Hydrological Information

The previous hydrological assessment of the Harlaw reservoir appeared to use the measured flows provided by Edinburgh Council.

We have used an alternative methodology to estimate the available in-flow and the long-term attenuated flow available from Harlaw and Threipmuir reservoirs:

1. The unaffected flow in to the Threipmuir and Harlaw Reservoirs has been estimated using the LowFlows 2000 (LF2000) software.
2. A daily time-series of flows was obtained for SEPA's Craigiehall river gauging station (the closest station with data available at short notice).
3. The Craigiehall data from 1990 to 2009 was compiled into a flow duration curve.
4. The time-series for Craigiehall was then used to simulate a time-series for the in-flow into the reservoirs using a matched-pair method: when Craigiehall = Q50, inflow = Q50 etc. The intention was not to model the in-flow hydrograph exactly but rather to simulate the intensity and duration of high flow events.
5. This simulated time-series was then used in conjunction with estimates of the available storage to account for the attenuation effect of the reservoirs.

The average in-flow to the reservoirs was estimated to be 0.346 m^3/s. The surface area of the Harlaw reservoir was estimated to be 83,000 m2, giving an attenuation volume of 83,000 m3 since the reservoir is normally held at 1m below the over-spill notch. We have assumed that a similar level of attenuation may be available from the Threipmuir reservoir.

Figure I.A shows the locations of the LF2000 prediction and the manual measurements taken by Edinburgh Council.

Figure I.B shows the simulated in-flow hydrograph.

Table I.A shows the effect of varying the turbine design flow and the available storage on the capacity factor, return on investment and energy yield of the system

Clearly more storage is better. Assuming that only Harlaw reservoir is available for attenuation the optimum design flow for the turbine will be 640l/s.

The availability of Harlaw reservoir as attenuation storage only increases the energy yield from the turbine by 9% when compared with the run-of-river case. There may be scope to increase the revenue of the system further by operating the system as a more traditional storage scheme under normal flow conditions. Limiting the turbine to the minimum compensation flow when the price of electricity is low and ramping it up to full power when the price peaks could increase the income from the scheme.

Proposed modifications to the compensation flow regime

In order to maximise the energy yield from the hydro-electric system the following reservoir release regime would need to be implemented:

1. Some capacity in both the Harlaw and Threipmuir reservoirs could be made available for flow attenuation and hydro-power storage. We suggest that this is the storage volume between the minimum allowable water level and the water level where water begins to spill over the flood mitigation notch
2. The outflow of the Threipmuir reservoir should feed the Harlaw reservoir, only spilling water to the bypass ditch when both reservoirs are full to capacity
3. The rate of flow of water from the Threipmuir reservoir to the Harlaw reservoir should be related to the remaining storage capacity in each. For example if Harlaw is at 100% capacity and Threipmuir is at 50% capacity then the outflow would be throttled back to the current turbine flow until Threipmuir reaches 100% capacity

In order to maximise the income from the hydro-electric system it may also be advantageous to implement a diurnal storage regime:

1. In periods of relatively high flow the attenuation storage would work as normal
2. In periods of relatively low flow the turbine would vary the rate of flow as a function of available storage, rate of in-flow and wholesale electricity price. If the electricity price is low and there is storage to spare then the turbine would throttle back to the minimum compensation flow. When the electricity price rises the turbine would then open up ensuring the best value for the community

The flow regimes outlined above will require in-depth consultation with Edinburgh Council, SEPA and the reservoir angling club to ensure that the best balance is found between community revenue, amenity impact and flood attenuation.

Detailed control algorithms can be formulated based on the outcomes of that consultation.

Figure I.A: Gauging Location (not to scale)

Figure I.B: Simulated in-flow hydrograph

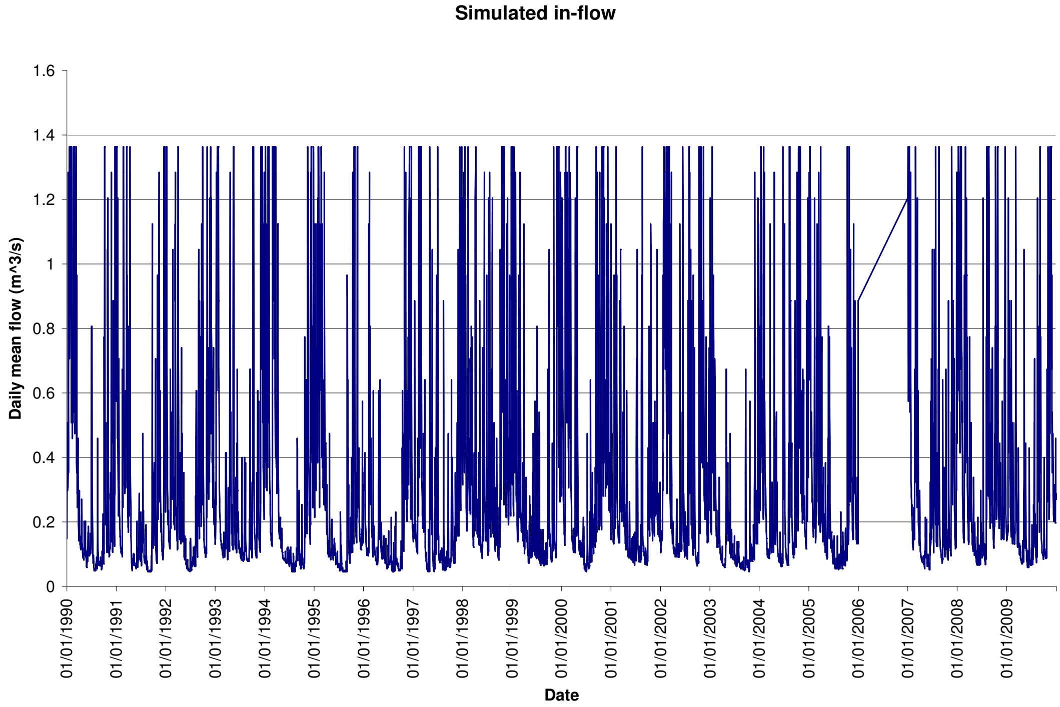

Table I.A: Attenuation Modelling

		Reservoir storage (m^3)					
		0	**50,000**	**100,000**	**150,000**	**200,000**	**250,000**
		Capacity Factor (%)					
Design flow (l/s)	**550**	44.7%	47.2%	48.4%	49.7%	50.3%	50.8%
	600	42.1%	45.1%	46.1%	46.8%	47.5%	48.2%
	650	40.1%	42.8%	44.3%	44.8%	44.9%	45.1%
	700	38.5%	40.8%	41.9%	42.3%	42.7%	43.0%
	750	37.0%	39.2%	39.9%	40.1%	40.7%	40.9%
		Return on Investment (%)					
	550	17.7%	19.0%	19.5%	20.1%	20.3%	20.5%
	600	17.8%	19.2%	19.7%	20.0%	20.4%	20.7%
	650	17.9%	19.2%	19.9%	20.2%	20.2%	20.3%
	700	18.0%	19.1%	19.7%	19.9%	20.1%	20.3%
	750	17.9%	19.1%	19.4%	19.7%	19.9%	20.0%
		Energy Yield (MWh p.a.)					
	550	227	248	254	261	264	267
	600	237	254	260	264	268	272
	650	240	257	266	269	270	271
	700	244	259	266	268	271	273
	750	246	261	265	269	271	272