Chargrove Lane, Cheltenham

Hydrology Report

July 2014

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DOCUMENT VERIFICATION RECORD

CLIENT:

Mr Jeremy Limbrick

INSTRUCTION:

The instruction to undertake these works was received from the client, Jeremy Limbrick of Avenue Lodge, Chargrove Lane, Cheltenham.

SCHEME:

Avenue Lodge, Chargrove Lane, Cheltenham GL51 3LD.

Hydrologist report investigating the effect of reducing the volume of a garden pond by 40%.
Pond location: 391836E 220714N

ISSUE HISTORY:

Issue Date	Comment
11/07/2014	First issue

DOCUMENT REVIEW & APPROVAL

Prepared by Steve Conway BSc (Hons)

Reviewed by Bethan Young BSc (Hons)

Approved by Peter Jones BSc (Hons) CEng C.WEM MICE MCIWEM

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Appendices

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Document and Software Reference List

- Flood Estimation Guidelines, Operational Instruction 197_08, *Environment Agency* (2012)
- Delivering benefits through evidence, Estimating Flood Peaks and hydrographs for small catchments: Phase 1, *Environment Agency* (2012)
- British Geological Society (BGS) – The physical properties of minor aquifers in England and Wales (2000)
- Institute of Hydrology Report No.126 Hydrology of soil types: a hydrologically based classification of the soils of the United Kingdom, *D.B. Boorman, J.M Hollis & A. Lilly (1995)*
- Soil Survey of England and Wales*, Lawes Agricultural Trust (1983)*
- Cheltenham Borough Council – Planning Application Documents, 14/00505/FUL
- Improving FEH statistical procedures for flood frequency estimation, Science Report: SC050050, *Environment Agency and DEFRA* (2008)
- The Revitalised FSR/FEH rainfall-runoff method, *Centre for Hydrology and Ecology* (2005)
- Flood Estimation Handbook, *Institute of Hydrology* (1999)
- FEH CD ROM 3

1 Introduction

1.1 Waterco Consultants have received an instruction from Mr Jeremy Limbrick on 24/06/14 to undertake a brief hydrologists report to demonstrate that partial infilling of an existing pond in the grounds of Avenue Lodge, Chargrove Lane, Cheltenham (NGR: 391836,220714) will not have a significant effect on flooding elsewhere relative to the existing pond arrangement. A location plan and aerial photograph of the existing site is provided in Appendix A for information.

1.2 The existing pond in the grounds of Avenue Lodge has an approximate area of 550 m^2 and an approximate maximum depth of 1.2m (4 ft.). The pond in its current form takes up about one third of the Avenue Lodge garden.

1.3 The proposed landscaping involves filling in approximately 40% of the existing pond with imported inert clay and soil and the extensive planting of 50 new trees. The proposals require planning approval as they are considered by the local planning authority, namely Cheltenham Borough Council (CBC), to be an engineering operation due to the amount of infilling required. Details of the development proposals are included in Appendix B.

1.4 There is no formal inlet to, or outlet from, the pond and water levels within it appear to be determined by variations of groundwater. Such variations being associated with seasonal changes and the prevailing weather conditions.

1.5 A planning application for the proposed earthworks was submitted in March 2014.

1.6 The application was recommended for approval by the planning officer but has been deferred at committee with a request that the applicant supplies a hydrologists report to assist with their understanding of the proposal.

1.7 A qualitative approach has been adopted for this report, which examines water flows in theory, constrained by hydrological science, to suggest the most probable effect of part-filling of Avenue Lodge pond. A quantitative report is not justified by the type of project i.e. garden landscaping, albeit on a larger scale; and there is no readily available, or existing data, currently available to make quantitative assessment viable.

2 Origin of Avenue Lodge Pond

2.1 The various comments and reports have been reviewed. There appears to be some confusion on the origin of this pond and on the hydrology of ponds in general. This section examines the theory in order to provide some content for logical deductions and conclusions to be drawn.

2.2 Lakes and ponds by their nature are ephemeral. In the UK some large lakes have disappeared within a few thousand years from continual sediment input, yet temporary ponds that dry out in summer can persist for much longer.

2.3 Permanent ponds, with sediment input from a stream, can have short lives of a few hundred years without continual maintenance. Such ponds, surrounded by trees and a healthy growth of pond vegetation, can slowly fill-in until a marsh is their last remnant. The pond at Avenue Lodge is permanent, as it does not dry out every summer. Its size and position in a lowland environment also suggests it would have filled in long ago without intervention, if it was a hollow persisting from the last glacial period.

2.4 Although the origins of the Avenue Lodge pond can only be speculated on without coring the sediments, that speculation can be useful in understanding the hydrology. Assuming it was present as a hollow shortly after the last glacial period (10,000 years before present), it is likely to have been peat filled early on and much later possibly excavated to burn the peat. (Extensive peat diggings in lowland areas produced the Norfolk Broads and smaller patches of peat were often removed during colder centuries).

2.5 The Avenue Lodge pond appears too large to have been excavated for a farm stock watering source. Hand-excavated ancient ponds, specifically removing worthless fill are often small and rounded to maximise water volume against the effort in removing soil. The waste soil was usually spread around the pond banks creating a higher lip. The ‘dew ponds’ of chalk areas are frequently rounded, lipped and clay-lined, collecting their water not from dew but from rainfall in the bowl-shaped catchment created. Hand-excavated ponds for retting in flax manufacturing or for fish farming are less likely possibilities.

2.6 The second smaller pond visible on early maps, where the garden of the present house ‘Brambles’ is now laid out, could have been an extension of the main Avenue Lodge pond or a separately excavated pond in an attempt to drain water away from the earlier 19th Century house. In conclusion, as to the origin, it is most likely an excavated pond where peat, or even a suitable patch of gravel or higher quality clay was removed for local use.

3 Pond Drainage Mechanisms

Streams

3.1 No stream channels enter or exit the pond. The pond itself is in a catchment of Hatherley Brook using a course resolution of the Flood Estimation Handbook CD ROM, but a watershed analysis indicates it belongs to Ham Brook that then flows into Hatherley Brook. There are few defined channels in most of the catchment due to: a) clay sediments being very cohesive, b) the low gradient, c) the small size of the catchment and d) from small unmapped natural channels being removed by development and being converted to general piped drainage.

3.2 The area, including Cheltenham, drains by streams and rivers trending north-west. No aquifers are present as the geology precludes them but groundwater will be present and is likely to drain towards those existing streams and rivers.

Springs and artificial inputs to Avenue Lodge pond

3.3 Springs, defined here as noticeable flows of groundwater issuing within the pond or nearby, are ruled out for the following reasons:

a) The pond level at times is low and there are no visible springs.
b) The word ‘issues’ or ‘spring’ is not present on historical or modern maps.
c) The geology and topography of the site do not rule out a spring but make it unlikely.
d) In winter the pond freezes over uniformly without holes or thinned ice which are often present above active springs.
e) The pond water quality is described as ‘murky’ in the summer. Spring-fed ponds can have extensive algae but the water is often fairly clear.
f) Springs with any easily visible flow of a few litres per second or more will normally create an outlet stream from any pond in clays.

3.4 Having ruled out springs and artificial inputs, (i.e. drainage pipes and septic tank overflows) we are left with slowly flowing groundwater and rainwater as the pond input sources.

Rainwater and groundwater

3.5 If the pond had no interaction with groundwater and collected only rainwater on its surface, the loss from evaporation would leave the pond empty in most summers. This assumes a mean rainfall of about 650mm/year and an evaporation rate of about 500mm/year. However, the pond rarely dries out. This indicates a localised catchment or depression surrounding the pond that channels near surface rainwater and/or an active, somewhat deeper, slow groundwater flow that passes into and out of the pond. It is likely that both mechanisms apply, as shown in Figure 1 and as discussed below.

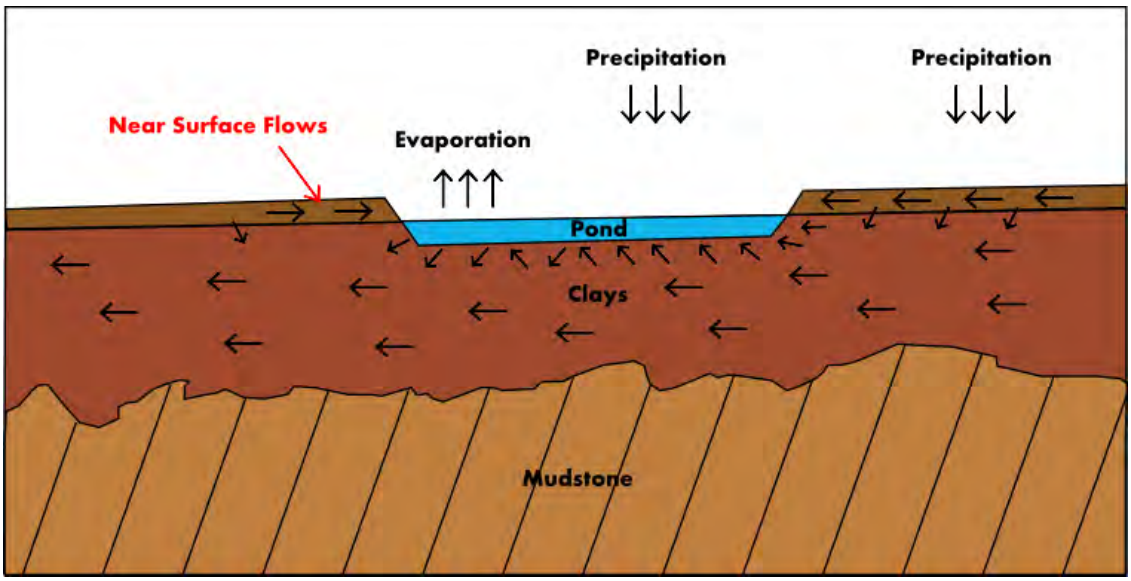


Figure 1 – Diagram of Groundwater flows in and around Avenue Lodge pond

3.6 The geology of the area is one of deep clays mixed with variable proportions of silt and sand. Below this, often 2-6m below, are mudstones whose weathering has created the clays. The mudstone has a very low permeability for water, i.e. very small amounts flow through compared to the upper layers of clay and hence the mudstone will not be discussed further.

3.7 Soil maps and a low BFIHOST of 0.2 (a hydrologist's measure of the ability of the rock and superficial deposits to absorb and transport rainwater) indicate the area has significant potential to flood in intense or prolonged rainfalls. The clays, in which the pond is situated, allow groundwater to slowly pass into and out of the pond perimeter (walls and floor). The direction is most likely north-west, downhill, roughly along the line from Avenue Lodge through the pond towards a neighbouring house, 'Brambles', at the far end. However, this 'water table' can be disturbed locally by changes in the permeability of the clay, which, without core sampling, makes groundwater routes less certain. The key point is: the situation is dynamic, in that water flows in and water flows out through the ground, trying to keep the pond surface in line with the groundwater level.

3.8 In clays the rate of water flow is low and it is known that the pond responds slowly to rainfall, a sign of groundwater influence. For slowly permeable clays there is often a mismatch between groundwater and pond water levels if there is a storm. During such times water flowing rapidly through the topsoil layer can deliver significant amounts of water to the pond that takes many days to drain/mix into the groundwater before levels are once again nearly balanced. Although this near surface water is actually flowing in the ground, it is from a hydrology standpoint rainfall runoff.

Winter flooding

3.9 Following a series of heavy rains the pond will be at a high level and groundwater will be flowing into the pond and then away down the slope of the water table, possibly to the north-west. Such groundwater may take weeks to months to reach the nearest brook.

3.10 The country drainage engineer used the phrase 'balance out' and in this case the pond in a winter flood is in a temporary balance where most of the water leaving via the clay (and a small amount by evaporation) balances the incoming groundwater and the near surface water to keep the flood level at Brambles near their decking for a short period. As the run-off rainfall recedes, the outgoing groundwater flow now exceeds the reduced incoming rainfall runoff flowing near the surface and the incoming deeper groundwater. The level of flood water in their garden then begins to fall. The owners of Brambles stated that the flooding can last for weeks. The extended duration of flooding may be explained by the direction of groundwater movement out of Avenue Lodge pond towards the Brambles. Until the level of Avenue Lodge pond falls it is available to drive groundwater through the narrow low bank on the boundary, continually replenishing the garden flooding.

3.11 The submission from the owners of Brambles indicating that their garden has flooded in 2008, 2009, 2012, 2013 and 2014 shows that the pond–groundwater interaction has passed through a series of wet periods that are noted as having several above average winter rainfalls. The fact that their house has not been flooded in these periods indicates an outflow of groundwater that increases as the flood level increases. It may be due to a 'spillover' below ground into near surface flows as the level exceeds the local depression in which the group of houses around the pond all lie. Superficial and deeper geology is often stratified or layered with upper levels being more permeable allowing larger flows of water to pass.

3.12 The measured levels of the pond and Avenue Lodge's surrounding garden show a clear fall from the house towards Brambles with a minimum at the boundary fence. Any increase in the level of the pond will transmit water flows through the near surface, and perhaps in storm conditions on the surface, filling the depression between Brambles decking and the Avenue Lodge pond. Two other sources will also be present in the Brambles flooding, near surface flows into the local depression from directions other than Avenue Lodge and roof drainage from the Brambles, which has a direct path through a drainage system.

3.13 True groundwater flooding, as in the Bournes of chalklands, where flooding happens much later after the rainfall, is very unlikely in Cheltenham's clay on mudstone geology.

Summer flooding

3.14 In summer flooding the low water level in Avenue Lodge pond is acting as flood storage and reducing its storage capacity by 40% is significant. However, in a summer flood, a 'cloudburst' from a convective event has to track across or form within a few kilometres or less from the pond. Such an event would have to have a very high rainfall to overtop the pond and run into the neighbouring gardens as the local depression for delivering rainfall runoff is not large, probably less than ten-times the pond surface area. In summer, groundwater supplies the pond's low level and any water increase from a cloudburst must come from near surface and surface runoff. With soils and rock having a BFIHOST of 0.20 and a very heavy summer storm of 50 mm (2 inches) rainfall in an hour, the pond may rise in level by roughly half-a-metre. This rise would still be held within the pond at typical summer levels and the storm would have 170 year return period for this area. Consequently, the reduced effect of summer storage will be minimal due to the rarity of the storm.

Urbanisation surrounding the pond

3.15 Over 150 years the pond surroundings have changed from open land to suburban surroundings. Assuming that road drainage is piped away, then the near surface ground water input to the pond has been reduced, with the likely outcome of less frequent flooding. Damaged or leaking highway drainage can be a source of groundwater into cellars, basements and more rarely garden depressions, but in this area of heavy clays it is probable that any leak would be confined to the pipe trench-line.

3.16 There may be some rapid near-surface groundwater flow paths following highway sub-base materials but any connection into the pond or neighbouring garden is unlikely.

4 Impact assessment

4.1 In order to consider the impact on the water table we will use an analogy. Imagine removing a block of water equal to half the volume of the Avenue lodge pond and replacing it with an equal size block of clay - the level remains the same. (Obviously, the actual filling of the pond would be carried out by pumping away water while replacing it with clay fill). From the analogy we can see that reducing the pond by half will not affect the level of the water table; and if the maximum level during any particularly wet period was to the decking in the Brambles' garden, then any similar wet period will produce a flood of the same level with the smaller size pond.

4.2 The above argument covers the 'in balance' situation and the Local Drainage Engineer's statement (included in the Planning Officer's report) appears to have it exactly right in relation to groundwater when stating that:
"*Infilling the pond (partial or complete) will have no long term effect upon ground water levels as they will balance out with time. However, if permitted, infilling operations would displace the water impounded within the pond at the time. Such displacement would need to be managed to ensure that the surrounding land and property was not adversely affected. In my view (subject to the appropriate management of displaced water during infilling operations), in the long term, the proposal will not increase flood risk upon the site or the surrounding land.*"

4.3 However, from the review, surface water inflows are also considered to be a factor here; and with the pond volume reduced, incoming surface water flows, during storm conditions will fill the remaining pond area more rapidly than before. The capacity reduction will not equate to the loss of pond volume. It will be much less, being the product of the plan area 'lost' (by infilling half the pond ~ 275 m^2) and the difference between the minimum winter level and maximum winter level in the pond (300 mm at most). The volume is therefore estimated as: 275 m^2 x 0.3m = 83 m^3

4.4 The increase in frequency of any flooding to the Brambles is unlikely to be significant. Nevertheless, provision of the above compensatory storage volume is recommended, so as not to increase the frequency of flooding, in accordance with NPPF.

5 Conclusions and Recommendations

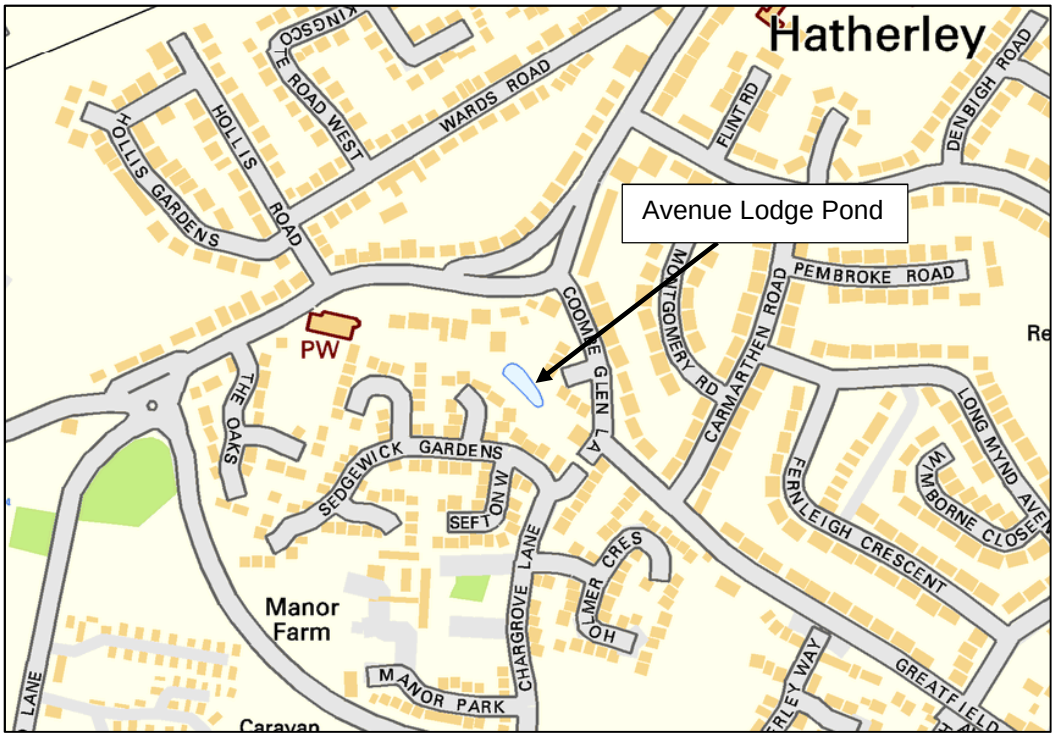
5.1 In conclusion, as to the origin of the Avenue Lodge pond, it was probably an excavated pond where peat or even a suitable patch of gravel or higher quality clay was removed for local use.

5.2 The water level in the pond is principally a reflection of the local water table and the operation of infilling half the existing pond area with clay will therefore have an insignificant effect in relation to groundwater flooding at the surrounding properties, including the most affected property, Brambles.

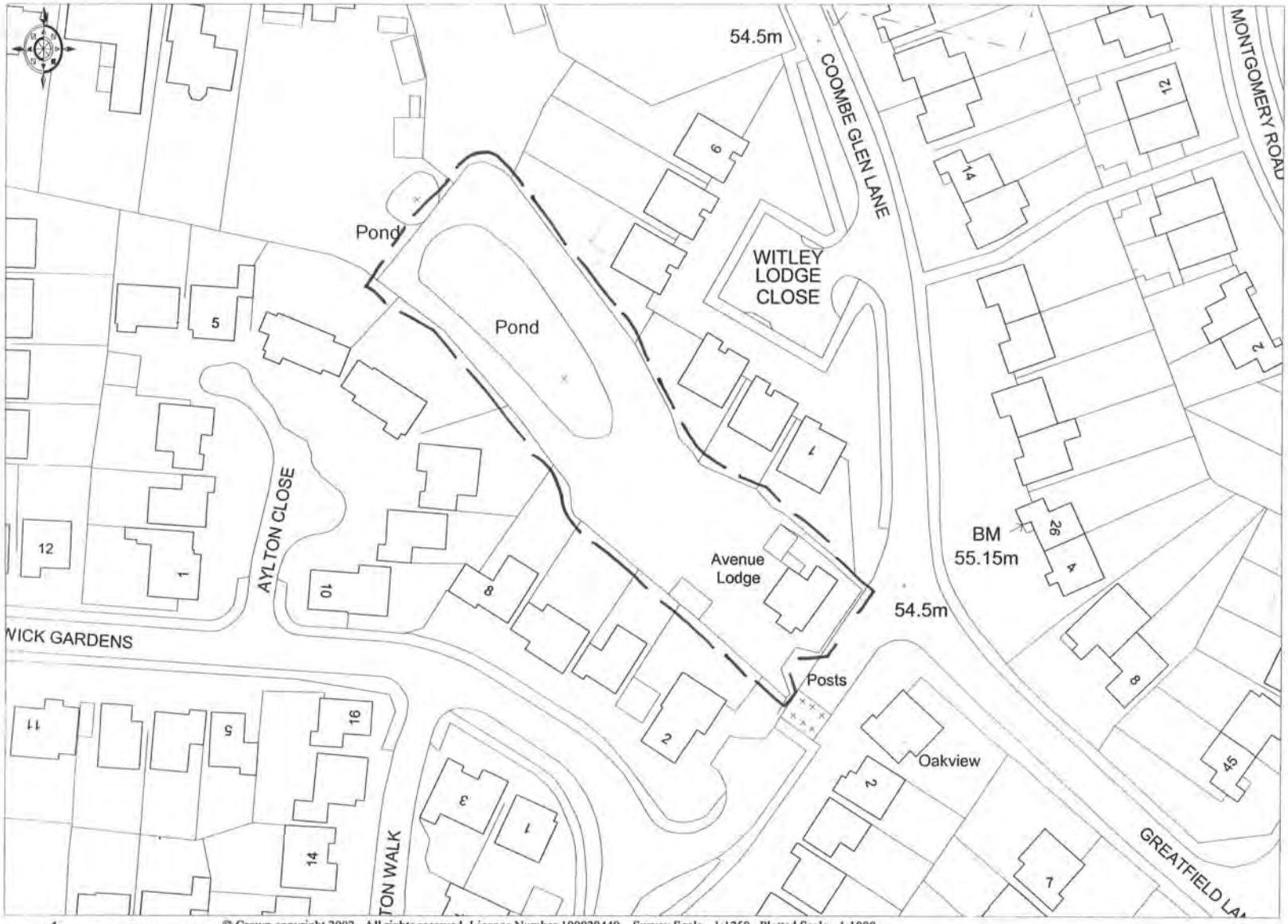
5.3 However, some increased risk of surface water flood frequency could result from the loss of pond area and it is recommended that a scheme of compensatory storage be designed and implemented to mitigate this risk. The compensatory storage volume would be around 80 m^3.

5.4 The mitigation measures could take the form of underground storage, as suggested in support of previous planning applications for the site. Another option is to design the landscaping such that there is a lower lying area, with appropriate planting, which would flood temporarily during an extreme rainfall event and then soak away, without damage.

Appendix A – Location Plan and Aerial Image


Hatherley
Avenue Lodge Pond
PW
WARDS ROAD
HOLLIS ROAD
HOLLIS GARDENS
FLINT RD
DENBIGH ROAD
PEMBROKE ROAD
MONTGOMERY RD
CARMARTHEN ROAD
COOMBE GLEN LA
THE OAKS
SEDGEWICK GARDENS
SEFTON W
CHARGROVE LANE
LMER CRES
OH
FERNLEIGH CRESCENT
LONG MYND AVE
MANOR PARK
GREATFIELD
Manor Farm
Caravan


Avenue Lodge Pond
Witley Lodge Close
Ayton Close
Sedgewick Gardens
Coombe Glen Ln



Appendix B – Development Details

Garden Plan - Top View

Woodland walk, utilising existing trees, with a curved path between composed of bark mulch. Informal arrangement of Athyrium niponicum, Dicentra eximia, Dryopteris atrata, Lamium maculatum, Liriope muscari, Pulmonaria saccharata, geranium macrorrhizum, lathyrus vernus, anemone sylvestris and arum italicum.

Secondary pond, at level of patio area to encourage water movement and allow planting of marginal plants, to include an informal arrangement of: Veronica spicata, Phlox subulata, iris ensata, Iris sibirica, Lythrum salicaria, Mentha aquatica and Mazus reptans.

Steps down to pond with small paved seating area with bench, straddled by terracotta pots planted with Acer palmatum.

I)Banks planted with wildflower mix suitable for watersides, to consist of: agrimonia eupatoria, Angelica sylvstris, lycopus europus, ranunculus acris, Filipendula Ulmaria, Lythrum salicaria, Geum rivale and iris pseudocorus. Highest water level to be interspersed with Gunnera manicata, Ligularia przewalskii 'The Rocket' and Rodgersia podophylla. Duck Island to consist of the same, with the addition of Persicaria amplexicaulis 'Taurus'.

Selection of fruit trees – Prunus avium (mixed cultivars) and Pyrus communis (mixed cultivars), underplanted with a commercial seed mix of native wildflowers and grasses suitable for meadow creation.

Pathways of chipped sandstone. Edges defined by Lavandula angustifolia 'Hidcote', with trimmed balls of Buxus sempervirens as per illustration. Vista leading to central Armillary sundial, underplanted with Hosta 'Dorset Blue'

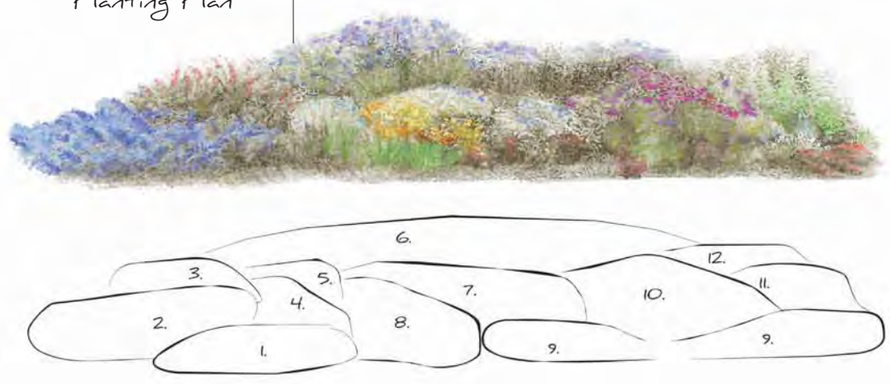
Crab apple Hedge (Malus Sylvestris)

Visualisations

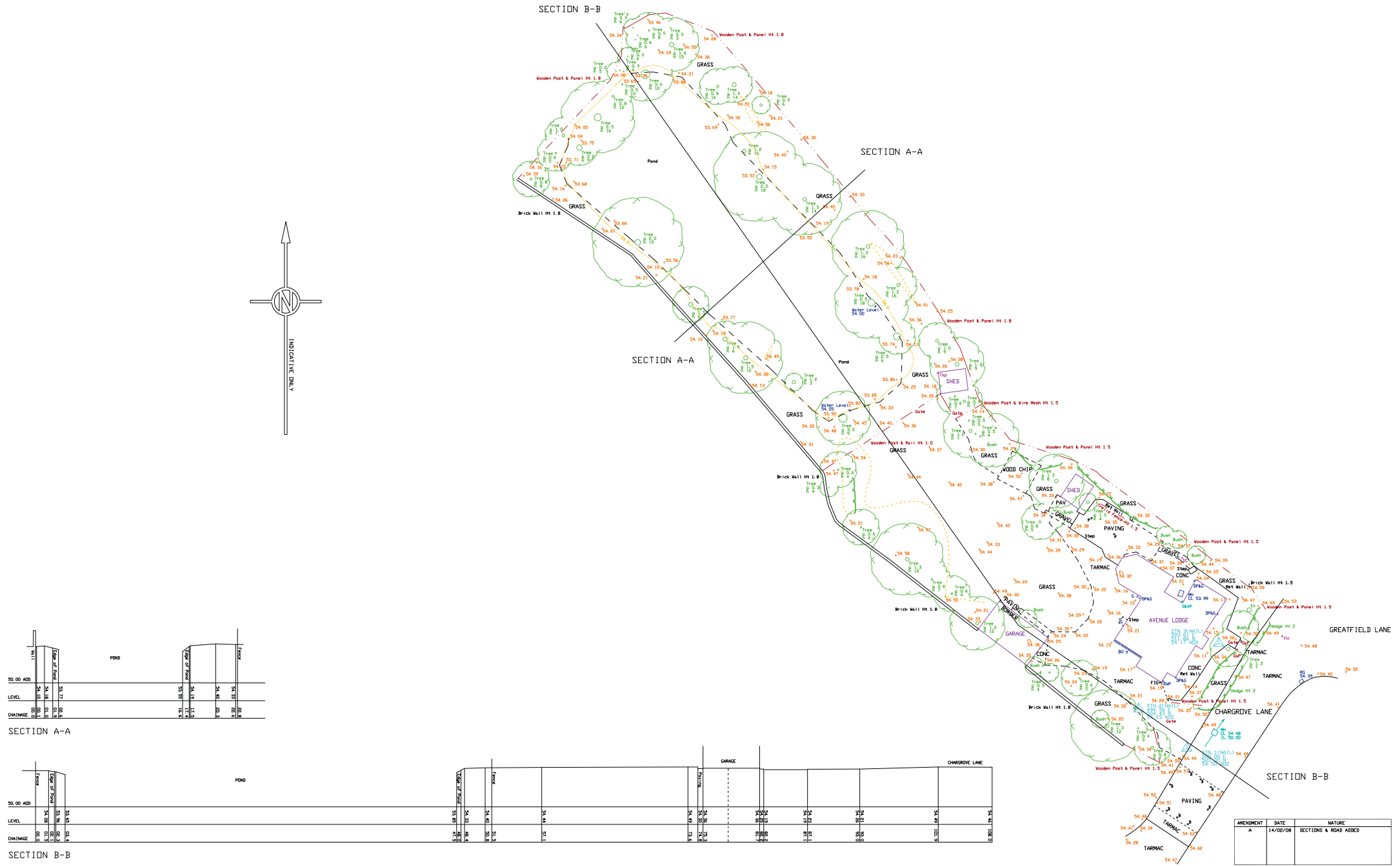
Woodland Walk

Patio Area / Flower Beds

Planting Plan



1. Heuchera 'Chocolate Ruffles'
2. Nepeta - Six Hills Giant
3. Fuchsia ' Riccartonii'
4. Datisca cannabina
5. Miscanthas Sinesis ' Gracillimus'
6. Verbena Bonariensis
7. Aster x Frikartii ' Monch'
8. Hemerocallis ' Beloved Returns'
9. Sedum ' Herbstfreude'
10. Echinacea Purpurea
11. Crocosmia x Crocosmiiflora 'Norwich Canary'
12. Lespedeza Thunbergii



AMENDMENT	DATE	NATURE
A	14/02/08	SECTIONS & ROAD ADDED

STANDARD REFERENCE

DATUM USED - ORDNANCE DATUM, NEWLYN

BENCH MARKS USED - CUT MARK ON 26 GREATFIELD LANE, VALUE 55.15

SITE BENCH MARKS ESTABLISHED - SURVEY STATIONS (SEE PLAN)

SURVEY STATIONS INDICATED THUS ▲

PROJECTION - ARBITRARY

ABBREVIATIONS

CL	COVER LEVEL	KD	KERB OUTLET	RWP	RAIN WATER PIPE
Dis	DISUSED	L	LIGHT	SC	STOP COCK
E	EARTH POINT	LP	LAMPPOST	SL	SUMP LEVEL
ECP	ELECTRICITY CABLE PIT	MH	MANHOLE	SP	SOIL PIPE
EP	ELECTRICITY POLE	Msr	SERVICE MARKER	SV	SLUICE VALVE
FH	FIRE HYDRANT	NB	NOTICE BOARD	TCB	TELEPHONE CALL BOX
FL	FLOOR LEVEL	NFI	NO FURTHER INFORMATION	TIC	TELEPHONE INSPECTION COVER
G	GULLY	OSBM	ORDNANCE SURVEY BENCH MARK	TP	TELEPHONE POLE
GC	GAS COCK	P	POST OR PILLAR	UTL	UNABLE TO LIFT
GV	GAS VALVE	RE	RODDING EYE	VP	VENT PIPE
IC	INSPECTION COVER	RG	ROAD GULLY	WO	WASH OUT
IL	INVERT LEVEL	RS	ROAD SIGN	WM	WATER METER

TITLE

AVENUE LODGE, UPPER HATHERLEY

CLIENT

JOHN T. LADLEY

SHEET DIAGRAM

SITECH SURVEYING SERVICES

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A MEMBER OF THE SURVEY ASSOCIATION

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SURVEY JOB No. 3497

SURVEYED - FEB 2008

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