

DYE TRACING AT OTTER HOLE, CHEPSTOW

by

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ABSTRACT

Results are presented of dye tracing experiments around Otter Hole, near Chepstow, Wales. Data is given for historical work, work carried out by the author on Itton North and South swallets and some more recent tests. An attempt is made to understand discrepancies in the naming of swallets in this area and a summary list of sites is presented.

INTRODUCTION

The origins of this article stretch back to the 1990s when the author was actively involved in surveying and extending Itton North Swallet, a cave with a stream which was believed to feed into the Otter Hole system. Research into previous published details of dye testing revealed discrepancies in both the testing and in the recorded data for the sinks and resurgences in the area, particularly with the accuracy of grid references and the names used for the various features. Assumptions had also been made which, although reasonable, were not supported by any actual data. A systematic review of the relevant published data with particular consideration of names and location of sinks and springs was carried out, using historic maps and fieldwork to produce a more accurate list of relevant sites which is reproduced here as Appendix Two. Further tests were carried out to check the original results and to complete the analysis by testing sinks not previously considered. Both positive and negative test results are included for completeness although it should be noted that negative results do not necessarily prove there is no connection but merely that one had not been detected at that time in those particular conditions.

The original testing is reviewed below under the heading Otter Hole Testing. The subsequent investigations carried out as part of the exploration of Itton North Swallet are reported under the heading of Itton North Testing. Subsequent investigations and other relevant information on the hydrology of Otter Hole are also included. Previous tracing work by the UBSS (Drew, *et al.* 1970) whilst searching for the source of the 'Great Spring' in the Severn Tunnel included the testing of the Itton North and Itton South swallets, which they called the Upper and Lower Sinks. Unsurprisingly these tests were without success as Otter Hole had not been discovered at that time.

OTTER HOLE TESTING

Test A1

After more than four years of digging, the main stream in Otter Hole (ST 5258 9615) was reached in 1974 (Elliot *et al.* 1979) The magnificent extensions were discovered in 1977, as was the stream at the end of the passage named Tunnels Left by the discoverers. The first dye

test of the hydrology of this cave took place on the weekend of 29th and 30th of May 1977, when John Elliot from the Royal Forest of Dean Caving Club (RFDCC) put 250 g of flourescein into the stream at the end of Tunnels Left. On 5th June 1977 the detector was collected from sump 2, of the main stream by Clive Westlake of the Eldon Pothole Club (EPC) and was “magnificently positive” (Westlake, 1977). A link between the two streams could therefore be reasonably assumed.

Test A2

On 7th June 1977, a 5 litre solution of 10% flourescein was poured into The Rookery Sink at St. Arvans (NGR ST 5138 9682) (Westlake, 1977). The Rookery is a local name for a large depression to the north-west of the village of St. Arvans where a stream sinks between boulders, approximately 5 m below the surrounding ground level. The water for this stream comes from Wet Wood, 1 km north of the sink, and crosses under the road from St Arvans to Devauden at Ford Bridge. The Cambrian Cave Registry (CCR) (Cambrian Caving Council, 2009) refers to this sink as St Arvans Main Sink. An earlier version of this registry, prior to it being available online, also gives the alternative name of Limekiln Swallet. The 1901 version of the Ordnance Survey (OS) 1:2500 map of the area shows “Old Limekiln” (ST 5136 9681) close to the sinks. It is not shown on the first edition of 1881. Approximately 100 m south west of Rogerstone Grange Farm, the 1901 OS map shows another limekiln (ST 5075 9654) which is also adjacent to a stream that appears to sink (see test A3 below). This suggests there may be some confusion regarding the use of the name Limekiln Sink. The process of slaking lime requires a source of both limestone and fresh water and it is not surprising that kilns appear adjacent to streams. It is unclear how much of The Rookery Sink depression is natural and how much enlargement was due to the extraction of limestone.

Detectors collected on the 25th June 1977, gave positive readings at sump 2 and negative readings at Tunnels Left. This reasonably indicates that although this water contributes to the main stream of Otter Hole it enters at a point downstream from the water visible at the end of Tunnels Left.

Test A3

On the 26th June 1977 dye was put into a sink near Rogerstone Grange Farm. Clive Westlake’s notes (1977) and subsequent article (Elliot, *at al* 1979) refer to this as being Rogerstone Grange East Sink. The CCR grid reference for the sink with that name is ST5086 9653 which locates it at the southern end of an old hedge line where that meets a limestone outcrop which also forms the southern boundary of the field. It is possible that a ditch ran along this hedgeline and sank in this location, there is however now no sign of either the hedge nor the sink. It is also possible that in calculating the grid reference an error occurred by confusing this hedge with the current one further east (see below regarding RFDCC dig site.)

Both the 1st Edition (1881) and the 1st Revision (1901) of the OS map show a series of copses running in a line roughly east from Rogerstone Grange Farm a little to the north of the outcrop. These represent a line of depressions which have been largely filled over a period of time by the farmer although their outlines were still visible in the 1990s. Discussion at that time with the farmer of Rogerstone Grange revealed that in wet weather water running down the field disappeared at these locations and a number of pipes for field drainage have been placed, feeding into them. A concrete ring is located directly above one of the sinks. There was previously also a sink at the top end of this field, that is nearest to the entrance to the farm, into

which a small stream ran. The local story is that this appeared overnight and was subsequently filled with the stone from a chapel. That depression has, however, been filled for many years. The 2nd Revision OS map of 1921 shows a sink at ST 5067 9661 as the end of a stream which on earlier OS maps continued further to form much of the south boundary of the field.

The stream is shown on the 1881 map as heading towards the corner of the field that is the CCR reference for Rogerstone Grange East Sink but ending/sinking at a point 400m before it gets there (ST 5082 9653). The 1901 version clearly shows the stream diverted into and ending in the largest one of the copses/depressions (ST 5081 9656), the one nearest to the limekiln referred to above.

At the time of the dye testing in June 1977, excavation work was being carried out at a sink less than 0.5 km east-south-east of Rogerstone Grange Farm by the RFDCC (NGR ST 5106 9646). This sink is directly in line with those referred to above being the furthest east and some 200 m further from the farm than the CCR reference for Rogerstone Grange East Sink. It is again reasonably large, approximately 20 m in diameter, and until relatively recently took a reasonable stream flowing from a pond on the north side of the road from St Arvans to Rogerstone Grange. That stream flows from a rising near the pond south towards the sink, passing under the road before following the line of the hedge as a ditch that runs as the east boundary of the field to the sink dug by the RFDCC. The stream sank among boulders in the floor of the depression. The presence of large trees growing from within the depression indicates that it is not recent. A large amount of debris and rubble has also been tipped into this hole over the years. There is no obvious face to dig against and the decision by RFDCC to dig in the floor of the depression and follow the stream may, with hindsight, have been in error and the reason for the lack of success. A depth of about 12 m through boulders was reached before the dig was abandoned. It is now backfilled. The CCR refers to the site of the RFDCC dig as St Arvans Lower Sink.

RFDCC members who were involved in the digging of that site have confirmed that the stream entering the dig site was that which was tested in the late 1970s. The majority of the water which previously fed this sink now disappears into a collapse which occurred during the dry summer of 1995. This is approximately 45 m south of the road to Rogerstone Grange, alongside the line of the ditch. This oval collapse was approximately 13 m x 12 m and 3 m deep. It has since been largely filled, but still takes the water from the stream. The only water that now sinks in the main depression is from field drains installed by the farmer at Rogerstone Grange and the overflow from the more recent sink which flows along the original ditch in wet weather.

To confuse the issue further the grid reference given in the BCRA article (Elliot *et al* 1979) for the tested sink is ST 506 967 which appears to be that of the Rogerstone Grange West Sink (otherwise referred to as Rogerstone Grange Main Sink). A stream previously sank in the front lawn of the farm adjacent to the road. This is the site of the sink given in the CCR as Rogerstone Grange Main Sink (ST 5064 9665). This has also been filled although subsequent subsidence means the extent of the depression could still be made out when inspected in 1995. To the North of the farm there was previously a water mill. There is still a stream near to the farm. It is believed that this formerly fed the mill chase and eventually went into the main sink referred to above. This stream now sinks in a small depression adjacent to the former mill (ST 5058 9670). There does not appear to be any local name for this sink although for ease of identification it would seem logical to call this Rogerstone Grange Mill Sink.

The list in Standing and Standing (1967) does not differentiate between the Rogerstone Grange Sinks by name but does give two separate grid references. One of these references is, however, for a location 1 km north of Rogerstone Grange, which is approximately at

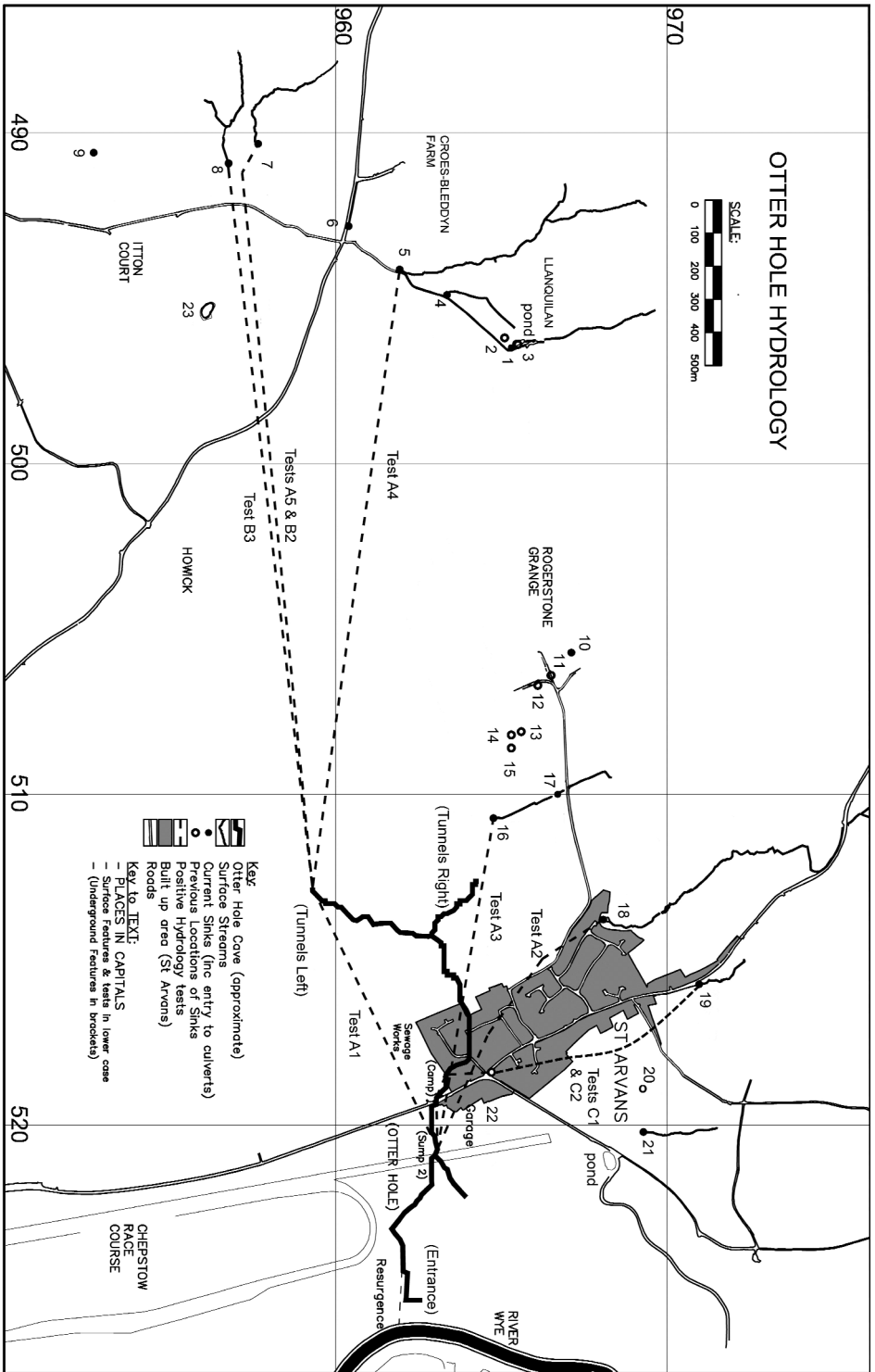


Figure 1. (opposite) Area map showing the sinks and proven traces to Otter Hole. Numbered sites as follows: 1. *Llanquilan Sink*, 2. *Llanquilan Sink A*, 3. *Llanquilan Sink B*, 4. *Llanquilan Quarry Sink*, 5. *Croes Bleddyn Sink*, 6. *Itton Road Sink*, 7. *Itton North Sink*, 8. *Itton South Sink*, 9. *Black Hole Sink*, 10. *Rogerstone Grange Mill Sink*, 11. *Rogerstone Grange Main Sink*, 12. *Rogerstone Grange East Sink A*, 13. *Rogerstone Grange East Sink B*, 14. *Rogerstone Grange East Sink C*, 15. *Rogerstone Grange East Sink*, 16. *St. Arvans Lower Sink (dig)*, 17. *1995 collapse*, 18. *The Rookery Sink*, 19. *St. Arvans Road Sink*, 20. *Piccadilly Pot*, 21. *Piccadilly Sink*, 22. *St. Arvans Sink*, 23. “*Big Hole*” (*quarry or collapse feature?*).

the site of a reservoir. There are known to be sinks in this vicinity which take water in wet weather but it does not seem appropriate to refer to these as being part of Rogerstone Grange. If the last two digits are transposed, however, the reference is that of Mill Sink. The other reference is that of the Main Sink.

The detectors collected by Ian Davinson, Eldon Pothole Club (EPC), during the weekend of 9/10th July 1977 gave the same results as those for The Rookery Sink, i.e. positive at Sump 2, negative at Tunnels Left. The hydrology map in the BCRA article (Elliot, *et al*, 1979, Figure 1) utilises the grid reference for Rogerstone Main Sink as the one tested, it also shows a further sink to the west of this, the identity of which is not given. The chapter on Otter Hole in *Limestones and Caves of Wales* (Westlake, *et al* 1989) adapts this map. The Eastern Sink (Main Sink?) is shown as tested, although it was the RFDCC dig that the dye was actually put into. This publication also shows the other sink to the west as being tested, in Figure 11.1, and shows the Eastern Sink as being at the end of a dry valley coming from the North. This is, again, not the case in respect of the stream understood to have been tested. There do not appear to be any records of any other tests in this location prior to this publication and it would therefore appear that by utilising previous data, inaccuracies have been compounded.

To summarise, the St. Arvans Lower Sink, a former RFDCC dig, was tested to the Otter Hole main stream, being detected at Sump 2. The Main Sink in front of the farmhouse has now been filled. An active streamway still exists to the Mill Sink although no testing has been carried out. There are also a number of previous sinks in the area most of which have now been filled. Noticeably a line of sinks follows the dry valley from the tested sink towards the farm. These only took water in wet weather.

It is perhaps of significance that a projected continuation of the Tunnels Right passage in Otter Hole would appear to head directly towards these sinks. It is therefore possible that the known passage in the cave is a high level fossil passage above a still active streamway, coming from the Rogerstone Grange area.

Test A4

The next dye testing took place in September 1977 with detectors being placed at the end of Tunnels Left on 18 September 1977 (Hutchinson, 1977) by a group from the Severn Valley Caving Club (SVCC) and the Hades Caving Club (HCC). Dye was placed into a surface sink near Llanquilan the following day.

The older Ordnance Survey maps show three small sinks on the road to the farm at Llanquilan:

Llanquilan Sink	ST 4965 9653
Llanquilan Quarry Sink	ST 4949 9633
Croes Bleddyn	ST 4941 9619

(Grid references taken from 1970s OS maps, see table of sites at end of article for alternative names). Again there has in the past been confusion regarding these sinks as a result of the misuse of the names.

Llanquilan Sink is adjacent to Llanquilan Farm although it appears in different locations on different date maps i.e 1881 and 1901 it is ST 4962 9651, in 1921 it is ST 4964 9655. During the 1980s the owners of the farm constructed a large ornamental pond in front of the property and Llanquilan Sink is now no more than the overflow from this feature, and only takes water in wet weather.

The quarry containing the Llanquilan Quarry Sink was significantly altered by the construction of the new road to the farm and instead of the stream sinking into a “drainhole like aperture” (Hutchinson, 1978b) in the floor of the quarry as was previously the case, the stream which is itself effectively a field ditch, now disappears into a pipe running below the road. A minimal amount of digging was carried out in the late 1970s by RFDCC members although their main efforts were concentrated on the Croes Bleddyn sink.

Croes Bleddyn sink, the actual site into which dye was put by Graham Crisp and Nick Geh (both HCC), was the dig commenced a fortnight earlier by Colin Shapter (RFDCC). This dig gained access to a small cave which later became known as Croes Bleddyn (NGR ST 4941 9619) or alternatively as Beaver Hole.

The entrance shaft of this cave is 6 m deep and located at the edge of the small depression 5 m south of the location where the water now (2012) disappears. At the time of inspection the dug entrance had largely collapsed. The stream was quickly re-encountered at the foot of the shaft and was followed through small chambers for a distance of approximately 45 m to where it disappeared into a gravel choked sump. At this point a side passage could be followed to the current end of the cave (total length 150 m) at a dig site. Part way along this, a smaller stream enters and was followed for much of the length of the side passage. It is considered likely that this stream is the water disappearing into the Llanquilan Quarry Sink although this has, as yet, not been tested.

On the 24 September 1977 the left hand inlet of the stream at the end of Tunnels Left was “visibly green” (Westlake, 1977) although the detector at Sump 2 was found to be negative. The link from Croes Bleddyn to Tunnels Left and the Otter Hole system was assumed on the basis of this, with possible reasons for the anomaly of the Sump 2 detector being negative suggested as:

Dye too dilute - unlikely as it was “visibly green” at Tunnels Left

Dye had not yet reached sump 2 - 19th to 24th is less than 5 days

Dye neutralised by pollution - Strong smell of fuel in the streamway when detectors installed. Charcoal will absorb fuel, blocking the absorption sites for the dye.

Test A5

The next testing took place on 22nd April 1978 when detectors were positioned in Otter Hole by members of the EPC. (Hutchinson, 1977; Badman, 1982). Detectors were also positioned in local surface springs (Hutchinson 1978a) including the Mounon Brook. On 30th April 1978 dye was poured into the Itton North Sink (ST 49033 95766) by members of Hades CC (Hutchinson, 1978a). Hades CC Magazine no. 15 indicates that the Tunnels Left detector was removed from Otter Hole on 13th May 1978 by Clive Westlake and found to have a positive result (Badman, 1982). This appears to contradict Hutchinson (1978b) who indicates that the “*dye tests in early May were inconclusive due to general confusion and the loss of some detectors*”.

The surface detectors located in the Mounton Brook were washed away by heavy rain so no results were obtained from them. The results obtained within the cave appear to be no longer available although the Hydrology section of Elliott, *et al* (1979) stating the positive result was produced by Clive Westlake shortly afterwards. He collected and tested the detectors.

The tested streams at Croes Bleddyn and Itton North were stated as both feeding the stream at Tunnels Left and this subsequently feeds the Main Streamway. The assumption was made that the other untested sinks in the vicinity are also likely to go to the Tunnels Left stream. This information had been adapted by the time the chapter on Otter Hole in Limestones and Caves of Wales (Westlake, *et al.* 1989) was published. In their Figure 11.1, the sink at Itton South is shown as having been tested to Tunnels Left as is the sink labelled as Llanquilan (actually Llanquilan Quarry Sink) although the text does make it clear that only Croes Bleddyn and Itton North were tested. The chapter also states that the “Far Streamway” (that visible at the end of Tunnels Left) enters the main stream at a point upstream of Sump 7 although, as there is no known testing to this effect, this can only be speculation at this time.

Ref.	Location	Date Retrieved	Result
A1	29th/30th May 1977: 250 g of fluorescein into stream at the end of Tunnels Left		
	Detector at Sump 2	7/06/1977	Positive
A2	7 June 1977: 5 litre solution of 10% fluorescein into The Rookery Sink		
	Detector at Sump 2	25/06/1977	Positive
	Detector at Tunnels Left	25/06/1977	Negative
A3	26 th June 1977: “Dye” put into St Arvans Lower Sink		
	Detector at Sump 2	9-10/07/1977	Positive
	Detector at Tunnels Left	9-10/07/1977	Negative
A4	19 th September 1977: “Dye” put into Croes Bleddyn		
	Detector at Sump 2	24/09/1977	Negative
	Detector at Tunnels Left	24/09/1977	Positive
A5	30 th April 1978: “Dye” put into Itton North Swallet		
	Detector at Tunnels Left	13/05/1978	Positive
A6	“Dye” put into water sinking at Camp 1 (date not known)		
	Sump 2	Not Known	Positive

Table 1. Summary of results from the initial Otter Hole dye trace experiments.

Test A6

The water appearing near to Camp 1 in Otter Hole has been dye tested and found to reappear at Sump 2. The source of this water, which has been drunk by many cavers, had not been established although there is a sewage treatment plant (ST 517 961) on the surface at the southern end of St. Arvans, very near to the point of entry of this water into the cave. Where treated water empties down a “nice hole in the ground”. (Anon, 1978). The water at the camp has subsequently been tested and found to be unfit for human consumption.

The hydrology map previously referred to from Westlake, *et al.* (1989 Fig 11.1), shows another sink in St. Arvans, which it refers to as the St. Arvans Sink. There is no sign of this on the surface. Locals who have lived all their lives in the village also cannot recall there being a sink in the location shown, although they do refer to a stream which used to flow down through the village which was culverted many years ago. This is the water from the spring at Hill Farm (ST 5151 9723) which now disappears into a piped culvert along side the road to Devauden at ST 5156 9708. This water is said to have flowed through the village and disappeared near to the Piercefield Hotel, that is, on the present site of the sewage works. This is partially supported by reference to the older Ordnance Survey maps which clearly show the stream alongside the road but only as far as the junction with then main Chepstow to Monmouth road, but there is no sign of the sink alleged to be on the site of the sewage works.

There are stories of collapses occurring in and around St. Arvans. On one occasion a lorry partially disappeared down a hole that occurred on the race course side of the main road junction. A collapse in a field north of St. Arvans was dug in the early 1990s by Hades CC and from 2008 by the Chepstow diggers and RFDCC as Piccadilly Pot (ST 5189 9695, alt 144 m). Its current length is 32 m and depth is 24 m.

ITTON NORTH TESTING

Hades Caving Club (HCC) commenced digging at the Itton North Swallet (ST 49033 95766) in October 1979. A large amount of effort was put in over many years to extend the cave to its current surveyed length of just over 300 m. Despite this modest length Itton North is said to represent one of the more awkward and arduous caving trips, and few who have struggled to the bitter end would disagree. In the early 1990s the cave was surveyed and investigation was undertaken into its hydrology. The anomalies described above regarding the previous testing resulted in uncertainty that the water in this cave did in fact connect to Otter Hole. The three sinks in the Llanquilan area (referred to above), the Itton Road Sink (ST4928 9603), the Itton North and South Swallets and the Black Hole Sink (ST4906 9527) a short distance down the valley, were at that stage all assumed to link to Tunnels Left. The comparatively small flow of the Tunnels Left stream when compared to its alleged catchment had also lead to questioning of the assumed hydrology. Part of the difficult here however is that Tunnels Left is only easily accessible when water levels in Otter Hole are sufficiently low, at which time some of the surface streams may be dry. A further series of dye tests was therefore undertaken, all using fluorescein and activated charcoal detectors.

Test B1

The first test to be carried out involved testing the Itton South Swallet. This had not been tested to Otter Hole, the only known prior test being that carrying out by the UBSS in the

late 1960s (Drew, *et al.* 1970). Detectors were placed in both the Tunnels Left stream and at Sump 2 in the main stream in Otter Hole on 14th May 1994 by David Hardwick (HCC). A base reading was also taken by leaving a detector at Sump 2 whilst placing the detectors at the end of Tunnels Left and collecting it on the way out. This detector was tested and found to be negative but it should be noted it was only in the stream a short period of time. Detectors were also placed at the end of the Itton North stream by Dave Little and David Hardwick (both HCC) on 17th May 1994 during a surveying/digging trip to the end of Itton North Swallet. After exiting the Cave, fluorescein was then poured into the stream entering Itton South Swallet (ST 4902 95677). In this way it was hoped that it could also be confirmed as to whether the confluence of the streams entering the Itton Swallets had been passed.

Detectors were recovered from sump 2 on 11th June 1994 although it was not until 30th July 1994 that a between tide solo trip to the end of Tunnels Left enabled the retrieval of the other Otter Hole detectors. The detectors were retrieved from Itton North Swallet and the surface streams on 24th May 1994.

All detectors were tested with negative results. A possible trace of fluorescein was detected in one of the Tunnels Left detectors although as it was very faint it was considered to be inconclusive. A large amount of organic material had also been absorbed by the detector. This may have limited the effectiveness of the detector to absorb the dye and possibly caused the result to be weaker than might otherwise have been the case.

Test B2

The second test involved Itton North Swallet. When collecting the detectors from Otter Hole on 30th July 1994, David Hardwick had also placed further detectors in the sump pool at Tunnels Left and adjacent to the gravel bank at Sump 2. Detectors were also positioned in the surface streams previously tested and at a resurgence near Chepstow Castle (ST 5331 9412). Paul Taylor (GSS) assisted by pouring the dye later that week. This is believed to have been on 3rd August 1994 as that was a usual digging evening in the Forest of Dean. The Sump 2 detector was collected on 14th August 1994, although the detector from the end of Tunnels Left was not retrieved until an evening trip by Steve Fowkes (HCC) on 16th August 1994.

Both the Sump 2 and the Tunnels left detectors tested positive confirming the link between Itton North Swallet and Tunnels Left and the link between Tunnels Left and Sump 2.

Test B3

The negative results from the earlier Itton South test lead to a further test. Detectors were positioned in Otter Hole by David Hardwick on 11th September 1994. A larger amount of dye, 250g of fluorescein, was put into Itton South Swallet by Paul Taylor on 15th September 1994. The flow at the time was very low and the stream dried up soon after. Both detectors were exchanged on 17th September by Dave Little. The replacement detector at Sump 2 was taken out on 24th September 1994 but the Tunnels Left detector was not retrieved until the following spring. Both of the first pair of detectors were found to be negative, initially appearing to confirm the earlier results. The second detector from Sump 2, however, proved positive and it would therefore appear that in low flow conditions it takes over two days for the stream sinking at Itton South Swallet to reach Sump 2. This slow flow rate is comparable with the earlier Croes Bleddyn results (test A4 above) where the water appeared to have reached Tunnels Left but had yet to get as far as Sump 2. The results of the second Tunnels Left

Test B1 100g fluorescein into Itton South Swallet 17/5/94

Ref.	Location	Date Retrieved	Result
S2b	Otter Hole - Sump 2 (base reading)	14/05/1994	Negative
S2.1a	Otter Hole - Sump 2 (adjacent to Divers entrance)	11/06/1994	Negative
S2.1b	Otter Hole - Sump 2 (adjacent to gravel bank)	11/06/1994	Negative
TL.1a	Otter Hole - Tunnels Left (In sump pool)	30/07/1994	Negative
TL.1b	Otter Hole - Tunnels Left (as far upstream as possible)	30/07/1994	Negative
IN.1a	Itton North - Stream visible at foot of 1st depression in Worm Chamber	24/05/1994	Negative
IN.1a	Itton North - At point where stream sinks (Below Attic)	24/05/1994	Negative

Test B2 100 g fluorescein into Itton North Swallet 3/8/94

Ref.	Location	Date Retrieved	Result
Surface Detectors			
SD.2.1	Well Head Spring ST501 942	Not recorded	Negative
SD.2.2	Stream Near Garashill Wood ST505 939	Not recorded	Negative
SD.2.3	Garage Spring ST572 943	Not recorded	Negative
SD.2.4	Traphill Wood Tributery ST514 935	Not recorded	Negative
SD.2.5	Mounton Bridge ST512 931	Not recorded	Negative
SD.2.6	Chepstow Castle Resurgence	Not recorded	Negative
S2.2	Otter Hole - Sump 2 (adjacent to gravel bank)	14/08/1994	Positive
TL.2	Otter Hole - Tunnels Left (in sump pool)	16/08/1994	Positive

Test B3 250 g fluorescein into Itton South Swallet 15/9/94

Ref.	Location	Date Retrieved	Result
Surface Detectors	as for test B2 –(SD.2.1-2.6 inclusive)	Not recorded	All Negative
S2.3a	Otter Hole - Sump 2 adjacent to gravel bank	17/09/1994	Negative
S2.3b	Otter Hole - Sump 2 (as above - exchanged 17/9/94)	24/09/1994	Positive
TL.3a	Otter Hole - Tunnels Left (In sump pool)	17/09/1994	Negative
TL.3b	Otter Hole - Tunnels Left (In sump pool - exchanged 17/9/94)	spring/95	Positive

Table 2. Summary of results from the Itton North Swallet related dye trace experiments.

detector were eagerly awaited and this too proved positive, suggesting that the assumption that Itton South Swallet connects to Tunnels Left is also correct. It must however be noted that as this detector had been in for such a long time there is a possibility that dye from an unknown source may have entered the system during the test period and given a false reading. There is also no background reading for natural levels of fluorescence.

The detector placed in the resurgence below Chepstow Castle was negative. No other testing of this resurgence is known of and the source of this water has yet to be determined.

LATER DYE TRACING

The water appearing near the Camp in Otter Hole had been tested to the main stream previously but its source had not been confirmed. Detectors were put into Otter Hole on the weekend of 24/25 September 2011. Mike Bertenshaw put detectors into the pool of water at the Camp and at Sump 2 during a trip with a party from Cambridge University. As it was not possible to put dye into the sink at the sewage works, a surface inspection was carried out to determine the first point of access to the culverted stream that previously ran through the village of St. Arvans. 250g of fluorescein was placed into the pipe where the stream sinks at ST 5156 9708 on 27th September 2011 by members of HCC. The stream was not flowing at the time but rain was forecast for the following week. Heavy rain did follow to the extent that access to Otter Hole for retrieving the detectors the following weekend was not possible. Following a dry October, David Hardwick and Andy Brander (both HCC) retrieved the Sump 2 detector during a between tide evening trip on 27th Nov 2011 but being so late in the year it was decided not to risk going as far as the camp. A replacement dye detector was left at Sump 2.

Test C1 250g Fluorescein into St. Arvans Sink (at ST 5156 9708) 27th Sept 2011

Ref.	Location	Date Retrieved	Result
T1-S2-1	Sump 2	27/11/11	Positive
	Other detectors not retrieved until spring (see below)		

Test C2 250g Fluorescein into St. Arvans Sink (at ST 5156 9708) 19th April 2012

Ref.	Location	Date Retrieved	Result
T2 -S2-1	Sump 2 - placed when T1-S2-1 detector collected 27/11/11	22/4/12	Positive?
T2 -S2-2	Sump 2 - placed when T1-S2-1 detector collected 27/11/11	22/4/12	Positive?
Camp-a	Pool of water at camp (placed prior to test C1)	22/4/12	Positive
Camp-b	Pool of water at camp	22/4/12	Positive

Table 3. Summary of results of later dye tracing experiments.

On 19th April 2012 a further 250g of fluorescein was placed into the same sink, with the streamway flowing on this occasion. The water was visually followed through the manholes for the road drainage in the direction of the sewage works. The detectors in the cave were collected during the Otter Hole leaders pre-season trip on 22nd April 2012. These were sent to Dr. P.L. Smart for testing (as had been the case with the earlier ones). The detectors from different locations and different time were kept separately and subjected to a rigorous testing (See Appendix 1).

Initial results gave only a faint positive for the detectors at Sump 2. The one from the first test, Test C1, was coloured but the two from the second test, Test C2, were visually clear although they did give a weak positive result for fluorescein under high intensity white light. Further testing with a filter fluorometer gave results in both the orange and green wavebands suggesting the result could be attributed to background fluorescein and should therefore be considered negative. Those detectors had however been stored wet and as a result (Dr. Smart states in his report) "dye can diffuse into the interior of the charcoal and become irreversibly bound to high energy sites". It is also difficult to compare them with the other Sump 2 detector which was stored dry. The size of the detectors was also larger than the ideal "walnut size" giving difficulty with homogeneity as the core does not absorb as much dye as the outer (although the samples were homogenised physically before eluting). The later Sump 2 detectors also had a lot of non-dissolved organic material present which again could have restricted the amount of fluorescein absorbed.

The detectors from Camp 1 gave a visual positive that was much more reliable than the others. Comparison by cross plotting of orange v green wavebands suggests that the other samples from the Sump 2 detector (T2-S2-1 and 2) were in fact positive and not simply background readings

CONCLUSIONS

The testing carried out for this article has on the whole confirmed the assumptions of the previous published work, i.e. that the sinks in the Itton/Llanquilan area go to Tunnels Left before going to sump 2 and that water from the Rogerstone Grange and St Arvans areas is not seen at Tunnels Left but does become part of the main stream at a point upstream of Sump 2.

The testing also suggests the water that appears at Tunnels Left can take several days to get there in low flow conditions. These are relatively small streams which can dry up in summer. The Rogerstone Grange sinks have been much altered and it is therefore difficult to ascertain their flow. The Rookery Sink at St. Arvans appears, visually, to be fed by the largest of the streams and may therefore be the principle source for the main stream.

The opening times of the tidal sump are mainly dependant on the tide times in the River Wye. It is however also affected by rain fall and the flow in the main stream. On 31st August 1997 a party from Devon CC, with David Hardwick as the appointed Otter Hole Warden, had an unplanned extended stay when the sump closed several hours before it was due to. An unexpected thunder storm with heavy rain in the Chepstow area resulted in a rapid rise in stream level within the cave. This suggests a short flow time from the Rookery Sink and/or other St. Arvans area sinks, although no direct testing of flow rates has been carried out.

The most recent testing also implies that the alleged sink below the sewage works and the stream feeding it, including the road drainage, is the source of the water seen at Camp 1. In the early years of exploration there were reports of a mystery illness. The symptoms varied,

with some describing a rash and others sickness. Both are consistent with possible pollution from this source.

FUTURE RESEARCH

There are elements of the above testing that are not as rigorous as they could be. Repeating the testing with a more rigorous framework would produce a more scientific base for conclusions although given the difficulties of obtaining samples in this particular cave a perfect solution may still be difficult to achieve. The benefit of repeating this research, given the results already obtained, is considered minimal.

Further consideration of flow rates and timed sampling to ascertain the flow time from The Rookery Sink to Sump 2 would be possible and might confirm whether this is the primary source of the main stream. Further work could also be carried out beyond Sump 2, with the assistance of divers, with detectors set at suitable spacings to determine where the tributary streams enter. Westlake, *et al.* (1989) states that the far streamway, that visible at the end of Tunnels Left, enters the main stream at a point upstream of Sump 7. As there has been no testing, it is presumed that this is speculation, based on reports by divers.

Whether the stream entering into Croes Bleddyn is that from Llanquilan has not been tested. To do so would require engineering works to make the entrance to the former safe.

The Mill Sink at Rogerstone Grange has not been tested. This is now the only accessible sink adjacent to Rogerstone Grange. The only original test in the Rogerstone Grange area was actually the St. Arvans Lower Sink which is relatively close to The Rookery Sink and, like that one, goes to Sump 2 without appearing at Tunnels Left. None of the sinks nearer to Rogerstone Grange have been tested and it is conceivable that they go in the same direction as the Itton/Llanquilan sinks, towards Tunnels Left.

Testing of the surface stream that sinks near Piccadilly Pot, here named Piccadilly Sink, and the stream encountered in the dig itself may confirm whether these go to Otter Hole.

Further investigation into the source of the water for the resurgence below Chepstow Castle could also be carried out. Previous tracing work by the UBSS, mentioned above, (Drew, *et al.* 1970) and on behalf of Welsh Water (unpublished report from the Water Research Council) have shown that the Cas Troggy sink (ST 4592 9271, also known as Nedern Sink) feeds the 'Great Spring' in the Severn Railway Tunnel. However, the eventual destination of Little Gondra Sink ('The Gondra' ST 4906 9357) was not discovered. It may be possible to delimit the catchments of the various risings, notably the Otter Hole resurgence, the Chepstow Castle rising and the 'Great Spring'.

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APPENDIX 1

Extract from testing report regarding test C by P.L. Smart.

... detectors were eluted in an azeotropic Propan-1-ol and 10% ammonia solution and analysed for rhodamine (orange) and fluorescein (green) fluorescent dyes after dilution.

On elution, the solutions for T1-S2-1 were coloured and free from particulates or organic scum. Those for all S2 detectors were clear but had a lot of non-dissolved organic material present as a scum and as settled particles. Examination in high intensity white light suggested a faint green fluorescence for the 2 T1-S2-1 samples. This possibly indicated a weak positive result for fluorescein.

The samples were diluted and analysed in a filter fluorometer at the 2 wavebands (table). It's pretty clear that the visible contrast was supported by the results, BUT note that the high values are in both green and orange wavebands not just in one. This is typical of background fluorescence which has a linear relation between values at the 2 wavebands (and unhelpfully has a visible green fluorescence of its own). Plotting the relative results defines a straight line, just using the low values gives predicted fluorescein values less than those for rhodamine in the T1S1 samples i.e. they could be simply background.

	RWT *10	F1 *100	
T1S1B	40	380	706.33
T1S1A	42	410	742.864
T2RA	3.9	56	
T2RB	5.6	77	
T2A	3.7	35	
T2B	3.3	36	
camp a	49	110.6	
camp a2	55	173.25	
Campb	45	189	
campb2	51	122.5	

APPENDIX 2

Site list of sinks and risings in the vicinity of Chepstow.

Name	Location			Elevation	Comment
	NGR	Easting	Northing		
Known Otter Hole feeders in bold . Alt. names in <i>italic</i>					
Itton North Swallet <i>Itton Upper</i>	ST	49033	95766	103.43	Cave passage heading towards Itton South (& Big Hole)

Itton South Swallet <i>Itton Lower sink</i>	ST	49092	95677	105.33	
Cas Troggy Sink <i>Nedern Sink</i>	ST	4592	9271		
Whitebrook Sink	ST	4219	9218		
Little Gronda Sink <i>The Gronda</i>	ST	4906	9357	107	
Crick Resurgences	ST	4972	9118		
Penhow Spring	ST	4204	9083		
Well Head Resurgence <i>Mounton Brook</i> <i>Tributary</i>	ST	5013	9420		
Rookery Sink <i>St Arvans Main Sink</i> <i>Limekiln Swallet</i>	ST	5138	9682		
Rogerstone Grange East Sink.	ST	5086	9653		Now filled
- Rogerstone Grange East Sink A	ST	5067	9661		1921 os map
- Rogerstone Grange East Sink B	ST	5081	9656		1901 os map
- Rogerstone Grange East Sink C	ST	5082	9653		1881 os map
St Arvans Lower Sink	ST	5106	9646		Former RFDCC Dig
Rogerstone Grange Main Sink <i>Rogerstone Grange West Sink</i>	ST	5064	9665		
Rogerstone Grange Mill Sink	ST	5058	9670		
1995 Collapse	ST	3510	9667		Overflow goes to St Arvans Lower Sink
Llanquilan Sink	ST	4965	9653		Overflow from Pond
- Llanquilan Sink A	ST	4962	9651		1881 & 1901
- Llanquilan Sink B	ST	4964	9655		1921
Llanquilan Quarry Sink	ST	4949	9633		Now Gulley at side of Road
Croes Bleddyn	ST	4941	9619		Cave Passage - picks up incoming stream (possibly Llanquilan Quarry Sink (not tested))
Sewage Treatment Site	ST	517	961		St Arvans sink is said to originally have gone here
Hill Farm Spring	ST	5151	9723		
St Arvans Road Sink (into culvert)	ST	5156	9708		
St Arvans Sink	ST	5184	9647		Now culverted back to St Arvans Road Sink
Piccadilly Pot	ST	5189	9695		Dig
Piccadilly Sink	ST	5202	9693		Not dye tested

Itton Road Sink	ST	4928	9603		Not dye tested
Black Hole Sink	ST	4906	9527		Not dye tested
Well Head Spring	ST	501	942		
Stream Near Garashill Wood	ST	505	939		
Garage Spring	ST	572	943		
Traphill Wood Tributary	ST	514	935		
Mounton Bridge	ST	512	931		
Chepstow Castle Spring	ST	5331	9412		

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