TECHNICAL NOTE:

River Teme Impacts

Prepared for:	Radnor Hills Water
Date issued	08/02/2022
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Reference:	P21-075 Radnor NA DET \ TN R Teme impacts 1
Revision:	0
Contents	5 pages, including 2 figures plus 1appendix

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1 INTRODUCTION

Radnor Hills Mineral Water Company Limited (Radnor) has submitted applications for abstraction licences to Natural Resources Wales (NRW) and the Environment Agency under The Water Abstraction (Transitional Provisions) Regulations 2017, for previously exempt abstraction of groundwater.

During a meeting with the Environment Agency on 24th January, in which additional information on the hydrological functioning of the River Teme and the interaction with Radnor's abstraction was presented by us, two specific questions were posed by the Environment Agency. These were:

1. Will abstraction impact the fisheries downstream of the River Clun, and affect the migratory species travelling upstream to the River Clun SAC?

2. Is the River Teme connected to the groundwater?

This technical note presents Envireau Water's response to these questions, together with technical evidence, to assist both NRW and the Environment Agency in their determinations of the applications.

For the sake of brevity, background information presented in the applications and previous presentations is not presented here. Neither have we given the regulatory background to the applications. However, it is important that when considering this note that the background and regulatory context with respect to The Water Abstraction (Transitional Provisions) Regulations 2017 is understood and that previous presentations and reporting is referred to.

2 QUESTION 1

Will abstraction impact the fisheries downstream of the River Clun, and affect the migratory species travelling upstream to the River Clun SAC?

The abstraction by Radnor lies approximately 6km upstream of the confluence of the River Clun with the River Teme. As such, the River Clun is up gradient of the Radnor abstraction, and therefore the Radnor cannot have a direct effect on flows in the River Clun.

However, **in theory** abstraction by Radnor could affect the River Teme, which could impact flow and depth downstream of the confluence and therefore affect migratory fish passage.

Discharge volumes in the River Teme downstream of the confluence with the River Clun at Leintwardine (the combined discharge of the River Teme and the River Clun) using LowFlows2 is 220,562,784m^3/yr (~600 ML/day; ~7 m^3/s). The net abstraction by Radnor is 0.1% of this discharge.

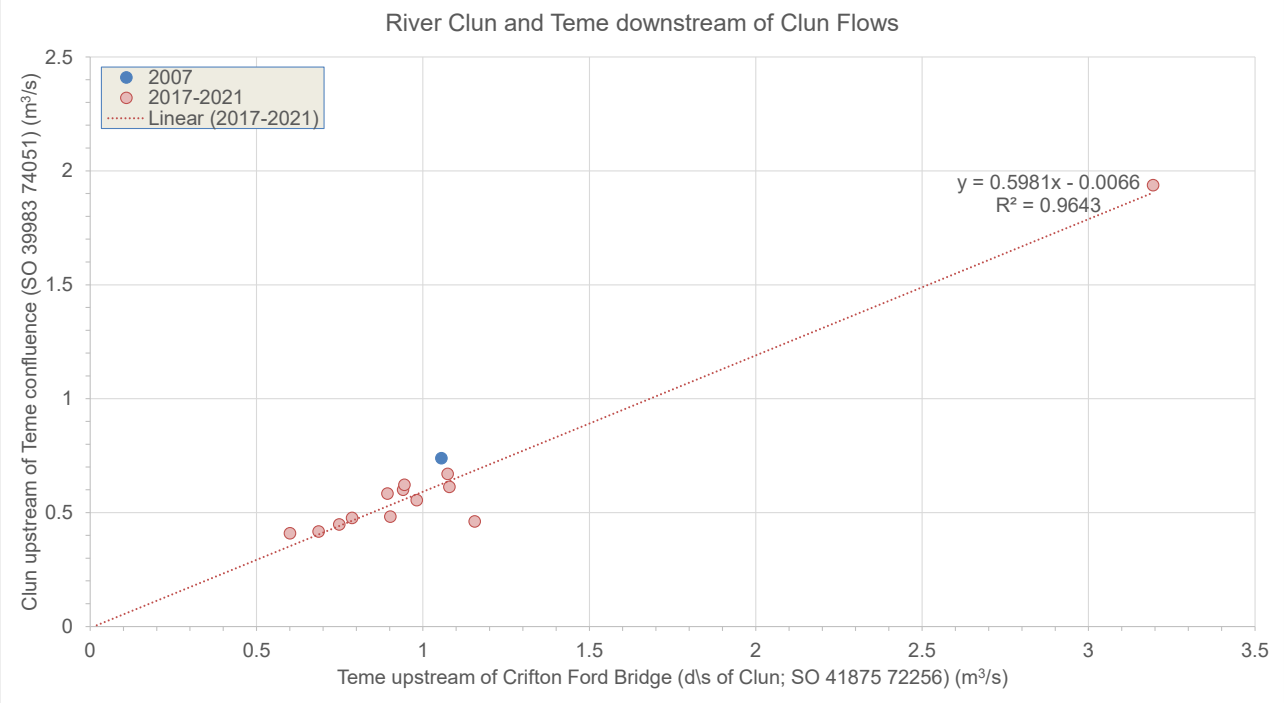
Appendix A provides a set of flow and stage duration curves for the Environment Agency gauge at Leintwardine Bridge (Station 2132 at SO 4040 7381). This location is downstream from the River Teme / River Clun confluence. The flow duration curves have been generated using LowFlows2, while stage duration curves have been generated using gauge data. We understand that there isn't a published rating for the gauge.

The validated daily abstraction for Radnor is 812m^3 (0.0094 m^3/s). There is also a permitted (EPR/AB3697CN) discharge of treated effluent of up to 194.4 m^3/day (0.00225 m^3/s) just downstream of the abstraction. The Q95 flow of the River Teme including the River Clun discharge is ~0.81m^3/s (LowFlows2), downstream of the confluence. Assuming the **extreme worst-case scenario** that all Radnor abstraction is seen at Leintwardine, then this is a 1.16% impact, ignoring Radnor's permitted discharge.

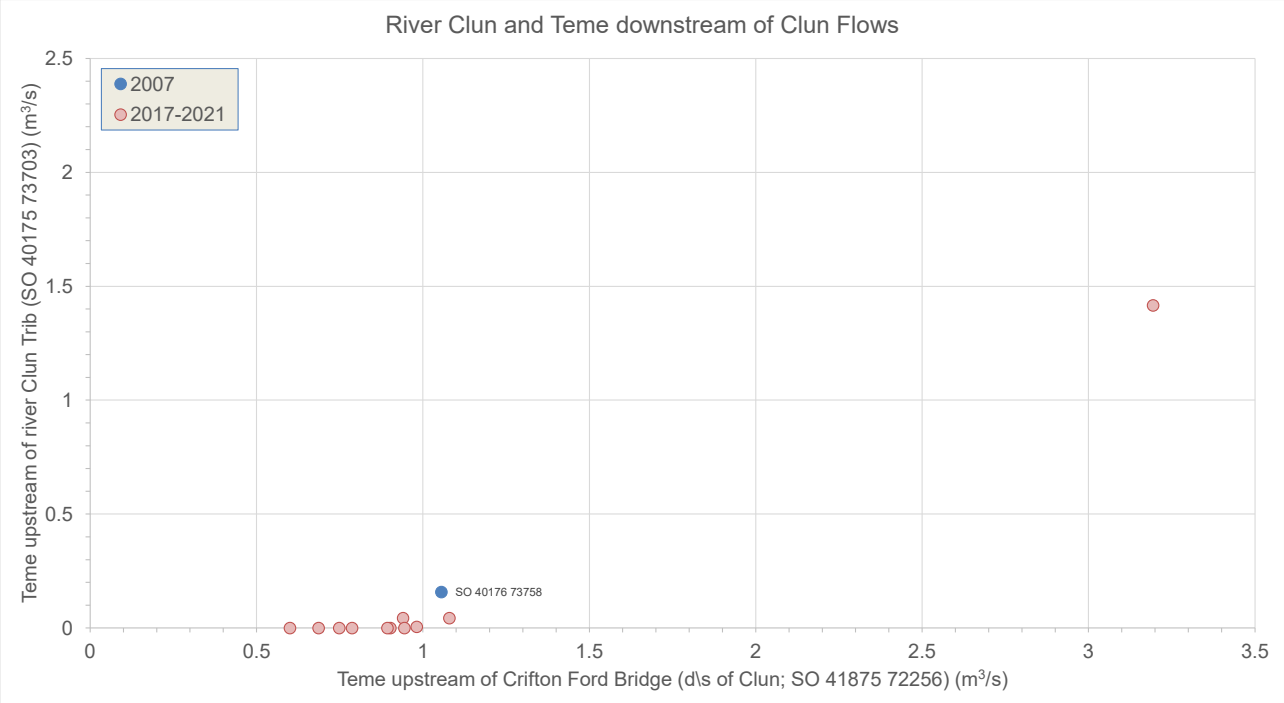
The Stage95 is circa 0.31m. A 1.16% impact would reduce stage by 0.0036m (~4mm) an almost imperceptible amount and would not hinder fish passage. As flow increases downstream in proportion to the increase in contributing catchment, the Q95 flow increases and therefore the theoretical effect decreases.

This calculation can be checked using a totally different method by analysing spot flow data from the River Teme some 2.3km downstream from the confluence, and from the River Clun.

The chart overleaf compares the spot flow gaugings and illustrates that ~60% of the flow in the Teme below the confluence is from the Clun and ~40% is from the Teme valley. This is consistent with the numbers produced by LowFlows2.



The chart below presents a comparison of spot gaugings from the Teme river just upstream of Leintwardine and the flows downstream of the confluence with the Clun. The gaugings represent low flows (Q89 – Q99 based on LowFlows2 data) and illustrate that at low flows the River Teme contribution above the confluence is negligible. At higher flow conditions (~Q85 based on the LowFlows2 data), the single value shows that the River Teme provides ~44% of the river flows downstream. Overall, this means that at low flows the River Teme downstream of the Clun gets about 60% of its water from the Clun and the majority of the rest from groundwater from the Teme Valley.



It has been shown and presented to NRW and the Environment Agency that the worst-case theoretical impact on the Teme valley discharge at Lingen Bridge is <1%. On this basis, the worst-case theoretical impact downstream of the River Clun influence, at low flows is less than 1% of the 40% contribution to the Teme flows downstream of the confluence of the Clun, which is a net effect of 0.4%. This effect is less than that indicated by the LowFlows2 analysis.

This analysis has disregarded inputs from the permitted Radnor treated effluent discharge of up to 194.4 m^3/day and a likely dry weather flow discharge of circa 450 m^3/day from the Knighton sewage treatment works, which is sourced via an import of groundwater from the Lugg catchment. These discharges of circa 600-650 m^3/day are more than 70% of the validated daily abstraction at Radnor of 812m^3/day.

The effect on stage and discharge is imperceptibly small at Leintwardine even taking the theoretically worst-case calculation, not taking account of return flows to the River Teme, and understanding that effects get smaller downstream. I**t is therefore beyond reasonable scientific doubt** that the abstraction by Radnor will not affect migratory fish passage to the Clun SAC.

3 QUESTION 2

Is the River Teme connected to the groundwater?

The River Teme is a naturally ephemeral river that runs over gravels. The degree of the connection to the underlying groundwater is dependent on the scale that is considered and the time of year together with the wetness of the season.

At the local scale (in the vicinity of the Radnor wellfield) during periods of natural low groundwater level and concomitant low (or no) river flow, the River Teme is disconnected from the groundwater in the underlying gravel aquifer. In this setting surface flow over the riverbed drains to the groundwater, but there is an unsaturated zone between the river bed and the phreatic surface in the gravels. During periods when both river flow and groundwater level is high then groundwater does overflow or discharge from the gravels into the river channel.

At the regional scale, as is the case with all catchments, groundwater discharges to rivers at some point and in this respect all water in all catchments is connected. The runoff from the Teme valley catchment is predominantly in the river upstream of Knighton and the gravels downstream of Knighton. Along certain reaches downstream of Knighton, where the gravel filled paleo-valley narrows or shallows, the capacity of the gravels to convey the water decreases, so there is a proportional increase in flow in the river. Conversely, for example between Milebrook and Lingen Bridge, and very significantly near Leintwardine, the transmissivity of the gravels is high enough to convey all of the valley water at times of lower rainfall.

An alternative way of approaching this question is to consider whether the water abstracted by Radnor is "connected" to the River Clun or the River Teme. In doing so we have conceptualised, and provided evidence that:

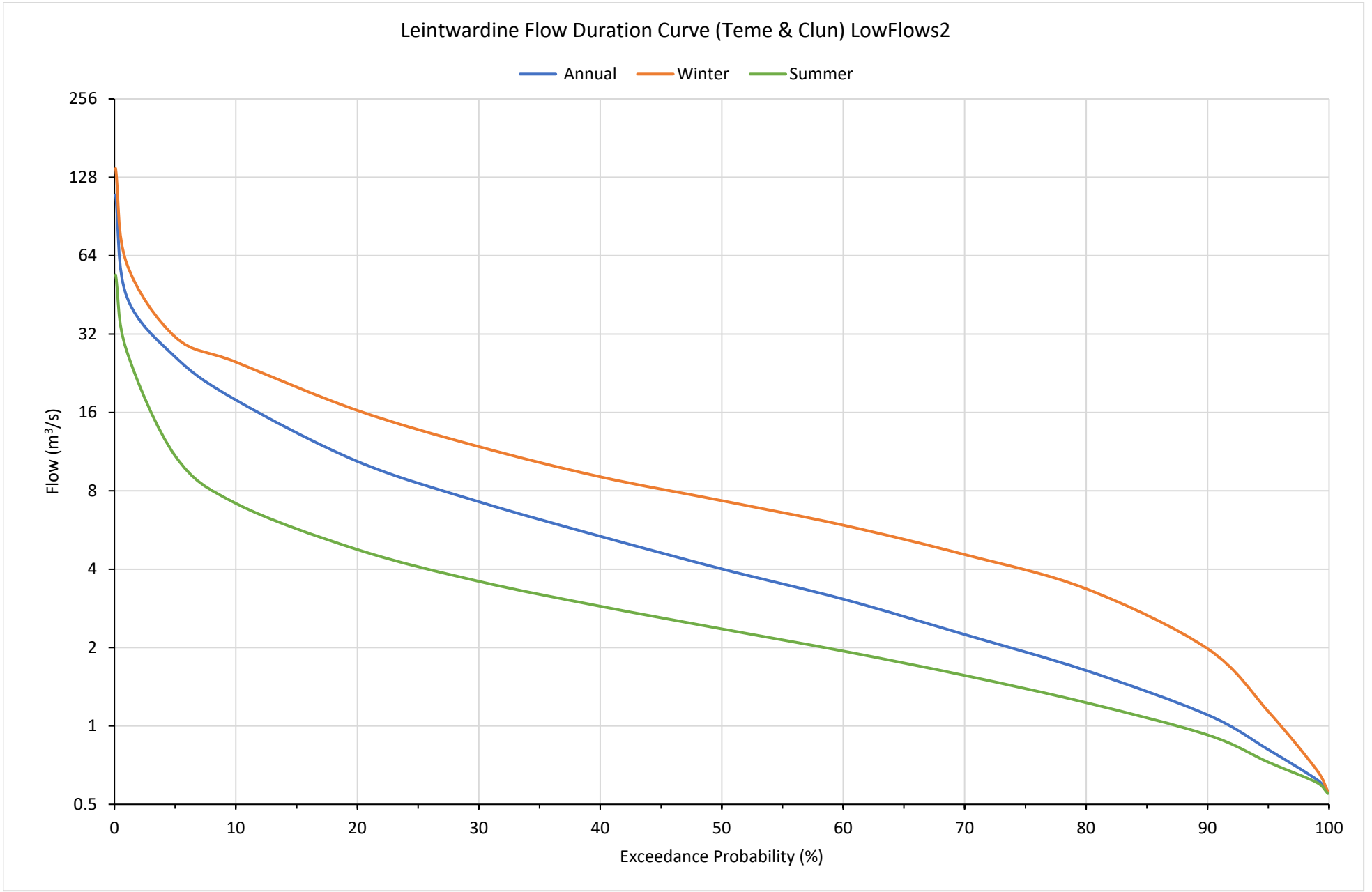
- The Radnor abstractions from the gravels intercept some of the runoff and bedrock flow from the hillside to the south of the Teme valley (supported by SPZ modelling);
- River water flows into the gravels upstream of Radnor and downstream of Knighton and that this was occurring before any significant abstraction by Radnor commenced;
- Water in the gravels discharges back to the river upstream of Lingen Bridge and continues to do so upstream of Buckton Bridge;
- River water flows back into the gravels as the gravel channel widens significantly upstream of Leintwardine; and
- Water in the gravels moves back into the River Teme downstream of Leintwardine;

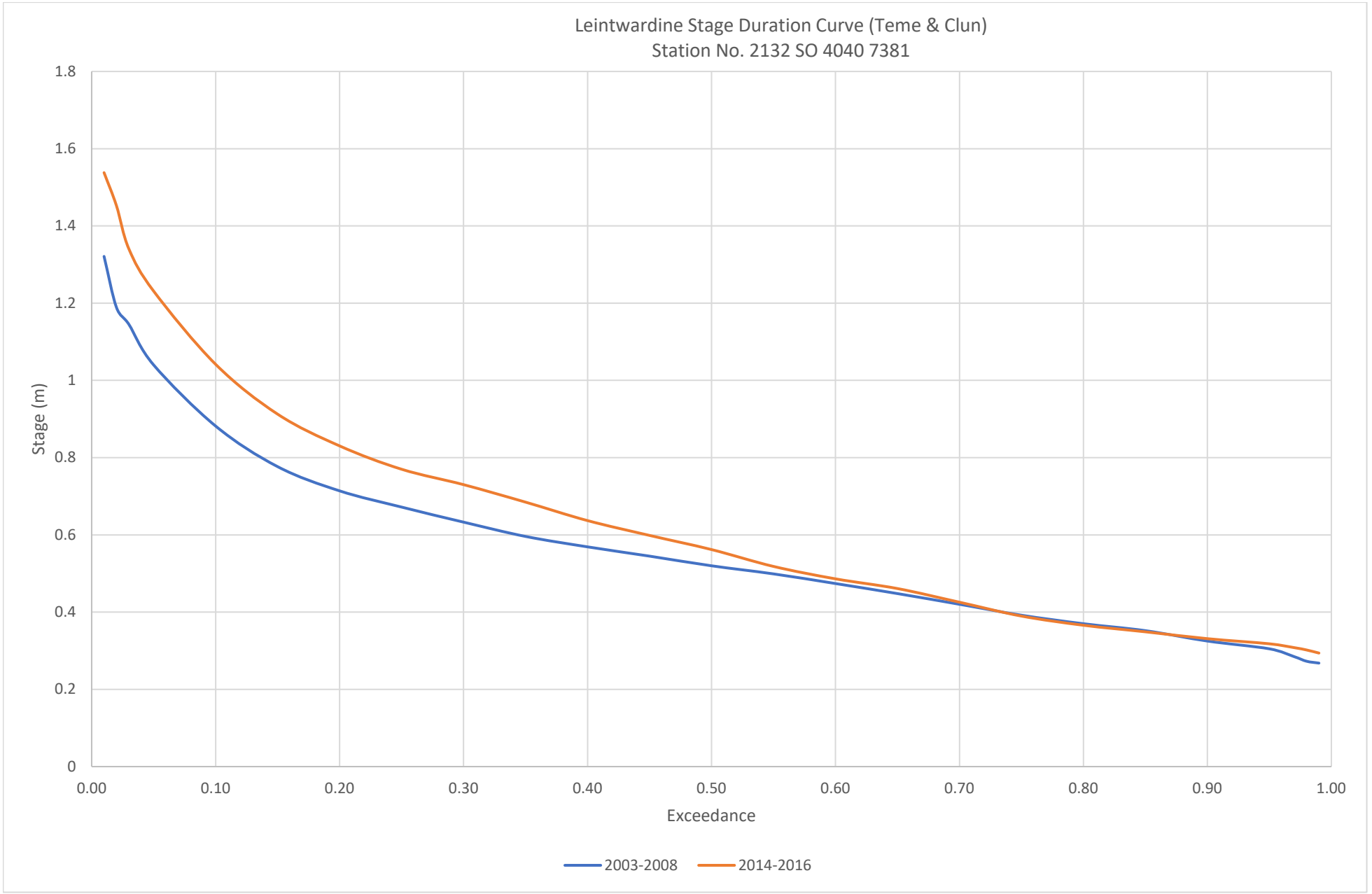
Thus, water moves into and out of the gravels and river channel as part of the natural functioning of the river.

The data and evidence presented to NRW and the Environment Agency demonstrates **beyond reasonable scientific doubt** that there is no material impact from the Radnor abstraction on flows in the River Teme.

APPENDICES

Appendix A Flow & Stage Duration Curves


Leintwardine Flow Duration Curve (Teme & Clun) LowFlows2
Annual
Winter
Summer
256
128
64
32
16
8
4
2
1
0.5
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
Exceedance Probability (%)


Leintwardine Stage Duration Curve (Teme & Clun)
Station No. 2132 SO 4040 7381
Stage (m)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Exceedance
2003-2008
2014-2016