6 Greater Manchester's ever changing rivers

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In a highly urbanized area, the landscape is often dominated by features created by human activity, from the Jumbles Reservoir and Hollingworth Lake, to the flashes caused by mining subsidence near Wigan and Leigh and the coal mine-waste hills of the Three Sisters Recreation area near Ashton-in-Makerfield. Rivers are long-lasting features with characteristics that have been greatly changed by both natural processes and human activities. Manchester's rivers evolved as the Irish Sea ice sheet, which had advanced from the west to the foothills of the Pennines, began to retreat between 20,000 and 12,000 years ago. A variety of hollows and low ridges were exposed as the ice disappeared. The hollows became meres that, sometime later, developed into peat covered moss lands such as Chat Moss. The ridges were deposits of sand and gravel once carried by the ice. Water draining off the Pennines formed complex outwash fans of debris, into which it had to cut channels. Eventually those channels merged into meandering rivers; as the meanders migrated, the river courses changed. Most of the bank erosion and the shifts of gravel bars within channels occurred during major storm and flood events. However, for several hundred years, people have been changing meander patterns by embanking rivers, making cut-off channels and using weirs, dams and field and moorland drains to alter both the quantity and the timing of water flow from the land to the streams.

Today, the streams of the Weaver, Mersey and Ribble catchments continue to readjust their channels, especially where their banks are not protected. If insufficient room is left for flood flows, local flooding and damage occurs. Many of the streams and rivers in Greater Manchester have flooded in particular places within the last 50 years. Much work has been undertaken to reduce flooding, from small scale flood detention ponds on urban streams, such as the Timperley Brook, to major flood basins on the Irwell at Lower Kersal. Part of the continuing flood risk arises because the steep upper reaches of rivers from the Pennines respond quickly to storm rainfall. The continuing expansion of built up areas, and the ever-expanding conversion of former gardens and other green spaces to paved or roofed areas, increase the rate of storm water flow to rivers. Flooding often occurs because culverts and bridges are too small to cope with the flows from highly localized, but severe, thunderstorms within the urban area. Nevertheless, both upstream and downstream of the urban areas, we can see nature changing river channels. In some cases it is possible to describe a history of change. A few examples of these changes are discussed here.

Rivers emerging from the hills in the eastern part of the conurbation

Exceptional river flows often cause dramatic channel changes, particularly where human activity has constrained the space that water can occupy. A good example of this is at Marple Bridge, where the River Goyt has flooded on many occasions. With a catchment area of 183 km^2 of steep Pennine hill slopes, the river rises rapidly when the ground becomes saturated by heavy

Figure 1: Repair work at Marple Bridge after the 1991 flood (source: http://www.marplelocalhistorysociety.org.uk/stories-from-the-archive/places/164-a-tale-of-two-floods.html)

Figure 2: Flooding in Town Street Marple Bridge in 2009 (source: http://www.manchestereveningnews.co.uk/news/local-news/flooding-anger-is-on-the-rise-926254)

rainfall. It reached its highest recorded level (1.96 m) at 2:45am on 22nd December 1991. The most recent peak (1.72m) was reached at 8:15pm on 5th February 2011. The 1991 flood caused part of Town Street to slide into the river, making repairs to the bridge and the channel walls necessary (Figure 1). The street was closed for many weeks for repairs, but the problem of a confined channel and a narrow bridge at the floor of a steep sided valley remained and further flooding occurred in Town Street in 2009 (Figure 2).

As streams such as the Goyt, Etherow, Medlock and Irk emerge from the hills, their valley floors generally are wide enough for the development of small amplitude meanders. When their gradients decrease, the amplitude of the meanders generally increases. The dynamics of a small meander on the Irk near Chadderton were examined in detail in the 1960s[1]. A small apron wall had been built on the north bank of the river immediately upstream of Street Bridge on the B6195, between Middleton and Royton. The wall caused the river to erode

Figure 3: Looking upstream at the former meander belt above Street Bridge towards the mass of invasive vegetation now affecting the work of the river.

Figure 4: The Irk at Chadderton in 2015 showing concrete blocks reducing erosion on the north bank upstream of Street Bridge.

the south bank, leading to the formation of a 20 m wide meander. In early December 1964, a major storm produced about 90 mm of rain over the Irk catchment upstream of the site. This increased the flow in the river, which spilled out of its channel and formed a chute that cut off the meander loop. Pictures taken at that time show the river flowing through an open space with no trees or shrubbery. By 2015, the situation was somewhat different with young trees and abundant Himalayan balsam (Impatiens glandulifera), an invasive weed that is now interfering with the movement of river sediments and water on floodplains, on both sides of the river (Figure 3). This vegetation represents another type of change as an indirect consequence of human action, as opposed to the deliberate, direct action of wall building and placing of concrete blocks against the river bank (Figure 4).

Meandering rivers on the lowlands

Rivers south of the conurbation, in Cheshire

The lowland landscape around Greater Manchester has changed throughout the last 12,000 years, not only through the impact of human settlement, farming, mining and industry, but also through the adjustment of rivers to the deposits left behind by the last glaciation and to changes in weather and climate. Signs of these changes can be found at many localities along present day rivers, despite the works that have been carried out to regulate and control them. Several rivers in Cheshire, south of Manchester, exhibit active meanders. The River Dane near Swettenham was described by Adrian Harvey[2] as "one of the few actively meandering piedmont rivers in northern England, with relatively little human modification". Successive maps and air photos show that, since 1840, the river's meanders have developed increased sinuosity and that many cutoffs have formed across the necks of meanders. Like the other rivers west of the Peak District, the Dane carries a mixed gravel/sand/silt sediment load and easily erodes the sand and silts of its banks. The meander bends tend to shift downstream, undercutting the banks and depositing the eroded sediments in point bars a little further downstream.

Such meandering is a natural process. Further north in Cheshire, however, urban areas such as Macclesfield have had a profound effect on the rivers that flow through them. Downstream of Macclesfield and Prestbury, just north of Mottram St. Andrew, the River Bollin has a remarkably

mobile set of meanders that have been carefully mapped by Janet Hooke.[3] The river in the study reach is about 8 m wide, flowing in an open floodplain through highly erodible alluvium. The banks are made up of layers of gravels and sand, comprising cobble-sized material at the base and sandy material above. Numerous old channels are present within the floodplain, but no resistant clay plugs have been found. During the winter of 2000–2001, four major cutoffs took place in a 600 m reach of channel (valley distance). One other cutoff had taken place in winter 1998–1999, and another two occurred between spring 2001 and spring 2003. The cutoffs were all neck cutoffs formed by rapid bank erosion of bends. A 2010 Google earth image of the same area reveals that further changes in the meander belt have occurred since 2003 (Figure 5). Do the rapid changes in this highly dynamic reach of the Bollin result almost entirely from natural causes or are they influenced by upstream land use changes associated with urban development and farming practices?

For much of its route through Macclesfield and Prestbury, the Bollin occupies an artificial channel with fixed banks. At times of heavy rain, storm water will run off all hard surfaces into drains. Some of that water passes through the sewage works just downstream of Prestbury and is then fed into the river. Other storm water enters the river more directly. This storm flow probably reaches the channel more quickly than it would do if the whole catchment were vegetated. Thus it is likely to increase peak flow velocities in the river, giving it more energy to erode its banks. However, because many kilometres of bank upstream are reinforced by stone or concrete, there is little opportunity to pick up sediment from banks in the urban area. This gives the river plenty of capacity to pick up sediment further downstream where its banks are natural. Such factors may contribute to the rapid meander changes in the reach north of Mottram St. Andrew.

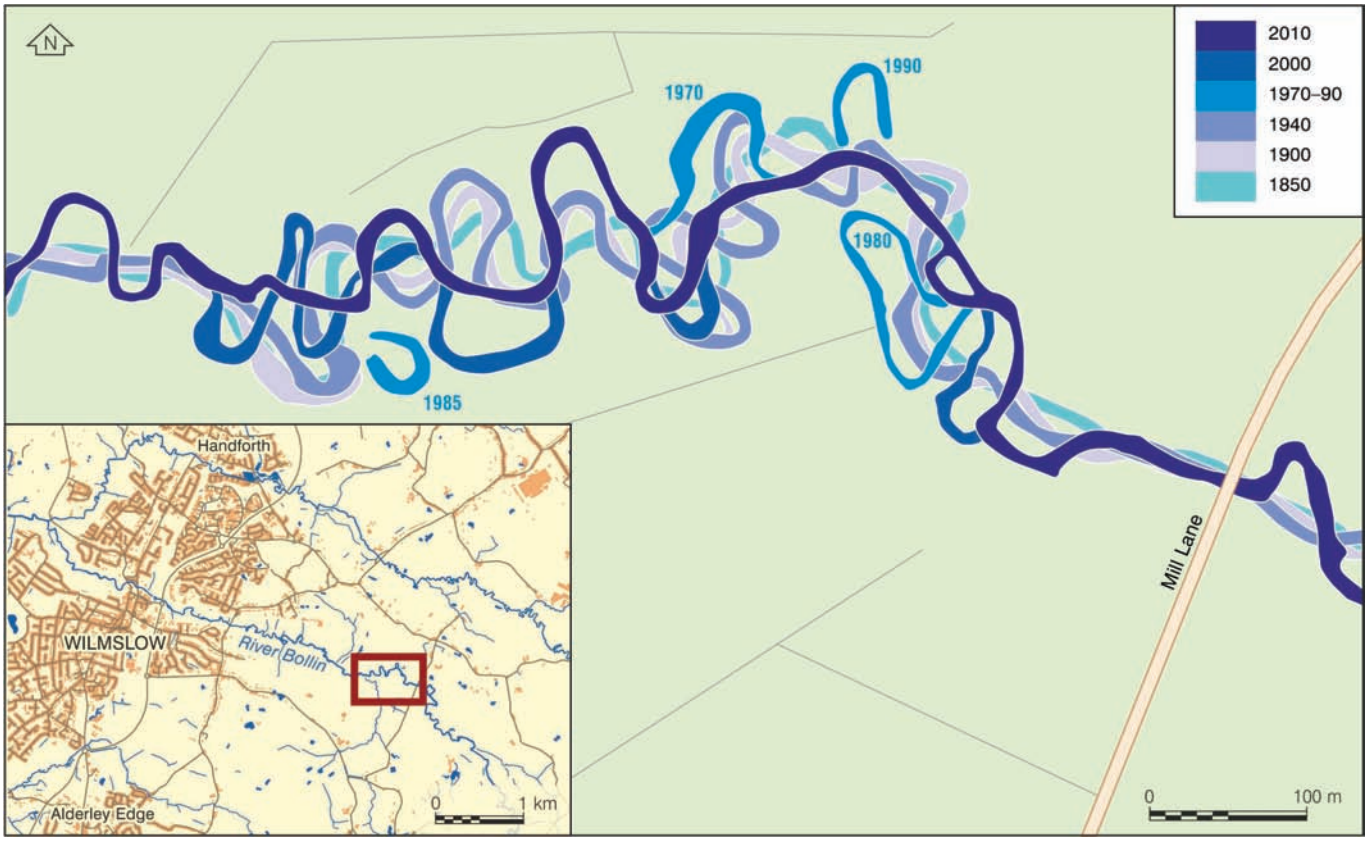

Figure 5: Meanders and cutoffs in the River Bollin north of Mottram St. Andrew (modified and augmented after Hooke, 2004).

Figure 6: Brickwork installed to stabilize the channel of the Medlock at Clayton Vale.

Meanders on the Mersey and its tributaries

Most of the rivers flowing through Greater Manchester had meandering reaches once they emerged from the hills. In many places, the meanders have been encased by brick or concrete walls to develop tightly regulated channels, but active meander evolution continues both upstream and downstream of these protected reaches. The Medlock at Clayton Vale illustrates the process of "fixing" meanders by hard engineering (Figure 6). Brick work was installed in 1909 to help prevent floods (Figure 7), thereby avoiding problems such as those of 1872 when floodwaters washed away gravestones and bodies from the nearby Philips Park Cemetery. Now the river flows either in tunnels (Figure 8) or in "fixed" meanders through Philips Park, the Sport City Etihad Campus area and Manchester city centre until it discharges into the Bridgewater Canal. One of these "fixed" meander bends can be seen between Oxford Road and Princess Street.

The River Mersey has a confined channel from Stockport to Ashton-on-Mersey weir. Its peak flows can be reduced by the release of water out of the embanked river, over weirs at Millgate Lane in Didsbury and at Jackson's Boat near Rifle Road, Sale, and onto parts of the natural floodplain which act as temporary storage basins. The water can return to the river through weirs at Northenden (Figure 9) and below Sale Water Park. At Chorlton (Figure 10) and Sale, former gravel pits that were used to supply aggregates for the construction of the M60 motorway have been converted into multi-purpose permanent artificial lakes (water parks), providing such ecosystem services as leisure activities, wildlife habitats and flood storage. The reductions of peak flows by

Figure 7: Photo of a picture of the double trapezoidal channel created in 1909 for the River Medlock round Philips Park and the Cemetery (from an information panel at Clayton Vale).

Figure 8: The regulated River Medlock entering the tunnel under Bank Bridge Road.

releases into storage basins limit the likelihood of bank erosion during extreme events. Nevertheless, rapid changes, including meander migration, are occurring further downstream near Urmston.

Below Ashton Weir, the Mersey is incised into its floodplain, probably because its bed was lowered when the Manchester Ship Canal was built and the river was diverted into the canal near Carrington, about five kilometres west of the weir. Because the channel is incised, it tends to undercut its banks at moderately high flows, causing rotational slumps into the river. This material is carried a short distance downstream, is sorted by the water flow and then deposited either against the opposite bank or as a midstream bar. This reach near Urmston is thus highly dynamic, with changes occurring almost every year (Figure 11). The impact of these changes is indicated by measurements of the sinuosity of the river, as indicated on maps of different dates[4] (Table 1).

Figure 9: The Didsbury flood basin outlet weir in the Mersey embankment near the M60 at Northenden.

Table 1: Changes in sinuosity of the River Mersey from Crossford Bridge, Sale to Wheat Hey, Ashton-upon-Mersey, 1845-2004.

Date	Sinuosity*
1845	1.77
1904	1.68
1927	1.67
1964	1.50
1971	1.28
2004	1.43

*Sinuosity is channel length divided by reach length.

In 1971, there was a large meander loop close to Urmston cemetery. By 1983, meander cut off had left an ox-bow lake about 80 m across. This still existed in 2015, although it was becoming more overgrown. It is an important bird habitat; herons, which use suburban fishponds as a food source, can be seen there. The cut-off lakes are indicated on the OS Explorer Map 277, 2004 Edition. In about 1980, iron piling was inserted to protect the opposite (left) bank of the river. This massive shift of the channel is a continuing process, and slumped pieces of turf are visible on the undercut banks. National Grid had to spend £500,000 moving a pylon from the top of the undercut bank to the point bar. To avoid further risk, a caisson was sunk to bedrock beneath the river alluvium so that, whatever the river changes, the pylon would be firmly anchored in position. By 2005, the river had shifted right across the site of the replaced pylon and the concrete foundations could be seen exposed on the channel bed at low flows.

A sequence of photographs (Figure 12) shows how a willow tree fell into the river from the bank in late 1986, when 2 m of the bank collapsed during a flood, and how the bank (left foreground) continued to be eroded as a small gravel bar which extended downstream (towards the photographer) in the decade after 2005. By 2015, the outer edge of the meander had migrated some 200 m downstream from the meander cutoff. Flood flows on 26th December 2015 eroded the banks even more. The 25th January 2016 photograph clearly shows that the far bank is closer to the pylon than it was four months before. The banks suffered significant erosion during high flows after the heavy rains of 26th December 2015 (Figure 13).

Figure 10: Chorlton Water Park.

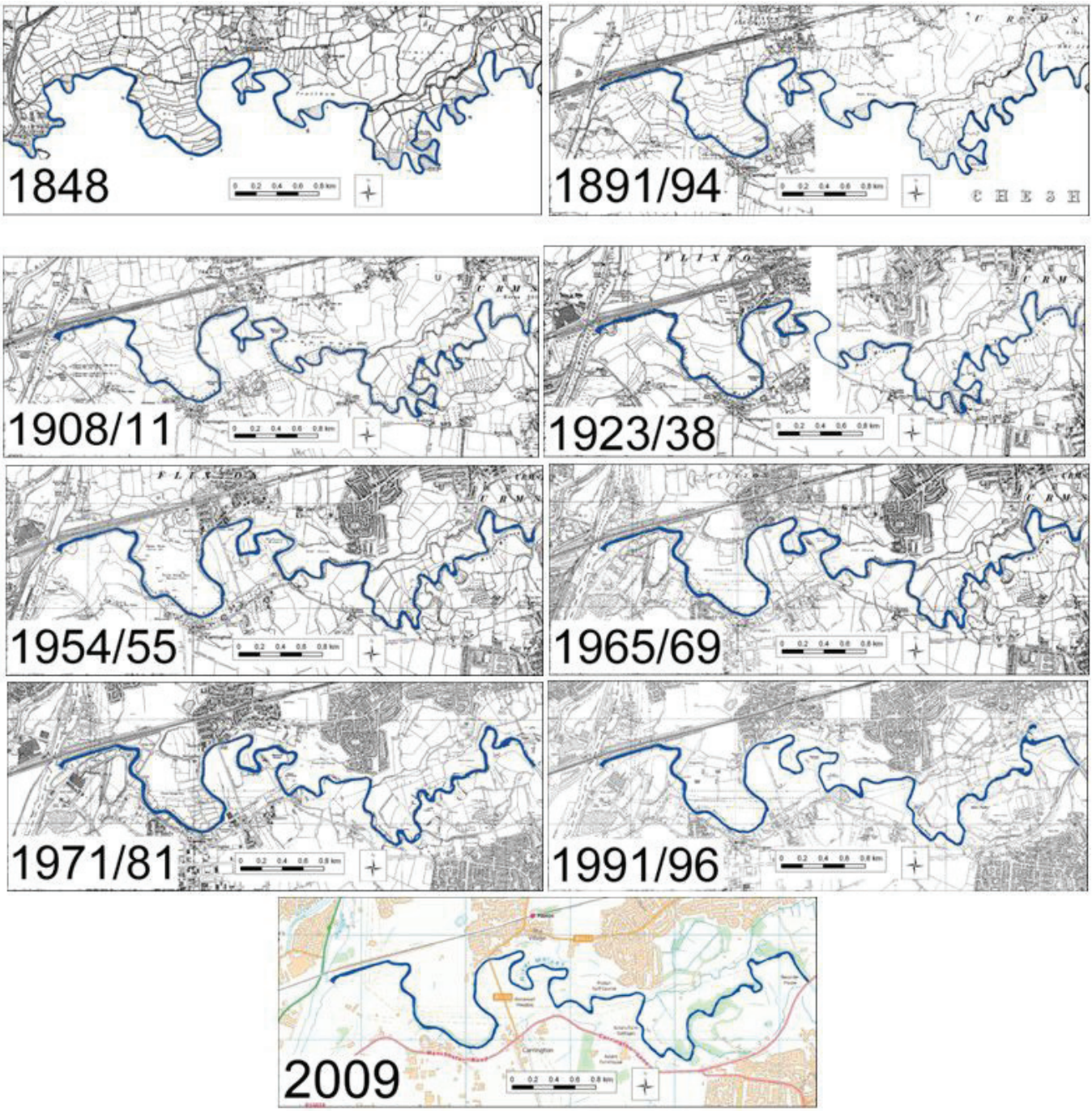

Figure 11: Changes in the meander belt of the River Mersey downstream of Ashton Weir (after da Luz et al., 2015).

Figure 12: Changes to the River Mersey near Urmston over 30 years 1986-2016

(a) 1983: Willow tree roots exposed on eroding bank.

(b) 1986: Bank has eroded significantly, sand accumulating around new branches growing from the fallen tree

(c) 1989: Fallen tree now surrounded by water, bank erosion continuing.

(d) 2005: Channel has changed considerably; major point bar in the centre.

(e) 2015: Point bar now almost clear of vegetation; far bank eroding.

(e) 2016: Further erosion of far bank.

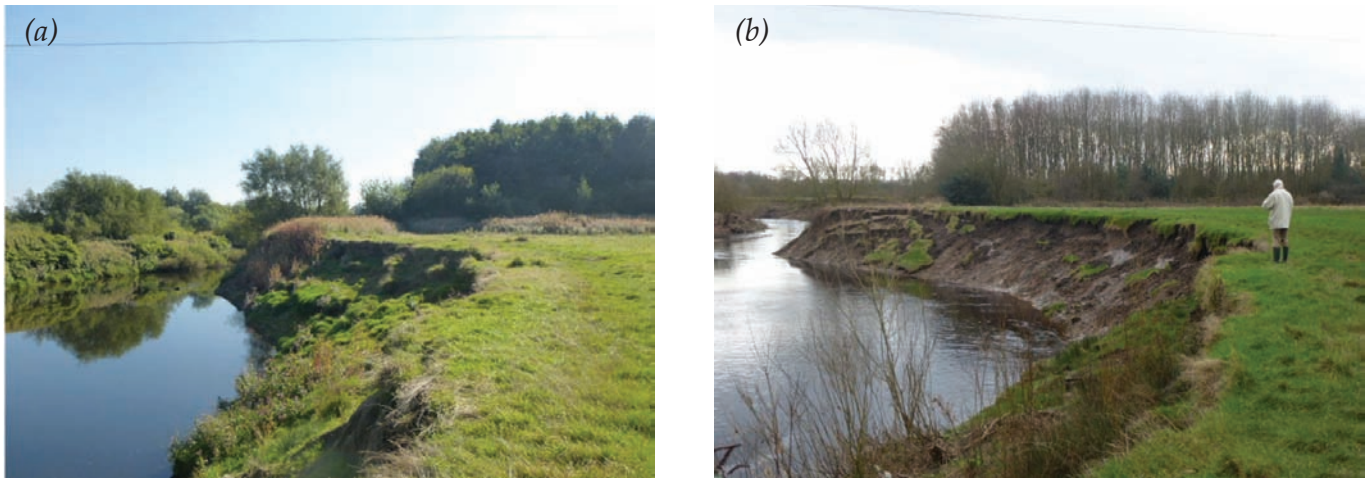

Figure 13: Pictures of the north bank of the Mersey at Urmston showing the situations in (a) September 2015 and (b) January 2016, with the changes due to the high flows in late December 2015.

Figure 14: The 19th century River Irwell at Bury where debris thrown into the river has left little room for high flows to pass under the bridge.

Historical changes resulting directly from human activity

In the nineteenth century, Manchester's rivers were frequently encumbered by debris thrown and dumped into their channels. As many localities lacked garbage collections, ashes from fires and other waste were simply thrown over parapets into the flowing water (Figure 14). The debris was carried downstream from the steep upper reaches and some of it was deposited as stream gradients decreased (Figure 15). So great was this deposition in the meandering Salford reaches of the Irwell that the local council took the upstream urban authorities to court, to restrain them from reducing the capacity of the river and contributing to the regular severe floods in Salford. In 1868, the increased flooding and pollution of the Irwell led to a government commission to enquire into "the best means of preventing the pollution of rivers (Mersey and Ribble basins)". The Royal Commission's report[5] contains excellent drawings showing the changing amount of silt in the Irwell below bridges in Salford and Manchester.

In addition to examining the siltation issue, the Royal Commission looked at water quality, comparing the environment of Lower Broughton with that of higher parts of Salford. This early progress towards understanding environmental quality highlighted problems of river pollution that Greater Manchester lived with for the next hundred years. The conditions of such streams as the Irk and Medlock were bad until the 1980s, when real efforts to improve water quality began to make an impact. Improvements in sewage treatment and the general decline in industrial effluent discharges played a major role. So too did the elimination of storm overflows from combined sewers that would carry both runoff from streets and untreated sewage matter.[6] Large tanks were built under floodplains to take storm water from sewers, to allow foul matter to settle to the floor of the tanks and to allow excess water to escape to the river from an outlet near the top of the tank. This technology reduced the number of overflows and the severity of the sudden depletions of oxygen in the stream when overflows did occur.[7] Such depletions of oxygen inhibited the survival of fish in the rivers. Now that there are only a few pollution events, fish can survive and, even in the Mersey at Urmston downstream of the conurbation, local residents enjoy seeing fish leaping in the river.

Figure 15: In the 18th century waste water is being discharged straight into the Irwell between Manchester and Salford and much debris partly blocks the channel.

Conclusion

Successful management of both flows and water quality has changed the rivers for the better. Nevertheless, as in the past, future extreme events will produce rapid changes. In many places, bridges and other engineering works cannot be enlarged. In particular, there now are old sewers in the lowest parts of the towns, and upstream areas that were once farmland and open space have been built over. Many front gardens have been paved. Industrial estates and supermarkets have built ever larger buildings and car parks, across whose roofs and surfaces rainfall flows rapidly to storm drains and combined sewers. All these changes mean that, when torrential thunderstorms occur, the peak flows will be higher than they were a few decades ago. This will lead to 'pluvial flooding', when drains overflow and flood the streets, and to the overflow of small streams carrying more water than the culverts can accommodate. These flows scour the approaches to bridges and eventually damage structures. They indicate the close connection between the way in which the land surface is modified and the consequent impact on streams further downslope. Many of the changes of local rivers result from human activity, not just from natural events. By understanding how rivers respond at the local scale, we can begin to comprehend how such changes combine to drive global environmental change.

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