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31 Jul 2024

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cc: Josh Carlon (IMCEFT)

From: Will Minchin

Dendrobium Mine: Briefing Paper on surface water flow monitoring

Your Ref: IMC request 07/03/2024 & NRAR Ref: 739-2018 (30/06/23) Our Ref: IMC114–M059d

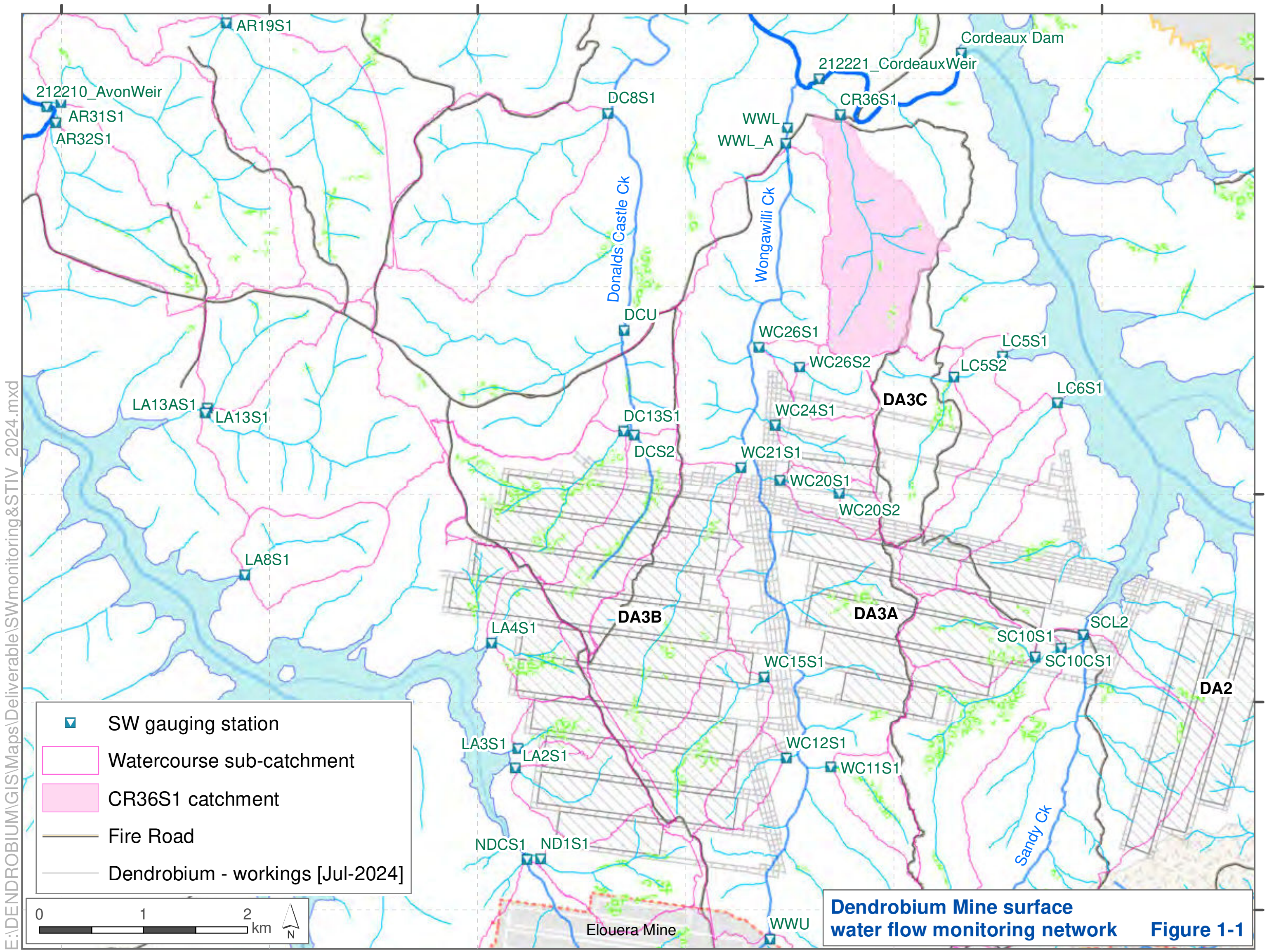
1 Introduction

In 2023 Illawarra Coal Holdings Pty Ltd (IC) entered into an enforceable undertaking (EU) with the New South Wales Natural Resources Access Regulator (NRAR) following NRAR's investigation into the Dendrobium Coal Mine's water take and water licencing arrangements.

As part of this EU, IC agreed to implement various activities at the mine in order to regularise and improve operations and ensure compliance with the *Water Management Act 2000.* This document outlines the actions taken thus far to address certain undertakings (related to hydrology) agreed to with NRAR:

Table 1-1 Undertakings addressed in this document

Item	Detail of Undertaking	Addressed?
4.17.	IC undertakes to provide NRAR publicly available briefing papers with a focus on technology and practices that could lead to improvements in water monitoring in the mining industry and achieve better industry regulation. The briefing papers may consider and report on the following:	
	a) measured and modelled surface water losses;	"Measured" losses in **Section 2.** See response to item 4.20
	b) investigation of technologies and techniques that could lead to improvements in surface water monitoring in the mining industry;	**Section 3.1 and Appendix A**
	c) the alignment of proposed technology with water reporting in mining;	**Section 3.2.**
	d) the progress and outcomes of any technological solution.	**Section 3.1 and Appendix A**
4.18.	IC will provide the briefing papers referred to at 4.17 to NRAR annually within a month of the Commencement Date. The first briefing paper will be provided within a month of the anniversary of the Commencement Date (before 31 July 2024). The briefing papers will be provided until 1 July 2027.	This document is to be submitted to NRAR at the end of July 2024.
4.19.	IC will make the briefing papers publicly accessible, with publication of the briefing papers on its website within 30 days of provision to NRAR (e.g. by 31 Aug 2024 if provided to NRAR on 31 July 2024).	This document will be available on the IMC website within 30 days.
4.20	IC commits to reviewing and updating the mine Groundwater Model required under development consent 60-03-2001 to improve surface water loss estimates from the Dendrobium Coal Mine based on improved stream flow gauging and using emerging technology, in accordance with the timeframes and reporting framework in the methodology set out in Schedule 4 (refer below).	This is addressed in **Section 4.**



Dendrobium Mine surface water flow monitoring network **Figure 1-1**

Created by: WMinchin | Date: 11/07/2024

1.1 Context

At Dendrobium Mine Illawarra Metallurgical Coal (IC) currently operates a significant surface water gauging network, which has expanded over time as mining progresses to new domains. The flow gauging network is shown on **Figure 1-1**. This is complemented by visual or qualitative observations of flow at multiple other sites (where gauging via a weir or flume is not practical or cannot be done without significant disturbance), as well as multiple pools where water levels (not flow) are measured.

2 Analysis of surface water take for 2023-24 (from measured data)

Surface water flow losses for the latest (and current) water year are provided in Section 2.2, noting the limitations documented in Section 2.1.

This estimate, made in late July-2024, uses available flow data from the site to date. For almost all relevant sites, the data provided by ALS (IMC's consultant hydrographers) covers the period July-2023 to approximately 20th or 25th June-2024. That is, approximately 355-360 days data are typically available (97-99% of the water year). This dataset is sufficient to make a reliable estimate of take, however a full dataset to the end of June-2024 is likely to be available in August-2024.

2.1 Limitations

These surface water flow losses are provided, noting the following points:

- Compared to some previous years, there is less missing or unavailable data in the 2023-24 period. More detail on data issues is stated in the following bullet points.
- Site O'Hares Creek at Wedderburn (213200): this is one of the Reference Sites used for analysis, operated by WaterNSW. 37 days of data during May and June-2024 (10% of the water year) is missing. This is unusual for this site. Most of the missing period has been infilled using ALS' flow data from an IMC site that is not mining affected. It is unlikely that any data for this period will be recoverable, given that data from after that period is already available from the WaterNSW data portal.
- DCU: This site, downstream of headwater gauging stations on Donalds Castle Creek, is missing data after 19/04/2024. As such, 72 days (or 20% of the water year) are currently missing. The data is likely available on the logger, but has not been collected as yet (expected in early August).
- LA2: The data from this small sub-catchment near Area 3B is missing data after 24/04/2024. As such, 67 days (or 18% of the water year) are currently missing. The data is likely available on the logger, but has not been collected as yet (expected in early August).
- Site WWL: The battery in the logger at this downstream site on Wongawilli Creek failed on 22/03/24 and was replaced on 19/05/2024 (after a period of catchment closures). This means that 57 days of data were missing. This period was infilled using pro-rated flows from the directly upstream WWL_A site.

2.2 Analysis of surface water take

The estimates of surface water take for the recent water years are tabulated below. The results for water years prior to 2023-24 were supplied previously to NRAR.

The 2023-24 estimates are provided here for the first time (**Table 2-1**), using the same methods as for the preceding water years. These include the more conservative estimates of reservoir loss from the local-scale model for Avon Reservoir. The regional model is calibrated to groundwater levels and mine inflow and watercourse losses, while the local-scale model of the Lake Avon shoreline was developed to inform Dams Safety NSW about seepage from Avon Reservoir.

With respect to Avon Reservoir losses in **Table 2-1**, mining in Area 3B (adjacent to Avon Reservoir) ceased in 2021-22, and recent longwalls (Longwalls 19, 21 and 19A) are more distant (>3 km) from Avon Reservoir. Therefore losses from that reservoir have likely peaked.

A similar local-scale model has been developed for Cordeaux Reservoir adjacent to Dendrobium Area 3C, although at the time of writing the mining in Area 3C is restricted to Longwall 21, which is relatively distant (1.8 km) from the reservoir. Losses related to earlier domains (Areas 1, 2 and 3A) are based on the regional model.

As described elsewhere, wet year losses from creeks are greater than dry year losses because of the increased frequency of water in the creeks that can be lost to drawdown or through fracturing.

Given the record rainfall in 2022 (i.e. the latter half of water year 2021-22 and the first half of water year 2022-23, surface water losses increased in those periods compared to those in previous years, and were also toward the top end of the range stated in the Longwall 18 SMP (Watershed HydroGeo, 2020) assessment (the relevant modelling at the time).

Losses in 2023-24 have declined from the losses that occurred around 2022 (which was a year of record rainfall).

The period February-2023 to March-2024 (13 months) had rainfall that was average to less than average (and less than average across the whole period), and was especially dry in the last 6 months of 2023. This was then followed by 3 months of wetter conditions in April-June 2024. Overall the water year 2023-24 experienced average rainfall, noting that there were few runoff events in the first 9 months of that period. As such, surface water losses related to mining were lower than in the previous 3 water years. Additionally, groundwater level recovery (due to the high rainfall in 2020-22 and recovery period since mining) has seen some baseflow return to some sub-catchments (notably WC21, WC15, SC10).

The Groundwater Assessment (Watershed HydroGeo, 2023) submitted for the Longwall 21A SMP stated:"

"the revised model suggests that Dendrobium Mine could take up to 1008 ML/yr (range **505 to 1,790 ML/yr**) of surface water during the period 2020-2040 and declining thereafter:

- 490 ML/yr (range: 140-820 ML/yr) from the water supply catchments; and
- 520 ML/yr (range 225-980 ML/yr) from Wongawilli and Donalds Castle Creek catchments."

Note that there is uncertainty in these estimates, based on the uncertainty regarding future weather conditions as well as uncertainty in model parameters and mining effects."

Table 2-1 Total surface water losses at Dendrobium Mine for recent water years

Component		2019-20	2020-21	2021-22	2022-23	**2023-24**
Stream losses (scaled)		0.2 to 0.3*	1.8 to 2.3*	3.0 to 3.7*	2.8 to 3.4*	0.8
+		**+**	**+**	**+**	**+**	**+**
Reservoir losses (regional	Avon	0.18	0.18	0.18	0.18	0.18
	Cordeaux	+ 0.14	+ 0.14	+ 0.14	+ 0.14	+ 0.14
	SUM	= 0.32	= 0.32	= 0.32	= 0.32	= 0.32
OR		**OR**	**OR**	**OR**	**OR**	**OR**
Reservoir losses (local-scale model)	Avon	0.52	0.69	0.75	0.75	0.75
	Cordeaux (A3C)	0	0	0	0	0 #
	Cordeaux (1-3A)#	+ 0.14	+ 0.14	+ 0.14	+ 0.14	+ 0.14
	SUM	= 0.66	= 0.83	= 0.89	= 0.89	= 0.89
Total (ML/d)		0.52 to 0.96	2.12 to 3.13	3.32 to 4.6	3.1 to 4.3	**1.1 to 1.7**
Total ML/yr		190 to 350	773 to 1143	1212 to 1675	1149 to 1580	**400 to 620**

Notes: * range due to uncertainty in WC21 rating curve.
local-scale estimate by HGEO (2024) does not include LW21 (because of distance) nor Areas 1-3A, so regional model estimate used for those)

Avon = Avon Reservoir
Cordeaux = Cordeaux Reservoir.

Because of the rainfall conditions and groundwater level recovery noted above, the losses estimated from field data for 2023-24 (**Table 2-1**) are 40-60% the moderate estimate (1008 ML/yr) made by groundwater modelling for the relevant period.

3 Surface water flow monitoring - research

IMC commenced a trial of image velocimetry at Dendrobium Mine, with hydrographic consultants ALS carrying out the field work and analysis. The aim of this is to improve the accuracy of surface water flow monitoring, especially at moderate to high flows, and then use this to refine the estimates of surface water flow loss related to mining.

Section 3.1 addresses the item:

(b) investigation of technologies and techniques that could lead to improvements in surface water monitoring in the mining industry;

Section 3.2 addresses the item:

(c) the alignment of proposed technology with water reporting in mining;

3.1 Investigation of new technology and methods.

ALS has installed a camera to trial the use of "Space-Time Image Velocimetry" (STIV) methods for measuring flow velocity and then estimating volumetric flow rate in conjunction with level or stage measurements. The equipment was installed at site CR36S1 (see pink shaded catchment on **Figure 1-1** in December 2023, and has been operational since then, with some periods of outages. ALS has prepared a brief report to document this trial, and this report is included as **Appendix A** to this document.

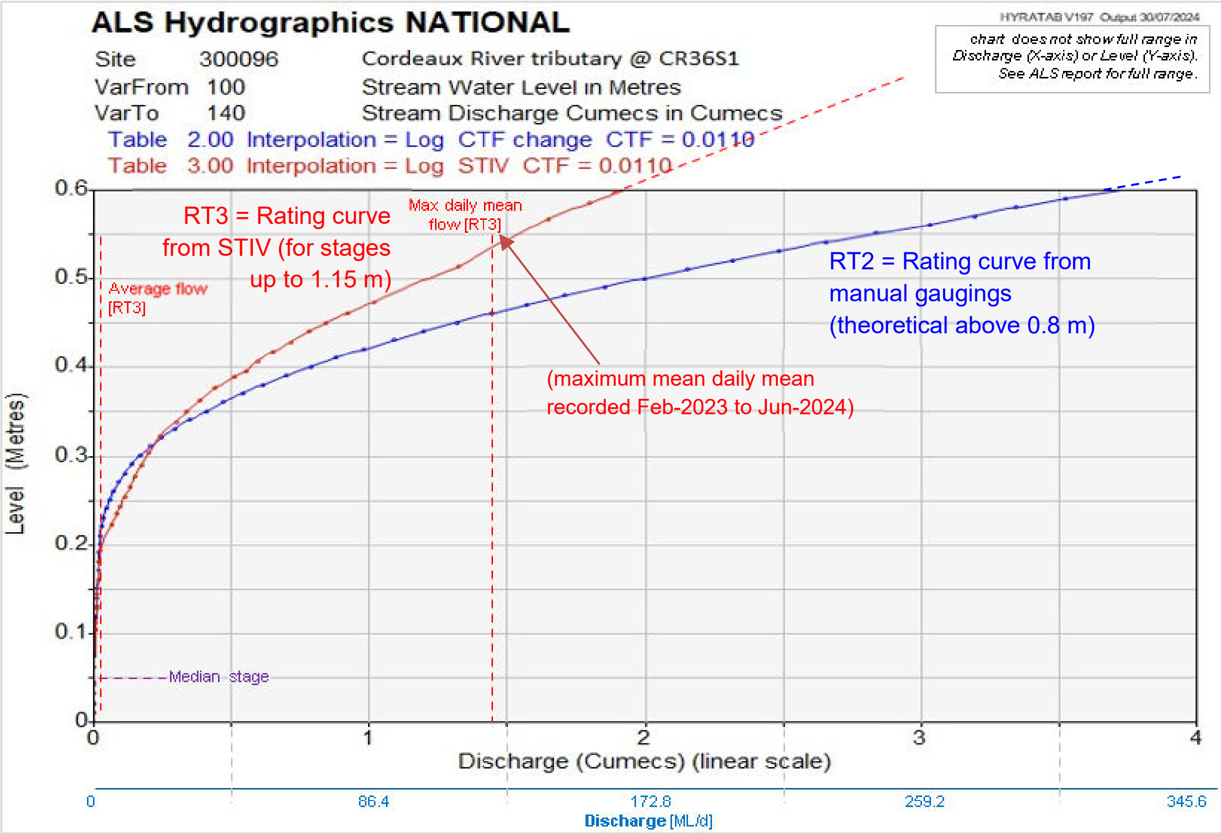
The aim of this method is to more reliably develop the stage-flow relationship, especially at moderate and high flows. To this end, it is proposed that should the trial at CR36S1 be successful, the equipment would be installed at most or all sites around Dendrobium, probably for a 6-month period at each. However, the STIV monitoring duration at each site might be adjusted if rainfall conditions do not lead to an appropriate range of flows recorded.

ALS describe some of the limitations and challenges of using this relatively new technology, as well as document some recommendations to address these. The aim of the trial is to act on many of these recommendations at the current CR36S1 trial site to review their effectiveness, before moving the equipment to another trial site (with the potential for a second set of equipment installed concurrently at a third site).

Regarding the benefits of the STIV method, the main advantage is related to the ability to monitor flow velocity at (theoretically) any time, rather than relying on a site visit. Site visits occur only periodically, and in-stream gaugings usually cannot be undertaken during high/moderate flow conditions due to safety and also due to WaterNSW catchment closures.

As such, the ability to set the camera to record at particular stage heights means that a more complete understanding of the stage-flow relationship can be obtained (see comparison on **Figure 3-1**), which improves estimation of both median and mean flows, although mean flows will still be influenced by the highest flows which have so far remained un-measured by the STIV.

Recommended improvements may assist with this, while there is also the issue of rainfall conditions being conducive to resulting in the desired flow conditions in the monitoring period.



(source: ALS, 2024, with additional annotations)

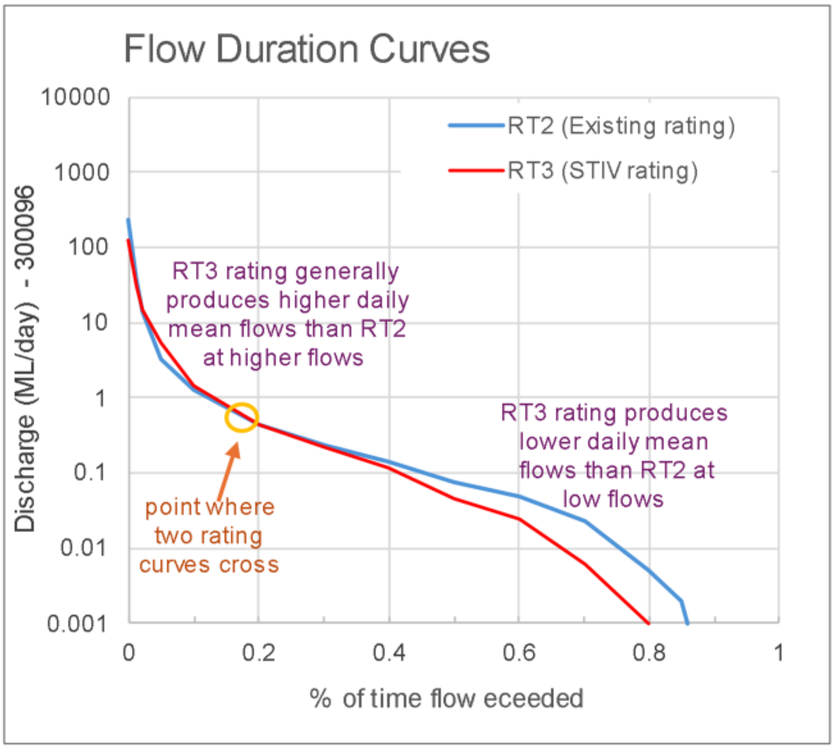
Figure 3-1 Comparison of rating curves developed from STIV and manual gaugings

ALS note that for low flows, manual measurement of the flow within the flume installed at all Dendrobium gauging stations would be relied on, and the STIV-based velocities used for flows above the top of the flume.

A finding from this particular site is that the flow velocity and volumetric flow rate estimated by STIV method is quite similar to manual-based measurements at low levels (e.g. at levels <0.4 m, **Figure 3-1**). However at levels >0.4 m, the STIV-based flows (RT3) are significantly lower than those based on the manual gauging/theoretical rating curve (RT3), e.g. 30% lower at level = 0.45 m or 40% lower at level = 0.5 m. ALS present some reasoning for this, however it is not clear whether this will apply at most/all Dendrobium sites.

In terms of the flows estimated by the existing (RT2) and STIV-updated (RT3) rating curves, **Figure 3-2** and **Figure 3-3** shows the timeseries of mean daily flows (expressed in ML/d) and flow duration curves.

Figure 3-2 Comparison of timeseries levels and flows at CR36S1



E:\DENDROBIUM\Tech\SurfaceWater\Monitoring\Velocimetry_ALS \20240605_Trial - CR36\Data_July24\[300096_CR36 Existing vs STIV.xlsx]300096_CR36 Mean Daily

Figure 3-3 Comparison of daily flow duration curves at CR36S1

The hydrograph and flow duration curves illustrate that there are differences in the daily mean flows produced by the revised rating curve. The changes occur at different levels of flow (as illustrated in **Table 3-1**). The main conclusion from the CR36 trial is that the new STIV-based flows are lower for the median (approx. 40% lower) and average (approx. 20% lower) statistics. It is not clear whether this finding will hold for other sites.

Table 3-1 Selected flow statistics from the two rating curves

Daily flow statistic	RT2 (Existing rating)	RT3 (STIV rating)		STIV RT3 as % of RT2
Median flow (Q50)	0.075	0.046	ML/d	61%
Average flow	1.829	1.525	ML/d	83%
High flow (Q10)	1.298	1.407	ML/d	108%
Maximum flow	230.23	126.51	ML/d	55%

3.2 Alignment with monitoring in the mining industry

Watershed HydroGeo has reviewed publicly available documents from a few (large) mines in NSW. For some of these sites, there was also some discussion with consultants at those sites related to the surface water monitoring methods, and the methods for analysis of flow losses.

At one of these sites (another longwall mine in the Southern Coalfield) the current mining domain is monitored by only one weir, and this is designed or acknowledged to be reliable only at low and possibly moderate flows, with higher flows being poorly quantified. Flow losses are then estimated via comparison against a rainfall-runoff model (AWBM) – this method was previously used at Dendrobium.

At another large mine in the Southern Coalfield, installations consisting of low-flow flumes and broad-crested weirs (similar to those at Dendrobium) are used to monitor flows. Flow losses are assed via comparison against AWBM modelled flows.

At a large coal mine in the Gunnedah Coalfield there is no surface water monitoring in place. This is on the basis that there is limited connection between groundwater and surface water. However this situation seems to ignore that infrequent storm flows may be affected by mining (via surface cracking). A method such as STIV *may* provide useful data in these instances.

A large mine in the upper Hunter, and one with significant water make, rely on downstream government gauging stations and their groundwater model to quantify water takes. From the publicly available documents, this is significantly less detailed than the process at Dendrobium.

It is therefore likely that the STIV method could be used to improve the reliability of gauging at these (and other sites). However if methods to assess flow losses similar to those at Dendrobium are not being used at these other sites, then the potential for STIV to improve the quantification of flow losses is limited.

We note that a more complete review of the methods employed at other mines or operations in NSW is likely best done by a statewide regulator.

4 Modelled surface water take

The EU requires that IC will use the results to progressively update estimates or forecasts of surface water loss (take) and provide written updates to NRAR and WaterNSW. These will be provided in regular reporting.

IMC has commenced a significant update to the groundwater model that is used to provide estimates of future surface water (and groundwater) take. This is being conducted in accordance with the conditions of the Water Access Licence (WAL), with the model update currently being undertaken in the second half of 2024.

An update of modelled surface water take will not be available prior to that. The next update will include improvement of some facets of the model, although will not (yet) incorporate the improvements to surface water monitoring that are currently being trialled (**Section 3.1**) and the trial remains in progress. It is likely that the STIV method would be rolled out progressively at other sites across the flow monitoring network at Dendrobium over a period of 2-3 years (limited by equipment availability).

Your sincerely,

Will Minchin
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5 References

ALS, 2024. Space-Time Image Velocimetry @ CR36S1. 31 July 2024 (v4).

Watershed HydroGeo (2023) Dendrobium Area 3C: Longwall 21A Groundwater assessment. R044c.

Watershed HydroGeo (2020) Dendrobium Area 3B: Longwall 18 Groundwater assessment. R014i4.

Appendix A: ALS (2024) – progressive review of velocimetry trial

ALS document dated 31/07/2024

ALS HYDROGRAPHICS

Space-Time Image Velocimetry @ CR36S1

ALS Memo:

Date: 31/07/2024

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Contents

1. Scope of Works

ALS Hydrographics installed a fixed camera STIV setup at CR36S1 on 29th December 2023. The trial setup consists of a Swift Enduro game trail style camera (1080p) triggered by a Campbells CR300 logger. The camera, tripod, cabinet and solar power are situated approximately 15m from the watercourse. Water level and a reference velocity is collected by the logger from a Nivus KDO; a doppler wedge sensor with pressure transducer for measuring water level and velocity, this was installed alongside the existing Orpheus orifice line to reduce disturbance to the banks. A Windsonic Option 4 windspeed and direction sensor was also installed to help isolate surface wind effects and discard recordings that are adversely affected.

Upon surveying the site during installation it was deemed that event capture be set to above 0.210m gauge height, that is the approximate height at which water would flow over the weir and not just through the half-pipe. This was determined because there was very little to no flow tracers at base flow and needlessly triggering a recording would fill up the camera storage very quickly.

Events to date have been captured in mid-January, mid-February, and early April. The January and February events only just reached the trigger height, and the shots were partially obstructed by vegetation and water on the lens. They also did not have sufficient velocity to get any accurate flow measurements.

Images 1&2. Initial tripod, logger and STIV camera setup (Left), STIV camera image of CR36S1 (Right)

2. Summary

2.1 Comparison with manual gauging

Thus far direct comparison to manual gauging is limited due to the trigger height coinciding with catchment closures and lack of access. However overall results appear to follow expected trends.

Initial setup and processing times are more cumbersome than manual gauging but benefits of repeated measurements during peak flows without site access proves very useful.

Surface velocities were compared with velocity measurements from a Nivus KDO mounted instream, just upstream of the weir.

Surface velocities were typically lower than those measured by the KDO for stages ~0.320-0.400m and higher than those outside that range.

The difference can likely be explained due to the fact the velocity measurement points of each method are not at the same point, that is the Nivus KDO is positioned closer to the weir and offset from half-pipe. To summarise the differences are;

- Low stage height KDO is located in a stagnant section of water and thus doesn't measure velocity approaching half-pipe accurately.
- Mid stage height KDO and STIV cross-sections significantly different, a smaller cross-section at the KDO corresponds to higher velocity as water approaches the weir
- High stage height KDO and STIV cross-section differences less significant and velocity through the whole section is more consistent, ie the velocity at the weir is similar to the velocity upstream as the weir is hydrologically "drowned out"

This made comparison for the alpha correction factor more difficult so a more generalised approach using advice from Le Coz et al. (2011), Fujita (2018) and Smart (2021b) and based on the alpha values already calculated an alpha value of 0.91 was selected for stages 0.320-0.400 and 0.86 for all other stages.

2.2 Velocity measurements from KDO summary

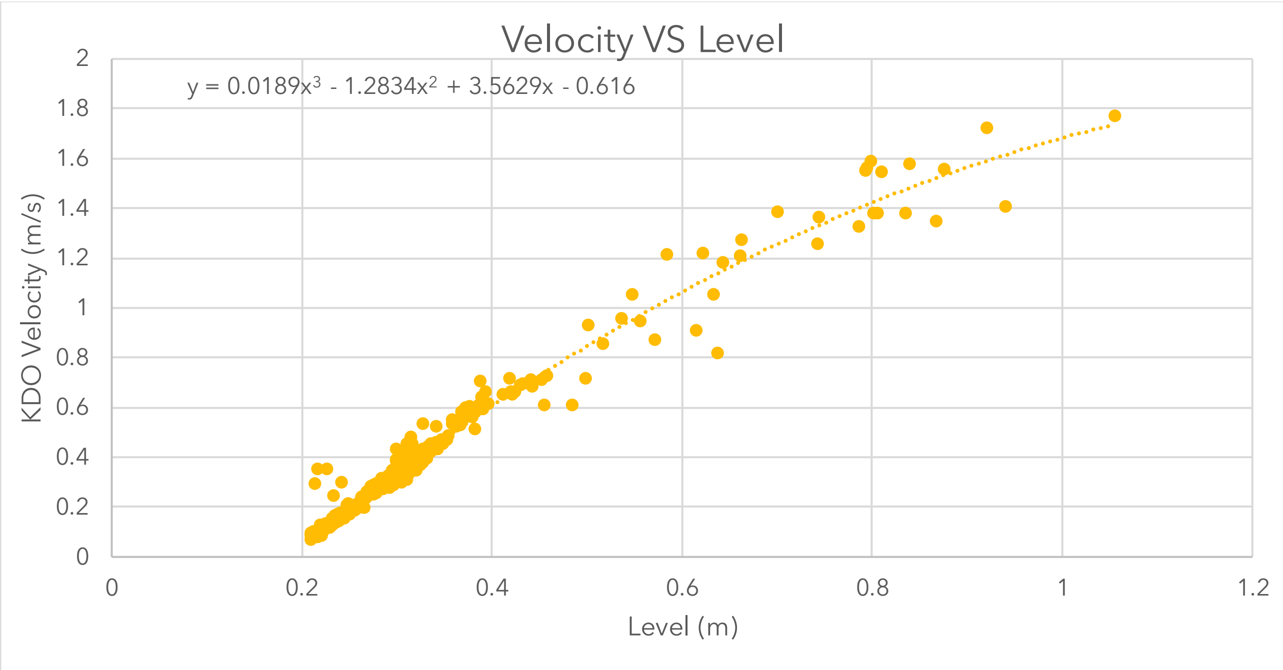

Figure 1. KDO Velocity vs Level – Uncertainty increases ~0.5m stage height.

- KDO velocity measurements below the trigger height of 0.21 are quite erroneous and have been omitted from Figure 1.
- The velocity measurements between 0.21 and ~0.5m appear the be quite consistent and would coincide with more laminar flow observed from video footage over the weir.
- above 0.5m the velocity measurements vary significantly likely due to the length of averaging of each measurement and the turbulent nature of the flow. This could be improved by taking more measurements above a set trigger height and averaging between them.

2.3 Comparison of stage-discharge rating table

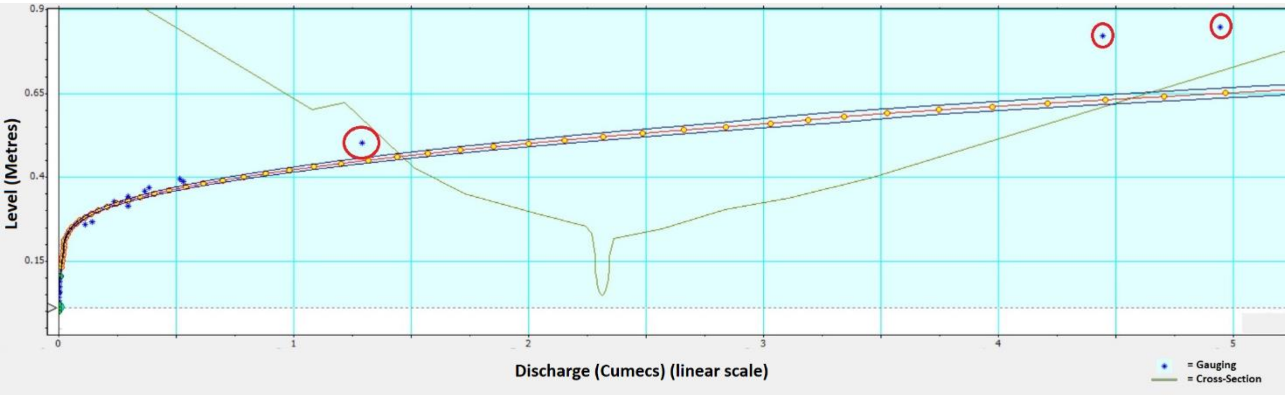

Figure 2. Old (Theoretical) rating table with STIV gaugings plotted, X-axis = Discharge (m3/s), Y-axis = Stage (m), Gaugings denoted by (*).

STIV gaugings were plotted against the current (mostly theoretical) rating table. As can be seen in Figure 2, the lower stage gaugings (~0.2-0.4m) deviate slightly but not majorly from the current rating. However at ~0.5m and above the gaugings show significantly less flow (Refer to Figure 3 and Figure 4), there are several possible reasons for this, the first is that these STIV gaugings were taken from night time footage with limited visibility and in the case of those ~0.8m the level exceeded the view from the camera. Secondly theoretical ratings often only consider one "friction" factor such as the Manning's equation. As there is significant vegetation above the weir level (upper limit ~0.4m) this is likely reducing the theoretical velocity significantly.

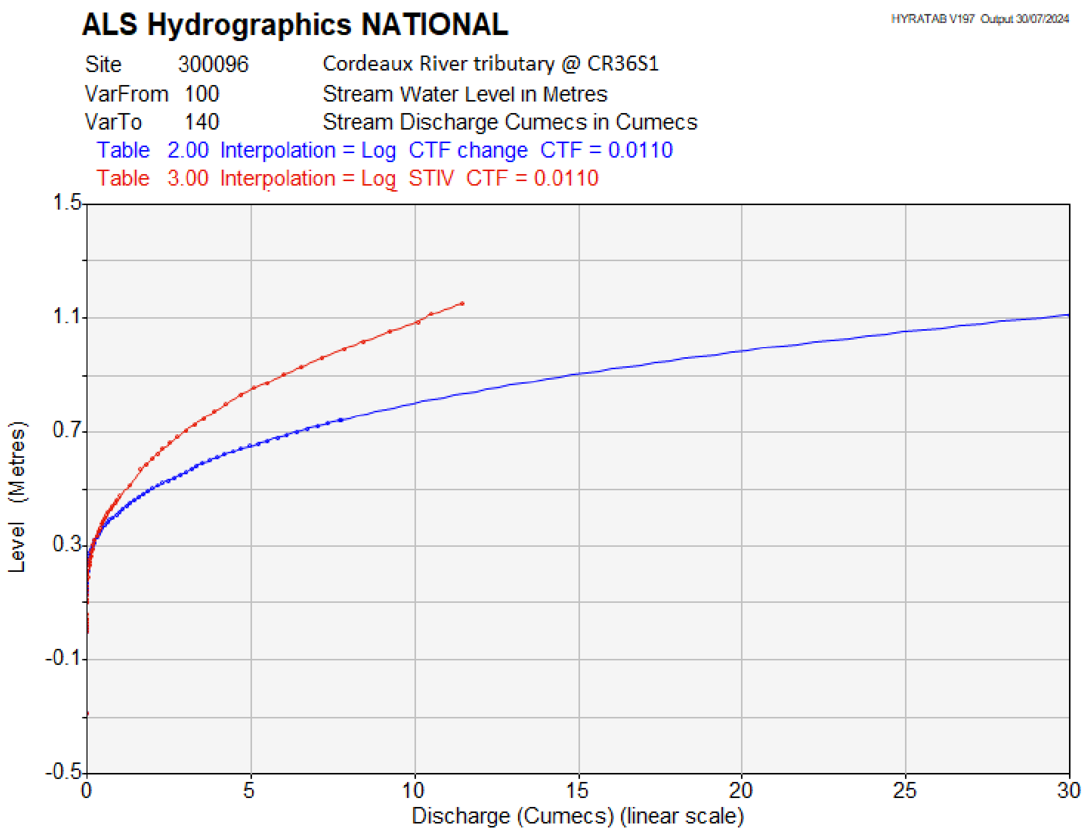

Figure 3. STIV rating (Red) vs theoretical rating (Blue) full scale

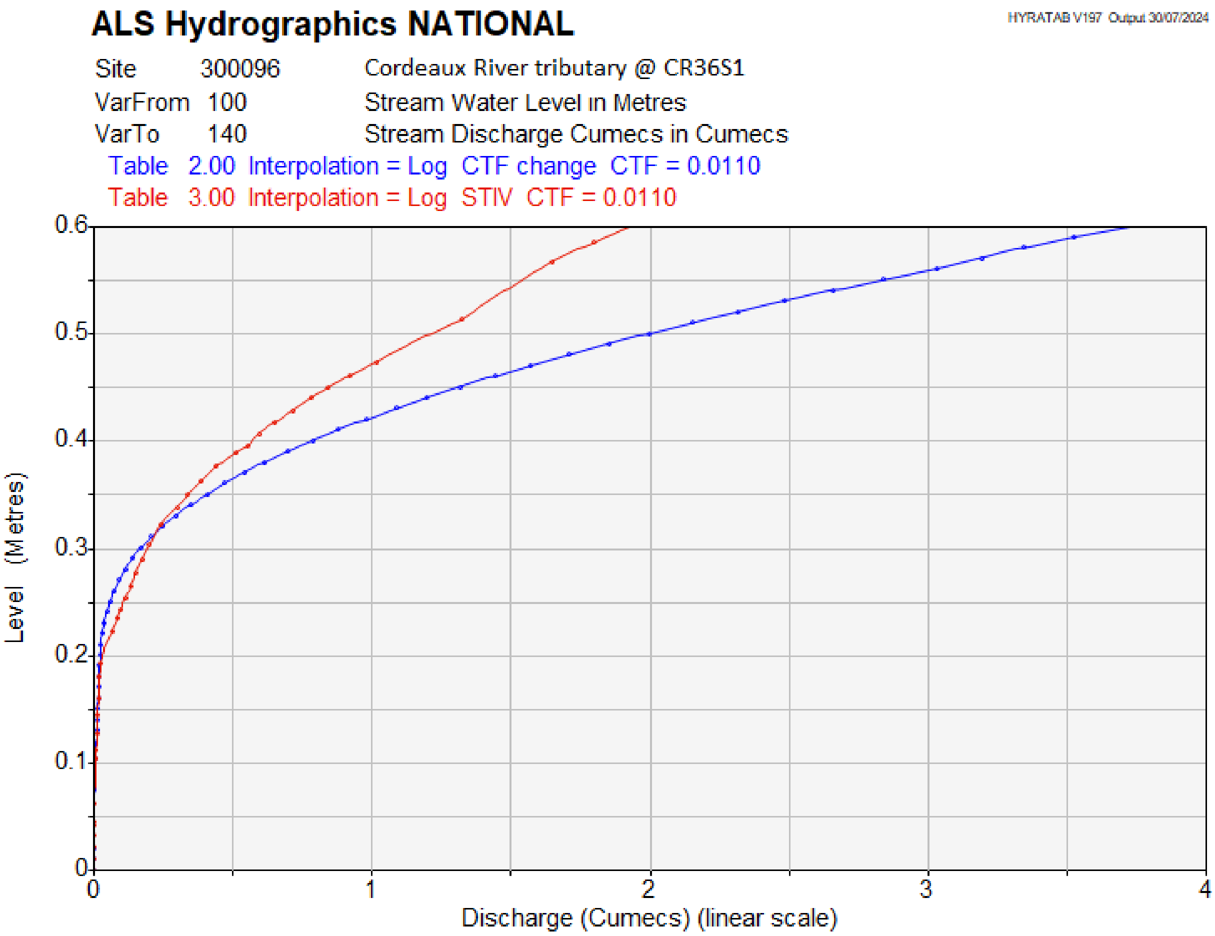

Figure 4. STIV rating (Red) vs theoretical rating (Blue) <0.6m

To summarise rating table development by both methods.

- Manual gaugings required to for rating table calibration for low-flow situations (below the height of the weir) as insufficient surface velocity tracers are present in clear, shallow water.
- Gaps in both rating tables between 0.09-0.25m which are impractical for STIV measurement. Theoretical should be sufficient given the dimensions of the half-pipe are known. Manual gaugings in this range would help fine tune this gap
- Greater flow between 0.200m and 0.350m when calibrating for STIV measurements
- Extrapolations between 0.4-0.5m and 0.5m-0.8m follow an expected curve for the inflexion points expected based on the cross-section. Further STIV measurements in this range would help to reinforce confidence.
- Above 0.8m data is extrapolated. Water surface extends beyond view of camera for further STIV measurements. Vegetation and site topography likely to make measurements at this stage prohibitive.
- Significantly less flow at higher stage than predicted using purely theoretical calculations (Refer to Figure 5.)

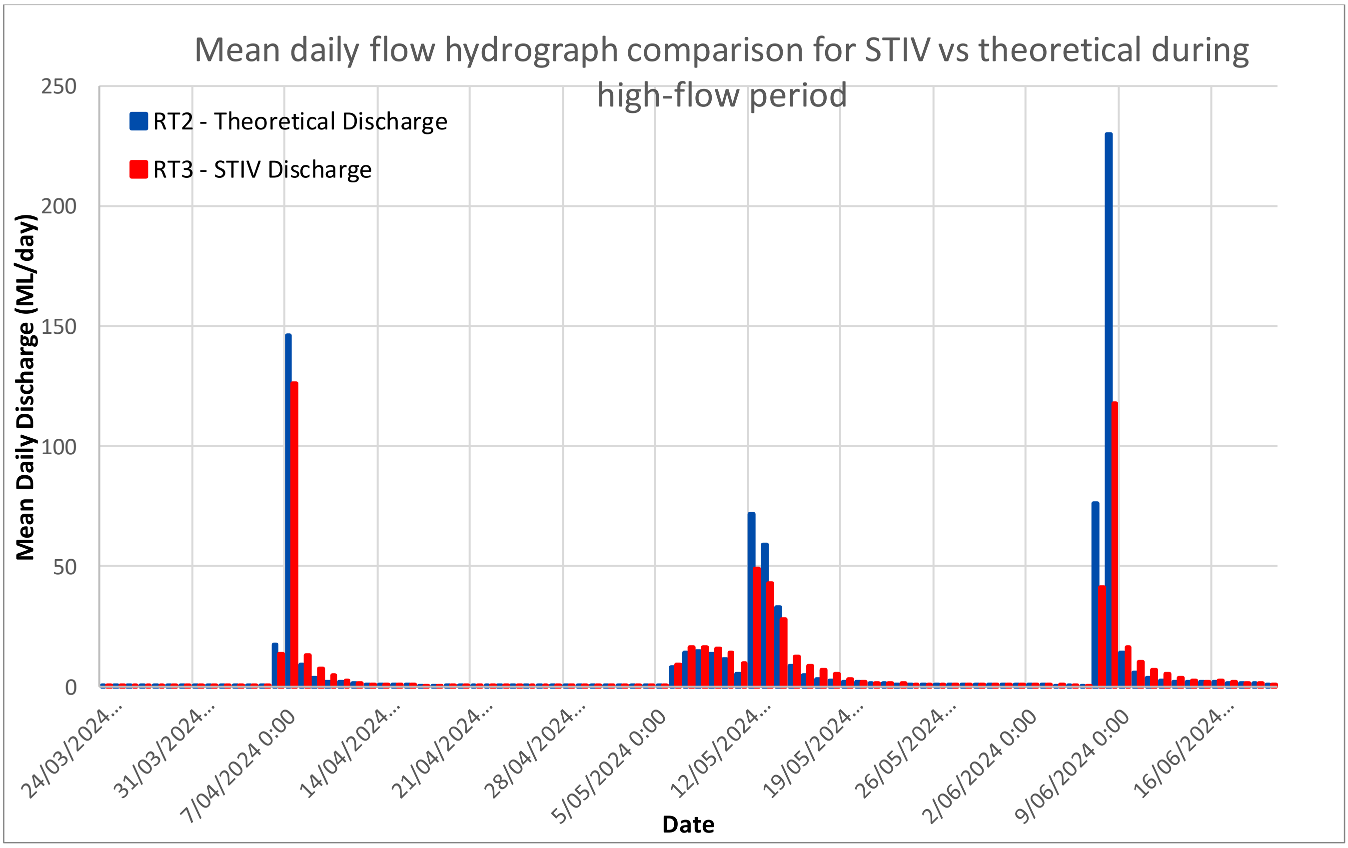

Figure 5. Mean daily flow for STIV rating (Red) vs theoretical rating (Blue)

3. Specific Challenges and Limitations

1. Vegetation growth – Vegetation can obstruct the camera view and impact on surface velocity measurements if it is moving with wind in front of the cross-section view. Trimming or tying back vegetation may be required if a suitable view cannot be obtained otherwise.
2. Camera communication – Currently there is no provision for direct communication with the game trail style camera used and as such when a fault occurs it is impossible to check if they camera has stored video internally even if an event has been logged. It may be possible to use a USB or similar style camera to directly trigger and record video to a storage device using a logger, though further investigation is required.
3. Lens distortions – Rain droplets, condensation, spider webs and dirt/dust can accumulate on the camera lens and impact on the accuracy of usability of captured video footage.
4. Site Power – Vegetation and site topography greatly effect access to good solar coverage, during the current trial we have experienced issues with providing enough power as of April due to lack of solar coverage.
5. Surface velocity tracers – tracers may only be present during certain flow conditions and can be impacted due to rain, wind, light (sun glare) and lens distortions. HydroSTIV software does an adequate job of filtering out most minor conditions. But proper site selection and good quality video are required for proper operation.
6. Wind – Wind sheer has been noted to adversely affect STIV measurements in other trials, windspeeds at this site have all been relatively low (3m/s peak, 0.4m/s average). As such little wind effect was noted on any of the event captures and wind sheer was not visibly observed in the videos.

4. Potential Improvements

- Communications between logger and camera – investigate ways to improve QA/QC with logged events, currently all video data is stored internally to the trail camera and is inaccessible from the logger. A method of storing video to a logger SD card so that time/date settings are not lost and remote monitoring is possible.
- Taller mast – Raising the height on the camera and solar panel in particular could help improve both visual coverage of the watercourse and improve power stability. However it must be noted it would make the camera less accessible during regular service and would need to be paired with communications improvements noted above.
- Ground survey marker visibility – initial ground control points of star pickets with yellow marker caps was very difficult to see in shot. These were replaced with larger orange "impalement" style caps which improved visibility but still difficult to spot in certain lighting.
- Camera resolution – Visibility of ground control points and flow tracers could be improved by using a higher resolution camera. Consideration should be given to file size, data transfer and cost.
- Ground control point positioning – Image rectification uses ground control points to determine the camera position and orientation. Any future installations should contain more control points with greater spread to improve overall accuracy.
- Position of velocity sensor – Position (Nivus KDO) further upstream of weir to reduce variance in velocity reading and position inline with STIV cross-section to better evaluate alpha correction factor. This will be subject to site suitability as a solid mounting point is needed such as a rockbar.
- Compact setup – Look into ways to reduce the complexity, weight and ergonomics of the current setup. For more remote sites where there is a more significant distance from the road, carrying equipment in will draw out the install time significantly and could present a manual handling issue. If multiple sites are to be considered in the future or a faster rotation between sites, reducing install time and complexity will be greatly beneficial.
- Adjust program settings - Collect more velocity data with Nivus KDO at certain trigger heights with turbulent flow and average results to reduce uncertainty in measured velocity.

5. Conclusion

Overall the trial has thus far been a success and proved an effective method of both building the higher flows of a stage-discharge relationship or reinforcing confidence in one already developed. This trial has highlighted some key improvement areas which can further improve the accuracy and effectiveness of this technology should it be considered for other sites.

Sincerely,

Rhys de Gruchy

Hydrographer – ALS Hydrographics

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