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Appendices A-D

Appendix A

Equipment required during water sample collection

- 6m boat with 18KW outboard motor,
- Secchi disk,
- Plankton net,
- Dissolved oxygen and temperature probe ,
- 2L jinx depth sampler,
- 1L clear PVC sampling bottles,
- 100L thermos esky (cooler box),
- 0.20m diameter marking buoys,
- 0.20m diameter plastic funnel

Appendix B

Representative Site Selection on Gara River

Abstract
Ortho-Phosphate, total oxidized nitrogen (TON) and turbidity where monitored at four sites on Gara River. Repeated measurements over 3 different flow regimes (low, low / moderate, and moderate) revealed that there was significant variability between sites of TON during low flows. Floating algae, low stream velocity and emergent vegetation in the immediate area of sampling locations were the cause of this. These factors had no significant effect on ortho-P or turbidity however mean turbidity levels where marginally higher when algae were present. During moderate flows there was less emergent vegetation and no algae present at any of the sites and subsequently no significant variation in any of the parameters measured.

Introduction
The water quality of a river is largely a function of the quality of water entering it from the catchment. This in turn is a function of:

- Catchment geology
- Volume and intensity of rainfall
- Initial soil saturation levels
- Intrinsic rate of infiltration of rainfall
- Level and type of ground cover
- Slope and aspect of land
- Land use

Once runoff has entered the stream system and is on its way to storage it continues to undergo chemical and physical changes following biotic and abiotic pathways

Water quality parameters within streams and rivers may vary in depth and width over a cross section. This occurs primarily when there is a marked difference in stream velocity between locations. Fluid dynamics predicts the velocity in a stream is always faster on the outside of bends than on the inside (velocity within depth is also predicted to be maximum at 2/3 of the total depth below the surface). This often contributes to a build up of sediments (beaches) on the inside of bends in many inland rivers.

The settling of these sediments will result in reduced turbidity and can potentially reduce the concentration of nutrients in the water column through co-precipitation (in particular ortho-P). Hence sampling on the inside of a bend may lead to an underestimate of the nutrient and sediment load on that occasion and ultimately to the water storage under investigation.

A further influence of differential velocity is that these sediment beds may also act as a prime location for the establishment of aquatic vegetation which act to stabilize stream banks / beds and filter stream flow. Once again reducing the levels of sediments and nutrients.

Often, as is the case with many inland Australian Rivers (Darling River, Lachlan River, Murrumbidgee River) flow may be reduced or halted so that blooms of algae occur. It is probable that the reduced stream velocity on the inside of bends favors algal growth relative to the faster flowing areas. Algae have the potential to influence all aspects of water quality from dissolved oxygen concentration to pH. They may utilize nutrients during growth and release nutrients during decay and will contribute to turbidity throughout.

Aim

To assess the impact of site characteristics on nutrient and sediment levels in samples taken from Gara River.

Background

General Location

Gara River is the main tributary servicing Malpas Dam on the New England Tablelands near Armidale, NSW. It contributes around 36,000 ML annually to the dam and drains approximately 80 % of the Malpas Catchment. The Department of Land and Water Conservation have had a water sampling/ monitoring station on Gara River since 1997 measuring discharge, water temperature and taking automatic water samples using a Gammit water sampler. The site is 10 Kms East of Guyra on the Guyra / Ebor Road (30°12'46", 151°43'30"), approximately 5 km upstream of the inlet to Malpas Dam. About 60% of Malpas Catchment runoff flows past this point.

Methodology

Flow Selection

Three flow regimes were selected for investigation (Table 1).

Table 1. Characteristics of Flow Regimes

Type of flow	River Level (m)	Discharge (ML/Day)
Base	0.11 - 0.55	0 – 12.3
Low / Moderate	0.56 - 0.68	12.3 -105
Moderate	0.68 – 1.00	105 - 1007

During high discharges Gara River flows in a straight line past the sampling points. Typically the river is uniformly muddy-brown and very turbulent. It was deemed unnecessary to investigate variations in water quality parameters during high flows due to the lack of physical factors with the potential to affect the direction or rate of discharge at this location.

Site Selection

Four sites were selected to incorporate the possible influence of vegetation, stream velocity and stream direction (bends) on dissolved reactive phosphorus, total oxidized nitrogen and turbidity during base flow conditions. (Plate 1.

Site 1. Midway across the old concrete fording area.

Site 2. On the opposite side of the river to site 1.

Site 3. The site of the existing DLWC sampling station. Located on the inside of a slight bend in river direction

Site 4. Located 20 meters up stream of sites 1 & 2

Sampling Procedure

Three to six 1litter water samples where taken using opaque PVC containers at each site approximately 2/3 down the water column. The samples were then transported on ice in an esky immediately to the laboratory where dissolved reactive phosphorus, total oxidized nitrogen and turbidity were measured.

All sample preparation was done in accordance with Standard Methods 1995.
Statistical analyses were performed using STATISTICS For Windows.

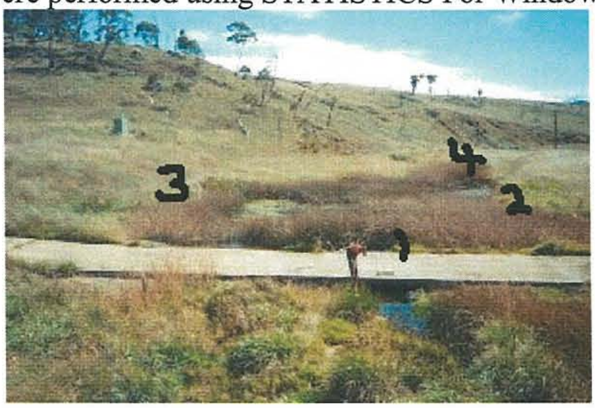

Plate 1 Sites selected for initial sampling at 'Willow Glen' Station.

Results

Sampling at various sites on Gara River near willow glen station was done on 4 separate occasions. Measurements of TON, Ortho-P and turbidity at all sites and times were normally distributed as indicated by the Wilk-Shapiro test.

27 April 1998
Stage Height 0.36 m
Zero-Low Flow Event (1.8 ML/day)
Temperature 12.8 °C

There were no algae or vegetation in the immediate area of Site 1 although the watercourse was heavily overrun downstream and upstream of the site. River flow was under the concrete bridge. Emergent vegetation was present at Site 2 with river flow not detectable by visual observation. Floating algae as well as emergent vegetation were prevalent at Site 3. There was no surface velocity. Site 4 was clear of vegetation and algae and had a surface velocity of around 0.17m/s.

Figure 2 Mean TON concentrations at various sites on Gara River during low flow conditions.

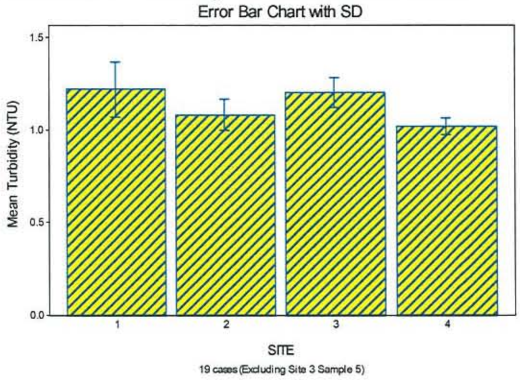

Figure 3 Mean Turbidity at various sites on Gara River during low flow conditions.

A one-way analysis of variance revealed that there was no significant variation in turbidity however TON[1] did vary between sites. Ortho-phosphate was not detectable on this occasion.

[1] Site 3 Sample 5 contained visible algae. The TON measured in this sample was 2500 μg/L. This value was not included in the statistical analysis.

4th May 1998
Stage height 0.39
Low Flow Event 0.39 m (2.83 ML/day)
Temperature 12.5 °C

River conditions and site characteristics were similar to those on the 4th of May.

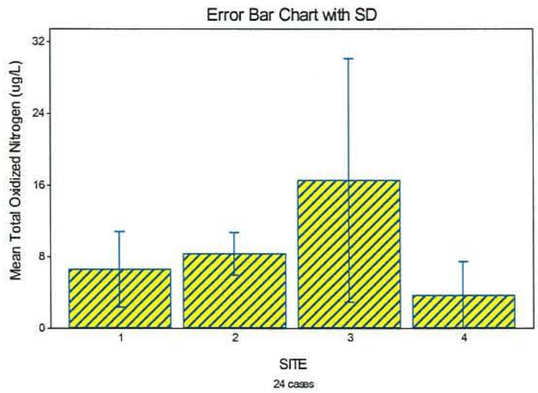

Figure 4 Mean TON at various sites on Gara River on the 4th of May 1998.

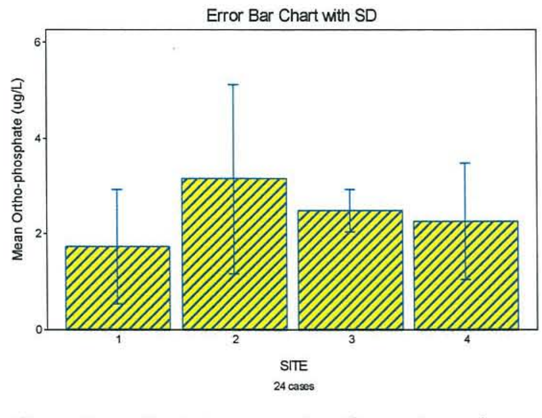

Figure 5 Mean Ortho-phosphate concentration at various sites on Gara River on the 4th of May 2000.

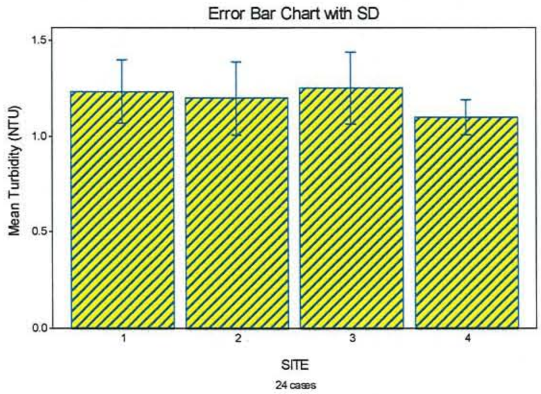

Figure 6 Mean turbidity at various sites on Gara Rive ron the 4th of May 1998.

Tukey test showed a significant difference between Site 3 and Site 4 in Total Oxidized Nitrogen. Mean TON concentration and standard deviations were 16.578µg/L and 13.62µg/L for Site 3 and 3.68µg/L and 3.75µg/L for Site 4. Both Ortho-P and turbidity were determined not to vary significantly (one way ANOVA and Tukey test)

26th May 1998
Stage Height 0.64 m
Low – Moderate Flow (65 ML/day)
Water Temperature 10.9 °C

Flow was over the concrete bridge at Site 1 (approximately 0.3 m/s). There was no vegetation or algae in the immediate area. Flow past Site 2 was unimpeded by vegetation at about 0.1 m/s. There was a stand of emergent vegetation 3m upstream of Site 3 extending about 5m across the river. Surface velocity was not detectable. Site 4 was clear of vegetation and algae and flowed cleanly past the sampling point.

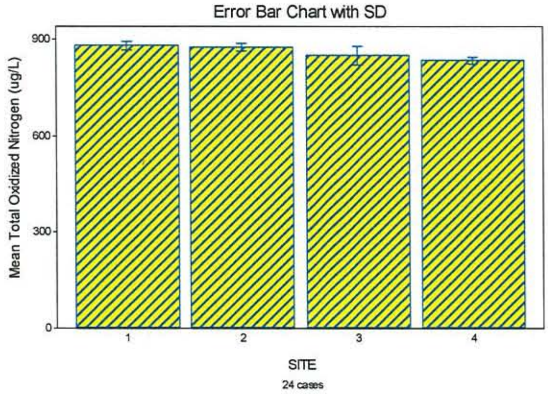

Figure 7 Mean TON at various sites on Gara River on the 26th May 2000

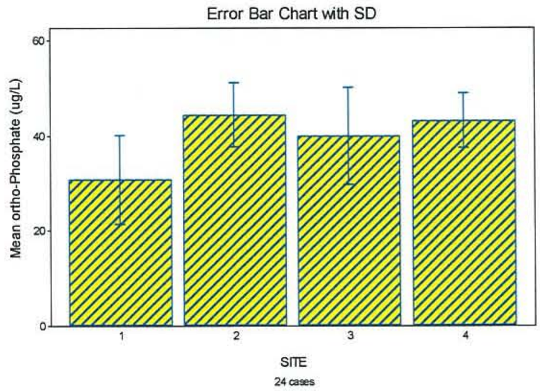

Figure 8 Mean Ortho-P at various sites on Gara River on the 26th of May 2000

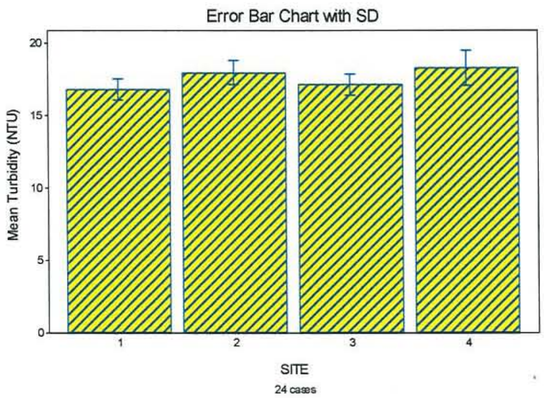

Figure 9 Mean turbidity at various sites on Gara River on the 26th of May 2000.

During these conditions one-way ANOVA and Tukey test showed no significant differences between sites for all parameters measured.

23 July 1998
Stage Height 0.68 m
Moderate Flow (105 ML/day)
Water Temperature 12.77°C

Samples were taken at sites 2,3 and 4. No samples were collected from Site 1. Site 2 was clear of vegetation, and had no scum or algae in the area. Water velocity at this site was steady (~0.2m/s). There was some emergent vegetation 3m upstream and 4m downstream of site 3. The velocity at this site was low (<0.05m/s). There was no algae or floating scum in the immediate area. Site 4 was clear of vegetation and had clear, free flowing water (~0.4m/s).

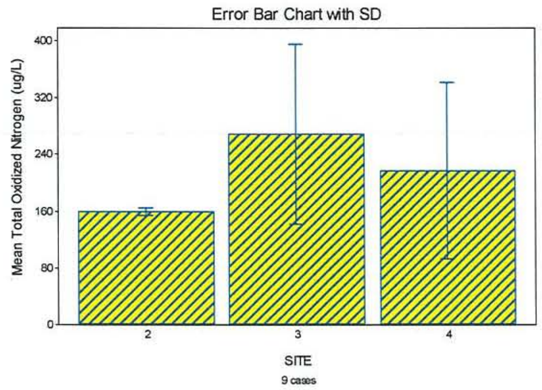

Figure 10 Mean TON at 3 sites on Gara River on 23rd July 1998

Figure 11 Mean Ortho-P concentration at 3 sites on Gara River on the 23rd of July 1998.

One-way ANOVA and the Tukey test revealed no significant variation between sites

Discussion

River Conditions

During low to low-moderate flow conditions of around 0.24 – 65ML/day the course of the river follows a general north south direction with a gentle bend to the left (30m upstream of the current DIPNR station) followed by a gentle bend to the right from which it continues in a north-south direction. Site 1 is usually free of algae and vegetation with water velocity the maximum at this location. Flow is under the concrete bridge. A heavy stand of vegetation is usually present on the upstream side of the concrete bridge. Site 2 may have vegetation present and typically has a low water velocity past this point. Emergent benthic vegetation often is established in the immediate surrounds of Site 3 extending upstream approximately 10m and halfway across the stream (approximately 3m). This type of vegetation may also extend completely across the river during extended base flow conditions. River surface velocity past this point is negligible. Site 4 is always free of algae and vegetation and flows swiftly past the sampling point.

During moderate flows (characterized by flows between 105 - 1007ML/Day) emergent vegetation present during low flows may continue to be present until scoured away by high flows or flattened after several days of moderate to high flow. River direction is in a general North-South direction.

High flows (>1000 ML/Day) run in a straight line past the DLWC sampling station for 60 meters in a North-South direction with no emergent vegetation showing in the river.

Water Chemistry

Zero-Low Flow

During low flow one sample measured 2500µg/L of TON at site 3 when the mean of the site was 26µg/L. This sample was also observed to have a visible floating algal clump. It was decided that the inclusion of this sample would bias the statistical analysis so it was discarded. When this sample was removed from the statistical analysis there was an observed difference between Sites 1 and 4. Site 1 had a significantly higher TON than Site 4 (76.34 & 22.15µg/L respectively). There was no detectable Ortho-phosphate present in the river at all sites. This variation in TON and the absence of Ortho-P may be due to utilization by the plants and algae, which were abundant at this time. The lack of input from the catchment due to runoff would also account for the extremely low Ortho-P concentrations. Turbidity was also higher at Site 1 than Site 4 but not significantly. Turbidity was a maximum (2.4NTU) at site 3. The presence of algae and the re-suspension of dead algal cells may have contributed to this.

On the 4th of May similar conditions were present as those on the 27th of April although flow was marginally higher and there was small amounts of Ortho-P in the water. There was once again a significant difference in TON but this time between Site 3 (16.58µg/L) and Site 4 (3.68µg/L). The continued low flow and extremely low Ortho-P may have resulted in nutrient limitation resulting in the death of some algal cells and the release of cellular TON and Ortho-P into the water column. It is also possible that cell lyses may have occurred as a result of photo-oxidation of algae floating on the surface at sites 2 and 3 or due to natural decay, which occurs at the end of the algal life cycle

Low-Moderate Flow
On the 26th of May there was no significant differences between sites for any of the parameters measured. All of the algae noted on the 27 April and the 4th of May had disappeared. Concentrations of TON were very high (~860µg/L) at all sites while Ortho-P also reached high levels also (~40µg/L). Turbidity peaked at 18NTU at site 2.

Moderate Flow
There were no significant differences between sites during the moderate flow on 23 July. A maximum of 361µg/L TON was measured at site 4 while the minimum was 122.2µg/L at site 2. There was very little variation between sites of Ortho-P.

There was variation between dates, which was to be expected. During zero - low flow concentration of nutrients and sediments were minor in comparison to those during low-moderate flows

Conclusion

During zero-low flows site characteristics were found to affect variability in TON measurements between sites in this locality. The main influences being algae, emergent vegetation and stream velocity.

The combination of slow or non-existent stream velocity and low turbidity, particularly at Sites 2 and 3 aided the establishment of vegetation and algae colonies. The algae colonies where seen to act as sink or a source for TON depending on the growth stage of the colony and irradiance. Although the entire locality was overrun with vegetation Site 1 allowed samples to be taken from clear free flowing water best representing the water chemistry flowing past this locality however when sampling from site 3 and site 2 care needed to be taken not disturb the dead algal cells and small turbidity particles covering the rocks on the river bottom. Floating algal cells also needed to be avoided when taking samples form Site 2 and 3. Ortho-P and turbidity were not significantly affected by site characteristics during low flows.

During low-moderate and moderate flows there was no significant variability between sites for the parameters measured. The lack or lessened presence of algal cells in conjunction with faster flow and less vegetation allowed representative sampling from each site.

Care is need when selecting sites to sample for water quality. During low flows samples should be taken from Site 1. Sampling of Gara River may be carried out at any of the 4 sites investigated during low moderate– high flows

All parameters measured were positively correlated with flow such that there were significant differences between all flow regimes. Baseline conditions should be taken as those present during zero-low flow (0-12.6ML/Day).

Appendix C

Correlation matrices between selected variables at Willow Glen Station

Table 1 Correlation Matrix of selected variables measured at Willow Glen Station for 1997.

Log Total Rain	Log Effective Rainfall	0.811
	Log Total Discharge	0.819
	20 Minute Rainfall Intensity	0.645
	6 Minute Rainfall	0.624
Log Effective Discharge	20 Minute Rainfall Intensity	0.411
	6 Minute Rainfall Intensity	0.324
20 Minute Rainfall Intensity	6 Minute Rainfall Intensity	0.959

Table 2 Correlation Matrix of selected variables measured at Willow Glen Station for 1998.

Log Effective Rainfall	Log Initial Discharge	0.65
	Log Total Discharge	0.98
	Log Total Rainfall	0.479
Log Total Discharge	Log Initial Discharge	0.743
6 Minute Rainfall Intensity	20 Minute Rainfall Intensity	0.98
	Log Total Rainfall	0.58

Table 3 Correlation Matrix of selected variables measured at Willow Glen Station for 1999.

Log Total Discharge	Log Effective Discharge	0.987
	Log Total Rainfall	0.822
	20 Minute Rainfall Intensity	0.568
	6 Minute Rainfall Intensity	0.55
Log Total Rainfall	Log Effective Discharge	0.84
Log Initial Discharge	20 Minute Rainfall Intensity	0.6
	6 Minute Rainfall Intensity	0.63

Table 4 Correlation Matrix of selected variables at Willow Glen Station for 2000.

Log Total Discharge	Log Effective Discharge	0.983
	Log Initial Discharge	0.589
	Log Total Rainfall	0.609
Log Total Rainfall	Log Effective Discharge	0.679
20 Minute Rainfall Intensity	6 Minute Rainfall Intensity	0.69

Year	Start	Finish	6 min (mm/hr)	20 min (mm/hr)
1997	23-Dec-97	24-Dec-97	72	37.8
1997	01-Feb-97	02-Feb-97	38	16.2
1997	12-Feb-97	13-Feb-97	58	40.8
1997	13-Feb-97	14-Feb-97	40	24.6
1997	14-Feb-97	15-Feb-97	34	22.2
1997	15-Feb-97	16-Feb-97	78	60.6
1997	12-Feb-97	16-Feb-97	78	60.6
1997	06-Mar-97	07-Mar-97	8	6.6
1997	05-May-97	06-May-97	26	12
1997	08-May-97	09-May-97	6	4.8
1997	16-May-97	17-May-97	24	16.2
1997	27-Feb-97	28-Feb-97	42	30
1997	27-Jul-97	28-Jul-97	6	3
1997	02-Sep-97	03-Sep-97	6	3
1997	05-Sep-97	06-Sep-97	12	7.2
1997	19-Sep-97	20-Sep-97	8	5.4
1997	23-Sep-97	24-Sep-97	10	3.6
1997	24-Sep-97	25-Sep-97	20	12.6
1997	06-Oct-97	07-Oct-97	10	7.8
1997	07-Oct-97	08-Oct-97	12	8.4
1997	19-Oct-97	20-Oct-97	6	4.8
1997	27-Oct-97	28-Oct-97	26	15
1997	03-Nov-97	04-Nov-97	8	6
1997	08-Nov-97	09-Nov-97	74	40.2
1997	09-Nov-97	10-Nov-97	28	20.4
1997	10-Nov-97	11-Nov-97	44	15.6
1997	08-Nov-97	11-Nov-97	74	40.2
1997	14-Nov-97	15-Nov-97	32	21.6
1997	15-Nov-97	16-Nov-97	40	16.8
1997	14-Nov-97	16-Nov-97	40	21.6
1997	27-Nov-97	28-Nov-97	34	22.2
1997	28-Nov-97	29-Nov-97	26	19.8
1997	27-Nov-97	29-Nov-97	34	22.2
1997	05-Dec-97	06-Dec-97	52	19.8
1997	07-Dec-97	08-Dec-97	30	18.6
1997	09-Dec-97	10-Dec-97	12	6.6
1997	14-Dec-97	15-Dec-97	8	7.2
1997	19-Dec-97	20-Dec-97	28	16.8
1997	28-Dec-97	29-Dec-97	18	10.8
1997	29-Dec-97	30-Dec-97	24	10.2
1997	30-Dec-97	31-Dec-97	16	7.2
1997	28-Dec-97	31-Dec-97	24	10.8
1998	08-Feb-98	09-Feb-98	34	15
1998	09-Feb-98	10-Feb-98	12	8.4
1998	10-Feb-98	11-Feb-98	8	5.4
1998	11-Feb-98	12-Feb-98	58	23.4
1998	08-Feb-98	11-Feb-98	34	15
1998	16-Feb-98	17-Feb-98	54	25.2
1998	01-Mar-98	02-Mar-98	38	16.2
1998	10-Apr-98	11-Apr-98	58	24.6
1998	23-Apr-98	24-Apr-98	8	5.4
1998	24-Apr-98	25-Apr-98	24	9
1998	01-May-98	02-May-98	34	18.6
1998	02-May-98	03-May-98	16	10.2
1998	04-May-98	05-May-98	8	6.6
1998	05-May-98	06-May-98	10	5.4
1998	04-May-98	06-May-98	10	6.6
1998	15-May-98	16-May-98	10	5.4

Year	Start	Finish	6 min (mm/hr)	20 min (mm/hr)
1998	16-May-98	17-May-98	30	16.2
1998	17-May-98	18-May-98	14	8.4
1998	18-May-98	19-May-98	8	6
1998	01-Jun-98	02-Jun-98	10	6.6
1998	16-Jun-98	17-Jun-98	2	1.8
1998	22-Jun-98	23-Jun-98	12	9
1998	23-Jun-98	24-Jun-98	6	2.4
1998	29-Jun-98	30-Jun-98	8	4.2
1998	30-Jun-98	01-Jun-98	8	5.4
1998	18-Jul-98	19-Jul-98	6	3
1998	21-Jul-98	22-Jul-98	8	7.2
1998	25-Jul-98	26-Jul-98	8	4.8
1998	27-Jul-98	28-Jul-98	38	22.8
1998	05-Aug-98	06-Aug-98	8	4.8
1998	07-Aug-98	08-Aug-98	6	3.6
1998	15-Aug-98	16-Aug-98	12	10.2
1998	16-Aug-98	17-Aug-98	34.1	17.4
1998	22-Aug-98	23-Aug-98	8	4.8
1998	04-Sep-98	05-Sep-98	36.1	24
1998	05-Sep-98	06-Sep-98	40.1	16.2
1998	04-Sep-98	06-Sep-98	40.1	24
1998	11-Sep-98	12-Sep-98	4	2.4
1998	14-Sep-98	15-Sep-98	12	9
1998	24-Sep-98	25-Sep-98	34	18.6
1998	14-Sep-98	15-Sep-98	12	9
1998	04-Oct-98	05-Oct-98	40	23.4
1998	06-Oct-98	07-Oct-98	22	9
1998	25-Oct-98	26-Oct-98	6	2.4
1998	26-Oct-98	27-Oct-98	20	9
1998	30-Oct-98	31-Oct-98	8	6
1998	07-Nov-98	08-Nov-98	10	9
1998	08-Nov-98	09-Nov-98	12	5.4
1998	23-Nov-98	24-Nov-98	40	21
1998	08-Dec-98	09-Dec-98	26	17.4
1998	14-Dec-98	15-Dec-98	92	50.4
1998	21-Dec-98	22-Dec-98	12	10.8
1999	01-Jan-99	02-Jan-99	4	2.4
1999	02-Jan-99	03-Jan-99	10	7.2
1999	01-Jan-99	03-Jan-99	10	7.2
1999	31-Jan-99	01-Feb-99	6	4.2
1999	01-Feb-99	02-Feb-99	6	6
1999	08-Feb-99	09-Feb-99	26	7.8
1999	01-Mar-99	02-Mar-99	12	7.2
1999	02-Mar-99	03-Mar-99	10	6.6
1999	03-Mar-99	04-Mar-99	4	2.4
1999	01-Mar-99	04-Mar-99	12	7.2
1999	05-Apr-99	06-Apr-99	6	4.8
1999	18-Apr-99	19-Apr-99	4	3.6
1999	07-Jun-99	08-Jun-99	8	4.2
1999	01-Jul-99	02-Jul-99	16	7.2
1999	09-Jul-99	10-Jul-99	10	6
1999	14-Jul-99	15-Jul-99	4	2.4
1999	24-Aug-98	25-Aug-98	14	9
1999	27-Aug-99	28-Aug-99	8	6.6
1999	10-Sep-99	11-Sep-99	8	4.2
1999	17-Sep-99	18-Sep-99	8	6
1999	26-Sep-99	27-Sep-99	14	9.6
1999	02-Oct-99	03-Oct-99	14	9

Year	Start	Finish	6 min (mm/hr)	20 min (mm/hr)
1999	04-Oct-99	05-Oct-99	28	22.2
1999	14-Oct-99	15-Oct-99	34	15.6
1999	23-Oct-99	24-Oct-99	20	11.4
1999	31-Oct-99	01-Nov-99	4	3.6
1999	06-Nov-99	07-Nov-99	18	9
1999	08-Nov-99	09-Nov-99	12	7.2
1999	16-Nov-99	17-Nov-99	50	22.8
1999	19-Nov-99	20-Nov-99	58	25.8
1999	22-Nov-99	23-Nov-99	16	10.2
1999	27-Nov-99	28-Nov-99	30	21.6
1999	09-Dec-99	10-Dec-99	28	15
1999	10-Dec-99	11-Dec-99	16	6
1999	11-Dec-99	12-Dec-99	6	3.6
1999	09-Dec-99	12-Dec-99	28.6	15
1999	17-Dec-99	18-Dec-99	10	6.6
1999	18-Dec-99	19-Dec-99	6	4.2
1999	17-Dec-99	19-Dec-99	10	6.6
2000	17-Jan-00	18-Jan-00	16	5.4
2000	27-Jan-00	28-Jan-00	16	9.6
2000	01-Feb-00	02-Feb-00	38	30
2000	13-Feb-00	14-Feb-00	6	3.6
2000	07-Mar-00	08-Mar-00	38	21
2000	09-Mar-00	10-Mar-00	4	2.4
2000	13-Mar-00	14-Mar-00	18	6.6
2000	15-Mar-00	16-Mar-00	30	12
2000	21-Mar-00	22-Mar-00	8	5.4
2000	22-Mar-00	23-Mar-00	4	2.4
2000	05-Apr-00	06-Apr-00	32	19.8
2000	16-Apr-00	17-Apr-00	8	6
2000	25-May-00	26-May-00	6	4.2
2000	26-May-00	27-May-00	16	11.4
2000	10-Jul-00	11-Jul-00	8	4.2
2000	26-Jul-00	27-Jul-00	8	4.2
2000	09-Aug-00	10-Aug-00	8	4.2
2000	14-Aug-00	15-Aug-00	6	3.6
2000	24-Aug-00	25-Aug-00	6	3.6
2000	25-Aug-00	26-Aug-00	8	4.2
2000	01-Sep-00	02-Sep-00	8	6.6
2000	13-Oct-00	14-Oct-00	16	8.4
2000	14-Oct-00	15-Oct-00	32	18.6
2000	13-Oct-00	15-Oct-00	32	18.6
2000	24-Oct-00	25-Oct-00	44	26.4
2000	25-Oct-00	26-Oct-00	12	6.6
2000	24-Oct-00	26-Oct-00	44	26.4
2000	13-Nov-00	14-Nov-00	14	7.8
2000	14-Nov-00	15-Nov-00	10	5.4
2000	15-Nov-00	16-Nov-00	4	2.4
2000	13-Nov-00	16-Nov-00	14	7.8
2000	19-Nov-00	20-Nov-00	4	1.8
2000	30-Nov-00	01-Dec-00	32	10.2
2000	01-Dec-00	02-Dec-00	22	13.2
2000	06-Dec-00	07-Dec-00	6	3.6
2000	07-Dec-00	08-Dec-00	8	5.4
2000	06-Dec-00	08-Dec-00	8	5.4
2000	12-Dec-00		24	13.8
2000	13-Dec-00	14-Dec-00	14	5.4
2000	14-Dec-00	15-Dec-00	8	4.2
2000	15-Dec-00	16-Dec-00	14	9

Year	Start	Finish	6 min (mm/hr)	20 min (mm/hr)
2000	12-Dec-00	16-Dec-00	24	13.8
2000	27-Dec-00	28-Dec-00	46	21
2001	17-Jan-01	18-Jan-01	78	24
2001	28-Jan-01	29-Jan-01	48	26.4
2001	29-Jan-01	30-Jan-01	14	12.6
2001	30-Jan-01	31-Jan-01	50	28.8
2001	31-Jan-01	01-Feb-01	12	10.2
2001	28-Jan-01	01-Feb-01	50	28.8
2001	01-Feb-01	02-Feb-01	12	9.6
2001	02-Feb-01	03-Feb-01	6	4.8
2001	01-Feb-01	03-Feb-01	12	9.6
2001	27-Feb-01	28-Feb-01	28	21.6
2001	28-Feb-01	01-Mar-01	26	18
2001	27-Feb-01	01-Mar-01	28	21.6
2001	08-Mar-01	09-Mar-01	14	7.8
2001	09-Mar-01	10-Mar-01	20	12.6
2001	10-Mar-01	11-Mar-01	8	6.6
2001	11-Mar-01	12-Mar-01	22	13.8
2001	12-Mar-01	13-Mar-01	16	8.4
2001	08-Mar-01	13-Mar-01	22	13.8
2001	22-Apr-01	23-Apr-01	66	34.2
2001	01-May-01	02-May-01	10	4.8
2001	02-May-01	03-May-01	6	4.9
2001	07-May-01	08-May-01	6	3.6
2001	20-May-01	21-May-01	8	7.2
2001	08-Jun-01	09-Jun-01	6	3.6
2001	09-Jul-01	10-Jul-01	2	1.8
2001	26-Jul-01	27-Jul-01	8	5.4
2001	26-Aug-01	27-Aug-01	14	10.8
2001	27-Aug-01	28-Aug-01	2	1.2
2001	26-Sep-01	27-Sep-01	10	6
2001	11-Oct-01	12-Oct-01	6	4.2
2001	13-Oct-01	14-Oct-01	8	4.8
2001	26-Oct-01	27-Oct-01	24	16.2
2001	07-Nov-01	08-Nov-01	12	8.4
2001	09-Nov-01	10-Nov-01	20	12
2001	11-Nov-01	12-Nov-01	18	8.4
2001	18-Nov-01	19-Nov-01	40	24.6
2001	19-Nov-01	20-Nov-01	12	10.2
2001	24-Nov-01	25-Nov-01	40	20.4
2001	25-Nov-01	26-Nov-01	20	10.8
2001	26-Nov-01	27-Nov-01	34	31.2
2001	24-Nov-01	27-Nov-01	40	28.8
2001	07-Dec-01	08-Dec-01	12	6.6
2001	14-Dec-01	15-Dec-01	6	3
2001		16-Dec-01	10	6
2001	18-Dec-01	19-Dec-01	56	33.6