprint for these alongside access roads and edges of parking areas, and/or to integrate these within areas of soft landscaping.

For the $\mathbf{Q_{100+CC}}$ event, the additional storage/attenuation requirement will be met by a combination of grass swales and infiltration strips and temporary storage on areas of open space including parking and soft landscaping areas.

It is stressed that this analysis is based on a single representative design storm of 1.3 hours duration. More rigorous analysis will be needed, including consideration of alternative storm durations and frequency, to formulate detailed designs for proposed SuDS measures.

5 TECHNICAL REQUIREMENTS FOR ASSESSING FLOODING CONSEQUENCES (TAN 15 APPENDIX 1 PART E)

The following table presents a check list of technical requirements for assessing flooding consequences as stated in TAN 15 Appendix 1 Part E[1]. For each listed technical requirement, it summarises the findings of the flooding consequences assessment and provides a cross reference to the relevant part of this report.

	TAN 15 Technical Requirement	FCA Assessment	Report Reference
1	*A location plan identifying all possible sources of flooding. The plan should be presented at an appropriate scale and should include geographical features, street names and identifies all watercourses or other bodies of water in the vicinity. This should include drainage outfalls and, if necessary, cross-refer to their operational arrangements in the body of the report.*	Location Map; NRW Flood Zones	Figure 1 Figure 7
2	*A plan of the site showing existing levels related to Ordnance Datum, both current and following the proposed development. Proposed development levels may well be only indicative at this stage.*	site contours site sections + FFL	Figure 3 Figure 4
3	*A more detailed indication, if appropriate, of flood alleviation measures already in place, their state of maintenance and their sustainability throughout the life of the development. This will also include an assessment of the performance of those defences under extreme overtopping conditions with particular attention being given to their susceptibility to breach and the flooding consequences on the development of doing so. The defended area dataset provided as part of this document will indicate the existence of formal flood defences/measures. It is however the responsibility of the promoter of the development to make contact with the owners of the structures and determine their detail.*	no formal defences. disused railway embankment provides *de facto* flood barrier	§ 4.1
4	*A plan of the area showing accesses/evacuation routes from the proposed development site giving existing levels relative to Ordnance Datum.*	safe access/egress to higher ground southwards via B4368	§ 4.3 Figures 6, 7
5	*An assessment of the source of potential flooding - rivers, tidal, coastal, groundwater, surface flow or any combination of these to include estimates of extreme flood flows from the threshold to the probable maximum flood.*	flooding from R. Mule NRW flood map	§ 4.1 Figure 8

	TAN 15 Technical Requirement	FCA Assessment	Report Reference
6	*A plan of the site showing any existing information on extent and depth of flood events or on flood predictions. Information may be anecdotal, photographic, survey results or model estimates. The events should be identified with date/time, source of the data and supporting information provided on rainfall and/or return period, or probability of occurrence of the flood or storm surge event, or combination. Recorded data are particularly valuable and, if available, should be highlighted along with evidence of any observed trends in flood occurrence. Any changes that have taken place since the last event should be identified.*	no known flooding of the site NRW flood maps (July 2016)	§ 4.1 § 4.2 Figure 8
7	*A plan and description of any structures which may influence local hydraulics. This will include bridges, pipes/ducts crossing the watercourse, culverts, screens, embankments or walls, overgrown or collapsing channels. This will also include an assessment of the likelihood of such structures to choke with debris and the flooding consequences of this on the development.*	disused railway embankment (informal flood defence). Bridges downstream represent possible pinch-points	§ 4.1
8	*An assessment of the probabilities and any observed trends and the extent and depth of floods for the location and in the catchment context and, if appropriate, routes and speed of water flow. At this stage best estimates, based on the most up-to-date findings, should also be made of climate change impacts on probabilities. The assessment should ensure that the development meets an acceptable standard of flood defence for the design life of the development.*	Latest NRW 1% and extreme 0.1% flood limits climate change impacts incorporated in site runoff calculations	§ 4.2 Figure 8 § 4.4.1 § 4.4.2, Table 2
9	*A cross-section of the site showing proposed finished floor levels or road levels, or other relevant levels relative to the source of flooding, and to anticipated water levels and associated probabilities.*	cross sections, 0.1% flood levels and proposed development FFL	Figure 4
10	*An assessment of the likely rate or speed with which flooding might occur, the order in which various parts of the location or site might flood, the likely duration of flood events and the economic, social and environmental consequences/impacts of flooding.*	not applicable. No development in the flood plain	§ 4.3

	TAN 15 Technical Requirement	FCA Assessment	Report Reference
11	*An assessment of the hydraulics of any drains or sewers, existing or proposed, on the site during flood events. The methodology for assessment must be clearly stated.*	not applicable	
12	*An estimate of the volume of water that would be displaced from the site for various flood levels following development of the site and of the run-off likely to be generated from the development.*	no displacement. future runoff restricted to existing rates	§ 4.4 § 4.4.2
13	*An assessment of the likely impact of any displaced water on neighbouring or other locations which might be affected subsequent to development. This should address the potential for change of the flooding regime both upstream and downstream of the site due to ground raising or flood embankments.*	no impact	§ 4.4
14	*An assessment of the potential impact of any development on fluvial or coastal morphology and the likely longer-term stability and sustainability.*	no impact	§ 4.4
15	*Because of the uncertainties in flood estimation and expected climate change impacts, hydrological analysis of flood flows and definition of defence standards should include the allowances for increased flows and sea-level rise provided in the latest project appraisal guidance.*	ample freeboard above NRW extreme flood levels	§ 4.3
16	*An assessment of the residual risks after the construction of any necessary defences. Consideration should always be given to the behaviour of any new or modified defences in extreme events greater than those for which they are designed and information should be provided on the consideration given to minimising risks to life in such circumstances.*	not applicable	

	TAN 15 Technical Requirement	FCA Assessment	Report Reference
17	*The report should include a clear and comprehensive summary describing the following in simple terms:*	Included	Executive Summary
	➢ *All potential sources of flooding to include potential blockages and breaching of defences*	R. Mule	§ 4.1
	➢ *Under the range of scenarios considered* ♦ *How flooding of site would develop* ♦ *How quickly floodwaters would rise across the site with particular reference to property and access/evacuation routes.* ♦ *How fast floodwaters would move across the site with particular reference to property and access/evacuation routes.*	not applicable	§ 4.3
	➢ *How the proposed development would impact on flood risk elsewhere in the catchment.*	neutral	§ 4.4
	➢ *What conditions should be imposed on the development to ensure no additional risk to life and minimal damage and disruption to people and property and the natural environment. This should include reference to the need for flood warnings, emergency plans, escape routes and the general design of the development.*	No direct risk to life. Applicant will register with Floodline Warnings Direct service	§ 4.3

REFERENCES

[1] Planning Policy Wales (July 2004); Technical Advice Note 15, Development and Flood Risk; Welsh Assembly Government

[2] David Floyd (February 2011); Proposed Gospel Hall and Residential Development, Abermule, Powys : Flooding Consequences Assessment; Report 2049; Dolafon Gospel Hall Trust

[3] David Floyd (July 2012); Proposed Gospel Hall Development, Abermule, Powys : Flooding Consequences Assessment; Report 2012; Dolafon Gospel Hall Trust

[4] RJS Design & management (May 2008); Topographic Survey, Land at Kerry Road, Abermule, Powys; Dolafon Gospel Hall Trust

[5] Barry Lowe Surveys (December 2009); Land Adjacent to Abermule House, Abermule, Powys; Dolafon Gospel Hall Trust

[6] MapInfo Corporation (May 2007); MapInfo Professional, Version 9.02

[7] MapInfo Corporation (April 2005); Vertical Mapper, Version 3.1.1

[8] British Geological Society; Superficial Geology, Abermule Area; NERC

[9] Centre for Ecology & Hydrology (September 2009); FEH CD-ROM (Version 3.0)

[10] Hydrologic Engineering Center (December 2013); Hydrologic Modeling System (HEC-HMS), Version 4.0; US Army Corps of Engineers

[11] Building Research Establishment; Soakaway Design; Digest 365

FIGURES

PLATES

ANNEX A

PERCOLATION TESTS

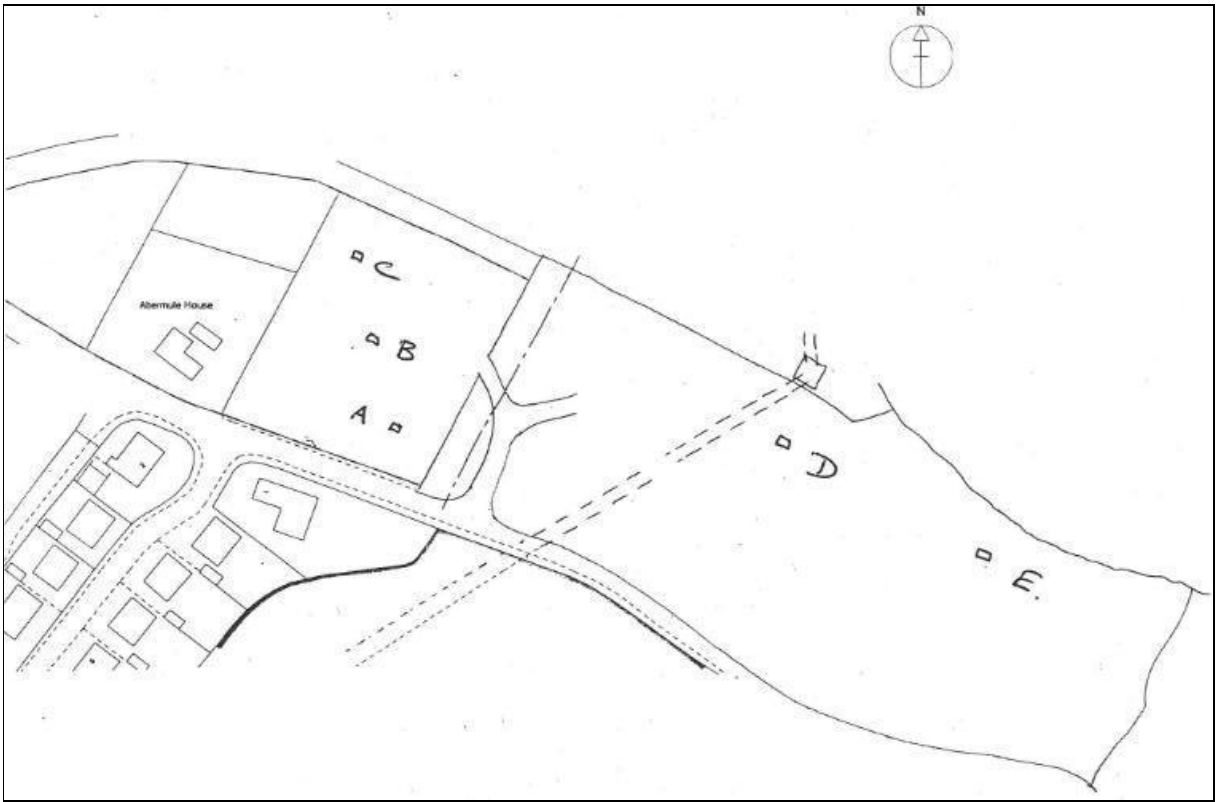
A.1 Introduction

A series of percolation tests was carried out on the housing plot and the church plot on 4 March 2010. The aim was to check the potential for soakaways to dispose of surface runoff from impermeable surfaces at full development. It was not, at this stage, intended to dimension/design appropriate SUDs measures. At the final design stage, soakaways will be designed in accordance with BRE Digest 365[11].

A.2 Test Pits

Test pit locations are shown in Figure A.1. Three pits (A, B, C) were located on the housing plot moving progressively towards the river at approximate elevations 98.0 mAOD [A], 96.8 mAOD [B] and 95.5 mAOD [C]. For each pit a trench was excavated using a mechanical digger to a depth of about 600 mm, within which a hole was hand-dug to a depth of 300-350 mm. Individual trench and pit dimensions are given in Table A.1.

Test Pit Locations **Figure A.1**



A stake was placed in each hole, marked at 25% and 75% of the depth of the hole (see Plates 9-11). The intention was to fill each hole with water from a bowser and record the time taken for the level to fall from the 75% to the 25% marker to establish the percolation value V_P.

A different approach was adopted for the church site which will generate much higher surface runoff rates from the church building and parking areas. Two large trenches were mechanically excavated near the lowest part of the plot at approximate elevation 97.5 mAOD, to depths of 1600 mm [D] and 1750 mm [E]. Trench dimensions are given in Table A.1. It was impractical to fill trenches from the bowser, so a known volume of water was added to each trench and the time taken to infiltrate was recorded.

Test Pit Dimensions **Table A.1**

PIT	TYPE	DIMENSIONS (mm)			NOTES
		Length	Width	Depth	
A	Trench	1700	600	600	
	Hole	450	350	300	
B	Trench	1900	700	600	
	Hole	600	300	350	
C	Trench	1700	700	600	
	Hole	350	300	350	
D	Trench	1600	600	1600	
E	Trench	1500	1200	1750	

A.3 Percolation Test Results

Percolation tests were repeated three times for each hole/trench. As expected, percolation rates reduced with successive tests as the surrounding subsoil became increasingly saturated. Results are summarised in Table A.2.

HOUSING PLOT

V_P rates were extremely low, especially for the two pits located on higher ground, Pit A (average V_P 0.7 secs/mm) and Pit B (average V_P 2.4 secs/mm). Drainage standards stipulate that if V_P exceeds 140 secs/mm then the soil is not suitable for soakaways, while V_P of 100-140 secs/mm indicates that underdrains are desirable (Malvern Hills District Council, 1999). Trial percolation values are well below these rates, even for Pit C located closest to the river (average V_P 70 secs/mm).

Equivalent infiltration rates per square metre (footprint) are 1.4, 0.4 and 0.02 lit/sec/m^2 for Pits A, B and C respectively.

CHURCH PLOT

Tests were not as robust due to problems of applying a sufficient volume of water in a short space of time. The indicative infiltration rate for Pit D averaged 1.2 lit/sec on an approximately 1.0 sq.m. footprint. The rate was significantly lower in Pit E, 0.21 lit/sec, equivalent to about 0.1 lit/sec/m^2. It should be noted that test pits were located towards the lowest part of the church plot. On higher ground, where the church building will be located, significantly higher infiltration rates can be expected.

BRE 365 Equivalent Infiltration Rates

Extrapolation of results of percolation tests to give equivalent infiltration rates in accordance with BRE 365 suggests rates between 4.36E^{-06} and 6.0E^{-04}, averaging 2.53E^{-04}. This is entirely suitable for the implementation of ground infiltration techniques. Further tests should be undertaken at the final design stage, following BRE 365 guidelines, to determine optimum location and dimensions of soakaways.

Percolation Test Results **Table A.2**

PIT	TRIAL	RESULTS [Vp]			NOTES
		Fall mm	Time secs	Vp sec/mm	
A	1	130	75	0.6	Not possible to fill hole to the top due to speed of infiltration.
	2	145	100	0.7	
	3	175	145	0.8	
	Average			**0.7**	equivalent infiltration rate 0.23 lit/sec (1.4 lit/sec/m^2)
B	1	150	362	2.4	
	2	175	405	2.3	
	3	175	435	2.5	
	Average			**2.4**	equivalent infiltration rate 0.07 lit/sec (0.4 lit/sec/m^2)
C	1	175	11700	67	
	2	175	12000	69	
	3	175	13200	75	
	Average			**70**	equivalent infiltration rate 0.002 lit/sec (0.02 lit/sec/m^2)
		RESULTS [vol]			
		Volume lit	**Time secs**	**Rate lit/sec**	
D	1	32	15	2.1	
	2	32	37	0.9	
	3	32	43	0.7	
	Average			**1.2**	1.2 lit/sec/m^2
E	1	30	90	0.33	
	2	32	210	0.15	
	3	32	220	0.15	
	Average			**0.21**	0.1 lit/sec/m^2

Reference

Malvern Hills District Council (1999); Percolation Tests and Calculations