RECONSTRUCTING THE IMPACT OF RIVER RESTORATION ON RIVER CONDITION: THE MAYES BROOK

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Aim

The Mayes Brook, which runs through Mayesbrook Park in the London Borough of Barking and Dagenham, was subject to a major river restoration scheme in 2011. This report, retrospectively applies the River Condition Assessment methodology (Gurnell et al., 2020) to illustrate how it can identify improvements in river condition following restoration.

Restoration of the Mayes Brook within Mayesbrook Park

Restoration of the Mayes Brook within Mayesbrook Park focussed on 4 reaches (Figure 1). The styles of restoration can be summarised as follows:

(i) Reach 3 was subject to the most elaborate restoration. Here, the floodplain was lowered to create 1 hectare of additional flood storage and the river was moved from its trapezoidal channel at the margin of the park into a new, more open, sinuous channel at the centre of the lowered area, with connections at moderate flow to newly created disconnected floodplain ponds. A new connected wetland pond was constructed in the location of the old channel to intercept flows entering the river from a storm sewer.

(ii) Reach 1 was also transferred from a deep trapezoidal channel into a new, sinuous and more open channel within a fenced nature reserve area.

(iii) Reach 4 was only restored in its downstream section. The river largely remained in its pre-restoration channel, although planform sinuosity was increased slightly in one location. Where space allowed one bank was reprofiled to give it a lower gradient and to widen the river bed slightly.

(iv) Reach 2 received minimal modification due to underground infrastructure. However, the gradient of one bank was reduced along the majority of the reach.

Stages in the estimation River Condition.

The River Condition Assessment methodology (Gurnell et al., 2020) consists of a field survey element (a minimum of 5 contiguous MoRPh module surveys, called a MoRPh5 survey) and a desk study to determine the type of river being assessed. The field survey generates observations for one or more MoRPh5 subreaches of a river and the desk study assesses an indicative river type for an extended reach of the river containing one or more MoRPh5 subreaches. These data sets are used to derive a Final Condition assessment for each MoRPh5 subreach as follows:

(i) Thirty-two Condition Indicator scores are estimated from the MoRPh field survey data. The Condition Indicators score a series of 'natural' (positive) and human-impacted (negative) properties of the bank tops, bank faces, and river bed within each MoRPh5 subreach. The Condition Indicators are assigned scores ranging from 0 to +4 (positive indicators) or 0 to -4 (negative indicators) based on a numerical synthesis of subsets of survey observations.

(ii) The average positive and average negative Condition Indicator scores for each MoRPh5 subreach are added together to generate a Preliminary Condition score.
(iii) A Final Condition assessment is then assigned to each MoRPh5 subreach based on the Preliminary Condition score and the River Type being assessed.

Data sources and methods used to assess River Condition.

Four main 'historical' data sources were used to assess the condition of each of the four reaches of the Mayes Brook (Figure 1) in 2009 (pre-project), 2012 (post-project) and after a period of recovery (2020). None of the data sets were specifically collected for the current purpose and so they were carefully sifted to provide the best possible underpinning for synthesising River Condition assessments appropriate to the three dates (2009, 2012, 2020):

(i) 35 MoRPh surveys captured between 2017 and 2019 on reaches 2 to 4.
(ii) 14 Urban River Surveys captured between 2009 and 2016. The Urban River Survey (URS, Davenport et al., 2004) is similar to the River Habitat Survey (RHS, Fox et al., 1998) but it has a greater discrimination of the human modifications found along (sub)urban rivers, and, instead of being applied to a fixed river length of 500 m, the URS is applied to a variable length of river (typically 200 m to 500 m) that conforms to a single river engineering type (a combination of planform, cross-profile and level of reinforcement), because engineering is such a fundamental control on the character of rivers in urban areas. On the Mayes Brook the URS surveys were conducted within each of the four reaches (Figure 1).
(iii) Ground photographs. A range of photographs were available following numerous site visits between 2009 and 2019, including photographs uploaded in association with MoRPh and URS surveys.
(iv) Aerial images. The time sequence of images available on Google Earth were inspected and four high-resolution images were used to characterise the river before restoration (05 March 2008 ((© 2021 Getmapping plc); 01/01/2010 (© 2021 Getmapping plc)), post-restoration (25 May 2012 (© 2021 Maxar Technologies)) and following a period of recovery (03 June 2020 (© 2021 Google))

The available MoRPh5 surveys (2017 to 2019) were inspected to establish the best set available (in terms of timing and location) to underpin River Condition assessments for reaches 2, 3 and 4. Some of the MoRPh surveys were relocated slightly to provide the appropriate spacing for a MoRPh5 survey and the survey information was fine-tuned for location and for a 2020 survey date using ground photographs and the 2020 aerial imagery. There were no MoRPh surveys for reach 1 and so a set of five MoRPh survey locations were selected based on the availability of recent ground photos and clarity of the 2020 aerial images. The locations of the 20 MoRPh surveys (4 MoRPh5 surveys) and four river reaches are shown in Figure 1 and images of each of the reaches close to the three survey dates are presented in Figure 2 (reaches 1 and 2) and Figure 3 (reaches 3 and 4).

The centre points of the 5 MoRPh survey locations in each of the four reaches were overlain on the appropriate Google Earth image for the 2009, 2012 and 2020 assessment dates. These images along with ground photographs and URS surveys and, where available, MoRPh5 surveys were used to estimate each of the 32 Condition Indicators for the four MoRPh5 subreaches in 2009, 2012 and 2020.

For the 2020 estimates, existing MoRPh surveys were used wherever possible and were updated to 2020 using information extracted from ground photos and aerial imagery. For reach 1, sedimentary

data were extracted from the 2012 URS survey and other data were generated from the 2020 aerial imagery and recent ground photos of the MoRPh5 subreach. In all cases, the available data were combined using the algorithms that generate the 32 condition indicators to gain the most accurate estimate possible for each Condition Indicator for each of the four MoRPh5 subreaches.

For the 2009 and 2012 estimates, URS surveys for each of these years provided the foundation for producing synthetic MoRPh5 Condition Indicator estimates and these were then fine-tuned to the MoRPh5 subreaches using ground photos and aerial images. The algorithms that generate the 32 Condition Indicators formed the basis for combining information from the various sources to produce the most accurate estimates that were possible of each Condition Indicator for the four MoRPh5 subreaches for 2009 and 2012.

The above analysis stages produced estimates of the 32 condition indicators for each of the four MoRPh5 subreaches for 2009, 2012 and 2020.

Figure 1: Four reaches (white-dashed lines) of the Mayes Brook, Mayesbrook Park, London, showing the locations of the five MoRPh surveys (green pins) within each of the four MoRPh5 subreaches simulated for the assessment of River Condition (The aerial image is for 03 June 2020 and was drawn from Google Earth (© 2021 Google)).

Figure 2: Ground photographs of reaches 1 and 2 close to the MoRPh5 subreach locations and simulated survey dates. Note that in reach 1, the river was moved into a completely new channel during the restoration; all photographs are looking upstream. For reach 2, the 2009 and 2012 photographs are looking upstream, whereas the 2019 photograph is looking downstream.

Figure 3: Ground photographs of reaches 3 and 4 close to the MoRPh5 subreaches and simulated survey dates. Note that in reach 3, the river was moved into a completely new channel during the restoration; the photographs for 2009 and 2012 look upstream and the photograph for 2019 looks downstream. For reach 4, all photographs look downstream.

River Condition Assessments for four reaches of the Mayes Brook

All stages leading to the simulated River Condition assessments from the Condition Indicators to Final Condition assuming a river type H (straight to sinuous, gravel-pebble bed) are presented in Table 1.

The four reaches show different changes in their local condition across the three investigated dates, reflecting their different styles of restoration:

(i) Reach 3 was subject to the most elaborate restoration with realignment to a new planform and excavated shallow floodplain. Table 1 shows that reach 3 has improved in condition from Fairly Poor in 2009 to Moderate in 2012 to Fairly Good in 2020. The main negative indicators that continue to depress its condition are filamentous algae (Condition Indicator (E12) suggesting poor water quality), superficial bed siltation (E7) and bank top managed ground cover (B5).

(ii) Reach 1 was also transferred from a deep trapezoidal channel into a new, sinuous and more open channel. Table 1 shows that reach 1 has improved in condition from Poor in 2009 to Moderate in 2012 and 2020. Like reach 3, it retains notable negative condition in relation to Condition Indicators E12, E7 and B5.

(iii) Reach 4 was only restored in its downstream section and this was where the simulated MoRPh5 surveys were located. Table 1 shows that this part of reach 4 did not improve from Fairly Poor in 2009 to 2012 (although the preliminary condition score increased) but has recently improved to Moderate in 2020. Like reaches 1 and 3, it retains notable negative scores for Condition Indicators E12, E7 and B5 but it also has poor scores for the extent of artificial bank profiles (C7).

(iv) Reach 2 received minimal modification during the restoration period and has shown no improvement in condition, rating as Fairly Poor in 2009, 2012 and 2020. It shows the same notable negative condition indicators as reach 4, but it achieves even lower negative Condition Scores.

Some Final Cautions

The following should be noted in relation to the methodology applied here and its outcomes:

(i) As the restoration works in some reaches covers only part of the whole reach length, the MoRPh5 subreach only reflects the local change in River Condition, which can then be extrapolated to the length of the channel that was treated in a similar manner. In the case of reach 4, for example, the estimated Final Condition can only be extrapolated along the downstream, treated section of the reach. The Biodiversity Metric spreadsheet requires a channel length to be entered for each RCA output line. For the baseline condition table, the RCA output line may cover a longer channel length than the post-intervention condition table (e.g. where a sub-section is restored and the rest is unchanged) and thus the number of lines will differ, although the overall channel length must remain consistent.

(ii) While it was possible to reconstruct pre-project and immediately post-project River Condition without any MoRPh survey data in the present example, this will not be universally possible. A wealth of historical data were available for the Mayes Brook. Although URS data does not have the spatial resolution and does not record the full range of features captured by a MoRPh survey, the application of URS to reaches displaying 'homogenous' engineering, allows the URS survey data to be cross-matched to MoRPh5 subreaches with good accuracy as long as contemporaneous ground photos

are also available for the MoRPh5 subreaches. Furthermore the open nature of the Mayes Brook (i.e. minimal overhanging trees) in 2009, 2012 and 2020 allowed aerial images to provide good additional detail on the character of the bank tops, bank faces and emergent features and vegetation within the submerged parts of the channel in each of the MoRPh5 subreaches.

References

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Table 1: Estimated Condition Indicator scores, average positive and average negative Condition Indicator scores, Preliminary Condition score and Final Condition for MoRPh5 subreaches of the four reaches of the Mayes Brook during 2009, 2012 and 2020.

		Reach Number and Simulated Survey Date											
Indicator	**Indicator name**	**R1 (2009)**	**R2 (2009)**	**R3 (2009)**	**R4 (2009)**	**R1 (2012)**	**R2 (2012)**	**R3 (2012)**	**R4 (2012)**	**R1 (2020)**	**R2(2020)**	**R3 (2020)**	**R4 (2020)**
	BED MATERIAL												
A7	coarsest bed mat	GP	GP	GP	GP	GP	GP	GP	GP	GP	GP	GP	GP
A8	average bed mat size class	SA	SI	SA	SI	GP	GP	GP	SI	SA	SI	GP	SA
	POSITIVE CONDITION INDICATORS												
B1	Bank top vegetation structure	2	1	2	1	1	1	1	1	2	2	3	3
B2	Bank top tree feature richness	0	0	0	0	0	0	0	0	0	0	1	0
B3	Bank top water-related features	0	0	0	0	0	0	2	0	0	0	3	0
C1	Bank face riparian vegetation structure	1	2	1	1	1	1	1	1	2	2	2	3
C2	Bank face tree feature richness	0	0	0	0	0	0	0	0	0	0	2	1
C3	Bank face natural bank profile extent	0	1	1	0	4	0	4	2	4	1	4	2
C4	Bank face natural bank profile richness	0	1	1	0	2	0	1	2	2	1	3	3
C5	Bank face natural bank material richness	0	1	1	1	2	1	2	2	2	2	3	2
C6	Bank face bare sediment extent	0	0	0	0	1	0	4	1	1	1	1	1
D1	Channel margin aquatic vegetation extent	1	2	3	1	2	3	2	2	3	3	2	3
D2	Channel margin aquatic morphotype richness	0	2	2	1	2	1	2	3	2	2	3	2
D3	Channel margin physical feature extent	0	3	4	0	2	4	2	1	3	3	2	2
D4	Channel margin physical feature richness	0	1	1	0	1	1	2	1	2	2	3	2
E1	Channel aquatic morphotype richness	0	4	3	2	2	1	2	3	3	3	3	3
E2	Channel bed tree features richness	2	1	1	2	0	1	0	0	0	2	2	1
E3	Channel bed hydraulic features richness	2	2	2	0	2	0	2	1	2	0	2	2
E4	Channel bed natural features extent	1	2	2	1	1	1	1	0	1	1	2	1
E5	Channel bed natural features richness	1	4	3	2	2	2	0	0	1	1	2	1
E6	Channel bed material richness	1	2	2	2	1	2	3	4	2	3	3	2
	AVERAGE OF POSITIVE CIs	0.6	1.5	1.5	0.7	1.4	1	1.6	1.3	1.7	1.5	2.4	1.8
	NEGATIVE CONDITION INDICATORS												
B4	Bank top NNIPS cover	0	0	0	0	0	0	0	0	0	0	0	0
B5	Bank top managed ground cover	-2	-4	-3	-3	-2	-4	-2	-3	-2	-4	-2	-3
C7	Bank face artificial bank profile extent	-4	-4	-4	-4	-1	-4	0	-4	0	-4	0	-3
C8	Bank face reinforcement extent	-4	-3	-3	-3	0	-2	0	0	0	-1	0	0
C9	Bank face reinforcement material severity	-4	-4	-4	-4	0	-3	0	0	0	-1	0	0
C10	Bank face NNIPS cover	0	0	0	0	0	0	0	0	0	0	0	0
D5	Channel margin artificial features	0	0	0	0	0	0	0	0	0	0	0	0
E7	Channel bed siltation	0	0	0	0	0	0	0	0	-2	-1	-2	-2
E8	Channel bed reinforcement extent	-3	0	0	0	0	0	0	0	0	0	0	0
E9	Channel bed reinforcement severity	-4	0	0	0	0	0	0	0	0	0	0	0
E10	Channel bed artificial features severity	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	0	-1
E11	Channel bed NNIPS extent	0	0	0	0	0	0	0	0	0	-1	0	-1
E12	Channel bed filamentous algae extent	-4	-3	-2	-3	-3	-1	-3	-3	-3	-3	-3	-3
	AVERAGE OF NEGATIVE CIs	-2.1	-1.5	-1.4	-1.5	-0.6	-1.2	-0.5	-0.9	-0.6	-1.2	-0.5	-1.0
	PROVISIONAL CONDITION SCORE	**-1.5**	**0.0**	**0.1**	**-0.7**	**0.8**	**-0.2**	**1.1**	**0.3**	**1.1**	**0.3**	**1.9**	**0.8**
	FINAL CONDITION (for river type H)	**Poor**	**F Poor**	**F Poor**	**F Poor**	**Moderate**	**F Poor**	**Moderate**	**F Poor**	**Moderate**	**F Poor**	**F Good**	**Moderate**