VARTRY WATER TREATMENT WORKS UPGRADE

REF. WICKLOW COUNTY COUNCIL PLANNING APPLICATION 16/363
AN BORD PLEANALA REF. 27.247745

REPORT ON HYDROLOGICAL ISSUES

INTRODUCTION

The planning application to Wicklow County Council (WCC) for an 'upgrade' to the existing water treatment works at Vartry Reservoir was specifically for the construction of a new "water treatment plant including water treatment building, pumping station, sludge treatment facilities, alterations to reservoir offtake tower, additions and alterations to pipework" at the Vartry Water Treatment Site at Roundwood. The planning application was appealed to An Bord Pleanala mainly on the grounds of potential environmental impact. An oral hearing was duly convened, in June 2017, to "consider the totality of the environmental issues involved in the context of proper planning and sustainable development of the area". It was emphasized and re-iterated by the applicants, Irish Water (IW), that the planning application did *not* concern a licence for water abstraction or the transfer of water across catchment boundaries (as the *de facto* water supply scheme had been in place for over 150 years and was not changing). However, the plan for a new water treatment plant did embody a change to the flow of water released to the Vartry River in the past. This change to the future discharges from the water treatment plant and its potential effect on the ecology and flow regime downstream was the focus of many of the planning appeals from stakeholders and riparian landowners.

HYDROLOGY OF THE VARTRY CATCHMENT AND THE WATER TREATMENT WORKS

The planning application and the appeals necessarily have to be considered in the context of the hydrological regime of the Vartry River catchment and the long operational history of the Vartry reservoir and associated water works. A map of the whole Vartry River catchment (Figure 1) and a diagrammatic flow chart of the operation of the abstraction and the downstream sub-catchments (adapted from evidence submitted at the oral hearing) are attached, to facilitate the understanding of this historical context. The original Vartry impoundment was constructed in the 1860s, (the existing lower reservoir) and the upper reservoir followed in 1923, together forming the existing impoundment, drawing water from the upland Vartry catchment which has an area of 56.8 km^2. The present Water Treatment Plant (WTP), which has also been operational for over 150 years, is based on treating the reservoir water by

passing it through slow sand filters. There are currently 16 such filters on site, all of which are essentially large sand-filled tanks in the ground, all but two being lined with natural materials (eg puddled clay). The last two are concrete–lined. The operation of these filters and their maintenance, as well as some subsurface leakage, gave rise to irregular but consistent discharges which were collected in a subsurface chamber and passed over a measurement weir to the old Vartry river channel, downstream of the dam. Weir flow measurements recorded from 1989 to 2007 indicated a mean flow to the river of some 4.6 million litres per day (MLD) (as given in evidence by IW). A significant change came in 2007 when the last two concrete filter tanks were installed and damage occurred to the subsurface, engendering increased but more erratic leakage from the filter bed area.

A new measurement weir was also installed which recorded an increased discharge (mean from 2008 to 2015 of 10.5MLD) to the river since 2008. With other more recent treatment problems (algal blooms), and occasional drought conditions, there have also been more frequent periods of 'pumping back' during which leakage and discharge water, upstream of the measurement weir, has been returned to the water treatment process. For example, recent IW evidence indicated that the net mean discharge to the river during the first five months of 2017 (during a period of also relatively low rainfall amounts) was reduced to approximately 7 MGD. As noted by Luke Drea (appellant witness), these statistics were determined without the benefit of any data for 2016, a surprising omission.

It is important to distinguish *abstraction* (water taken from the Vartry Reservoir) from water *supply* (water finally delivered to the pipeline to south Dublin). During this erratic period, from 2011 to 2015, the IW evidence indicated that the daily abstraction from the reservoir was of the order of 79 MLD which, with a mean leakage rate of 10.5 MLD gave a *net mean* water supply of 68.5 MLD. However, overall, for the longer period from 1989 to 2015, records indicate a *mean* abstraction rate of 83 MLD (Figure 2 of IW Hydrology Report) was achieved.

The new, upgraded water treatment plant is to abandon the use of these slow sand filters and thereby to control and improve the reliability of the yield of the reservoir. The proposed *capacity* of the new plant is 80 MLD but it is now proposed to install a branch pipe from the main reservoir abstraction to allow a managed discharge to the river of 5 MLD. Although not necessary, it is proposed to feed this 'compensation water' through the old sand filters (9 will be kept in place) in order to maintain their integrity and to measure this flow over the original weir and discharge it to the river through the current culvert. The IW evidence (Angela Ryan: 'reliable source yield') indicated that the new plant will operate at 75 MLD, so the supply of 5MLD compensation water indicates a future *abstraction* rate from the Vartry of 80 MLD.

Apart from the WTP discharge of sand filter water and leakage over the measurement weir into the river, there is a second culvert, known as the 'interceptor channel,

discharging water from sludge pond overflow and for which there exists a discharge licence. Historically, this channel also took effluent water from a wastewater treatment process in nearby Roundwood but this was reported by IW to have ceased some time ago. The flow from this interceptor channel, although not measured directly, appears to be relatively steady but small and probably less than 1 MLD. A Capital Water survey for IW during July 2016, reported a mean flow of 0.43 MLD at the time. The channel is to be maintained post-project but IW reported that the licence to discharge process water will be relinquished following commissioning of the new plant.

Although, at the dam, the historical record indicates a mean abstraction from the reservoir of 83 MLD, there is significant annual variability about this mean. Depending how failure in terms of supply is defined, this yield level has a recorded (IW evidence from 2003 report) failure rate of 6 years in 121 or 5.9%. The proposed abstraction rate of 80 MLD has a recorded failure rate of 4 years in 121 (or 3.3%), somewhat higher than the usual definition of 'reliable yield' having a failure of once in 50 years.

It is surprising that, with the unusually long history of recorded flows at Vartry, a reliable hydrological determination of catchment yield, or level of acceptable risk of failure, was apparently not determined. The level of compensation water (of 5 MLD) which has been offered, therefore, appears to be a somewhat arbitrary determination.

THE VARTRY CATCHMENT

The 'natural', un-impounded Vartry River is draining an upland catchment with steep gradients, thereby exhibiting a 'flashy' hydrological regime, strongly responsive to individual rainfall events. While that flashy nature still prevails, the reservoir has damped the hydrological response in the upper reaches and, in that sense, has assumed a flood control function for the lower catchment. However, it should be noted that the portion of the catchment upstream of the dam (56.8km^2) forms approximately half of the overall catchment (104.1 km^2) discharging to Broad Lough north of Wicklow town. Thus, the runoff contribution from the lower half of the catchment remains flashy and undamped. However, the contribution from the weir overflow/spillway at the reservoir can be significant, albeit delayed and damped by the storage effect of the reservoir. From the historic record, the spillway flows into the Vartry river can be as high as 500 MLD and, in some years, negligible. There is a small but consistent discharge below the spillway weir of 0.5-1.5 MLD arising from spring flows below the dam. The OPW CFRAM (flood risk) study for this area indicated hydrograph rise to peaks (water level rises of more than 1 m) in less than 12 hours in mid catchment (Ashford).

Overall, and from the limited data presented, runoff (flow) at any point in the catchment below the dam is roughly proportional to the contributing catchment area. This assumption is partly the basis of the calculated flow duration curves presented by IW (Prof. Bruen's evidence).

At the discharge end of the catchment, at Broad Lough, it should be noted that the Vartry is not the only contributing river. Other tributaries, particularly to the south, give an area of 148 km^2 as the total contributing catchment to Broad Lough, ie nearly 3 times the area of the Vartry impounded catchment. Thus small changes (reduction) in the current mean compensation flows of the order of 5 MLD will have negligible impact on salinity levels in Broad Lough when the mean flow from the Vartry alone is estimated to be of the order of 80+ MLD and from all the contributing area, at least 50% greater.

DATA

In a very responsive hydrological regime such as the Vartry river, spot measurements of discharge/flow are difficult to interpret in a regional context, as the flows change so rapidly. The only semi-continuous flow record (apart from the flows from the WTP weir and from the spillway weir) is from a gauging station in Devil's Glen run by the ESB from 1952 to 1979 (with gaps). The paucity of flow data anywhere on the Vartry downstream from the dam is very surprising, given the nature of the impounded catchment, the change in 'leakage' regime in 2007 in the face of a needed WTP upgrade, the occasional flooding downstream (eg Ashford), and the needs of the Water Framework Directive since 2000. 21 spot measurements at each of 6 points along the river between the dam and Broad Lough by IW (Capital Water) in 2017 is hardly enough to characterize such a flashy flow regime when assessing impact of a proposed change in WTP discharge.

In July 2016, IW commissioned a hydrometric survey (by Capital Water) of flows in the Vartry at the WTP site over 29 days. Daily measurements of flow were made from the interceptor channel which takes surface water drainage and process pond water flows discharging to the river. Also, corresponding daily measurements were made of river flow downstream of the WTP leakage discharge (but upstream of the interceptor culvert). The mean flow from the interceptor channel was 0.43 MLD and in the river upstream was 15.1 MLD. The value of these data is marginal in terms of estimating WTP leakage discharges as no account was made of any included spillway flows (Luke Drea reported an estimate of spillway flows six weeks later of 4.75 MLD). Moreover, there was no evidence in the data of pumping back which had apparently started on 5th July as reported by IW (J. Oliver evidence). The utility of such short surveys is limited anyway, as they have little value in characterizing a long term hydrological regime. Little was made of these data either by IW in the response to a request for further information.

The reported long historical record, from 1989, of flows to the Vartry river from the WTP and spillway remains as invaluable evidence, but the lack of useable data for 2016, during the 'leakage regime', is surprising and, consequently, of unknown significance. Data were presented by an appellant (Luke Drea) from spot gauging in the river at the WTP site and at two points (Annagolen Bridge and Newrath Bridge) downstream on 8th September 2016, although unsupported by evidence of source or

methodology. These reported flow measurements followed a particularly dry period (little rainfall at Vartry in August and one event of 24.1mm in early September), which raises unexplained questions as to the validity of the reported spillway flow of 4.75 MLD and an apparent WTP discharge of 10.3 MLD during a reported period of WTP 'back pumping' (J. Oliver : IW evidence). In spite of these reservations, the usefulness of such spot gaugings in a flashy hydrological regime remains, unfortunately, limited as ecological impact or status is necessarily better related to the *duration and frequency* of flows.

Nevertheless, useful insight into the hydrological regime was gained (by the applicant) through the analysis of the data that were available, although there inevitably remains significant uncertainty in the relevant predictions.

In summary, the longstanding impoundment of the Vartry river, represented by the dam and WTP, has been accompanied by an irregular but consistent *mean* discharge to the downstream catchment of 4.6MLD, exclusive of any spillway overflows (although measurements were only shown for 18 years by IW since 1989). Since 2007, for the subsequent 10 years, the unplanned but net leakage discharge to the downstream catchment has increased to a *mean* rate of 10.5 MLD. The applicant is now proposing to substitute a *steady* discharge to the river from the reservoir of 5MLD in place of the original, unsteady and irregular mean flow of 4.6 MLD. Thus, the applicant has based their assessment of the environmental impact of the WTP upgrade on changes to the river regime from that prevailing *before* the unplanned leakages which started in 2007. The applicant's contention is that the normal, 'reference' condition for the river is that prevailing before the increased leakage from the WTP began. Most of the appellants, however, have implicitly taken the *new* regime, since 2007, as the one against which the effects of the plant upgrade should be assessed (and for which a full EIS was demanded). Unfortunately, there was little hard evidence presented (flow and ecological data) on which to determine whether the environmental state of the river has, in fact, significantly changed since 2007, under the increased leakage regime.
Irrespective of the current or past hydro-ecological state of the river, however, there is an imperative under the EU Water Framework Directive (2000) to determine an appropriate level of compensation water flow in what is now, and has been, a 'Heavily Modified Water Body' (ie a permanently impounded catchment).

EVIDENCE FOR HYDROLOGICAL IMPACT OF PROPOSED WTP DISCHARGE

The Vartry as an upland river is very 'flashy' so the *mean daily flow* of a very irregular flow regime can be misleading as a characterizing parameter, particularly for ecological conditions. As pointed out by McGarrigle (for IW), it is a 'spate flow' regime which has a rising flow to peak discharge, in response to a rainfall event, measured in hours This responsiveness makes daily (and particularly spot) flow values give a

somewhat distorted, damped picture as far as relevant statistics describing the regime are concerned. Although the *mean* flow to the river is to be effectively depleted by a mean 5 MLD (compared to 2007-2015 figures), the actual flow change and its proportional impact at any location, on any given day will be highly variable and thus, its significance may also be highly variable.
Because of the way these statistics were originally presented by IW, there was also a perception by the appellants that flows at downstream locations could be depleted by significant amounts (eg from quoted spot values of 15 MLD down to 5 MLD) and hence their concern. This perception did not take account of the role of the flow contribution from the intervening sub-catchments downstream of the dam (see Flow Chart attached). The lack of hydrological data on the river since 1979 did little to alleviate these concerns.

Justification of the choice of 5 MLD as compensation flow

Notwithstanding these caveats, there was little evidence presented by IW to justify the choice of a steady 5 MLD as the new discharge to the river from the WTP. An earlier proposal by IW to discharge process water from the new plant to the river initiated a determination of 'Dry Weather Flow' (DWF) which is taken as the annual minimum daily flow in the river with a return period of 50 years (q_{50}). Although, the proposal to discharge process water to the river was abandoned for the current scheme, DWF appears to be the basis of the 5 MLD. It may be coincidence that this roughly equates to the historical WTP discharge (since 1989) to the river of 4.6 MLD.
Another recognized low flow statistic in hydrology is the 95 percentile (95%ile :Q_{95}) flow which is the flow exceeded 95 percent of the time, as determined from a daily flow record. It is usually taken as approximately twice the DWF.

As there is no flow record for the flow in the Vartry river immediately downstream of the WTP, and the natural (ie un-impounded) catchment flows anyway are distorted by the presence of the dam and WTP, resort has to be made to empirical methods for 'ungauged catchments'. Using a method/model devised by Cunnane and Martin (1977) for Irish catchments, the Q_{95} for the dam site is estimated to be 0.8 MLD. IW (Prof. Bruen), in the absence of local data from the river at the dam site, used a reconstructed daily flow data series for Devil's Glen downstream, based on the intermittent water level data from the historical ESB gauging station (1952-1979). The catchment area at Devil's Glen is 30% larger than the catchment behind the dam and the data record includes unknown discharge flows from the WTP site. Nevertheless, the Q_{95} from the flow duration record at Devil's Glen is approximately 3.8 MLD. Allowing for the extra area of the intervening catchment, this translates into an estimated 2.9 MLD for the dam site, below the WTP. Notwithstanding the probably small discharges from the WTP during low flow periods, and the resolution of the different estimation techniques involved, these evaluations of Q_{95} (0.8 and 2.9 MLD) are of similar order. They help to indicate that the proposed steady discharges from the upgraded WTP (5 MLD) represent an improvement on the *natural* historical dry weather flows that might have occurred in the upper part of an un-impounded Vartry

river, below the WTP site. These estimates of Q_{95} flow also happen to be consistent with the measured mean flow of 4.6 MLD released from the WTP from 1989 to 2007, although perhaps not by design.

Flow Duration Curves

One of the hydrological methods for determining flows for sustainable ecology in rivers ('ecoflows') is accepted as the flow-duration curve, indicating the expected duration (% of time) for different levels of discharge in the river (in m^3/s or MLD). Certain levels, such as Q_{95} for low flows and Q_{40} for migrating fish, have been established as guides for ecological criteria. IW (Prof Bruen) has used the Flow Duration Curve (FDC) as an indicator of likely changes in the hydro-ecological regime resulting from the effects of the proposed WTP. However, given that the only river flow data available (for a limited period at Devil's Glen) was prior to 2007 (and before the current leakage started), the only FDC based on observed data that could be constructed was for the Devil's Glen flows which included any discharges at the time from the WTP. Comparison was then made between this FDC and an FDC estimated from hydrological modelling but including the proposed new regime of a steady 5 MLD from the WTP. This comparison of FDCs was undertaken using established numerical models (Mandel, UCG, 2011 and EPA's HYDROTOOL) to predict the 'natural' FDC from the various sub-catchments (exclusive of the dam) and then adding the proposed steady 5 MLD to determine the changed FDC. The only 'observed' frequency duration curve was for Devil's Glen but modelled predictions of regime change were also undertaken for 4 other locations (Annagolen Bridge, Nuns' Cross Bridge, Ashford and Newrath Bridge). Thus, the proposed hydrological regime was compared to conditions that were estimated to prevail before 2007 when the increased leakage began.

Notwithstanding the lack of comparison with conditions over the last 10 years, the applicant's analysis did establish some likely key effects from the proposed scheme.

- The steady discharge of 5MLD will slightly improve low flow conditions over the historical situation before 2007
- The proposed 5 MLD WTP discharge can be justified on the basis of natural dry weather flows.
- The new minimum flow of 5 MLD is probably slightly above the likely natural DWF/Q_{95} that might have prevailed in the natural catchment at the dam site.
- The effect of the steady 5MLD discharge (and thereby a mean decrease of ~ 5MLD on current conditions) diminishes downstream in proportion to the additional area of the tributary catchments.

This analysis is somewhat idealistic, and probably conservative, in the sense that a number of conditions in the catchment were not included such as the abstraction at Annagolen Bridge, the effect of spillway flows (except at Devil's Glen) and the influence of discharges from the interceptor channel below the WTP.

CHANGES FROM THE *CURRENT* REGIME

The current, increased leakage from the WTP site of 10.5 MLD (mean) which has lasted for approximately 10 years is perceived by the appellants to have significantly changed the eco-flow regime of the river downstream. The hard evidence for this is scarce, given the lack of hydrological data below the WTP site over this period. The only available data is from the sets of flow gaugings made on the Vartry at 6 separate points on each of 21 days between 13th January and 2nd June 2017. Flow measurements were made upstream and downstream of the WTP discharge (so that the net release from the WTP could be determined), at Annagolen Bridge, Nun's Cross Bridge, Ashford and Newrath Bridge (Figure 1). From these data, the mean discharge to the river from the WTP in 2017 was 7.0 MLD during this period. Based on data given in evidence by IW, a plot of these data is drawn in Figure 2 to show the difference with the flows that would have occurred under the proposed regime at Annagolen Bridge.
As stated by IW, the relative contribution to the river flow made by the flow from the WTP decreases downstream but is at its most acute at Annagolen Bridge (whose natural sub-catchment is only 7.6 km^2).

The lowest recorded flows (10th May 2017) indicate that the WTP discharge forms 89% of the flow at Annagolen Bridge (9.6 MLD) which would increase to 91% under the new regime (5.5MLD). On the same day, downstream, the proportion of the flow at Newrath embodied 28% from the WTP which would become 18.5% under the change. At Annagolen Bridge, this reduction in flow amounts to a change in water level of approximately 50mm, (based on the rating given by Capital Water) whereas at Newrath it amounts to a change of only 6mm.

However, the *natural* median flows (Q_{50})as modelled by IW, coupled with the WTP discharges, would likely decrease by 23% at Annagolen Bridge (22MLD to 17 MLD, equivalent to 20mm change in water level) and 7% at Newrath under the new regime compared to current leakage conditions but *not* taking into account any contribution from spillway overflow.
In summary, compared to the *current* leakage regime,

- The new steady discharge from the WTP of 5 MLD would decrease current hydrological conditions in the upper part of the river, above Devil's Glen particularly in terms of low flows. This was acknowledged by the applicants following a direct question.
- The flows in the catchment as a whole would show a small decline in FDC but a relatively small magnitude in terms of water levels, especially in the lower reaches. Estimates of absolute changes were not provided by the applicant.

- From the evidence presented at the hearing, assessing the current regime has many additional complicating factors which will affect the levels and/or flows seen at any one point on the river : these include spillway flows which are highly variable (and often absent) but have a mean of the order of 20 MLD; spring flow leakage in the spillway channel (~ 1MLD); abstraction at Annagolen Bridge which is said to be ~ 1-1.5 MLD; discharges from the interceptor channel downstream of the WTP (not gauged, except for July 2016) but currently probably <1 MLD); wastewater effluent discharges from Ashford until 2009; constrictions such as culverts, broken weirs and other channel modifications downstream.
- Nevertheless, in the light of lack of direct evidence from the applicant to the contrary, the above analysis is likely to be conservative.
- To reiterate, the applicant is minded only to look at changes with respect to the 'old' hydrological regime, ie before 2007 while the appellants were focused on possible detrimental changes to the regime that developed since 2007, under increased leakage from the WTP.

ECOLOGICAL EVIDENCE

Assessing the ecological health of the river downstream of the dam can be divided between criteria affecting the macroinvertebrate fauna and the fish population. McGarrigle for IW set out the records of the assessment of ecological status based on four separate subcatchments below the dam (as reproduced in Figure 1). Based mainly on hydro-chemistry, hydromorphology and macroinvertebrate sampling, for variable periods since 1971, the river was reported as having generally maintained its good to high status (as defined more recently under the Water Framework Directive). Fish were only included for the sampling on the lower reaches of the river, below Ashford, since 2007. Although generally in good status during this period, the river was reported as having sustained impact from fish kills (2012 and 2017, downstream of the dam) and from wastewater effluent discharges from Ashford (2000-2009) which affected the lower reaches around Newrath Bridge. Nevertheless, the affected reaches of the river appear to have recovered their good ecological status relatively quickly. More importantly, there was no apparent effect on the reported ecological status of the river at various locations which could be attributed to the change in discharge regime from the WTP which began in 2007. No hard evidence was offered by the appellants in this regard.

Concerns relating to impacts on fish concentrated on migratory species, as the Vartry is a designated salmonid river. However, upstream migration is limited by the presence of Devil's Glen waterfall. The catchment area below Devil's Glen represents 63% of the overall catchment below the dam although the spate flows at and just below Devil's Glen rely largely on spillway overflow from the reservoir. This implies that small changes in mean flow from the WTP are likely to have a proportionately small effect

on these flows in reaches below Devil's Glen, as the flow from intervening tributaries increases with catchment area. Spawning areas were reported as being around Nun's Cross Bridge where water level is as critical as flow. Using data from IW (Capital Water survey) during a low flow period (10th May 2017), the discharge from the WTP was 8.53 MLD which would be reduced to 5 MLD under the proposed regime. From the rating curve at Nuns' Cross Bridge, this would result in a water level reduction of 30mm in the vicinity of the spawning beds, although the actual water depth at the time is unknown.

In short, compared to the current leakage regime, there will be a reduction in flow/water level (but for limited periods given the flashy nature of the catchment), particularly in the reaches closest to the dam.

O'Farrell's (IW) evidence was that, based on observation on a day when discharge from the plant was only 4 MLD, observed water levels were 'adequate for upland fish' (ie above Devil's Glen) but that the adequacy of flow in the spawning areas could be defined by the frequency-duration curve. As modelled at Nun's Cross Bridge (by Prof. Bruen), the low flow criterion of Q_{95} (ie the flow exceeded 95% of the time), as advocated by O'Farrell, was predicted as approximately 9 MLD under the proposed regime of 5 MLD from the WTP. Although this does not take account of any flow from the spillway/leakage, the rating indicates that this still represents a very low water level at Nun's Cross Bridge. Nevertheless, this is likely to have been the minimum situation under the original flow regime from the dam up until 2007. The critical data on fish populations during this period, however, is absent as it appears no surveillance monitoring was undertaken before 2008. Ideally, as agreed by both experts for the appellants and applicant, a 'wetted habitat' survey should form the basis of determination of minimum flows for fish-related habitats.

Fish (salmon) populations have not yet reached the conservation limit (CL) in the lower Vartry and hence fishing has been suspended since 2007. Nevertheless, as reported by O'Farrell and not disputed by the appellants, the fish populations (salmon, brown trout, eel and sea trout) based on electro-fishing sampling at Newrath Bridge in 20013, 2014 and 2015 have shown a steady increase in numbers although the timing and sampling methodology were criticised in his evidence. Thus under the leakage regime, fish populations have been at least relatively stable since 2008 and, indeed, may have improved, apart from the occasions of fish kills.

While the long term flows in the impounded Vartry may have had an effect on reducing habitat from its original, 'natural' condition, there are many additional factors common to other salmonid rivers in the country that are having an impact on relevant fish populations.

Finally, the ecological health of the river and sustainability of the migratory fish population also depend on the 'spate nature' of the flows. These are driven by rainfall on a catchment of steep gradient and low baseflow, such as the Vartry. These conditions became established over the last 150 years through spillway flows and the flashy runoff from the sub-catchments below the dam – and would not be altered by the change in the low flow regime as dictated by the proposed steady discharge of 5 MLD from the reservoir.

The IFI, as an appellant, recorded its concern that the proposed WTP upgrade would result in 'hydrological change' which *could* affect the sustainability of the fish population in the Lower Vartry. While no specific concerns were offered, it was suggested that an EIS should be undertaken and preferably a 'wetted habitat' survey be carried out to determine the ideal flows for sustainability. Nevertheless, fishery surveillance surveying and sampling is being continued at least annually on the Vartry meanwhile.

In summary,

- The ecological status of the river downstream of the dam, in terms of its macroinvertebrate fauna, has been relatively stable for over 40 years at good to high status, as defined by the Q-rating and used under the Water Framework Directive.
- There was no evidence presented as to any change or improvement in the ecological condition resulting from the increased hydrological regime which began in 2007.
- Although there are many other factors affecting the river's ecology, the proposed change in the hydrological regime, involving a steady discharge of 5 MLD to the river, was unlikely to change the present good-high status.
- Although the Vartry is a designated salmonid river, there was a lack of baseline surveillance data on fish populations before 2007.
- Sampling from 2013 has indicated an improvement in fish populations (salmon, trout and eel) although the sampling techniques were criticized by the applicant.
- Reliance was therefore placed on the adequacy of the proposed hydrological regime (as modelled) to sustain the current fish populations.
- Based on a few recent flow gaugings, there remains doubt as to the adequacy of water levels (under the proposed regime) in the reaches immediately below Devil's Glen to fully support the spawning habitat, although the *flows* would be adequate to support migration.
- Ideally, a 'wetted habitat' survey is required to determine the hydrological regime (which would include spate flows) appropriate to the needs of the sustainable fish population, given the impounded character of the catchment.

WATER FRAMEWORK DIRECTIVE

The hydrological consequence of the proposed WTP upgrade will be, effectively, to revert to the regime in the river that prevailed before 2007, albeit with a steady discharge from the WTP of 5 MLD (as opposed to a more variable historical discharge of *mean* 4.6 MLD). Control of the flow in the river downstream was effectively ceded to the water management authority of the time by legal Act of the 1860s. Leakage and discharge of process water from the maintenance of the sand filters produced this

variable historical flow to the river, albeit this was distinct from the leakage and episodic overflow from the reservoir spillway. There was no legal requirement to discharge this water from the WTP although this flow was also supplemented by an adjacent interceptor flow from the sludge ponds for which there now exists a discharge licence. The additional leakage flow to the river since 2007 was effectively unintended but over the last 10 years has become an inadvertent but established part of the river regime. This additional flow has been very irregular in magnitude and timing, amounting to an *additional* mean flow of approximately 5 MLD but affected by requirements to pump back leakage flows in times of drought.

The advent of the EU Water Framework Directive (WFD) in 2000 and implemented in Ireland since then, has, however, imposed new conditions on maintaining the ecological health of water bodies. The River Vartry is part of Hydrometric Area 10 and is in the Eastern River Basin District (EBRD) in the context of WFD management. As an impounded catchment, it is classified as being 'at risk' in the Characterization Report for the WFD (2005) since it has an existing and established abstraction of water for transfer outside the catchment. While there is no requirement to change that situation, it is consequently ranked as a Heavily Modified Water Body for which the requirements are to establish and maintain at least 'Good Status' in terms of ecological criteria. That remains the published objective for the management of the catchment in the EBRD.

Under the characterization study also, the lower reach of the Vartry below Ashford has been classified as '*probably at risk*' in terms of water quality but this status is probably related to the nitrate vulnerable lower catchment (due to agriculture) and not related to Vartry flows up stream. Overall, the latest WFD status report for the EBRD (in *EBRD River Basin Management Plan 2009-2015, CDM/Dublin City Council 2010)* shows the river as a whole (surface water body) as having 'Good Status', as re-iterated by the applicant. Based on the ecological Q-rating system, it is widely acknowledged that discriminating between levels 4 and 5 can be difficult, hence the frequent use of the category '4-5'. Indeed, the Strategic Environmental Assessment for the EBRD shows the bulk of the Vartry above Ashford as having Good-High status.

However, Dublin City Council in their report on *Strategic Environmental Assessment (SEA) for the WFD River Basin Management Plans and Programmes of Measures (POMs) for the Eastern River Basin District* (2009) lists 'Measures for Abstractions' to be undertaken which include the 'examination of compensation requirements on regulated rivers' so as to maintain 'minimum flow or flow variability, where applicable', and 'to maintain good hydrological status and support ecology'. While the report lists the Vartry as an impounded river, the link to this requirement 'to examine compensation flows' is implied, although the Vartry is recognized as a major water supply source in the region.

The planning application for the WTP plant upgrade did address the needs of the WFD in terms of assessing ecological status from available data and reports. However, it appears that such WFD requirements were seen almost as a fortuitous outcome of the hydrological situation rather than as a result of a commitment to determine an appropriate level of compensation flow (as the latter was perceived as not being legally required). Nevertheless, it is likely, given the salmonid designation of the river and its connection to an SAC, that, in due course, there will be a requirement to determine an appropriate, variable compensation flow regime (ie not just a steady flow).

SPILLWAY

Part of the planning application is for regrading and deepening the first 170 m of the spillway channel immediately downstream of the spillway weir on the reservoir. Virtually no evidence was given (written or oral) as to the justification for this construction other than to indicate that it was requested as the result of a 'Panel 1' Reservoir Engineer's inspection and the calculation of a 'Probable Maximum Flood'. No details of this request or determination was provided although the result is direction to improve the spillway channel by lowering (excavating the rock) the channel, above the existing water fall (see attached photographs), at the downstream end by as much as 3 m. This channel improvement is to enable supercritical flow over the reach and thereby increase the minimum capacity of the channel to 160 m^3/sec (=13,800 MLD). Given that the historical maximum spillway flow over the last 150 years is recorded as approximately 500 MLD, the purpose of this re-construction remains somewhat obscure, especially when considering that it will merely serve also to accelerate the considerable flood that will occur downstream in the catchment upon the delivery of this level of flow!

Of more immediate concern is the observation that there is a small residual flow in the spillway (exclusive of the spillway weir overflow) which appears to originate partly along the side of the channel to be excavated and to arise from spring flow emerging from rock fractures. While this flow is small (0.5 – 1.5 MLD?), the lowering of the channel bed may well increase this spring flow by effectively increasing the driving head. It may not be significant but should be closely monitored during and after construction as the flows may originate close to the dam itself.

CONCLUSIONS :

- The Vartry Reservoir is an impounded river occupying approximately half of the total catchment area discharging into Broad Lough north of Wicklow town.

- The present Water Treatment Plant utilizing slow sand filters has been operating for over 150 years and, since 1989, abstracting an average of 83 million litres per day (MLD).
- Of that abstraction, irregular discharge of process and maintenance water to the river has been recorded at an average of 4.6 MLD
- Since 2007, irregular and variable discharge to the river from the WTP has risen to a mean of 10.5 MLD as a result of unintended leakage from reconstructed sand filters.
- The application is for an upgraded WTP which will result in a change in the discharge to the river to a steady 5 MLD and a sustainable yield to water supply of 75 MLD making the maximum level of abstraction from the reservoir of 80 MLD.
- Irish Water (IW) are maintaining that their overall level of abstraction is unchanged from historical precedent and that the proposed discharge to the river of a *steady* ('guaranteed') 5 MLD is an improvement on the regime before 2007 and is more than sufficient to maintain the ecology of the river downstream.
- The appellants are concerned that the new regime will be significantly different from that which has become established over the 10 years since 2007 and therefore requires a more detailed impact assessment than IW has provided.
- The one key characteristic of the various analyses undertaken by the parties to this application, contributing to the significant uncertainties involved, is the lack of hard hydrological data – extraordinary, given the importance of the water source, the salmonid designation of the river and interests of the various riparian parties concerned. IW have contributed to this uncertainty through confusing, and sometimes contradictory and non-specific data (eg virtually none at all for 2016).
- While the new hydrological regime will differ from that of the last 10 years, particularly at lower flows in the upper part of the catchment above Devil's Glen, the degree of change is likely to be less than appellants apparently perceive. Nevertheless, it is likely be a slight improvement on the historical regime before 2007, in terms of flow and water levels at most points in the catchment.
- The new regime, nevertheless, based on the limited available data will *probably* be enough to maintain the 'good' ecological status as historically established insofar as it is known, particularly for macroinvertebrate fauna, although it is less certain for fish populations as there are no historical data before 2007.
- There are many extraneous factors affecting the flow in the river at various locations within the catchment and that have mostly not been taken into account in the assessments of regime change. These factors include the discharge from the interceptor channel (~1 MLD), the apparent abstraction for water supply at Annagolen Bridge (1 -1.5 MLD), part-time discharge of wastewater treatment effluent to the river below Ashford until 2009, and the residual flows in the spillway channel (~ 1MLD) apart from the contributions from the spillway

overflows (which will mostly affect higher river flows depending on the lag time introduced by the reservoir).

- The Water Framework Directive (WFD), as recognized in the Strategic Environmental Assessment (SEA) of the River Basin District Management Plans (Vartry is in the Eastern RBD), demands a specific assessment of the appropriate level of (variable) compensation water in impounded catchments such as the Vartry – in due course.
- While there is, as yet, no consensus on how ecoflows should be determined, and while, on 'balance of probabilities', the proposed hydrological regime is likely to be sufficient to maintain the good ecological status of the river, the applicant should be prepared to accept that the regime may have to change in future, under the strictures of the WFD. The proposed steady 5 MLD discharge can be interpreted as a 'building block' in any future determination of ecoflows.
- Hydrological monitoring is required to be initiated as soon as possible to provide support for the ongoing hydroecological assessment that will be required a) to justify the proposed new regime and b) to support any future requirement for determination of appropriate compensation flows (notwithstanding the historical legal position in respect of the Vartry catchment)
- Residual spillway flows arising from springs may increase as a result of the proposed regrading of the channel – and should be monitored and particularly in terms of dam safety.
- The changes in the hydrological regime will mostly affect only low flows but with decreasing impact downstream, particularly below Devil's Glen. In this context, there will be no significant impact on current salinity levels and the associated ecology at Broad Lough.

RECOMMENDATION AND CONDITIONS

In terms of hydrological issues, and in the light of the evidence presented before and during the oral hearing, planning permission may be granted for the upgrade to the WTP at Vartry but, it is suggested, subject to, and contingent upon, the following conditions:

- As proposed, the discharge of raw, natural water from the reservoir to the Vartry River via the remaining sand filters at the plant site should be a minimum of 5MLD as a steady flow. Reason : to maintain the downstream hydro-ecological status of the river.

- The branch pipework which is proposed to deliver the discharge to the Vartry River from the reservoir (via the remaining sand filters) should have a capacity of at least 15MLD, to allow for any future change that may be required in

compensation flow including the possible need for the delivery of episodic environmental flows. The remaining sand filters which will route the flow to the river will have more than enough capacity to accommodate any additional flow. The valve controlling the flow on the branch pipework should be able to be remotely controlled, also to allow for variability in discharge, should it be required.
This control is envisaged as a contingency measure also. As Mr Weiss (appellant) suggested at the hearing, much reduced flow through the sand filters, as is envisaged by the new regime, could cause flow and quality management problems and the presence of an effective valve mechanism would allow control of direct discharge to the river, should it be necessary.

- A water level and flow (hydrometric) gauging station to be established *immediately* in the Vartry river on-site, but downstream of the discharge culvert. Such station should be permanently established with a fixed structure such as a flat-V weir in order to accurately measure (and record) in real time the combined flows from the WTP discharge and the spillway channel. The existing weir in the discharge chamber to be calibrated (it was replaced in 2007) and its performance evaluated, to allow an evaluation of uncertainty in the flows to be determined. The measurements of flow in the Vartry river adjacent to the plant site made by Capital Water have suffered from the significant uncertainty at low flows – which needs to be addressed by a standard gauging structure, built and run by IW. Reason : to allow precise determination of the releases and discharges to the Vartry River from the new plant and the reservoir, in support of maintaining good ecological status downstream, as required under the WFD.

- A second hydrometric station should be established further down the catchment, probably in collaboration/cooperation with the EPA as the relevant government agency. Again, it should be a permanent structure, such as a flat V weir, but which would not impede fish migration. Ideally, it would be located in Devil's Glen near the site of the earlier historical record but local conditions may require a site further downstream, such as Nuns' Cross Bridge. The station would provide much needed hydrological data in support of determinations of ecological status and assessment of the relative contributions of the sub-catchments downstream of the dam in a 'heavily modified catchment (WFD). It would also allow assessment of the actual changes in hydrological regime as experienced by riparian landowners.
  This station should be able to record water levels in real time but not necessarily remotely interrogated.

- In the interim period, during construction of the new plant (understood to be ~3 years), flow monitoring should be continued, not only beside the plant but at least at one other location in mid-catchment (eg Nun's Cross Bridge) as used

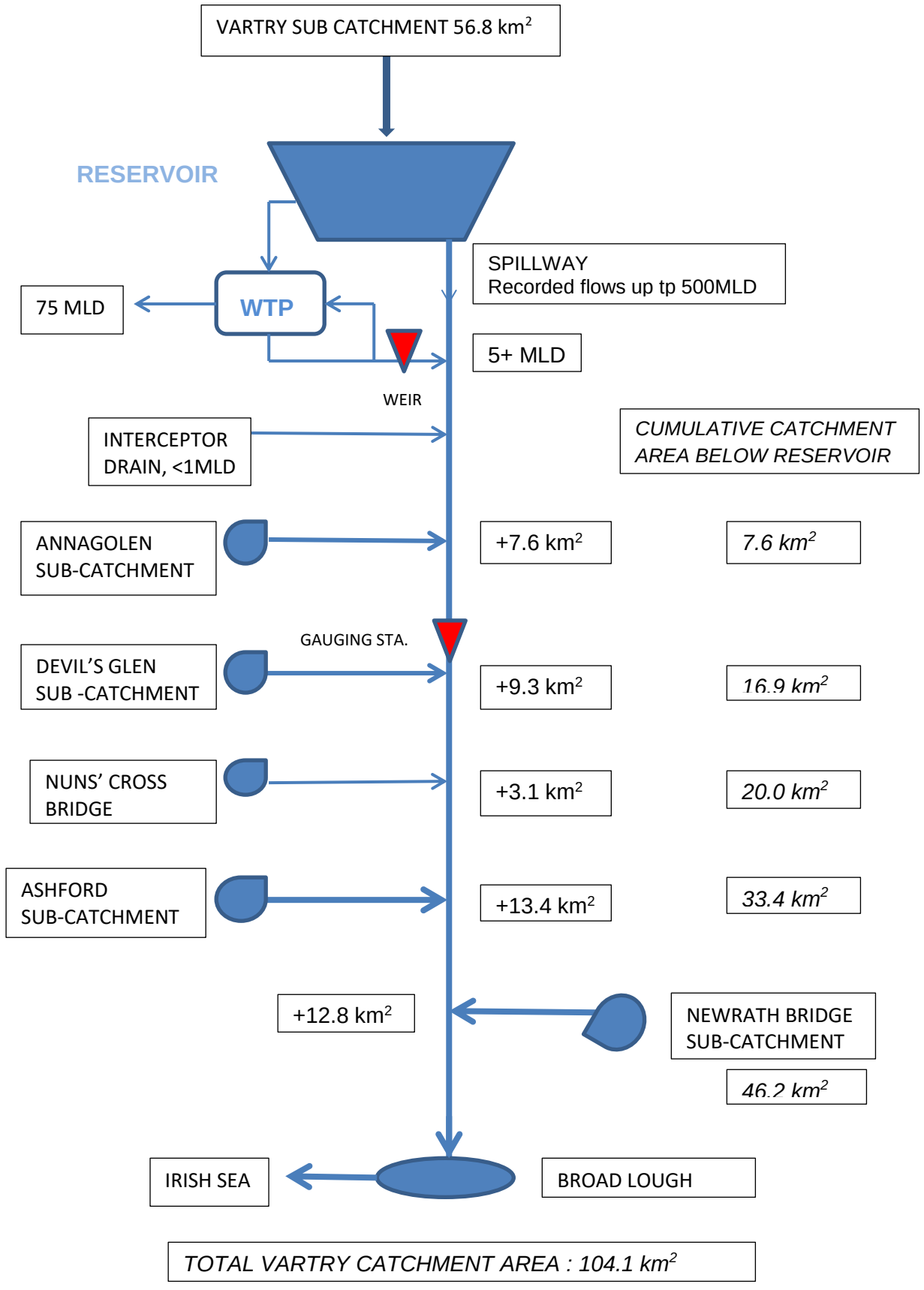
by Capital Water. Reason : to properly establish baseline hydrological information from which to assess future impact of the new plant.

- The chemical dosing station currently located adjacent to the river (and responsible for at least one leak into the river) be re-located into the new plant compound with appropriate bunding and containment. This re-location is for security of the river quality and to reduce the risks of spillage.

- It is assumed (rather than as a condition) that the Annagolen abstraction will cease when the new plant is commissioned. It is also assumed that the interceptor channel will remain but cease to function as a discharge point for sludge pond/process water when the new plant starts to operate and that the current discharge licence will be extinguished.

Paul Johnston
15 July 2017; revised 7 August 2017

FIG.1 : THE VARTRY RIVER CATCHMENT AND SUB-CATCHMENTS (EPA) AMENDED TO INDICATE GAUGING AND SAMPLING POINTS USED BY THE APPLICANTS. NOTE VARTRY RESERVOIR SUB-CATCHMENT IS APPROXIMATELY 50% OF THE TOTAL CATCHMENT AREA.



FLOW CHART FOR THE VARTRY RIVER CATCHMENT

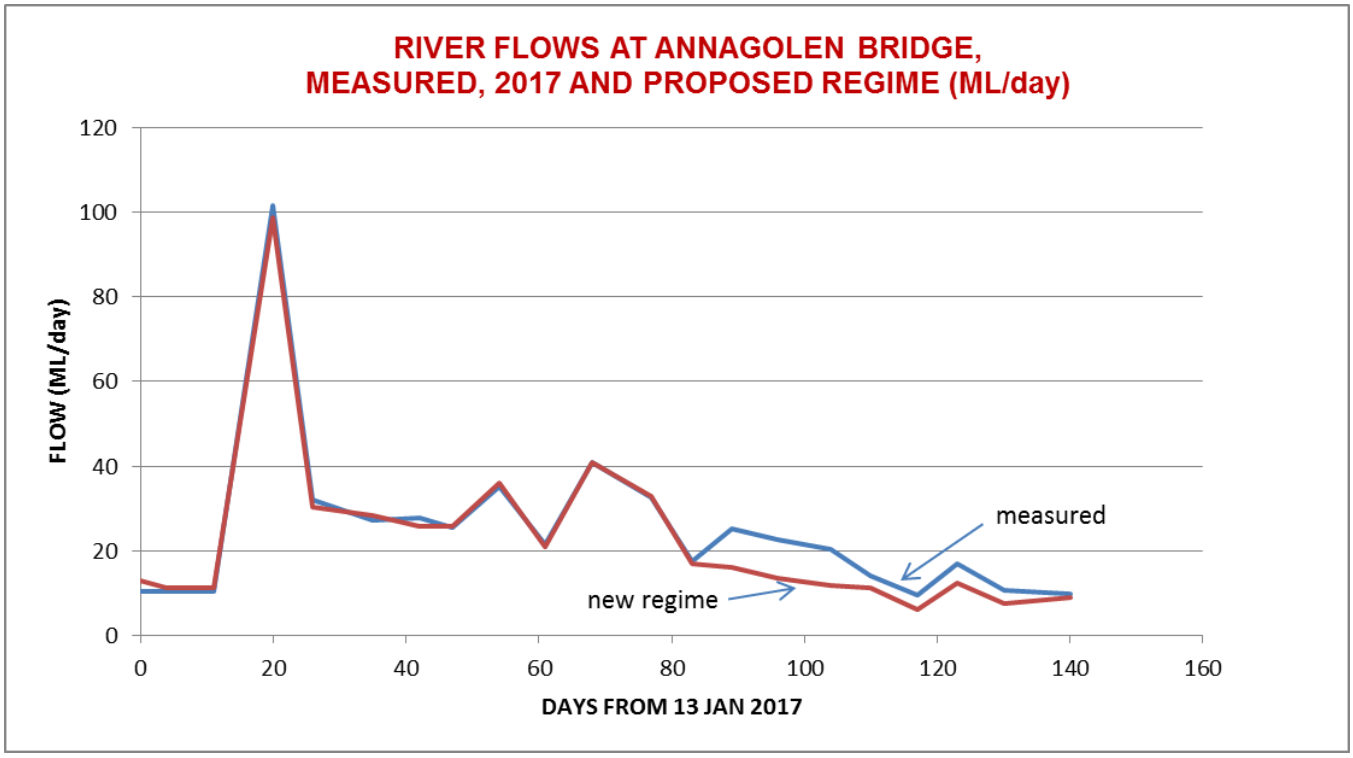


FIG. 2 : 21 MEASUREMENTS OF FLOW IN THE VARTRY RIVER (13 Jan to 2 June 2017) AT ANNAGOLEN BRIDGE BY IRISH WATER (CAPITAL WATER) COMPARED TO THE FLOWS LIKELY TO HAVE OCCURRED UNDER THE PROPOSED NEW REGIME (graph based on evidence presented at oral hearing)

VARTRY RESERVOIR

EXISTING SPILLWAY CHANNEL DOWNSTREAM OF OVERFLOW WEIR

(TO BE REGRADED AND LOWERED BY UP TO 3m)

Looking downstream along channel to be regraded

Looking upstream to waterfall, limit of proposed regrading

Photographs taken 2nd June 2017

EXISTING DISCHARGE FROM WATER TREATMENT WORKS TO RIVER VARTRY. (DISCHARGE ROUTE TO BE MAINTAINED)

MEASURED FLOW FROM WTP HERE ON
2nd JUNE 2017 : 5.7 MLD

PROPOSED HYDROMETRIC STATION TO BE LOCATED JUST DOWNSTREAM OF THIS DISCHARGE, INSIDE THE SITE