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# Using DTM's –
# The Technical and Financial Case

**Andy Adams**
Southern Water
Southern House
Lewes Road
Falmer
Brighton
BN1 9PY
Andy.adams@southernwater.co.uk

**Richard Allitt**
Richard Allitt Associates Ltd
The Old Sawmill
Copyhold Lane
Lindfield
Haywards Heath
West Sussex
RH16 1XT
Tel: (01444) 451552
richard.allitt@raaltd.co.uk

## 1. Synopsis

*The technical benefits and the true cost of using high quality Digital Terrain Models (DTM's) in modelling complex urban catchments are examined in this paper which uses the Brighton & Hove catchment as a case study. The background to the use of a DTM for the Brighton catchment and the costs of acquiring the data from a Lidar survey will be explained. The costs of obtaining the same data accuracy from other sources will be explored and the cost-benefit aspects will be assessed.*

## 2. Introduction

Richard Allitt Associates were commissioned in July 2005 to construct and verify a new Infoworks model of the Brighton & Hove catchment which has a population of nearly 260,000 and covers an urban area of some 4,000ha. The proposals made by Richard Allitt Associates Ltd for this project included for a Lidar survey of the catchment so that an accurate DTM could be constructed.

This paper will use the Brighton & Hove model as a case study and will investigate the costs and benefits of obtaining and using high quality DTM's as part of the modelling process. The paper will investigate these aspects in 3 main sections:-

The first section will concentrate on the improvements which can be made in the Asset Records including:-

- Providing a consistent and uniform assessment of the ground levels in a catchment enabling the accuracy of manhole cover levels to be assessed;
- Poor quality Sewer Record data can be identified and corrected;
- Inaccuracies in sewer gradients caused by incorrect manhole cover levels can be rectified;
- A realistic assessment can be made of missing manhole cover levels and ground levels at junction nodes;
- Inferencing of missing sewer record data can be undertaken with greater confidence;
- Cost savings can be made by reducing the number of manhole surveys required;

The second section will concentrate on modelling aspects which will include:-

- Terrain can be visualised on the desktop;
- Contributing areas can be determined with greater accuracy with associated cost savings in fieldwork;
- Overland flow routes can be visualised;
- Overland flow routing can be modelled with high confidence;
- Flood depth analyses can be undertaken;
- Integrated catchment modelling using Infoworks CS and Infoworks RS can be undertaken with full flood routing;
- Exceedance modelling and assessments of flood pathways can be achieved;

The third section comprises indirect benefits which are where the DTM can be found to assist with other work.

## 3. Brighton & Hove Catchment

The City of Brighton & Hove is located on the south coast of England and is served by the Portobello Marine Treatment Works which is located almost 8km further east along the coast at Telescombe Cliffs. There are a number of smaller towns and villages between Brighton and Portobello which are also part of the Portobello catchment.

The topography in the catchment is variable because of the proximity of the South Downs and the catchment has a maximum elevation of about 180m OD dropping down to a lowest elevation of about 5m OD. In places the roads and hillsides are very steep and it is common where roads follow the contours for houses on the downhill side of the road to be built up to road level with basements – of course many of these basements have now been converted into flats.

Figure 1 : Catchment Location

The drainage system for Brighton and Hove is generally separate in the upper areas where surface runoff is drained to soakaways, whilst in the lower lying areas in the older parts of the city surface water is drained to combined sewers. The eastern catchments (between Brighton and Portobello) are predominantly separate. The layout of the sewer network is dendritic in the upper areas and looped in the flatter coastal areas. All flow is generally drained southwards towards the coast where flows are collected by a Victorian brick Interceptor Sewer which runs from west to east all the way along the seafront from Hove to Portobello. Until 1997 there were 8 large CSO's each with a short sea outfall along the seafront of Brighton & Hove. In 1997 a 6m dia Stormwater Tunnel was constructed along the beach at depths of about 30 metres below the beach which intercepts all of the CSO's. Water stored in the tunnel is pumped back into the Interceptor Sewer when the flows have subsided.

A number of hydraulic models have been built for the Brighton Portobello catchment starting in the very early days of WASSP with increasing levels of detail added to the model as modelling software has progressed. The hydraulic model has been used at various times to assist with implementation of flood alleviation schemes. However, the stage was reached when it was recognised that in order to resolve all the remaining flooding problems, many of which were associated with overland flow or rural runoff, it would be necessary to have a far more detailed model which included overland flow routes where applicable. The new model built by Richard Allitt Associates Ltd is almost a Type III model (see the WaPUG Code of Practice) and it contains just over 10,100 nodes.

## 4. LiDAR Survey

A LiDAR survey was undertaken by Infoterra Ltd on 31st August 2005 for the 145km$^2$ catchment area shown on the plan below. The surveyed area was larger than just the urban area because some of the flooding problems in the catchment are associated with runoff from the South Downs.I It was considered necessary to have the LiDAR data extending over the whole watershed such that all potential flow routes and areas uphill of the urban area could be identified and modelled if necessary.

The LiDAR data was acquired during two sorties flown on 31st August 2005 on a clear day between 12:01hrs and 17:21hrs with a re-fuelling stop inbetween. The aircraft was flown at an elevation of 850m along 29 flight lines orientated approximately east-west with each flight line covering a swath of about 619m. Data was acquired at approximately 1 metre intervals.

A GPS ground station was established during the acquisition at a point on the southern edge of the survey area. Ground truthing surveys were undertaken at 4 other locations such that the data from the truthing surveys and the LiDAR surveys could be compared.

Figure 2 : Extent of LiDAR Survey

The QA checks undertaken by Infoterra showed that the final survey data was well within the required tolerances throughout the survey area. The truthing surveys showed that all the LiDAR data was within 53mm with a standard deviation of 0.059. This was well within the ±150mm which is the normally quoted accuracy of LiDAR surveys with data points at 1 metre centres.

The cost of the LiDAR survey and the preparation of the data to produce a DTM and a DEM of the survey area was £24,500.

# 5. Analysis of Level Data

The first step after converting the raw LiDAR data into a DTM was to gain an understanding of how well the DTM compared with the Sewer Record information. A number of longitudinal sections were viewed within Infoworks and within InfoNet; these showed a very close correlation for the majority of manholes but a more thorough analysis was required. An analysis was carried out to compare the cover level at each manhole (dummy manholes and junctions excluded). Figure 3 below shows the distribution of the differences between the manhole cover levels from the Sewer Records and the DTM value at the same location.

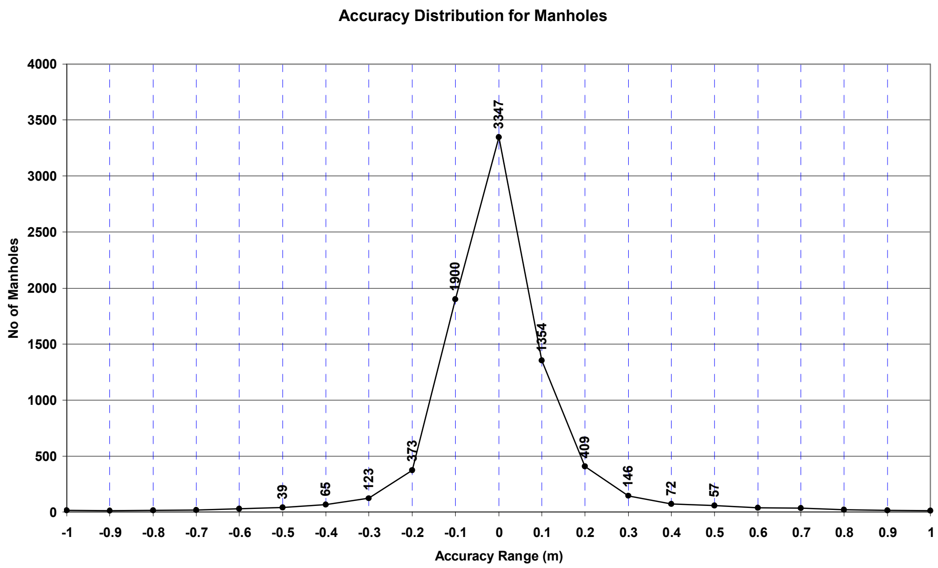



Figure 3 : Distribution of Manhole Cover Levels compared to DTM

Of the 8,274 manholes in the Sewer Records 3,347 of them (40.4%) had cover levels with ±50mm of the DTM value and 6,501 of them (79.8%) had cover levels within ±150mm. This is a lower percentage than was anticipated in view of the very good coverage of the Sewer Records in the Brighton Portobello catchment. Of concern were the number of manholes where surveys had been completed but the accuracy of the cover level was outside of the range ±150mm. There were 1,773 manholes in this category. The worst deviations found were -15.8m and +16.2m. There were a total of 185 manholes with cover levels greater than 1.0m different from the DTM and 34 manholes with a difference greater than 5.0m. Differences of this magnitude can have a profound effect on the gradients of the sewers between manholes.

It would be wrong to think that the Sewer Record data for the Brighton Portobello catchment is unusually poor – on the contrary all the manholes in the catchment were surveyed in 1998 as part of a comprehensive and fully quality controlled survey strictly following the requirements of the "Model Contract Document for Manhole Location Surveys and the Production of Record Maps[1]". The specification for the accuracy of level information in that document is ±25mm and all quality control checks were passed with no failures. It should be recognised that the quality control checks specified within that document is only 5% (5 manholes selected at random from each 100 manholes surveyed).

By comparison with other dense urban areas in the UK the Sewer Records for the Brighton Portobello catchment with 8,274 of the 9,529 manholes (ie 87%) in the catchment surveyed are considerably above the norm. It maybe a function of the steep topography in parts of the catchment which have caused such a wide error range combined with possible erroneous bench mark data.

## 6. Sewer Records

The next stage in the model building process was to use the DTM to improve the quality of the Sewer Records such that they could provide sufficiently detailed and comprehensive data for the Type III model required.

The most obvious aspect of this was to use the DTM to obtain reliable manhole cover levels for those manholes which were either dummy manholes (junctions) or the manholes which did not have any level data. Infoworks and InfoNet are able to interrogate the DTM and obtain a ground level at each of these manholes. In the Brighton Portobello catchment there were 1,255 manholes and lampholes with no level data and 750 dummy manholes at junctions (2005 locations in total). Using InfoNet it took less than 1 minute for the program to obtain ground levels and cover levels for these 2005 points. A conventional operation to calculate these manually by interpolation would have required approximately 75 man hours at a cost of about £3,000. It maybe possible to use some of the routines in Infoworks and InfoNet to determine ground and cover levels at these points by means of the proximity estimation tools – experience has shown that these work reasonably well when there are lots of manholes around but it becomes unreliable when manholes are more isolated or well spaced. Using these methods it may have been possible to obtain reasonably estimates for a cost of about £1,500. It could be argued that neither of the manual or partially automated methods above would have provided the cover and ground level to the same accuracy as the DTM, especially in areas with steep or varying topography. Perhaps a more realistic cost comparison to obtain the data to the same accuracy would be to undertake surveys (perhaps by GPS) which could cost as much as £10,000.

The second aspect of using the DTM is to identify errors and anomalies in the Sewer Record data. In the preceding section it was explained how 6,501 manholes had level data within ±150mm of the DTM value – this meant that there were 1,773 manholes with level data outside this range. It is a simple matter to produce a spreadsheet listing the deviation for each manhole. This information can then be used to target the manholes where attention is required. A high percentage of the manholes which had level data also had depths from cover level to invert level for each pipe at the manhole – it was considered reasonable to assume that these depths were correct. In most cases the reasons why the pipe invert levels were wrong was because the cover level was incorrect. A comprehensive exercise was undertaken to correct manhole cover levels and hence the pipe invert levels. Rather than do this as an automatic exercise it was undertaken on a more individual basis because not all manholes had depths; some just had the invert levels and thus correcting the cover level would not have changed the invert level. This procedure was undertaken within InfoNet because this uses depths to calculate invert levels rather than Infoworks which just uses invert levels. By means of this procedure many locations within the sewer network where the Sewer Records showed very flat sewers or even backfalls were corrected. Overleaf there are some examples of how the invert levels and hence pipe capacities were corrected by this procedure.

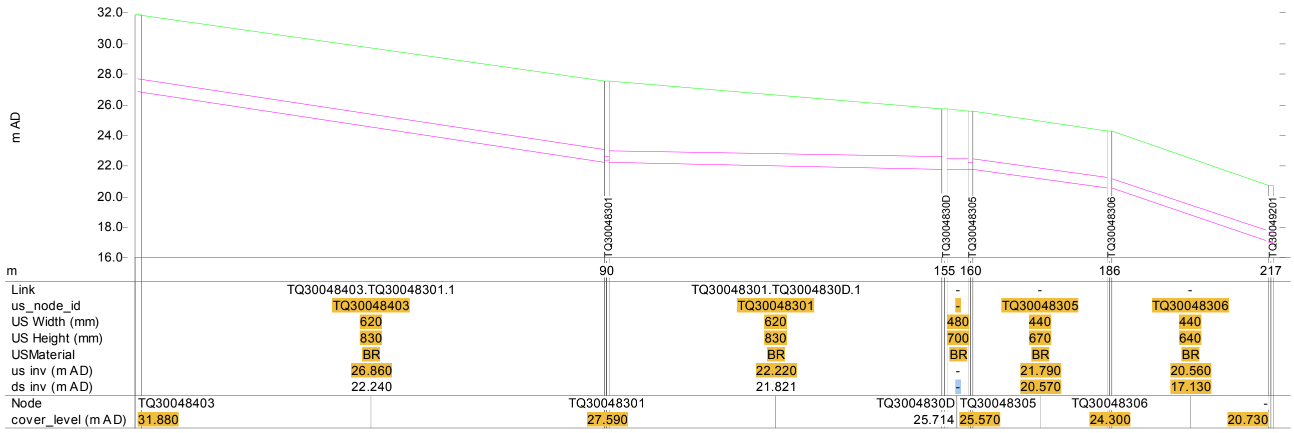



Figure 4: Example 1 as original Sewer Records

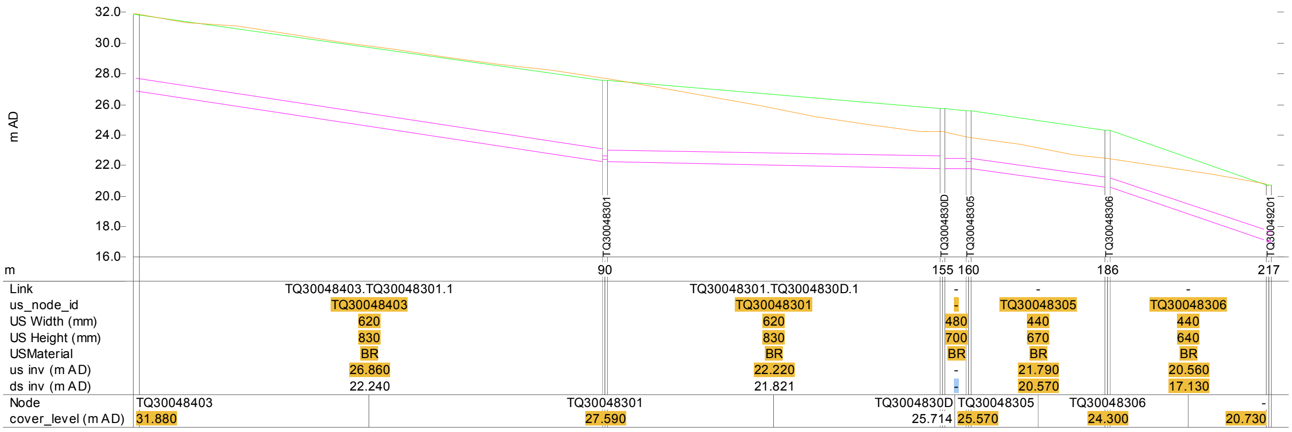



Figure 5: Example 1 with DTM on original Sewer Records

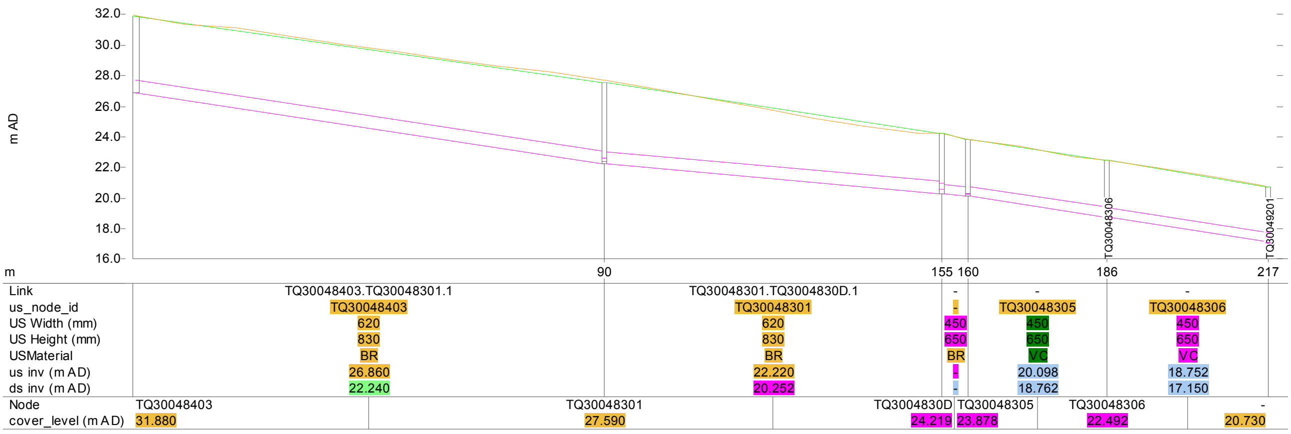
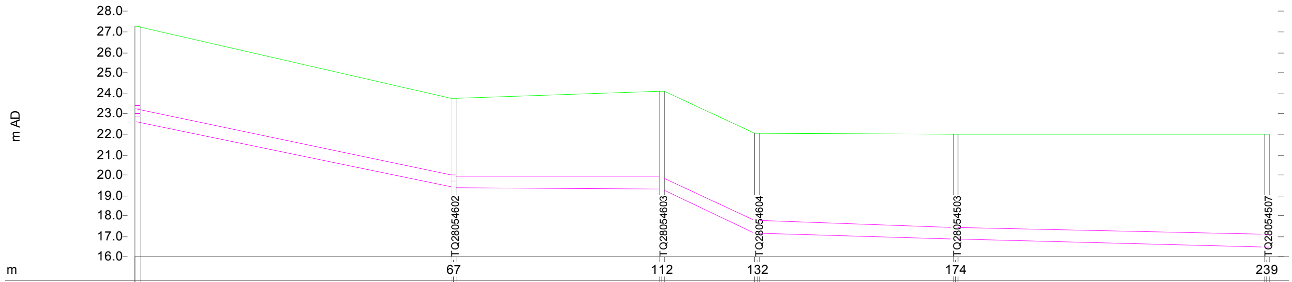



Figure 6: Example 1 with corrected Sewer Records

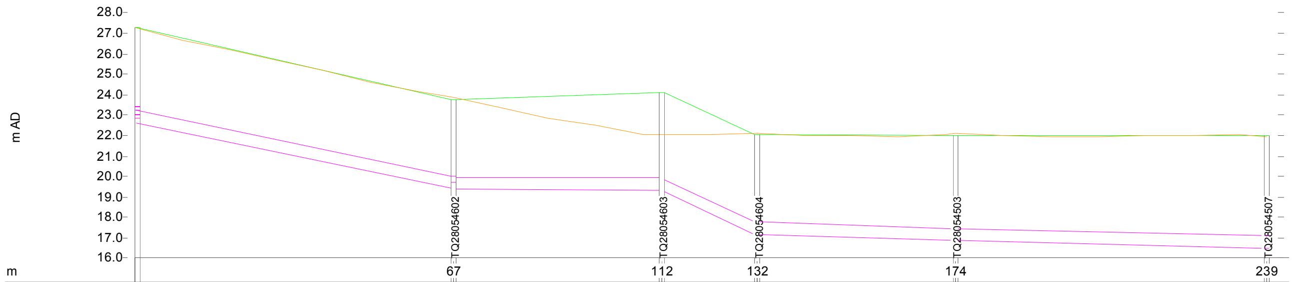
In Example 1 (see Figures 4 – 6) the cover level at 3 manholes was incorrect as shown in Figure 5. Keeping the depths to invert the same but re-setting the cover levels caused the invert levels of the sewers to be adjusted. Of particular note is the 830mm x 620mm egg shaped sewer in the centre of the diagrams. The original Sewer Records had this sewer with a capacity of 655 l/s whilst the corrected version had 1,457 l/s.



| Link | TQ28054701.TQ28054602.1 | TQ28054602.TQ28054603.1 | - | TQ28054604.TQ28054503.1 | TQ28054503.TQ28054507.1 |
|---|---|---|---|---|---|
| us_node_id | TQ28054701 | TQ28054602 | TQ28054603 | TQ28054604 | TQ28054503 |
| US Width (mm) | 0 | 0 | 0 | 0 | 0 |
| US Height (mm) | 600 | 600 | 600 | 600 | 600 |
| USMaterial | CO | CO | CO | CO | CO |
| us inv (m AD) | 22.640 | 19.370 | 19.250 | 17.170 | 16.860 |
| ds inv (m AD) | 19.430 | 19.330 | 17.170 | 16.860 | 16.482 |

| Node | TQ28054701 | TQ28054602 | TQ28054603 | TQ28054604 | TQ28054503 | TQ28054507 |
|---|---|---|---|---|---|---|
| cover_level (m AD) | 27.290 | 23.790 | 24.080 | 22.070 | 22.000 | 0.000 |

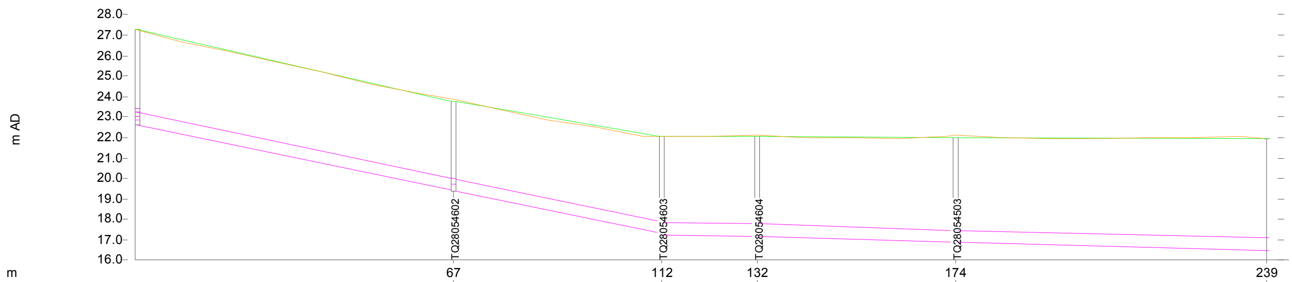
Figure 7: Example 2 showing original Sewer Records



| Link | TQ28054701.TQ28054602.1 | TQ28054602.TQ28054603.1 | - | TQ28054604.TQ28054503.1 | TQ28054503.TQ28054507.1 |
|---|---|---|---|---|---|
| us_node_id | TQ28054701 | TQ28054602 | TQ28054603 | TQ28054604 | TQ28054503 |
| US Width (mm) | 0 | 0 | 0 | 0 | 0 |
| US Height (mm) | 600 | 600 | 600 | 600 | 600 |
| USMaterial | CO | CO | CO | CO | CO |
| us inv (m AD) | 22.640 | 19.370 | 19.250 | 17.170 | 16.860 |
| ds inv (m AD) | 19.430 | 19.330 | 17.170 | 16.860 | 16.482 |

| Node | TQ28054701 | TQ28054602 | TQ28054603 | TQ28054604 | TQ28054503 | TQ28054507 |
|---|---|---|---|---|---|---|
| cover_level (m AD) | 27.290 | 23.790 | 24.080 | 22.070 | 22.000 | 0.000 |

Figure 8 : Example 2 with DTM overlying original Sewer Records

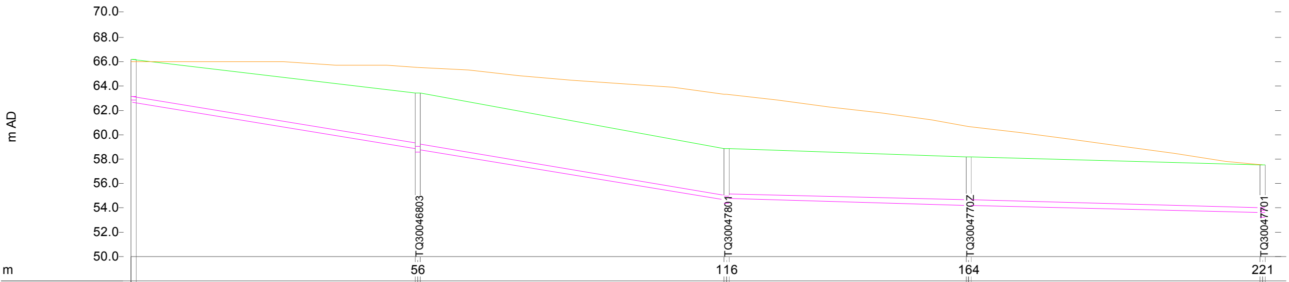


| Link | TQ28054701.TQ28054602.1 | TQ28054602.TQ28054603.1 | - | TQ28054604.TQ28054503.1 | TQ28054503.TQ28054507.1 |
|---|---|---|---|---|---|
| us_node_id | TQ28054701 | TQ28054602 | TQ28054603 | TQ28054604 | TQ28054503 |
| US Width (mm) | 600 | 600 | 600 | 600 | 600 |
| US Height (mm) | 600 | 600 | 600 | 600 | 600 |
| USMaterial | CO | CO | CO | CO | CO |
| us inv (m AD) | 22.640 | 19.370 | 17.241 | 17.170 | 16.860 |
| ds inv (m AD) | 19.430 | 17.321 | 17.170 | 16.860 | 16.483 |

| Node | TQ28054701 | TQ28054602 | TQ28054603 | TQ28054604 | TQ28054503 | TQ28054507 |
|---|---|---|---|---|---|---|
| cover_level (m AD) | 27.290 | 23.790 | 22.071 | 22.070 | 22.000 | 21.938 |

Figure 9 : Example 2 showing corrected Sewer Records

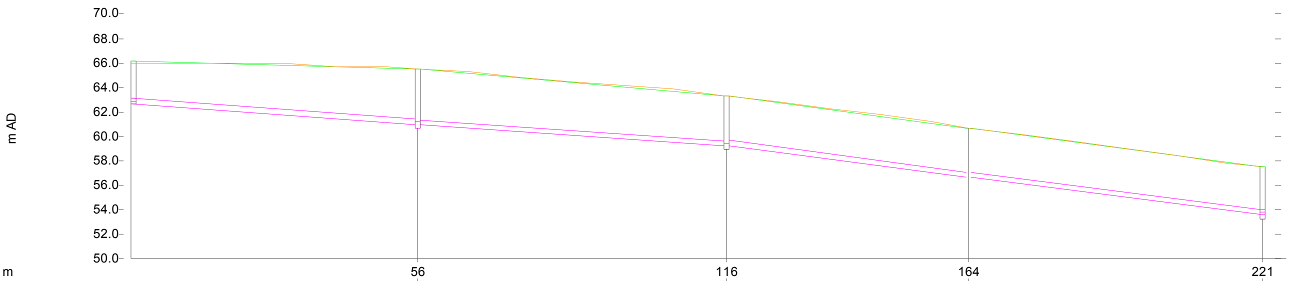
In Example 2 (see Figures 7 – 9) the important distinction is the cover level at manhole TQ28054603 in the centre of the diagrams. By keeping the same depth to invert but re-setting the manhole cover level the downstream invert level of one pipe was lowered at the downstream end which eliminated the very flat section of sewer. The original Sewer Records had the incoming sewer with a capacity of 205 l/s whilst the corrected data shows this pipe with a capacity of 1,489 l/s.




| | | | | |
|---|---|---|---|---|
| Link | TQ30046801.TQ30046803.1 | TQ30046803.TQ30047801.1 | TQ30047801.TQ3004770Z.1 | TQ3004770Z.TQ30047701.1 |
| us_node_id | TQ30046801 | TQ30046803 | TQ30047801 | TQ3004770Z |
| US Width (mm) | 390 | 300 | 300 | 300 |
| US Height (mm) | 520 | 400 | 400 | 400 |
| USMaterial | VC | VC | BR | VC |
| us inv (m AD) | 62.630 | 58.800 | 54.770 | 54.253 |
| ds inv (m AD) | 58.830 | 54.700 | 54.253 | 53.640 |

| Node | TQ30046801 | TQ30046803 | TQ30047801 | TQ3004770Z | TQ30047701 |
|---|---|---|---|---|---|
| cover_level (m AD) | 66.130 | 63.420 | 58.840 | 0.000 | 57.530 |

Figure 10 : Example 3 as original Sewer Records but also showing the DTM




| | | | | |
|---|---|---|---|---|
| Link | TQ30046801.TQ30046803.1 | TQ30046803.TQ30047801.1 | TQ30047801.TQ3004770Z.1 | TQ3004770Z.TQ30047701.1 |
| us_node_id | TQ30046801 | TQ30046803 | TQ30047801 | TQ3004770Z |
| US Width (mm) | 390 | 300 | 300 | 300 |
| US Height (mm) | 520 | 400 | 400 | 400 |
| USMaterial | VC | VC | BR | VC |
| us inv (m AD) | 62.630 | 60.911 | 59.269 | 56.687 |
| ds inv (m AD) | 60.941 | 59.199 | 56.687 | 53.640 |

| Node | TQ30046801 | TQ30046803 | TQ30047801 | TQ3004770Z | TQ30047701 |
|---|---|---|---|---|---|
| cover_level (m AD) | 66.130 | 65.531 | 63.339 | 60.691 | 57.530 |

Figure 11 : Example 3 showing corrected data

In Example 3 (see Figures 10 & 11) above the upper diagram is entirely plausible for data on these sewers and if it was not for the DTM it is likely that a modeller would simply accept this data as being correct. However, once the data is corrected it is clear that the sewer gradients are far more uniform and importantly by the right hand side of the diagram the capacity of the last section of sewer has increased from 157 l/s to 351 l/s (an increase of 223%).

Because the tolerance of the original manhole survey for Brighton and Hove is more onerous than that of the Lidar survey one could query whether so much faith should be put in the Lidar data. Should the records and model be altered purely on the basis of the DTM without further checks using traditional methods being carried out ? In some circumstances this type of further checking may be necessary, however, in the examples above, which are typical of the changes made to the Brighton model, it can be seen that the alterations have had a smoothing affect on the sewer profile. It is much more likely that the sewers were constructed to the corrected profile than the profile given by the original sewer record data. Without the benefit of the Lidar data this type of anomaly may never have been queried.

The particular benefit of using a high quality DTM in these circumstances is that it can be established very quickly and easily which manholes have incorrect cover level data. It is only with such a DTM providing a consistent, catchment-wide means of checking the accuracy of the cover levels that the problem areas can be identified. Without the DTM it might be possible to highlight some areas where the sewer gradients look suspect, where they are very flat or where there are backfalls. Having identified the suspect areas the next step would be to undertake manhole surveys and ensure that the cover levels are measured accurately. By careful scrutiny of the Sewer Record data it might be possible (in the case of Brighton & Hove) to identify perhaps 100 locations where further surveys were warranted and this might on average require 3 manhole surveys at each location. The cost of the manhole surveys would amount to about £9,000 but this is on top of perhaps as much as 75 man-hours scrutinising the Sewer Record data at an additional cost of about £3,000. However, this may not be a fair comparison because a manual scrutiny of the Sewer Records would be unlikely to pick up all of the anomalies. It could be safely assumed that having obtained the correct data it takes a similar amount of time to revise the Sewer Record data. Overall, it is likely that to achieve a similar level of confidence in the Sewer Record data would cost in the region of £12,000 more if it was done manually compared with by use of the DTM.

In almost any catchment there are important manholes at which there is no data for one reason or another. In the Brighton Portobello catchment there were 256 manholes which were scheduled to be surveyed but a similar number would probably have been scheduled irrespective of whether or not the DTM was used. Therefore in terms of a cost comparison these manholes surveys were not a relevant factor.

There will always be a situation where the correct sewer invert levels cannot be established by surveys either because of lack of access, buried manhole covers etc. It is usual for these items of missing data to be calculated by means of interpolation, extrapolation or inferencing. The extent of the calculations etc required is not influenced by whether or not a DTM is used though an accurate DTM will give greater confidence in the results. With the DTM it is possible to see whether an estimated depth of dig to achieve a certain sewer invert level is realistic, or whether it is too shallow or too deep. In terms of comparison of the costs it is unlikely that this is a factor though the increased confidence which the DTM gives should not be dismissed.

## 7. Modelling

Since it first became possible to view DTM's within Infoworks many users have just considered this as a gimic. However, experienced Modellers were very quick to realise the potential which this ability gave, especially in terms of far greater appreciation and visualisation of the catchment. A high quality DTM will clearly show to the modeller a number of important things, many of which can be seen in the geoplan view without needing to visualise the area in 3D. It is possible, for example, to tell which houses are above a road and which are below a road simply by the choice of suitable colouring for the DTM.

Of particular use when model building is the ability to visualise the slope of the ground within the geoplan view which allows the contributing areas to be defined quickly and confidently without the need for site visits. Figure 12 shows an illustration of the DTM set up within the geoplan in Infoworks with a colour sequence such that there is a different colour for each 2m elevation band. It can be appreciated from this how easy it is to understand the topography and in turn how easily the contributing areas can be defined.

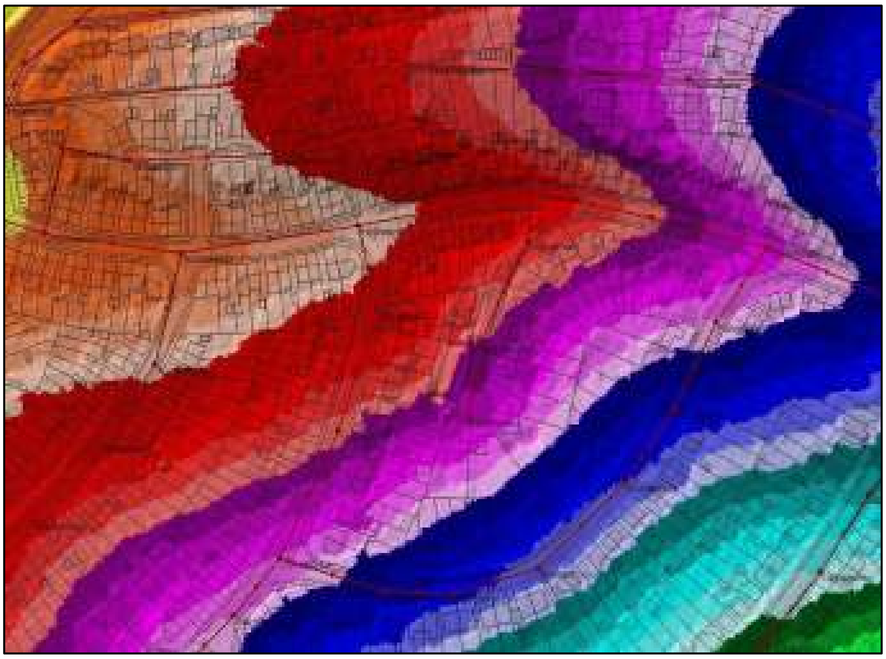


Figure 12 : Geoplan View showing DTM arranged with a different colour for each 2m band

To achieve the same degree of accuracy and confidence in defining the contributing areas it would be necessary to undertake extensive and time consuming site visits. In the fee proposals for this project Richard Allitt Associates offered a £5,000 discount if a DTM was available and this discount was almost entirely in respect of the time and cost savings which would be achieved if a DTM was available. Having completed the model building the £5,000 discount offered was a realistic assessment of the savings achieved.

An aspect which is becoming more important in the modelling of urban sewerage systems is the appreciation and modelling of overland flow routes. This is particularly the case in the Brighton & Hove catchment where there are several known flooding locations where overland flow is a factor. Some of these are known to be Highway Drainage related where the road gullies etc are not capable of collecting or intercepting all the highway runoff with the consequence that some of the roads become 'rivers' during heavy storms. In other instances there is rural runoff flowing into the urban area. It could be argued that neither of these are the responsibility of Southern Water, however there are a limited number of other cases where flooding of properties and gardens occurs due to overland flow of floodwater which escapes from manholes further up the catchment. Modelling of these cases was a specific requirement of the project.

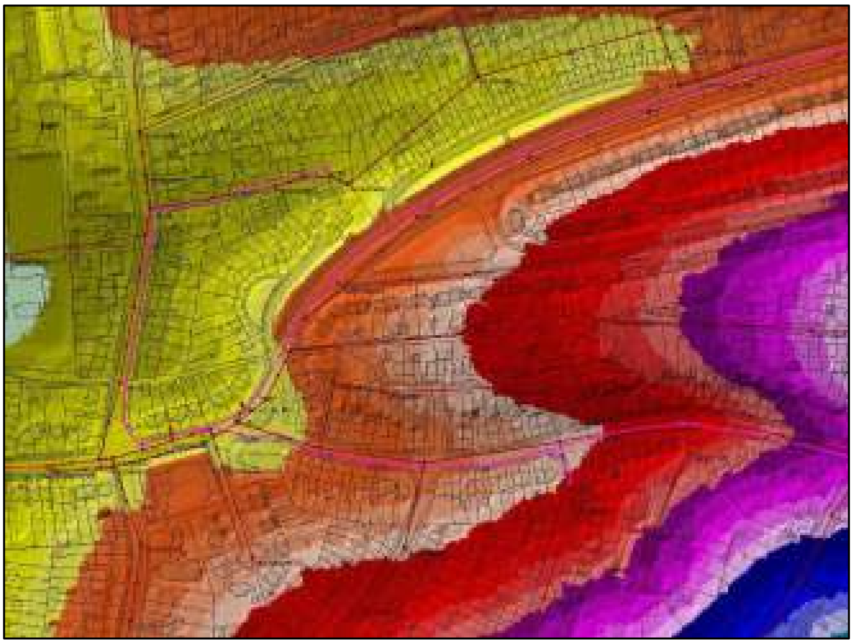


Figure 13 : DTM with overland flow routes identified

With the DTM it is not only possible to quickly and easily visualise the topography but it is also quick and easy to obtain reliable ground levels along the overland flow route. This becomes a simple desktop exercise rather than a laborious matter of rushing out to site on rainy days and taking lots of levels along possible routes.

It is now not only possible but it is very easy with a high quality DTM to determine with a reasonably high degree of confidence (a) where any floodwater would flow, what properties would be affected and what the flooding volume is and (b) to be able to understand where any floodwater has originated. This represents a tremendous step forward in urban drainage modelling.

There are understood to be plans for future releases of Infoworks to contain further functionality which will enable the extent of flooded areas to be represented in the geoplan views. The only way for the benefits of this to be fully realised is if there is a high quality DTM underlying the model.

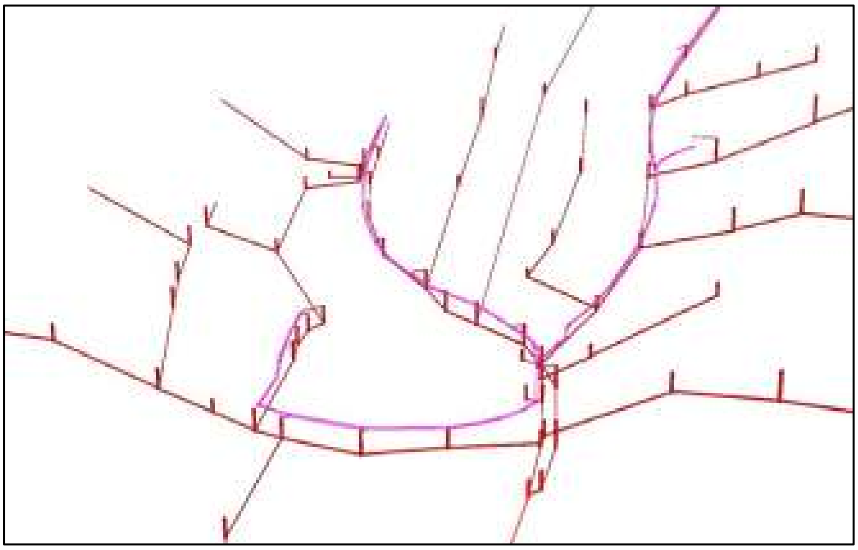


Figure 14 : 3D representation of the overland flow network

Within the Brighton Portobello catchment there are 10 locations where overland flow routes have been modelled. These are all associated with known flooding problems. The DTM has allowed the determination of overland flow routes at these locations as a desktop exercise. If the DTM had not been available it would have been necessary for extensive site surveys to be undertaken which would probably have involved some 150 man-hours in total at a cost of about £6,000.

At 'Optioneering' stage or preliminary scheme design the existence of the DTM brings further benefits. Firstly it enables sewer gradients etc to be checked as described earlier; this in turn helps to track down the restriction or other cause for the flooding or other problem. The DTM enables ground levels along potential diversion routes to be easily obtained such that any new sewers along those routes are not excessively deep or too shallow. In some cases routes for new duplicate sewers can be found rather than expensive on-line upsizing.

## 8. Other Benefits

In addition to the above points there are a number of other benefits of having a DTM which have been found during the course of the study and a bit of lateral thinking. These include:-

- More effective and improved presentations to members of the public, councillors, MP's etc;
- Improved assessment of the impact of development flows on the network performance. It can now be established whether new development flows are likely to be pumped into the sewerage system or whether a gravity connection is viable;
- Improved DG2 boundary definition – more accurate level data allows a DG2 pressure boundary on the water distribution network to be identified with greater confidence;
- Improved advice to customers on pressure related problems – as the DEM includes information on height of buildings, it is possible to assess whether top floor flats require booster pumps to enable supply. Although water companies are only obliged to provide a minimum pressure at the boundary of the public and private system it is always useful to be in a position to advise developers of potential supply problems;
- Emergency planning – Southern Water is using models to undertake 'what if' scenarios to understand the impact of asset failure on customers. A traditional model will allow the point of flooding to be determined but not necessarily to determine the point of impact, as overland flow could cause ponding of flood waters some distance from the release point. The DTM obtained for Brighton will be used in a pilot study to determine which properties/areas are at risk of asset failure, be it sewer blockage/collapse or pump failure. It is anticipated that this study will further justify the acquisition of Lidar data for other high profile catchments;
- The working relationship with the Highway Authority and Land Drainage Authority can be improved because of the greater clarity which can be brought to flooding problems (ie the source of the flooding can be demonstrated);
- An improved understanding of the geology of a catchment and particularly the effectiveness of soakaways by draping the geological maps over the DTM;
- In areas of mining subsidence the Sewer Records can be quickly updated at regular intervals and any sewers which become too flat or have backfalls can be quickly identified;
- Other data which is acquired during the LiDAR survey could also be of use. Other uses of the reflectivity results are currently being explored (see Figure 15);
- The major cost of the Lidar survey is getting the plane in the air. Once the decision has been made to fly the area, the unit cost of other aerial based surveys is greatly reduced. The cost of aerial photography at the same time as the Lidar data acquisition becomes more viable.

Figure 15 : Reflectivity Intensity Image

# 9. Cost Comparisons

The table below summarises and compares the costs of the model building and verification project for the Brighton Portobello catchment assuming in one case that the high quality DTM was undertaken as part of the study and in the other case where there was no DTM. In both cases the costs have been intended to represent the cost of achieving the same standard.

| Activity | Without DTM | With DTM |
|---|---|---|
| Consultants Fees | £ A | £ A |
| Reduction in Consultants Fees if DTM is available | £ nil | £ -5,000 |
| LiDAR Survey | £ nil | £ 24,500 |
| Flow Survey | £ B | £ B |
| Impermeable Area Surveys | £ C | £ C |
| Ancillary Surveys (Overflows, pumping stations etc) | £ D | £ D |
| Obtain manhole cover levels for dummy manholes and manholes with no data | £ 10,000 | £ nil |
| Manhole surveys for key manholes with no data | £ E | £ E |
| Identify anomalies requiring additional manhole surveys | £ 3,000 | £ nil |
| Additional manhole surveys | £ 9,000 | £ nil |
| Revising and updating Sewer Records | £ F | £ F |
| Surveys etc for Overland Flow Modelling | £ 6,000 | £ nil |
| TOTALS | Common elements plus **£ 28,000** | Common elements plus **£ 19,500** |

It can be seen from the above table that in the case of the Brighton Portobello catchment the same level of detail and accuracy in the model has been achieved at lower cost by use of the DTM than would have been the case without the DTM.

# 10. Conclusions and Recommendations

The results of the analysis undertaken for the preparation of this paper clearly show that the financial and technical advantages of including the acquisition of a high quality DTM within the project have outweighed the costs. It has clearly been advantageous to the project for the high quality DTM to be acquired. It should also be recognised that the DTM is an asset which could have a useful life in excess of 10 years and that there are many related benefits in obtaining the data against which the cost of the survey can be further justified.

It is clear from the work done for this paper that it would be wrong just to view the acquisition of a high quality DTM as simply being a cost – in many catchments it will be the most cost effective way of achieving the modelling objectives. On this basis the acquisition of DTM data should not just be dismissed but an assessment of the benefits should also be considered.

It is worth noting however that the costs of acquiring LiDAR data are not directly proportional to the area surveyed. A substantial part of the cost is getting the aeroplane airborne. It is likely to be the case with smaller catchments that the increased cost of the DTM in relative terms would give smaller cost-benefit ratios and in many cases it could be below unity.

It may be possible to reduce the overall costs of acquiring DTM data by means of surveying a number of smaller catchments during a single sortie even though there would be additional costs associated with setting up separate ground stations in each catchment.

The merits of acquiring DTM will vary from catchment to catchment and in many cases it will not be a cost effective exercise though some of the non-financial benefits should not be ignored. It is recommended that at the commencement of a project an evaluation is undertaken of the merits of acquiring DTM data and the cost effectiveness of doing so.

## 11. Acknowledgements

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## 12. References

[1] Model Contract Document for Manhole Location Surveys and the Production of Record Maps, WRc & FWR, 1993