Dry Season Stream Flows in the Daly / Katherine Rivers, 2008

REPORT 21/2008D
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DARWIN
OCTOBER 2008
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1. SUMMARY
Late Dry season stream flows are relatively high compared to historic measurements. The October flow at Mt. Nancar (G8140040), the first site downstream of the Daly Basin was 30.9 cumecs. The most of that water is sourced from aquifers within the Daly Basin. Groundwater discharges along sections of the rivers which cut into the aquifers. An exception is the Katherine River between the King River and Limestone Creek (G8145747 to G8145126) which was losing a small amount of water to the aquifer in late September. The Katherine River where it crosses the Ooloo Dolostone is delicately balanced between being a gaining and a losing stream.

INTRODUCTION
Dry season stream gaugings and water quality sampling were done on the Daly River and some major tributaries in July and September/October 2008. It was part of a project to determine carbon, nitrogen and phosphorus mass budgets in the river. The project is being done jointly by TRaCK (Tropical Rivers and Coastal Knowledge-Charles Darwin University) and NT government (NRETAS). This report documents the stream gaugings and field water quality measurements. The main thrust of the project, the carbon, nitrogen and phosphorus mass budgets will be reported later by TRaCK.

The field work was carried out by staff from the Land and Water Division of NRETAS. Two parties were involved, one did the sites downstream of Dorisvale Crossing and the other did Dorisvale Crossing and the sites upstream from there. The field staff included Robert Chaffer, Roger Farrow, Steven Tickell, Hayden Lowe, Errol Kerle and Laurie Dunn. The stream waters were sampled for total nitrogen and phosphorus, nitrate, nitrite, ammonia, filterable reactive phosphorus, dissolved organic carbon and particulate carbon. During July, sampling was done for major ions as well as for trace metals. pH, electrical conductivity, turbidity, temperature and dissolved oxygen were measured in the field using a Hydrolab Quanta instrument. They were calibrated at the start of each survey.

All gaugings were done by ADCP (acoustic doppler current profiler) with the exception of the King River which was gauged manually with a fan and tape measure. The accuracy of the ADCP method is considered to be of the order of 2%.

Seventeen sites were visited (Figure 1). Of these, gaugings were made during both field trips at fifteen sites (Figure 2). No gaugings were done on the Flora River in July due to logistical reasons. Stream flows and field water quality measurements are listed in Table 1. The difference in flows between July and September is shown in Figure 3 as a percentage of the July flow. Electrical conductivities of the river waters are shown in Figure 4.
DISCUSSION

Stream flows
During the Dry season the Katherine / Daly Rivers are largely fed by groundwater discharge from aquifers in the Daly Basin. Only three sites fall outside of the basin. G8140029 is located upstream of the basin while G8140040 and G8140003 lie downstream. Flows progressively increase downstream and the maximum flow recorded was 41.88 cumecs in July at the Daly River Police Station (G8140003), the most downstream of the sites. No rain fell in the catchment during the study period so flows receded at all sites between the July and September visits.

Some variation in the recession rates at the different sites was noted (Figure 3). The Daly River and Douglas River sites showed decreases in flow between 20 and 30%. The sites on the Katherine River that are within the Daly Basin and the Stray Creek site had decreases of 40 to 50%. Blue Metal Crossing (G8140029) located upstream of the basin had a 70% decrease in flow. The Flora River was not gauged in July but an inspection of historic Dry season gaugings from that site (Jolly and others, 2000) suggests that the decrease between July and September is likely to be less than 25%. The flow recession at a site is related to the storage capacity of the aquifers that discharge to the river upstream. Aquifers with larger storage capacities will show more gradual declines. Blue Metal Crossing (G8140029) showed the greatest percentage decrease in flow (70%), reflecting the limited extent of the Cretaceous Sandstone aquifers located in the headwaters of Seventeen Mile Creek. Those aquifers are the source of the baseflow in the Katherine River upstream of the Daly Basin. The lowest percentage decreases in flow were in the Daly and Douglas Rivers and very likely in the Flora River. These are fed by the most extensive areas of aquifers. They include the Tindall Limestone on the Sturt Plateau to the south and on Tipperary Station to the north and the major part of the Oolloo Dolostone. The Katherine River sites showed intermediate percentage decreases in flow reflecting smaller catchment areas of both Tindall Limestone and the Oolloo Dolostone.

The stream flow data also give an indication of the location and magnitude of groundwater discharge zones. Previous late Dry season gaugings and spring mapping exercises have broadly defined these (White, 2001, Tickell, 2002, Tickell and others, 2002, Russ and others, 2005, Tickell and Farrow, 2005 and Tickell, 2008). The current results conform to previous findings. Note that gains or losses to the river have been estimated below by subtracting flows at the upstream site from that at the downstream site. A factor for loss of river water through evapotranspiration has also been subtracted. This was assumed to be 4 litres/second/kilometre of river.

During the July trip flows increased progressive downstream however in late September /early October two reaches of the Katherine River showed a downstream decrease or no change in flow. From upstream to downstream the discharge characteristics in the late September /early October visit can be summarised as follows:
• Katherine River upstream of the Daly Basin: There is negligible groundwater inflow into this section of the river. Most of the 0.68 cumecs recorded at G8140029 originates from Seventeen Mile Creek and is sourced from aquifers in Cretaceous sandstone.

• Katherine River between G8140029 and G8140301: The river gained 2.71 cumecs in this section and most is sourced from the Tindall Limestone. The downstream third of the section cuts through the Jinduckin Formation between the new railway bridge and G8140301 but only minor discharge occurs there.

• Katherine River G8140301 to G8145747: A small gain of 0.26 cumecs was recorded along this stretch. In this section the river cuts Jinduckin Formation and then passes into Cretaceous Sandstone. The Oolloo Dolostone underlies much of this section but is only exposed from beneath a covering of Cretaceous sandstone immediately upstream of the King River junction. Springs have previously been mapped in the area where the dolostone is exposed.

• King River at the Katherine confluence, G8145746: The flow was 0.17 cumecs where it enters the Katherine River. All of that discharge originates from the Oolloo Dolostone between the confluence and the old Victoria Highway. Upstream from there the dolostone is confined by Cretaceous claystone.

• Katherine River between G8145747 and G8145126: A loss of 0.11 cumecs was recorded along this stretch. Such a low figure is close to the accuracy of the gauging method. In July it was gaining 0.97 cumecs. Oolloo Dolostone is exposed along part of this stretch of river.

• Katherine and Daly Rivers G8145126 to G8145748: The river gained 2.33 cumecs in this section. It is sourced from the Oolloo Dolostone that is exposed in both of these rivers as well as in the lower section of the Flora River.

• Flora River upstream from G8145021: The flow at that site was 3.29 cumecs all of which is sourced from the Tindall Limestone.

• Daly River G8145748 to G8140347: The river only gained 0.32 cumecs along this stretch as it cuts into Jinduckin Formation which has few aquifers in it.

• Daly River G8140347 to G8140067: The river gained 0.96 cumecs along this stretch which is cut into Cretaceous sandstone and claystone.

• Daly River G8140067 to G8140098: The largest groundwater inflow occurs along this stretch of river, with a gain of 6.76 cumecs recorded. Previous work has indicated that the main discharge zone is located downstream from a point which is located about 8 km upstream of the Stray Creek confluence. Stray Creek also picks up more water downstream from G8145749. The water is sourced from the Oolloo Dolostone.

• Daly River G8140098 to G8140038: The river gained 3.97 cumecs in this section, also derived from the Oolloo Dolostone.

• Daly River G8140038 to G8140042: The river gained 5.22 cumecs in this section, also derived from the Oolloo Dolostone.

• Daly River G8140042 to G8140040: The river gained 2.53 cumecs in this section. Most discharges from the Tindall Limestone where the river cuts it but a minor amount is sourced from pre-Daly Basin aquifers which outcrop along the river, downstream of the basin.
Previous snapshots of late dry season stream flows have been carried out in September of 2002 and 2005. The September flows from the current survey are intermediate in amount between those of the previous surveys. For example the flows at Mt.Nancar G8140042 in September of 2002, 2005 and 2008 were 34.0, 29.9 and 30.9 cumecs respectively. Other sites show a similar pattern. The late dry season flows in the Daly and Katherine Rivers are currently close to the highest recorded. By comparison the lowest flow measured at Mt.Nancar was only 8.35 cumecs in November 1970.

**Electrical Conductivity**

River waters had relatively high electrical conductivities (EC) during both field trips (Figure 4). This reflects their main source which is from carbonate aquifers of the Daly Basin. High calcium, magnesium and bicarbonate in the groundwaters result in elevated EC’s. The only exception is the most upstream site, G8140029 which had much lower electrical conductivities. That site is upstream of the Daly Basin and the river water there is sourced from Cretaceous aged sandstone aquifers.

Sites in the Katherine River (with the exception of G8140029) showed higher EC’s in September than in July. This reflects the declining contribution of low EC from upstream of the Daly Basin. Between the July and the late September / early October the Flora River site and most sites downstream of the Katherine River showed little change in EC. Most changes were less than the accuracy that could be expected with field measurements of EC. This indicates that by July the river water downstream of the Katherine River was dominated by Daly Basin groundwater. The large flow from the Flora masks the influence of the low EC waters that was noted above in the Katherine River. A small downstream decrease in EC in September between G8145748 and G8140067 may indicate the influence of low EC waters discharging from Cretaceous sandstones in that area.

**pH**

From the July to the September surveys the average pH decreased very slightly. Sites upstream from Dorisvale Crossing showed small decreases in pH while sites downstream increased slightly. The changes were generally so minor as to be within the range of error inherent in the measurement of field pH.

**Turbidity**

Between the July and September surveys there was a small decrease in the average turbidities (1.6 to 1.4 ntu). Over that period decreases occurred in the Katherine, Douglas and Flora Rivers, Stray Creek and in the Daly River at G8145748. Sites in the Daly River downstream of G8145748 recorded slight increases in turbidity.
**Dissolved Oxygen**

There was a slight decrease in the average dissolved oxygen content of all sites between the July and September surveys (8.1 to 7.1mg/l). Most sites decreased over that period except for the Flora River and the Daly River at G8140067 and G8140003. Changes in dissolved oxygen are complicated by the fact that it is influenced by numerous factors, including biological activity, turbulence and wind.

**Temperature**

The temperatures measured during the current survey were done at various times throughout the day. River temperature varies on a daily cycle. A temperature probe and a data logger at Ooloo Crossing (G8140038) shows daily water temperature fluctuations of around 3°C.

The average water temperature of all the sites in July was 24.8°C. By September this had increased to 31.1°C. Every site had a higher temperature in September than in July. The seasonal increase in air temperature appears to be the main factor controlling water temperatures.
REFERENCES


Tickell, S. J. and Farrow, R., 2005. A survey of springs along the Daly River between Beeboom and Daly River Crossings Report 35/2005, Natural Resources Division, Northern Territory Department of Natural Resources, Environment and the Arts


White, E., 2001 A late dry season survey of the Katherine and Daly rivers. Report 24/2001D, Natural Resources Division, Northern Territory Department of Lands, Planning and Environment.
Figure 1
Stream Gaugings
July / September 2008 (Cumecs)

Figure 2
Percentage Decline in Stream Flows Between July and September 2008
Figure 4
<table>
<thead>
<tr>
<th>Date</th>
<th>Zone</th>
<th>Easting</th>
<th>Northing</th>
<th>Time</th>
<th>Depth (m)</th>
<th>Temp (°C)</th>
<th>pH</th>
<th>DO (mg/l)</th>
<th>EC (mS/cm)</th>
<th>Turb (nu)</th>
<th>Flow (cumecs)</th>
<th>Gauging method</th>
<th>Remarks</th>
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<td>7.66</td>
<td>9.02</td>
<td>0.035</td>
<td>1.3</td>
<td>2.3</td>
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<td>7.99</td>
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<td>9.32</td>
<td>0.497</td>
<td>1.9</td>
<td>6.64</td>
<td>ADCP</td>
<td>Limestone Ck flow estimated 50l/sec., EC 0.917, pH 8.24, DO 9.5, Turb 2.6, Temp 21.38</td>
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</table>

Table 1 Stream flows and field water quality measurements