Controlling your own water supply – building a golf course reservoir

Approximately 250 thousand million cubic metres of water falls onto Britain each year with around 60% of it running into the sea. Much of that 60% is required by the environment, for hydrological processes, for navigation, and for other purposes, but saving just a tiny fraction of the excess of this quantity would provide all the country's irrigation water requirements. Water can be intercepted as it falls to the ground via rainwater harvesting and drainage collection techniques, or it can be taken from the rivers themselves under abstraction licences. Generally, for abstractions of less than 20m^3 per day and up to 7,300m^3 a year, a licence is not required, but whether a licence is or isn't required – often the best way of ensuring your summer water supply is to store water in your own dedicated reservoir. Any water stored in a reservoir has been temporarily taken out of the hydrological cycle and is 100% yours – to do with exactly as you will, when you will.

Once a club has decided to investigate a reservoir for the course, the first question to address is where might one be sited? Often the club's first conjecture is, 'We have a low part of the course that is wettish in any case, how about there?'

42,000m^3 synthetically lined reservoir

Reservoir siting

If the club has negotiated an abstraction licence for winter storage then they must show that the water that comes out of the reservoir in the summer is the same water that went in to it in the winter. If this were not the case, the club would scratch out a hole at the lowest part of the course, deep into the water table, and keep abstracting from this all summer – the water actually flowing in from the sides and the bottom! A reservoir must therefore be lined to prevent not only water escaping, but also water entering.

Most small reservoirs (small in this case being less than 50,000m^3) are lined with a synthetic polymer liner. Any reservoir which is synthetically lined and empty in the autumn when the water tables start to rise again will face problems. Unless the water

table can be permanently artificially lowered below the base of the reservoir, the liner may push out from the bed and the sides and be damaged. In addition, digging at or beneath the water table, is extremely difficult – the walls and bed of the hole rapidly merging into a large amorphous pudding. Reservoir sites should therefore be up and away from valley bottoms, and on plenty of deep well structured and drained land.

The next question normally asked is, 'Can we put one in the centre of the course and use it as a water feature?'

Unfortunately the answer to this is normally, 'no'. The accepted depth to which water in an ornamental pond or lake can be drawn down is just eight to twelve inches. Full reservoirs are often pretty, but a less than full one can be ugly. A reservoir is used for storage and by design must be drawn down to a great extent in the season. If the reservoir is not drawn down, all the water below that level is unnecessary. A reservoir in August that has been lowered by four metres may look very ugly indeed and must be sited well out of the way of aesthetically sensitive eyes.

'Ah, but such-and-such club have a reservoir they draw from and that looks fine!' is the common rejoinder, but in fact that club will almost certainly have a borehole that tops up the reservoir during the day at a low constant rate, or they have another reservoir which does the same. Either way, the lake from which they pump is just a temporary holding, or balancing reservoir, with little nett loss occurring from it.

Survey & Design

Once a club has decided it needs to investigate the viability of a reservoir, potential sites need to be investigated to determine the construction feasibility and thus the site design parameters. A good relief survey of the site should be taken at an early stage and trial holes excavated as deep as possible – ideally to the water table or even bedrock. Most small reservoirs are generally constructed on a balanced excavation basis, whereby the amount of spoil arising from the excavation, becomes the impounding embankments above the excavation.

13,500m^3 reservoir for greens tees and approaches at Spalding Golf Club

Observing the structure of the substrate, testing its on-site strength and compressibility, removing samples and analysing them as required in a laboratory will give a good indication as to all the elevations and slope angles needed on the finished structure. It will also allow the maximum depth of excavation to be set. Correct slope angles and a detailed specification for the embankment construction methodology is critical to the long term stability of the reservoir structure. Only on-site investigation and geotechnical examination will ensure that, with the correct safety factor, a reservoir's embankments will pass the 100 year test mark.

Test digging will indicate the presence of suitable clay on or near a site, which can then be further explored. Clay lined or clay cored reservoirs are fine - if all other conditions are ideal. However, leaving slopes open to saturation and erosion almost always results in the design requiring shallower embankment slopes. This makes for a bigger reservoir 'footprint' and thus a larger reservoir site. The economies of scale mean that ordinarily clay lined reservoirs are not considered for small projects. Guarantees that the water will not leak out can also only be given for synthetically lined reservoirs. Almost all synthetic lining systems incorporate a polymer membrane above a protective 'carpet underlay'. The quality, specification and thickness of both the waterproof membrane and the protection layer need to be very carefully specified. Correct site investigation should lead to the most suitable lining system, but it is important that the lifespan of the lining is accurately accounted for, and the liner warranty carefully scrutinised. Clubs should be budgeting to replace their reservoir liners every twenty-five to thirty years, not ten or fifteen years, irrespective of whether the reservoir is constructed in soft sand or flinty chalk.

The optimum depth for a golf course reservoir is between 4m and 8m. This allows for an efficient excavation whereby, in principle, one cubic metre of excavation stores not only one cubic metre of water below ground, but also one cubic metre of water above ground by its contribution to the embankments. The capacity of the reservoir is calculated as being the amount of water required by the irrigation system in a 40 or 50 year drought. To this must be added nett losses due to evaporation, a safe freeboard for wave action and an allowance for dead water at the base of the reservoir. On a reasonably level field a reservoir of 12,000m^3 (sufficient for most 18-hole greens and tees systems) may occupy a total footprint area of one and a half to two acres. A reservoir of 25,000m^3 (for many 18-hole fairway systems) may require two and a half acres. A 50,000m^3 reservoir may require four or five acres.

Health and safety

Many reservoirs are scraped and pushed into shape by bulldozers and similar plant. Others are constructed using 360 degree excavators and dump trucks. However they are constructed, the most crucial component of the build is the correct specification for the construction of the embankments, and a variety of plant is available for this. All of this plant must be transported to site. Ensuring an adequate and safe haulage route through tight rural roads and across the golf course is an important consideration in the siting of the reservoir and its safety planning.

Slope facing at Kent National

Almost all reservoir construction projects are subject to the Construction Design and Management Regulations 1994 (the CDM Regs). As a golf club, this means that you have legal responsibilities to the health and safety of the project both during and after construction. No blind eye should ever be turned to these regulations and clubs can be prosecuted for not following the regulations irrespective of whether any injury actually occurs. The very positive side of the CDM regulations is that by following a few simple codes of practice, accidents are very few and far between in reservoir construction. The CDM Regs also lay out the relationship between all the

parties. The club will be the *client*, the engineer is the *designer* and possibly the *planning supervisor* and the contractors are *principle contractors* and *sub-contractors*. This prevents any grey areas of responsibility and ensures that the contract relationships are seamless. The creation of an agreed Health & Safety Plan by the planning supervisor at the project's feasibility stage is a must. As with much modern regulations (though not all), embracing the CDM Regs wholeheartedly is the only way to ensure your project is safe and that you are protected as a club. It is even possible to nominate an '*agent*' to assume these risks for you.

The issue of a safety fence around the finished product is one of the most talked about subjects in a reservoir project. All reservoirs must have some escape method if somebody falls in, but keeping the wildlife and local teenagers out is a major issue. Any reservoir situated near a housing estate or public footpath ought to have around it a properly specified fence to recognised health and safety standards. This should be situated at the bottom of the external embankments so as to minimise its visual impact against the sky-line. However a more remote reservoir need not require one. It is one of the vagaries of law and insurance that one can walk directly off a cliff into the sea or a river with little recourse to the landowner, but a strong case would need to be made that a reservoir's risks had been minimised if a suitable fence had not been included within the design.

<u>Environmental and Planning Considerations</u>

Reservoirs can be almost any shape and size. Fitting them into corners of fields, between hedgerows, or fitting them to existing hillside contours are common processes. If the reservoir construction is part of a new abstraction licence, often a consideration at an early stage is to look for the nett environmental benefits of a reservoir.

Putting energy into water in order to move it long distances in municipal pipelines; chlorinating that water at great expense; and then applying it to a golf course is plainly wasteful of energy. Simply abstracting, conserving and applying water locally has an immediate environmental benefit. However in recent years treating the reservoir itself as an environmentally beneficial structure has become important to the Environment Agency and to planning departments around the country. A properly managed and fenced off area can provide excellent protected habitat. About

the only animals that need to be excluded are deer, foxes, rabbits and, of course, pet dogs. Using wildflower seed blends can provide a valuable habitat for small rodents and birds.

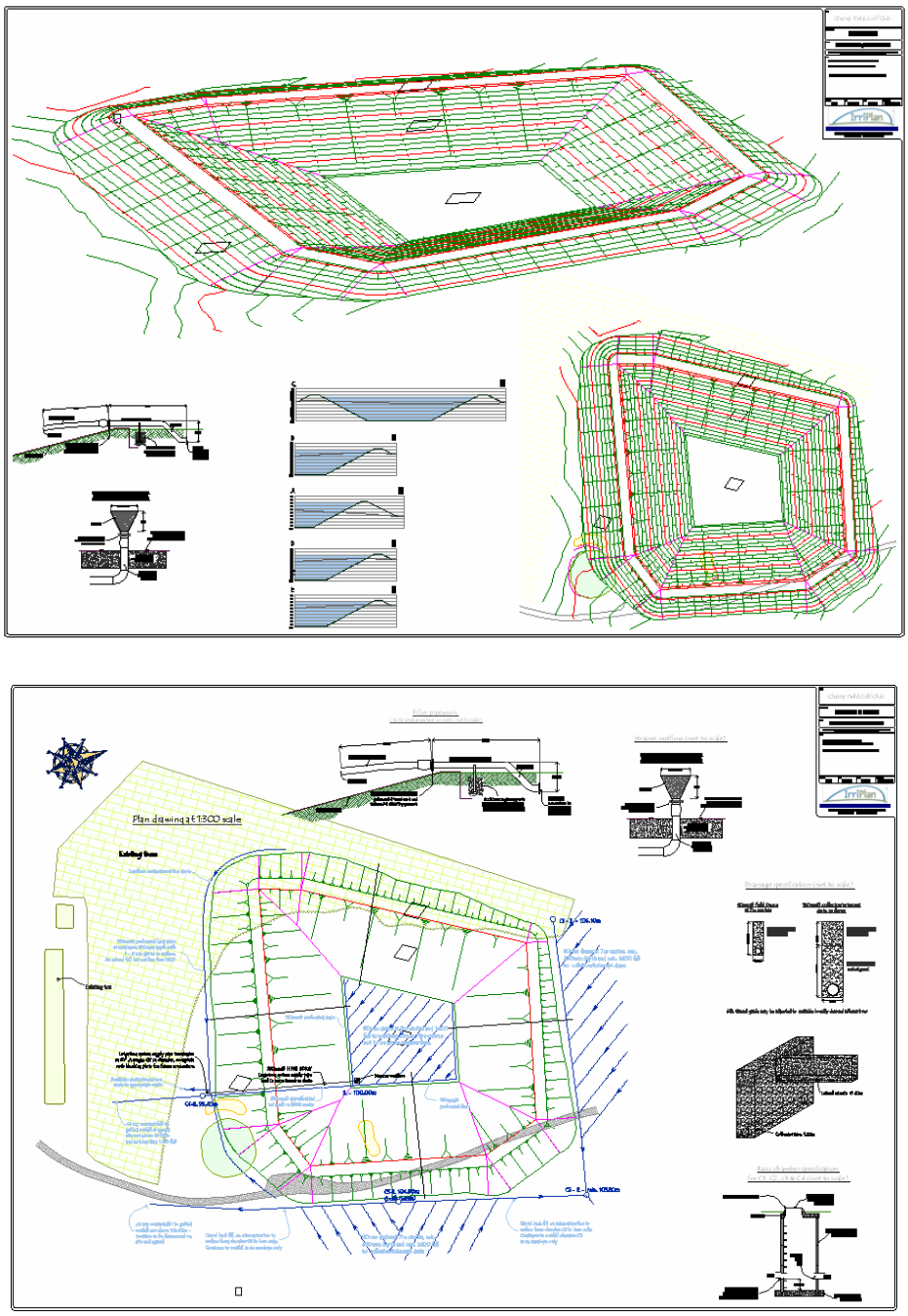
Synthetically lined reservoir embankment sown with a wildflower seed mix

Non-geometric shapes, marginal shallows, access ramps for amphibians and ducklings, and even floating islands that rise and fall with the water level can help to promote a reservoir both visually and environmentally. For very little cost, a new reservoir can be favoured and supported by the Environment Agency, your local Wildlife Trust and the Local Authority by making a significant contribution to habitat creation.

A floating island provides refuge and shade for fish and nesting sites for wildfowl

Construction

The whole process, from feasibility, through engineering design and specification, to supervision and post-construction observation, should be handled by an independent firm of suitably qualified consulting engineers. The finished design should be well modelled and presented using dedicated civil engineering software so that the club and the local planning department know exactly what will be constructed.



A good design is essential for planning and for tendering contractors

Correct plans with sections and detail drawings will allow competing contractors to provide prices on a like-for-like basis.

A lined reservoir not far off being ready for filling

Finished embankment surface

The purpose of the golf reservoir is to store water so that it can be applied through the irrigation system in the summer. Though construction must be seen as an individual project, the reservoir is just one component of a larger system – from the collection of the water, through to its emission from the sprinklers' nozzles. Fitting the reservoir into the overall abstraction and irrigation system must not be left to chance.

Each reservoir is a bespoke component of the irrigation system and so budget prices are notoriously difficult to predict without the feasibility, design and tendering stages being complete. Generally, the deeper the excavation and the more level the site, the lower the costs. Shallow reservoirs above high water tables and reservoirs constructed in rocky or hard ground tend to be the most expensive.

At today's prices, a 12,000m^3 synthetically lined construction may cost in the region of £70,000 - £130,000, a 25,000m^3 lined reservoir may cost £120,000 - £180,000 and a 50,000m^3 lined reservoir is likely to be in excess of £160,000.

An abstraction licence itself may take some time to be awarded, but reservoir planning and design processes also do not happen overnight. The most appropriate time of year to construct a reservoir is in late summer or early autumn when the land is generally drier. Carrying out major earthworks in winter can dramatically push prices up as contractors have to cost in the days when the weather makes excavation and movement too difficult. With this in mind, for a late summer construction, a contractor must be appointed at least three months before and as planning consent can take six months or more, clubs should allow themselves a minimum of one year planning.

As pressure on water resources grows the cost of water increases, and its reliability of supply decreases. One of the best ways to ensure that you have a sufficient known quantity of water for your summer's irrigation system is to be able to stand beside your own private reservoir in March, and see the water for yourself. Saving your little bit of water that would otherwise run off to the sea, puts you back in control and removes your dependence on third parties.