Memo

SUBJECT
Wern Reserve Water Balance

TO
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This Technical Note documents the data sources and methodology for calculating the water balance for the proposed new wetland reserve at Wern adjacent to the Montgomery Canal.

Figure 1 illustrates the model that has been used to determine whether the reserve would be in surplus or deficit. It is based on the fact that the pound in which Wern is located (Pound E) is the lowest pound on the canal and hence any ‘waste’ outflows can potentially be considered as an available water resource for the canal. This assumes that the reserve is connected to the canal by simple weir inlet structures, with the reserve and canal designed to be at the same level and passive flow between them.

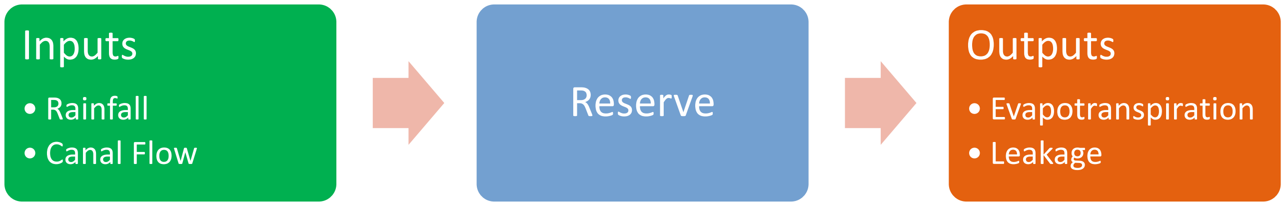

Figure 1: Water Balance Model Schematic

Datasources

The following data sources have been used in calculating the water balance.

- Natural Resources Wales (NRW) rain gauge in Welshpool (Station 1149) - two sources:
  - NRW website
  - Shoothill Gaugemap
- Monthly Potential Evapotranspiration (PET) dataset published by the Environment Agency (EA).
- SCADA data provided by the Trust for T9 Wern Canal Outflow, T10 Wern Reserve Outflow and T11 Pool Quay Lock.
- Leakage Assessment prepared by Arcadis (dated December 2022).

The period of record available for the time series datasets and missing data are detailed in Table 1

Table 1: Period of record and missing data

Dataset	Period of Record Used	Missing Data
Rainfall	01/01/2017 to 30/09/2023	03/04/2021 to 24/10/2022
PET	01/01/2017 to 30/09/2023	None
SCADA	01/01/2017 to 20/09/2023	25/05/2021 to 25/11/2021 10/05/2022 to 17/05/2022 13/10/2022 to 17/10/2022 18/11/2022 to 06/12/2022 30/12/2022 to 01/01/2023 10/02/2023 to 12/02/2023 16/03/2023 to 26/03/2023

Key assumptions

The following key assumptions have been made to simplify the calculation of the water balance:

- The water surface of the reserve is assumed to cover an area of 1 hectare (ha) and is fixed for the purpose of this assessment. In reality, the water surface area will change as the water level rises and falls – the magnitude of the change will depend on the reserve design.
- Only rain falling directly into the reserve is included. Any runoff from the surrounding slopes that would enter the new reserve directly is assumed to be accounted for in the current waste flows from the canal.
- Only the waste flow at Wern Canal Outflow (T9) is assumed to be available for supply to the new reserve. It is assumed that the profile of Wern Reserve Outflows (T10) from the period of record will be maintained in the future – i.e., none of the recorded outflows to the existing reserve would be available for supply to the new reserve.
- It is noted that Sluice 13 also has an outflow associated with it, but no flow data is available. Some additional 'waste' flows via Sluice 13 could, realistically, also be expected to be available for supply to the proposed reserve; however, without being able to quantify this amount, the potential additional water resource has been ignored. The new reserve is most likely to need additional water during the summer months when waste flows via Sluice 13 are likely to be negligible; therefore this appears to be a reasonable assumption.

Methodology

Rainfall

A search was undertaken for nearby rain gauges on NRW's website, and the nearest gauge identified was at Welshpool. NRW's website only makes the last 12 months of data available, and to avoid delays in acquiring this directly from NRW, Shoothill's Gaugemap was reviewed to see if this held data prior to October 2022. Data was available up until April 2021 so this was used to extend the period of record.

The NRW dataset was in 15 minute intervals, which was converted to daily totals and combined with the daily totals acquired from Gaugemap. Using this combined dataset an average daily depth of rainfall was calculated for each calendar month. This was then converted to Ml/d based on the assumed water surface area of 1 hectare. A summary of the rainfall data is included in Table 2.

Table 2: Summary rainfall input data

Month	Average Daily Rainfall (mm)	Average Daily Rainfall (Ml/d)
January	2.5	0.025

Month	Average Daily Rainfall (mm)	Average Daily Rainfall (Ml/d)
February	2.1	0.021
March	2.3	0.023
April	1.4	0.014
May	1.3	0.013
June	1.9	0.019
July	1.8	0.018
August	2.1	0.021
September	3.0	0.030
October	2.4	0.024
November	2.8	0.028
December	3.0	0.030

Canal Flow

The SCADA data for T9 Wern Canal (Waste) Outflow has been used to calculate the average daily flow for each month of the calendar year. No other conversion has been necessary as the flows are provided in Ml/d.

Evapotranspiration

The PET data is provided in 1km grid format as daily values measured in mm. Values were extracted for the 1km grid square that covers the reserve location and average daily values were calculated for each month of the record. As a conservative approach, negative values that are associated with foggy or misty days were ignored when calculating the average.

The average daily PET values were then converted to open water evaporation using the empirical factors in Table 6.1 of 'Estimation of Open Water Evaporation' (R&D Handbook W6-043/HB) published by the EA (dated October 2001).

Finally, the average daily values for each calendar month were calculated and then converted to Ml/d and a summary of the data is provide in Table 3.

Table 3: Summary of PET losses.

Month Name	Average Daily Open Water Evaporation (mm)	Average Daily Open Water Evaporation (Ml/d))
January	0.768	0.008
February	0.929	0.009
March	1.216	0.012
April	1.985	0.020
May	2.693	0.027
June	3.215	0.032
July	3.966	0.040
August	3.540	0.035
September	2.414	0.024
October	1.907	0.019
November	1.313	0.013
December	0.936	0.009

Leakage

The Leakage Assessment provided an upper and lower estimate of the likely infiltration rates within the site for the reserve. The document converted these to Ml/d based on an area of 1.8 ha. The leakage rate has now been recalculated for an area of 1 ha and this is summarised in Table 4. In addition, a 'mid-range' infiltration rate of 10% of the upper estimate has been used as a sensitivity test and included in the analysis. This value has been selected based on recent hydrogeological interpretation of the 2022 leakage assessment ground investigation factual report, which indicates that the infiltration rate at Wern is now thought more likely to lie towards the upper end of the range originally quoted.

Table 4: Summary of leakage rates.

Leakage Estimate	Infiltration Rate (m/s)	Infiltration Rate (m/d)	Leakage Rate (Ml/d)
Upper	1.00×10^{-6}	8.64×10^{-2}	0.864
Mid-range (Sensitivity)	1.00×10^{-7}	8.64×10^{-3}	0.086
Lower	1.00×10^{-9}	8.64×10^{-5}	8.64×10^{-4}

Water balance

Based on the inputs and losses estimated above an average daily water balance has been calculated for each calendar month and a summary of this can be seen in Table 5. The average of the 6 month 'summer' period (April to September) is also included as this is likely to be when water levels in the reserve are more likely to drop and available supply will be diminished.

Table 5: Water balance summary.

Month	Rainfall (Ml/d)	Wern Canal (waste) Flow (Ml/d)	Evaporation (Ml/d)	Leakage (Ml/d)	Water Balance (Ml/d)		
					Upper	Mid-range	Lower
Jan	0.025	7.029	0.008	See Table 4	6.183	6.960	7.046
Feb	0.021	7.014	0.009		6.162	6.939	7.025
Mar	0.023	7.105	0.012		6.251	7.029	7.115
Apr	0.014	3.730	0.020		2.861	3.639	3.724
May	0.013	2.961	0.027		2.083	2.861	2.946
Jun	0.019	2.004	0.032		1.127	1.905	1.990
Jul	0.018	0.345	0.040		-0.541	0.237	0.322
Aug	0.021	0.659	0.035		-0.219	0.559	0.644
Sep	0.030	1.149	0.024		0.290	1.068	1.153
Oct	0.024	2.787	0.019		1.927	2.705	2.791
Nov	0.028	3.691	0.013		2.842	3.619	3.705
Dec	0.030	7.306	0.009		6.463	7.240	7.326
'Summer'	**0.019**	**1.808**	**0.030**		**0.934**	**1.711**	**1.797**

This demonstrates that for the mid-range and lower estimate of leakage rates there is very likely to be a surplus throughout the year. However, if leakage rates are at the upper estimate, then a deficit is predicted in the months of July and August when the amount of 'waste' flow recorded by T9 is much lower.

Using the upper leakage rate the associated drop in water level in the new reserve has been estimated as up to 2.35m by the end of August. This assumes a constant loss without any adjustment for the reduced water surface that would gradually occur. It also assumes that the stopboards on the inlet structures are in place such that there is no flow from the canal to the reserve once the reserve water levels start dropping. Nonetheless, if the upper leakage rate is realised it demonstrates that the reserve could potentially run dry in the summer without any additional inflow.

The analysis has been used to advise on the maximum leakage rate that could be sustained without the reserve falling into deficit. Using the critical month of July, a leakage rate of 0.323 Ml/d would balance the other inputs and losses. This is equivalent to an infiltration rate of 3.74×10^{-7} m/s which is between the mid-range and upper estimates. If the actual leakage rate is lower than this, which is considered likely, then the reserve should be in surplus in an average year.

It should be noted that the Water Control Manual indicates that Sluice 13 is the main sluice used to control the pound. However, the flows lost via this sluice have not been considered in this assessment as there is no available flow data. Whilst this might suggest that there is more water available from the canal, it is likely that there is negligible waste flow via Sluice 13 in the summer months when it would be most needed. As such, disregarding this potential "source" of water is considered reasonable.

The Water Control Manual notes the proactive actions to take in response to low levels in Pound E. Preference is given to increasing the feed from the pound above (Pound F) before considering supplementing the feed from Lledan Brook. It is understood that the Trust no longer has an abstraction licence for Lledan Brook and this source cannot currently be used. Nonetheless, this could be a potential source of additional water should the leakage rates be greater than 0.323 Ml/d, depending on the success of any abstraction licence application made to NRW.

Other Considerations

Flood Risk

The above assessment indicates that additional supplies are unlikely to be needed. As such there would be no increase in the flows entering the canal from the proposed new reserve which could impact flood risk to the canal.

Installation of a liner

Whilst the above analysis suggests that a liner would not be necessary, if a liner was installed then the leakage rate should, in theory, be negligible. Liner permeability rates have been acquired from suppliers ranging from 1×10^{-9} m/s to 6.59×10^{-12} m/s. The maximum of these rates is the same as the lower estimate of the unlined infiltration. Therefore, the lower estimate of the water balance would be indicative of the water balance in a lined scenario. This shows a continuous surplus through the year and a very low chance of water levels in the reserve dropping significantly in a dry summer.

Given the wide range in current estimates of the leakage rates for the new reserve, it could be beneficial to have a liner to minimise the risk associated with this uncertainty. Consideration could also be given to undertaking further ground investigation to determine a better estimate of leakage rates prior to making a decision on whether to invest in a liner or not.

Abstraction Licensing

Consultation was undertaken with NRW and subsequent advice was sought from the Trust's Senior Environmental Lawyer (Helen Sillitto). NRW initially suggested that an abstraction licence would be required; however, the legal advice received indicates that, under Section 26 of the Water Resources Act 1991, the Trust's abstractions are exempt when transferring water from a "water system of the authority's" to "the same water system". The new reserve would be considered part of the Montgomery Canal 'water system' since it will be connected with the canal with a passive flow between the two and it will be constructed as part of the Trust's improvement to the canal. The Trust is the navigation authority for the canal and using water from the canal to supply the new reserve would be transferring water within the same system and would therefore be exempt.

Conclusion

The analysis has shown that there is very likely to be sufficient water resource available in Pound E of the canal to supply the proposed new reserve, without the need for a liner and without any additional supplies from elsewhere. It is possible, however, that in particularly prolonged dry summers in 'drought' years, insufficient water may be available, in which case water levels in the reserve could temporarily drop significantly. Therefore it could be beneficial to install a liner to minimise the risk of water levels dropping significantly. However, consideration should also be given to undertaking further ground investigation prior to deciding whether to invest in a liner.