Ecological Responses to Wetland Flooding, Deniliquin NSW

Sylvia Zukowski

Shaun Meredith, Nick Whiterod, Robert Walsh

Lynnbrae wetland Site A, 23rd Nov 02

Murray-Darling Freshwater Research Centre,
Lower Basin Laboratory, Mildura VIC 3502.

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Table of Contents

Executive Summary

A post-wetting ecological survey, partially funded by the NSW Murray Wetlands Working Group Inc., was conducted at three Deniliquin wetlands (Forest Creek, Greenacres and Lynnbrae) in NSW between October and December 2002. Sampling of three wetlands commenced on the 27th of October 2002 and was conducted over 5 weeks after flooding. Water was released into the wetlands from three separate channels fed from Lake Mulwala through the main Mulwala channel. The water formed part of an environmental water allocation managed by the NSW MWWG. The aim of the study was to determine post flood responses of water quality, nutrients, phytoplankton and microcrustaceans.

Throughout the study period changes in the following water quality parameters were observed. Water depth in all three wetlands ranged from 5-28 cm and were influenced by additional inflows. Temperatures ranged from 25-30^{o}C. The Forest Creek wetland was acidic throughout most of the sampling period (pH range 3.5 – 7.0), while the Greenacres and Lynnbrae wetlands were slightly basic (pH ~ 7.5). High initial post flood turbidities were recorded in the wetlands, however these declined rapidly 4 days after inundation then continued to decrease gradually for the remainder of the sampling period. Electrical conductivity remained low, peaking at ~135 µS/cm on day 15 in the Forest Creek and Lynnbrae wetlands and 220 µS/cm on day 27 in the Greenacres wetland. Inflow salinities followed similar patterns to wetlands, however remained 5-50 µS/cm below wetland salinity. Dissolved oxygen (DO) concentrations were generally below 6 mg/L in the three wetlands. The lowest DO was recorded in the Lynnbrae wetland on day 15 (1 mg/L).

Initial peaks in all nutrients examined - total nitrogen (TN), Oxides of Nitrogen (NOx), total phosphorus (TP) and filterable reactive phosphorus (FRP) - were recorded within a few hours after inundation in all three wetlands and had decreased rapidly by 5 - 12 hours after inundation. Secondary peaks in TN, TP and FRP were also seen on day 15 in the Forest Creek and Lynnbrae wetlands. Maximum TP concentrations of 250, 505 and 835 µgP/L and TN concentrations of 2410, 4185 and 2405 µgN/L were recorded in the Forest Creek, Greenacres and Lynnbrae wetlands, respectively.

Chlorophyll trends during the sampling period were similar in the Forest Creek and Lynnbrae wetlands with 2 peaks occurring on day 15 (38 and 14 µg/L, respectively) and on the last day of the study (19 and 15 µg/L, respectively). The Greenacres wetland recorded an initial peak in chlorophyll concentrations on day 7 (16 µg/L) and a second peak on day 35 (39 µg/L). Chlorophyll peaks were mainly due to increases in blue-green algae (*Anabaena* sp.)

Microcrustacean abundances remained below 10 individuals/L until day 27 in the Forest Creek wetland and channel sites, after which they increased to 42 individuals/L by the end of the study period. This final peak was dominated by Daphniidae and Cyclopidae taxa. Very similar trends were reported between the Greenacres and Lynnbrae wetlands in relation to timing of peaks and dominant species found at the peaks. Two peaks were recorded on days 5 and 27 in both wetlands with the initial

smaller peak being dominated by Cyclopidae, Centropagidae and Bosminidae and the larger second peak consisting mainly of Cyclopidae, Centropagidae, Moinidae and Daphniidae.

Temporal responses of nutrients, chlorophyll and microcrustacea in the Forest Creek and Lynnbrae wetlands followed responses reported for other wetlands (Geiger et al. 1985, Culver and Geddes 1993, Ingram *et al.* 1997), with an initial peak in nutrients occurring within the first day, followed by a peak in phytoplankton at 2 weeks and finally a peak in microcrustacea at 5 weeks after inundation. The Greenacres wetland demonstrated the same short response time of a few hours for nutrients, however microcrustacea and phytoplankton responses differed. Following the initial nutrient peak, a peak in microcrustacea was seen on day 27, one week prior to the phytoplankton peak.

Future suggestions

Due to the very high nutrient concentrations found within all the wetlands there is an urgent need to keep out grazing animals not just from wetlands but also from adjoining channels and/or decrease possible fertilizer run-off into the channels and wetlands. Future monitoring should be extended past 35 days to more clearly identify macroinvertebrate responses, which are likely to be slower than the other parameters examined. Further filling of the wetlands performed on a natural time scale should be monitored for the above examined parameters to determine the possible change in response times and effects in concurrent wetting cycles. Monitoring future flood events occurring at different times of the year within the studied wetlands will help identify possible post flood responses to seasonal variations.

Introduction

River regulation has altered the natural flow regime and reduced the frequency of inundation of many freshwater wetlands. The NSW Murray Wetlands Working Group Inc. (NSW MWWG) manages an environmental water allocation that targets wetlands deprived of their natural inflows. This study examines the post-inundation ecological responses in three privately-owned wetlands that received a water allocation from the NSW MWWG in October 2002.

It is generally agreed that both wet and dry periods are critical in maintaining ecosystem integrity in ephemeral wetlands (Boulton and Jenkins 1998). Under natural conditions, freshwater wetlands are filled at irregular intervals by flooding, drying out between inundations. Many native plants and animals, including invertebrates, fish, waterbirds and river red gums, have adapted to this irregular cycle and depend on it for breeding and survival. The wetlands act as sponges, storing water for natural flood mitigation and absorbing and recycling nutrients. They act as biological filters, improving water quality and increasing the productivity of associated aquatic and terrestrial ecosystems. Freshly flooded wetlands provide a rich source of nutrients for plant and animal growth. Periodic flooding of freshwater wetlands is essential for the breeding and survival of many species of native fish (Billyard 2002). Previous research (Culver 1988; Culver and Geddes 1993; Ingram *et al.* 1997) has illustrated some of the post flood responses that bacterial, phytoplankton and zooplankton communities undergo. However, past studies do not provide information on the patterns and of response between these communities or their relative response times.

The aim of this study was to examine the post-inundation responses of water quality/chemistry (including nutrients), phytoplankton and microcrustacean communities in three freshwater wetlands in South Western NSW. The wetlands are situated on private properties within 30 km of Deniliquin (Figure 1) and comprise the Forest Creek, Greenacres and Lynnbrae wetlands (Figure 2). Forest Creek (14.7 ha) contains scattered black box trees with an understorey of moderately-dense lignum and has not been grazed for ca. 10 years. Greenacres (10.1 ha) contains black box trees and has very little understorey or vegetation cover due to recent heavy grazing pressure. Lynnbrae (6.8 ha) contains black box, needlewood, rosewood and dense areas of lignum and differs to the other two wetlands in that it is relatively flat rather than gilgai.

Methods

The Forest Creek, Greenacres and Lynnbrae wetlands were each monitored between 27th October and 3rd December 2002. The first day of sampling coincided with the commencement of inflows into each wetland. Sampling occurred on days 1, 2, 3, 4, 5, 7, 14, 20, 26, and 35. On each sampling day, water depth, water quality, nutrients, phytoplankton and aquatic microcrustacea were measured at each of three randomly chosen sites (A, B and C) within each wetland and at one channel site situated approximately 5 metres from each connecting wetland (Figure 3).

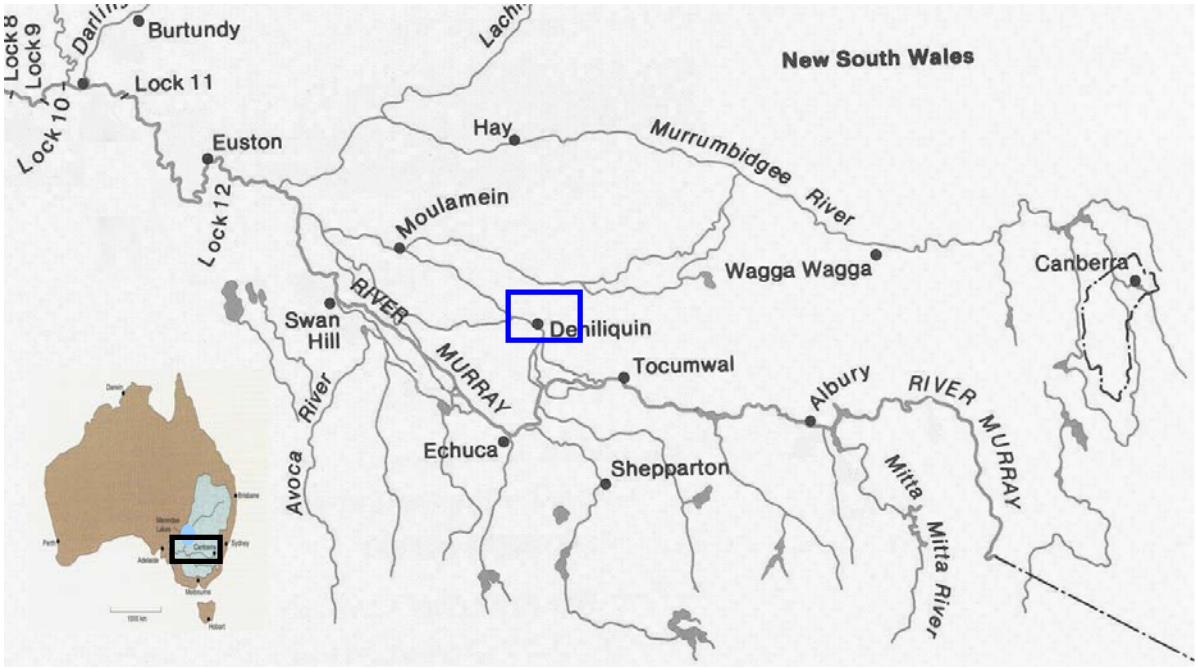

Figure 1: Location of Deniliquin within Australia

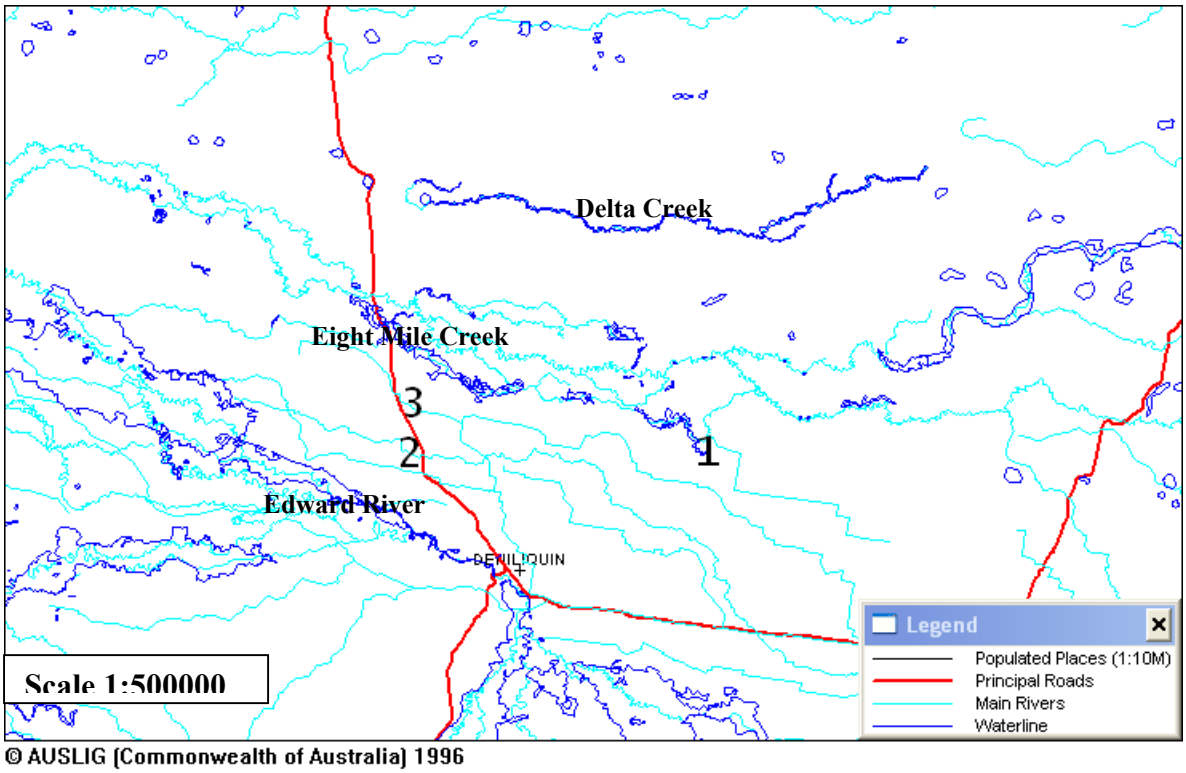

Figure 2: Location of the three study wetlands near Deniliquin, NSW.
(1 = Forest Creek; 2 = Greenacres; 3 = Lynnbrae).

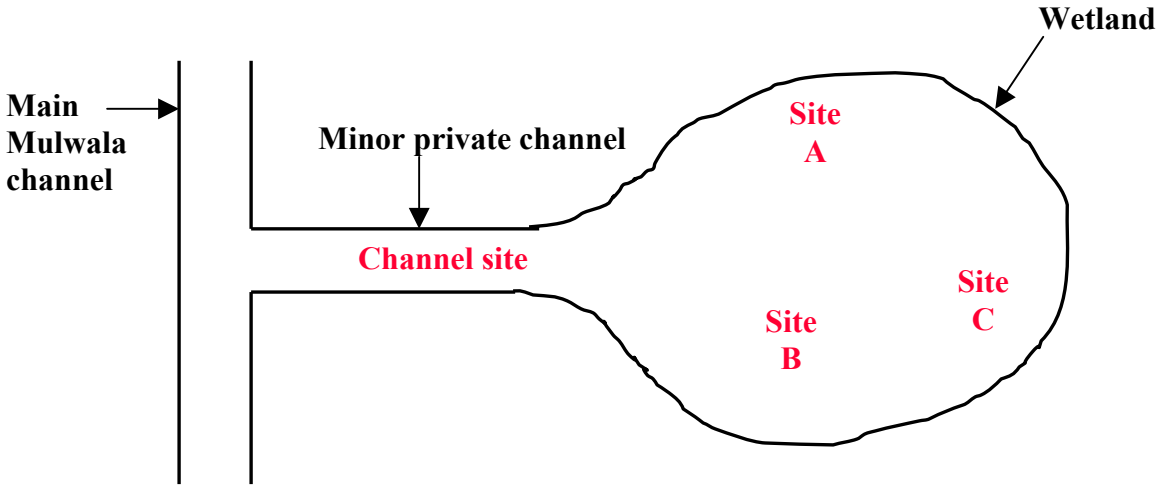

Figure 3: Stylised diagram highlighting the four study sites within each wetland.

At each site on each sampling day, water depths were measured at garden stakes that were secured into the ground at each site. Temperature (^{o}C), pH, turbidity (NTU), electrical conductivity (µS/cm) and dissolved oxygen concentration (mg/L) were measured *in situ* with a HORIBA Ltd U-10 multi-probe water quality checker (Australian Scientific Ltd.).

A 200 ml water sample was collected to measure total nitrogen (TN) and total phosphorus (TP) A 10 ml sample was filtered through a 0.45 µm filter for determination of oxides on nitrogen (NOx) and filterable reactive phosphorus (FRP) concentrations. Nutrient samples were frozen and sent to the NATA certified MDFRC Chemical Laboratory (Albury) for analysis.

Phytoplankton biomass was determined indirectly by measuring chlorophyll *a* concentrations. Chl *a* was determined from 1 L dip samples collected below the water surface, filtered through GF/C filters and analysed using hot ethanol extraction without acidification (APHA 1995).

Aquatic invertebrates were sampled by passing 75 L of water through a 53 µm mesh and preserving the contents in 70% ethanol. Abundances were determined quantitatively. Microcrustaceans were identified to genus level or below following the keys of Bayly (1992), Smirnov and Timms (1983) and Shiel (1995).

Results / Discussion

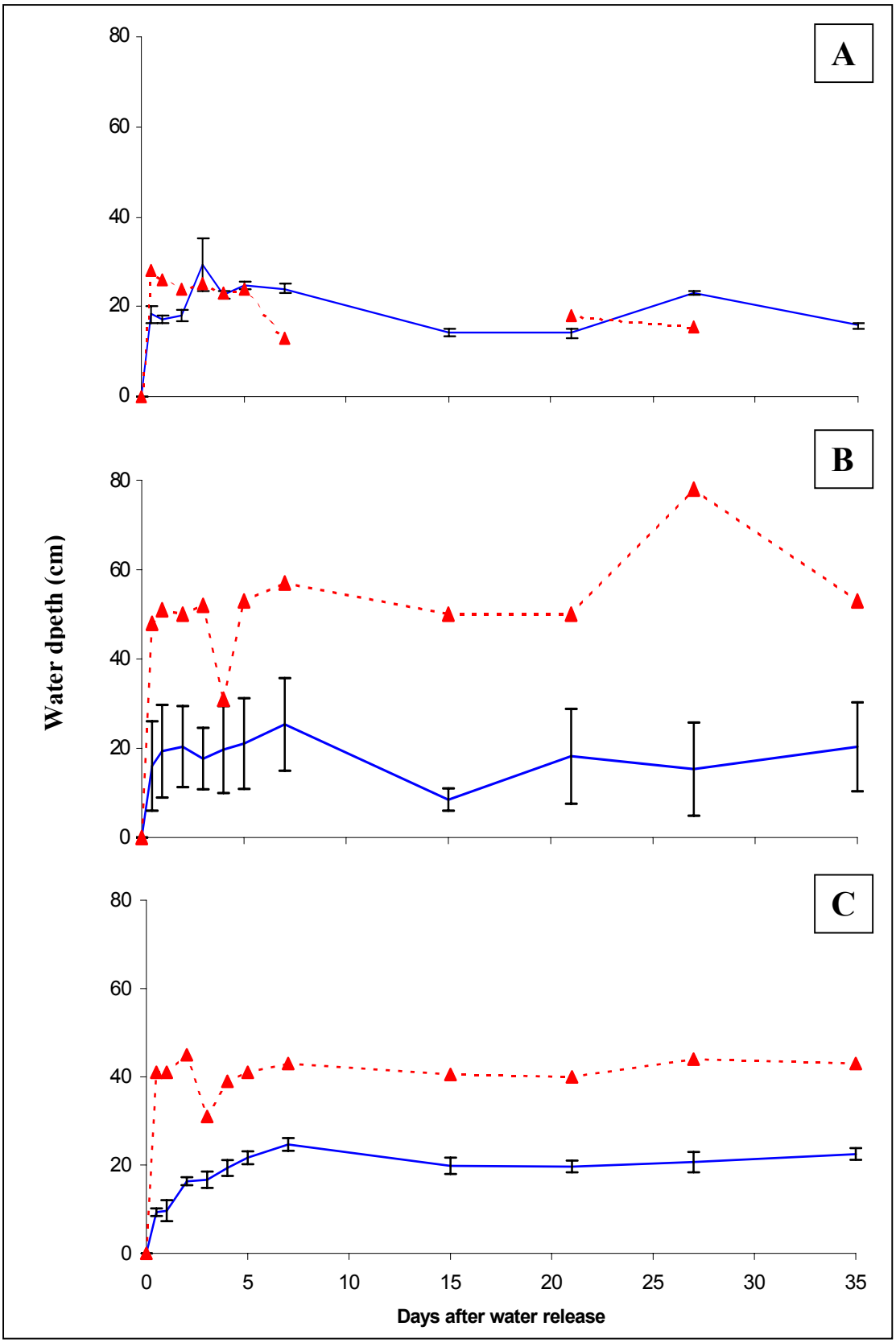

Figure 4: **Relative water depth (cm) in a) Forest Creek, b) Greenacres and c) Lynnbrae** (Mean (± SE) of 3 replicate wetland sites ——; Channel site ------).

The water levels in the inlet channels and wetlands of the Forest Creek, Greenacres and Lynnbrae wetlands are highlighted in Figure 4. Forest Creek received 42 ML of water between days 0-7 and a further 17 ML between days 21 to 27 to 'top up' the wetland. Greenacres was flooded initially then received a monthly allocation of ca. 8 ML for three months (delivered over 3 days in the middle of each month) to maintain water levels in the wetland. In contrast, Lynnbrae received inflows for most of the sampling period.

Wetland water levels may be influenced by a number of factors including duration and volume of inflows from adjoining irrigation channels, the wetland surface area:volume relationship, groundwater interactions, evaporation and precipitation. These vary between the 3 wetlands, resulting in water level fluctuations that are unique to each wetland. This may have been a contributing factor to the accompanying water quality results obtained during the surveyed period.

Water quality / chemistry

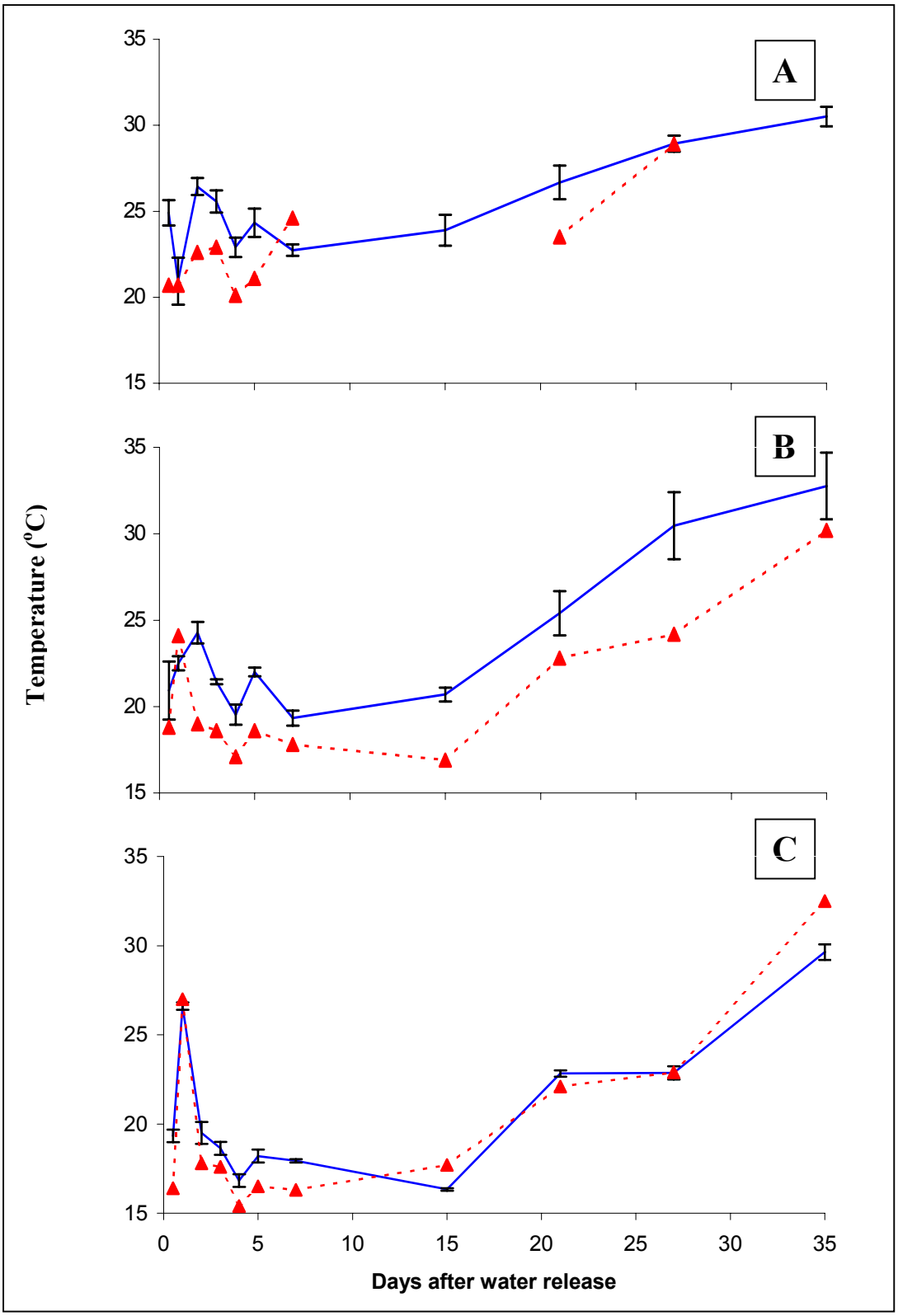

Figure 5: Temperature (°C) in a) Forest Creek, b) Greenacres and c) Lynnbrae **(Mean ± SE of 3 replicate wetland sites ——; Channel site ------).**

The water temperatures in the three wetlands followed a similar pattern over time with a general increase in temperature over the sampling period (Figure 5). Maximum temperatures reached 30^{o}C at the end of the sampling period, however remained around the mid twenties for the majority of the sampling period in the three wetlands. The wetlands are shallow and hence poorly buffered from ambient air temperature fluctuations.

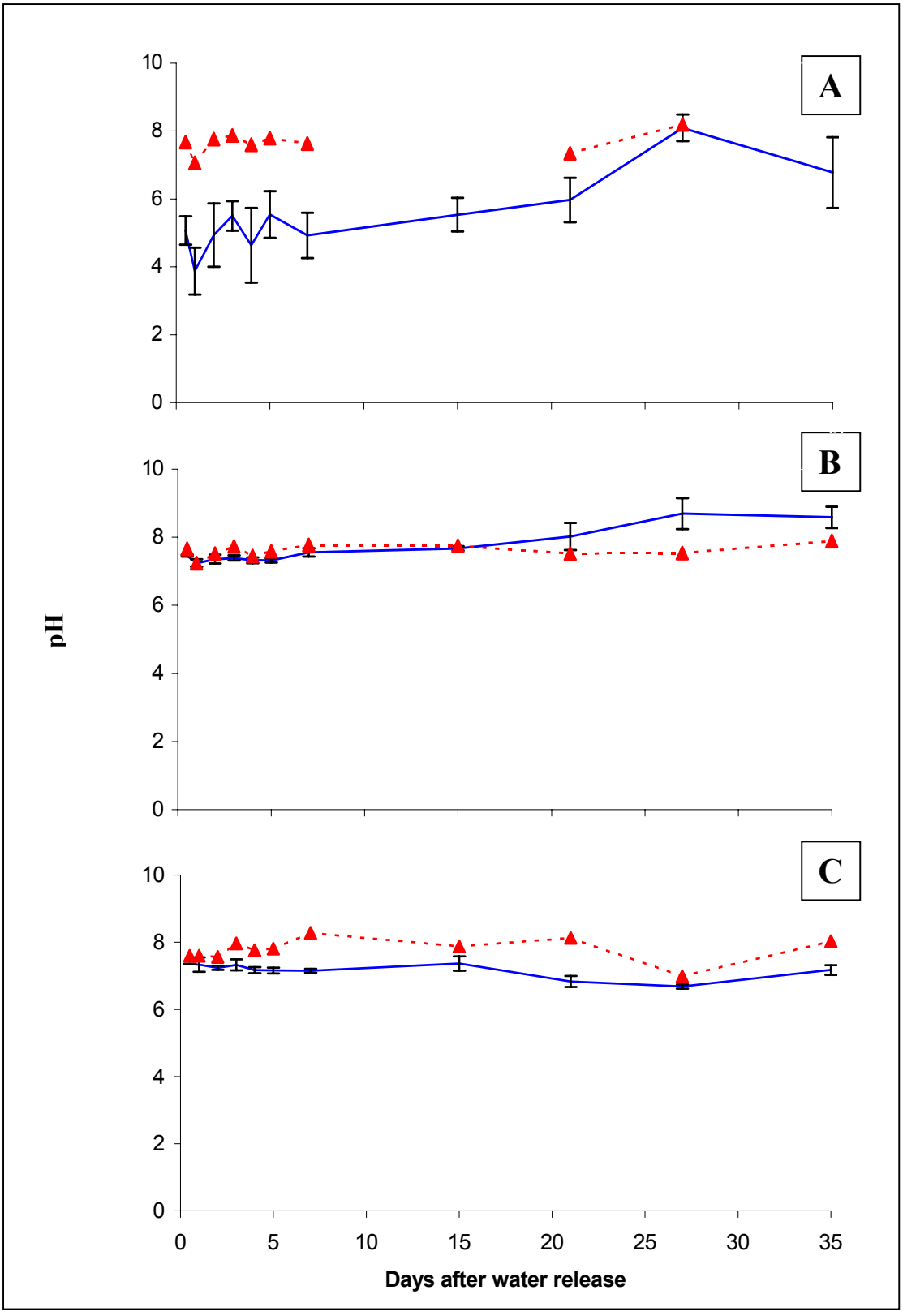

Figure 6: pH in a) Forest Creek, b) Greenacres and c) Lynnbrae.
(Mean ± SE of 3 replicate wetland sites ——; Channel site ------).

Differences in pH were observed between wetlands and within wetlands over time (Figure 6). pH levels measured in Forest Creek in the first week following inundation ranged from 3.5 to 5.5 and remained well below the worldwide optimal pH of 6.5-9 (ANZECC 2000). These acidic pH readings for the initial week (pH <7) were not attributed to the inflows, but may be due to an initial release of acid from the sediments (e.g. McCarthy *et al.* 2003) and/or the decomposition of organic matter. The increase in pH levels from day 21 to day 27 may be associated with the second inflow event into the wetland and associated higher pH levels in the incoming channel water (inflow pH>7). In contrast to Forest Creek, pH levels in the Greenacres and Lynnbrae wetlands were relatively stable, remaining alkaline at pH values around 7.5

The variations in pH found in the wetlands may be attributed to a range of factors including daytime photosynthetic consumption of carbonic acid and/or bicarbonate (increased pH), the metabolic aspiration of carbon dioxide (decreases pH levels at night) and the microbial oxidation of compounds such as hydrogen sulfide and ammonium (lowers pH) (Scholz *et al.* 1999).

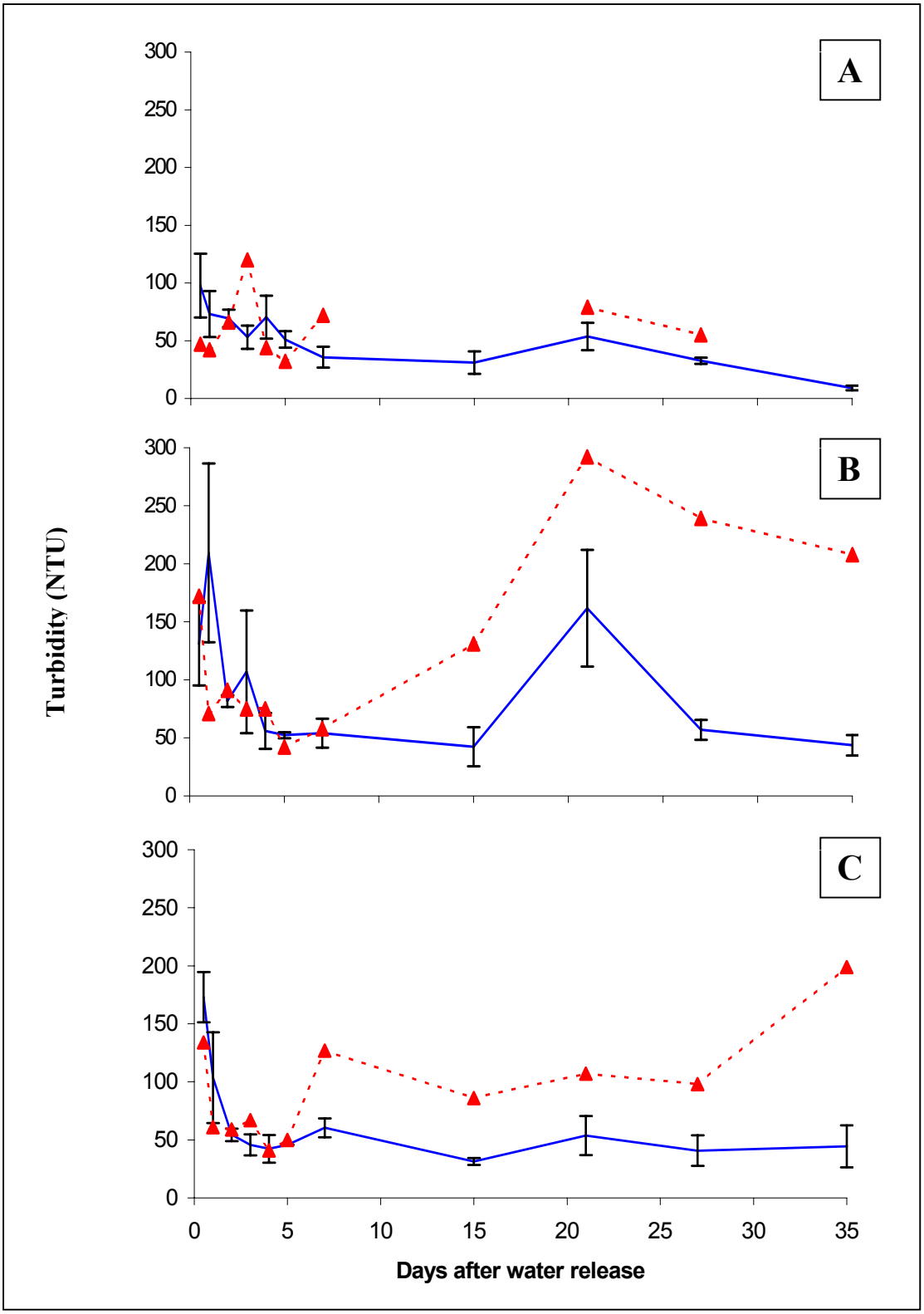

Figure 7: Turbidity (NTU) in a) Forest Creek, b) Greenacres and c) Lynnbrae.
(Mean ± SE of 3 replicate wetland sites ——; Channel site ------).

Turbidity arises from the presence of suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter and plankton and other microscopic organisms. Through its affect on reducing light penetration, turbidity is an important factor in controlling primary production and in increasing the potential for thermal and chemical stratification. Turbidity within the wetlands is influenced by various factors including water level, sediment structure, wind and the turbidity of inflows from the irrigation channel (Scholz *et al.* 1999).

The three wetlands showed a similar trend in turbidity over the 35-day sampling period (Figure 7). Wetlands were highly turbid (>50 NTU) on day 1 following the initial water influx, with Forest Creek, Greenacres and Lynnbrae wetlands reaching turbidities of 98, 209 and 173 NTU, respectively, but decreased rapidly from day 1 to day 4. Turbidities decreased gradually until day 15 when turbidities were less than 50 NTU in all three wetlands. This pattern was likely the result of an initial sediment disturbance as waters entered the wetland followed by a gradual settling period/biofilm establishment.

The sudden increase in turbidity in all three wetlands on day 21 was likely due to high winds resuspending wetland sediments through wind-induced wave action and turbid inflows with the highest recorded turbidities on day 21 found in the adjoining wetland channels. Overall highest turbidities were found in the channel sites of Greenacres, followed by Lynnbrae and finally Forest Creek.

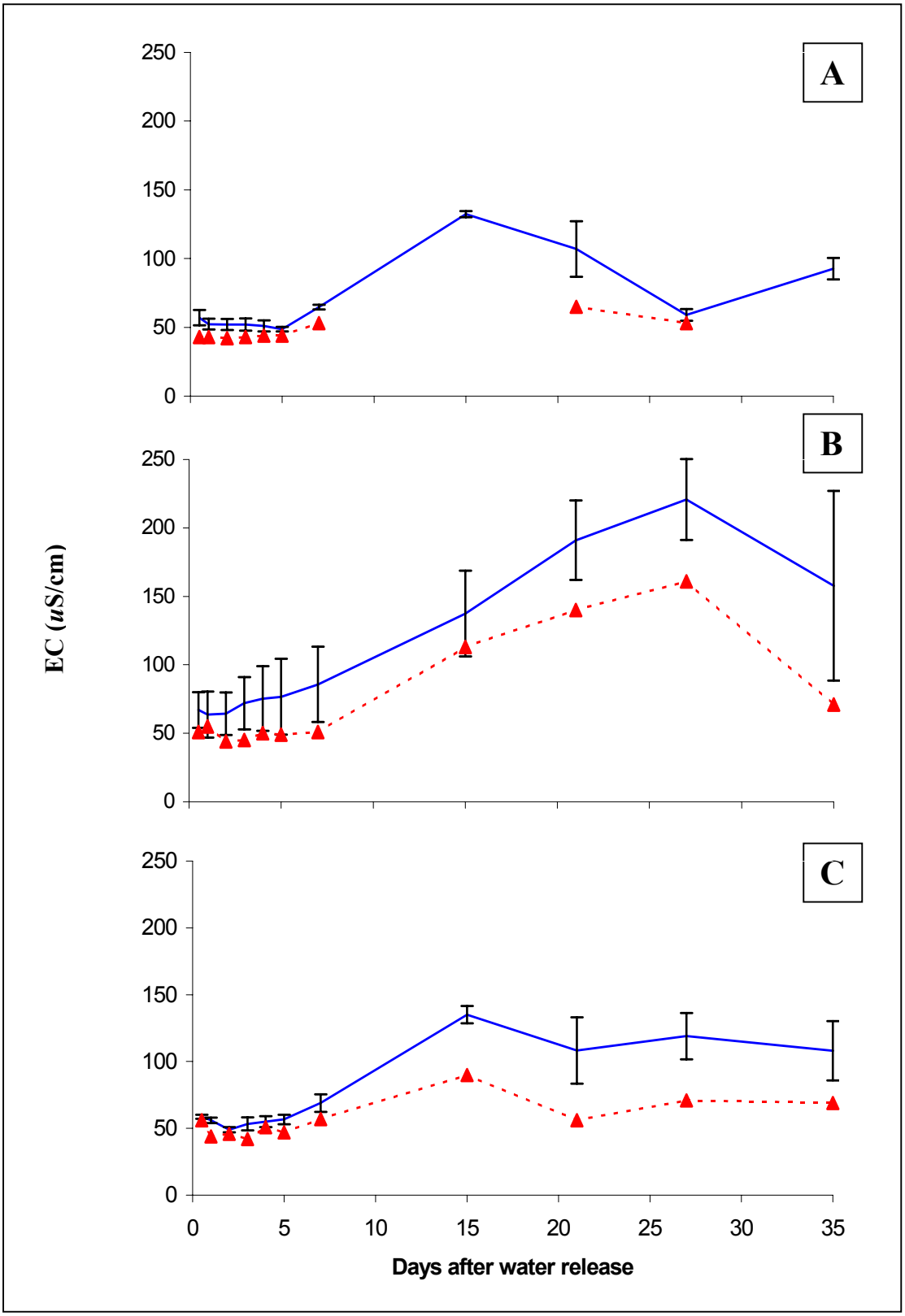

Figure 8: Electrical conductivity (*u*S/cm) in a) Forest Creek, b) Greenacres and c) Lynnbrae. **(Mean ± SE of 3 replicate wetland sites ——; Channel site ------).**

Electrical Conductivity (EC) at all sites was relatively low with Greenacres consistently higher than the other sites (Figure 8). The greater electrical conductivity in the wetland relative to the inlet channel when filling suggests that some salts were present in the dried wetland and have become dissolved upon flooding (particularly evident for Greenacres). Despite this contribution, EC did not exceed 220 *u*S/cm in any wetlands and thereby was well below thresholds for biological/chemical reactions. Subtle differences in EC in the wetlands were not thought to have influenced the inundation response variables. Following the initial inflow of water into the wetlands the general trends found were increased EC between days 5-14 in Forest Creek and Lynnbrae and days 2-26 in Greenacres which were likely the result of evaporation concentrations as water levels fell and/or salt was released from the sediments. A decrease in EC between days 20-25 in Forest Creek and Lynnbrae and days 27-35 in Greenacres was well correlated with inflows during this time which would have diluted the wetland EC.

Inflow salinities were continually lower than salinities found in the wetlands. As salt picked up by the water was diluted with increased inflows, an inversely proportional relationship between EC and water depth was apparent in the wetlands, but not in the channels.

EC fluctuations impact directly upon the physiological functioning of aquatic organisms. Although an upper salinity limit of 1,000 *u*S/cm has been recommended for the protection of freshwater ecosystems (ANZECC 2000), management objectives for water extracted from the system for agricultural (horticultural) purposes suggest a lower operational upper limit of 750 *u*S/cm (Scholz *et al.* 1999). Salinity in the three wetlands remained well below these thresholds.

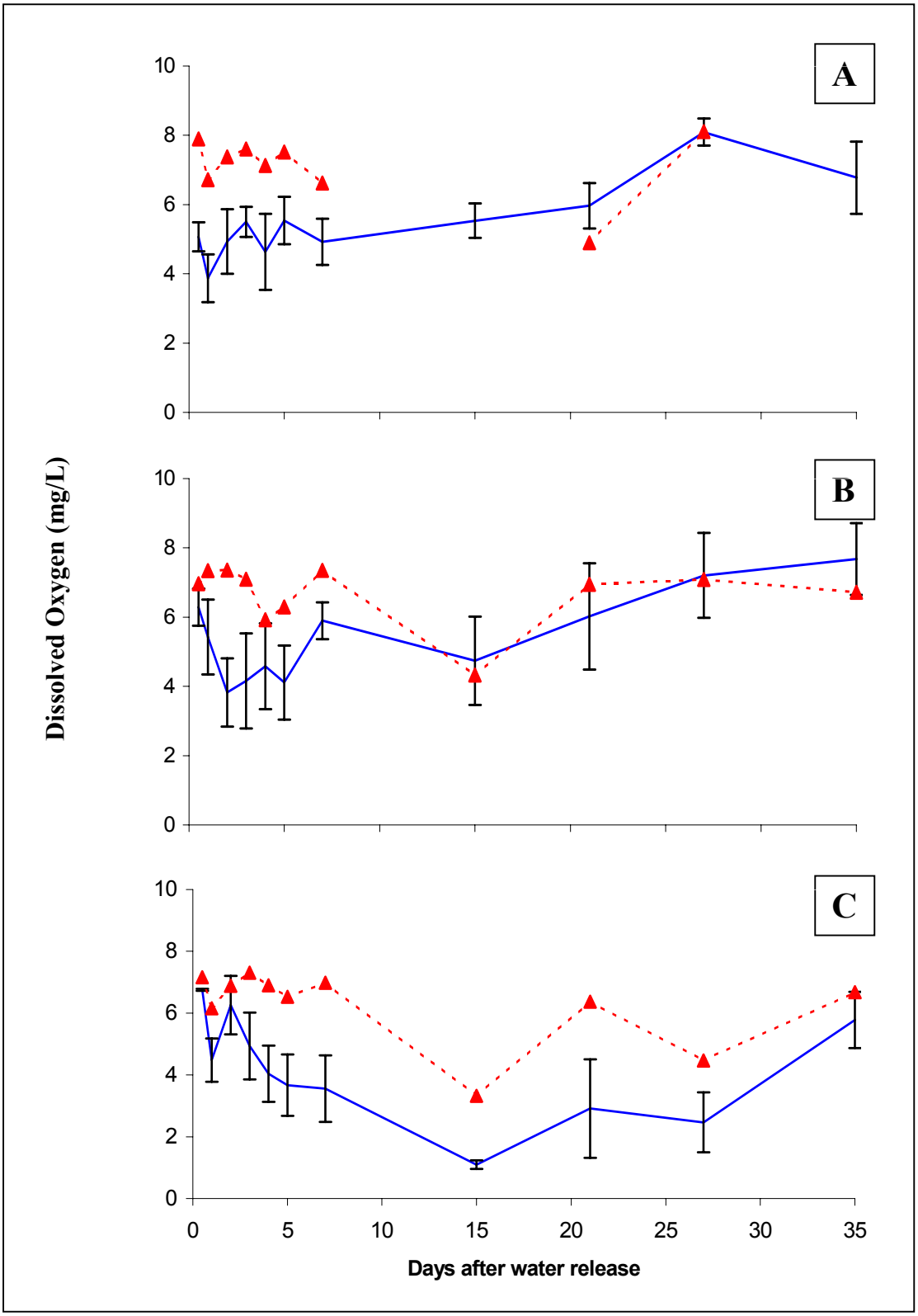

Figure 9: Dissolved Oxygen (mg/L) in a) Forest Creek, b) Greenacres and c) Lynnbrae.
(Mean ± SE of 3 replicate wetland sites ——; Channel site ------).

The dynamics of oxygen distribution in wetlands in governed by a balance between inputs from the atmosphere and photosynthesis, and losses due to chemical and biotic oxidations. Because of this, the DO concentrations of a water body may vary significantly throughout a 24-hour period with lowest oxygen saturation levels generally occurring at dawn prior to the re-commencement of photosynthesis (Scholz *et al.* 1999). For accurate comparison of DO, samples should be taken at the same time each day. Due to logistical constraints, this was not possible. However, the Lynnbrae wetland was consistently sampled between 9am-12pm, the Greenacres wetland between 12.30 and 3.30pm and the Forest Creek wetland between 4-7pm.

ANZECC (2000) guidelines recommend that DO concentrations do not fall below 6 mg/L (less than 80-90% saturation) for the production of aquatic ecosystems in fresh waters (Scholz *et al.* 1999). DO concentrations fell below this level in all wetlands for the majority of the survey period, however some peaks above 6 mg/L were recorded. The initial nutrient increase within the wetlands (Figure 10) would have stimulated microbial growth and given rise to a boom in bacteria abundance which would in turn consume oxygen during the breakdown of organic matter.

Extremely low DO levels were recorded in the Lynnbrae wetland sites with 1 mg/L recorded on day 15 and levels below 6 mg/L for all days except day 1 (Figure 10). The Lynnbrae wetland was always the first wetland sampled (~9am) which may partly account for the low dissolved oxygen readings as minimum oxygen saturation concentrations generally occur at dawn prior to the re-commencement of photosynthesis. This, coupled with microbial breakdown of organic matter in the wetland, may explain the low dissolved oxygen levels recorded.

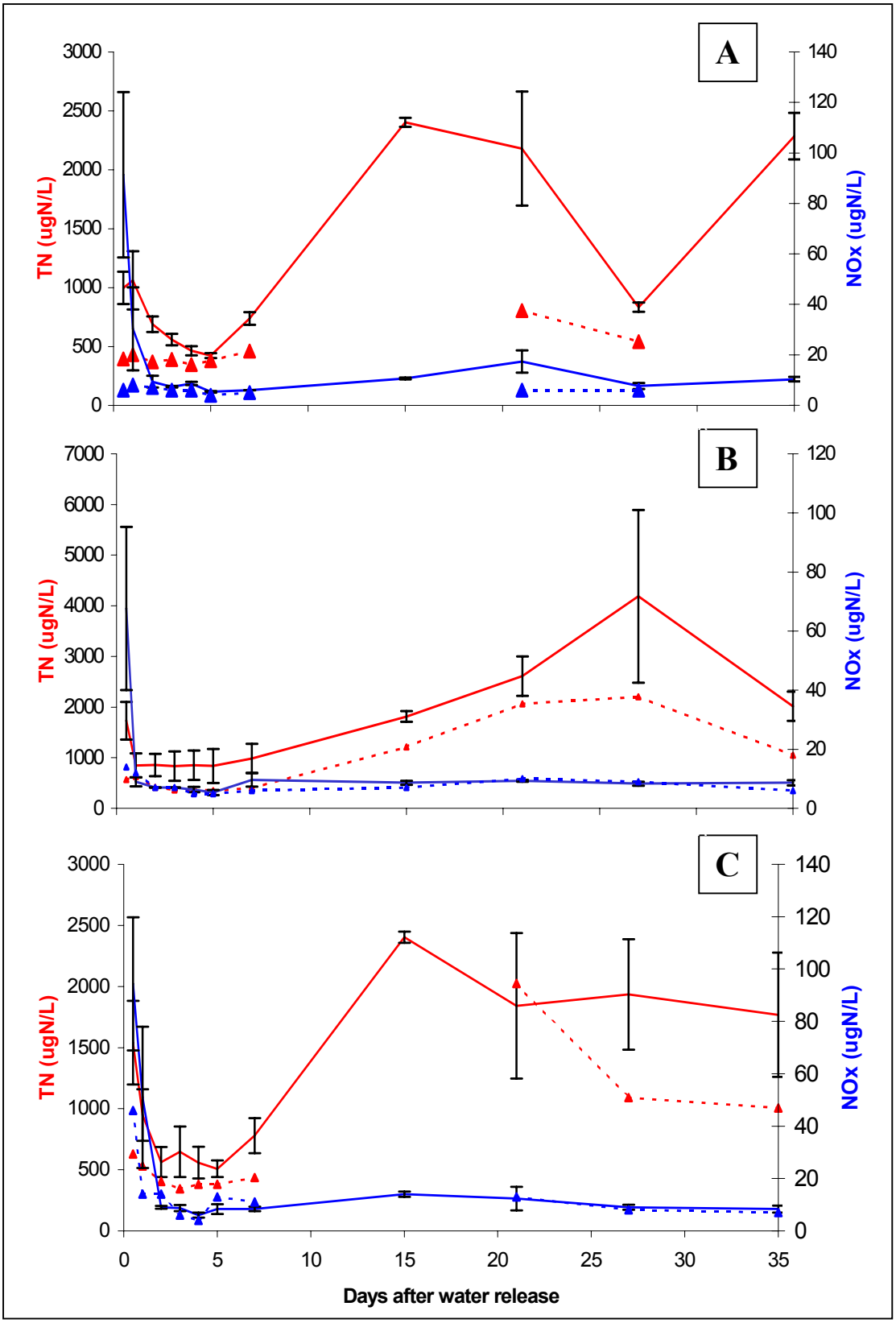

Figure 10: Total Nitrogen TN (µgN/L) and Oxides of Nitrogen NOx (µgN/L) in a) Forest Creek, b) Greenacres and c) Lynnbrae. ***Note different Y scale values**
(TN mean ± SE of 3 replicate wetland sites ——; Channel site ------)
(NOx mean ± SE of 3 replicate wetland sites ——; Channel site ------)

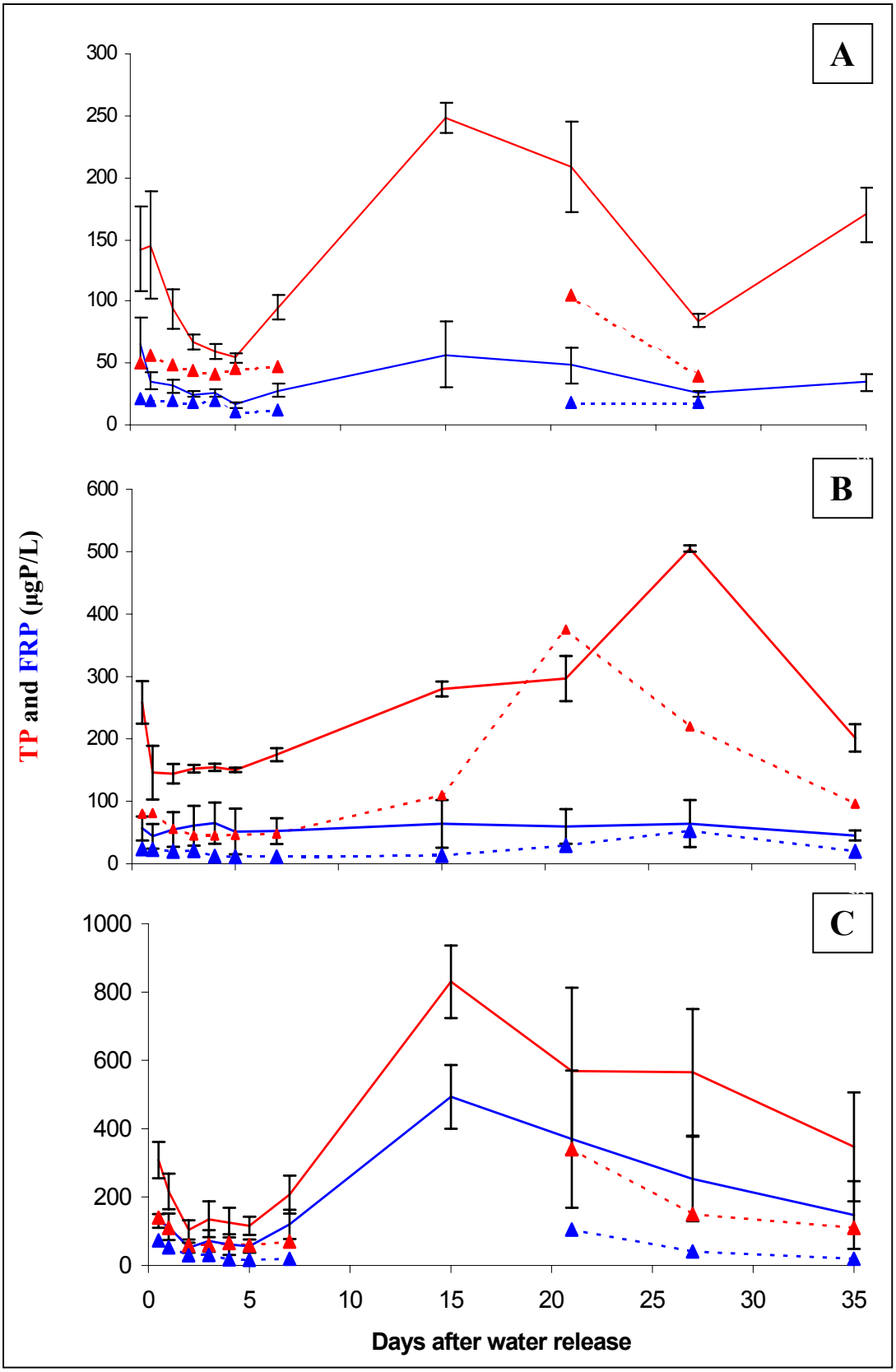

Figure 11: Total Phosphorus TP (µgP/L) and Filterable Reactive Phosphorus FRP (µgP/L) in a) Forest Creek, b) Greenacres and c) Lynnbrae***Note different Y scale values**.
(TP mean ± SE of 3 replicate wetland sites ——; Channel site ------)
(FRP mean ± SE of 3 replicate wetland sites ——; Channel site ------)

Both nitrogen and phosphorus are present in various dissolved and particle-associated forms. Nitrogen is an essential nutrient for growth and is rapidly cycled in the ecosystem. Total Nitrogen (TN) is a measure of the potential pool size of available nitrogen. NOx-nitrogen is a measure of the nitrate/nitrite fraction of the total nitrogen pool. It represents one component of the soluble nitrogen pool that is most able to be used by plants (EPA 1999). Filterable Reactive Phosphorus (FRP) provides a measure of the amount of soluble phosphorus present in a form that is readily available for algal growth, whilst Total Phosphorus (TP) represents the total pool of phosphorus in the water sample (EPA 1999).

In each wetland, the total nutrient level fluctuated resulting in several peaks being observed during the survey period (Figures 10 and 11). The initial peak in total nitrogen and phosphorus in each wetland was observed within the first few hours following water release into the wetland. Indeed the initial sampling 2 hours after water had begun to enter the wetland may have missed the real peak. Much of the TP in the initial peak was found in a bio-available form (FRP). This is not so much the case for total nitrogen. These initial peaks may be explained by the release of nutrients stored in the previously dry sediments. These areas have experienced grazing pressures in the past, which combined with possible fertilizer run-off into the channel and/or wetlands, may have contributed to these initial high nutrient peaks.

Following the initial peaks, nutrient levels declined in each wetland after only a few hours, perhaps a result of dilution effects with the greatest water depth occurring during this period. These reductions in TN and TP and also NOx and FRP, led to the lowest levels being recorded at this time. TN dropped to between 500 and 1000 μgN/L (still well above the ANZECC (2000) guidelines recommendations of 500 μgN/L for TN), whilst TP stabilized at 50 to 200 μgP/L. Bio-available levels (NOx and FRP) where found to only be slightly lower at each wetland with the exception of TN at Forest Creek and Lynnbrae. Further, a higher FRP level compared to the TP level at Greenacres during this nutrient reduction may represent a sampling error.

The influence of dilution/evaporation (represented as water depth) (Figure 1) contributes to the increase in all nutrient levels, from the initial dips to the subsequent maximum peaks that where observed. As inflows into the wetlands ceased and water depths declined, nutrient levels increased. Highest TN and TP peaks were observed at day 15 in Forest Creek and Lynnbrae, when water depths were lowest. This increase in TN is suggestive of increased productivity which is confirmed by increased Chlorophyll concentrations on day 15 in Forest Creek and Lynnbrae (Figure 12). Despite water depths also being lowest at day 15 at Greenacres, nutrient levels continued to increase and peaked after 25-30 days.

An overall comparison between NOx and FRP concentrations in the wetlands shows that there is continually more FRP being released than NOx during the survey period. This data contradicts previous research conducted by (Baldwin and Mitchell 2000) which demonstrates that more NOx than FRP is released after inundation.

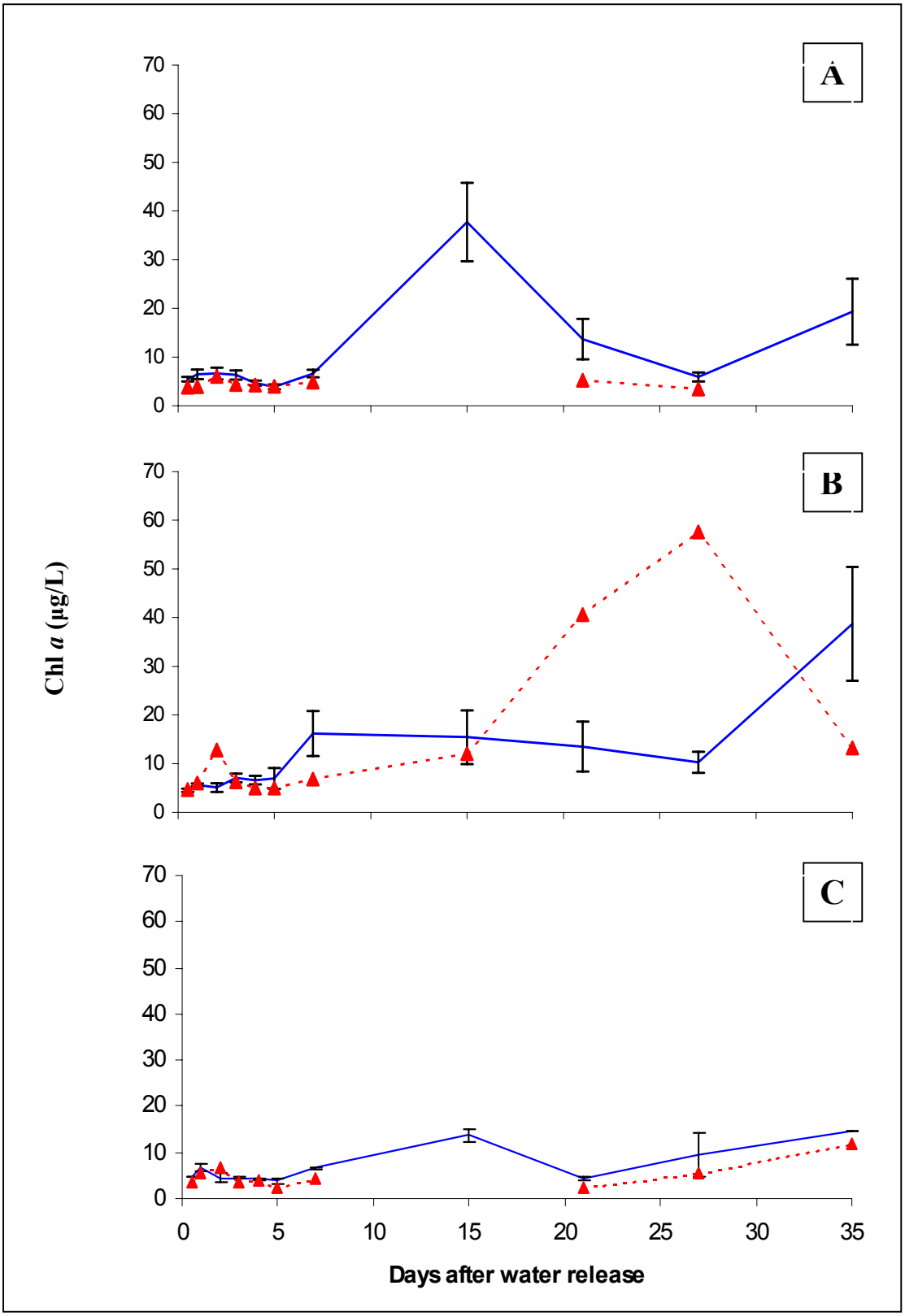

Figure 12: Chl *a* (µg/L) in a) Forest Creek, b) Greenacres and c) Lynnbrae.
(Mean ± SE of 3 replicate wetland sites ——; Channel site ------).

Phytoplankton not only provide the basis of a food and energy chain that extends to fish and water-birds, but through photosynthetic oxygen production and the production of cellular exudates also has a significant impact on water quality (Sullivan 1990; Wetzel 1983). Despite these benefits, environmental conditions that favour the development of large phytoplankton populations may also lead to extremes in oxygen saturation, altered water colour, taste and odour and production of toxins. Phytoplankton have rapid turn-over times (in the order of days), and are sensitive indicators of environmental stresses. Differences in phytoplankton composition and abundance between the wetlands may have been affected by physiochemical factors including nutrients, light, temperature and mixing of the water column and by grazing pressure (Scheffer 1998; Wetzel 1983), making them valuable in monitoring programs.

Wetland Chlorophyll concentrations did not differ from that of the inflowing water and revealed initial phytoplankton peaks two weeks after inundation in Forest Creek and Lynnbrae and one week after inundation in Greenacres (Figure 12). These peaks were dominated by *Anabaena sp*. or blue-green algae which may have been the result of TN:TP ratios of <16:1, (limiting the available nitrogen and favoring cyanobacterial growth). Forest Creek and Lynnbrae recorded very similar patterns in chlorophyll over the course of the sampling period and peaks in all wetlands well-exceeded ANZECC (2000) guidelines of 5 µg/L. The initial peak in both wetlands was dominated by blue-green algae (*Anabaena sp.*) and to a lesser extent by ciliate protozoan. Green algae (*Closterium*) were also found in lower numbers in the Forest Creek wetland. In the Greenacres wetland an initial peak in chlorophyll concentrations dominated by *Anabaena sp*. was found on day 7.

The peak on day 35 in the three wetlands was also dominated by *Anabaena sp.*, followed by the green algae *Closterium* and to a lesser extent by *Planktonema* and Ciliate protozoan in the Forest Creek wetlands and Euglena species in the Lynnbrae wetlands. *Anabaena* has the ability to maintain production in low oxygenated waters as well as anaerobic conditions which would have allowed it to peak even when dissolved oxygen was at very low levels in the three wetlands (Figure 9). It also has a greater capacity to obtain and store nutrients than other algae (Whiterod and Meredith 2003) which may account for the high drop in nutrient levels (Figures 10 and 11) in the wetlands once the chlorophyll levels had begun to increase in the two wetlands.

Blue-green algae are common in waters with high nutrient levels (particularly phosphorus). Figures 11 and 12 demonstrate a positive relationship between increased nutrient levels and an increase in the chlorophyll levels in the Forest Creek and Lynnbrae wetlands. The peaks in chlorophyll on days 15 in the Forest Creek and Lynnbrae wetlands and on days 35 in all wetlands strongly correlate to peaks in nutrients recorded during these same days. Although the *Anabaena* species dominated the peaks in the three wetlands, the difference in secondary algal species composition between the wetlands may have been contributed to the inflow of different water sources into each wetland. Due to favorable conditions as described above for the *Anabaena sp.* (increased temperatures, low dissolved oxygen levels and high initial nutrient levels), the blue-green algae dominated over the secondary species and constituted the majority of the peaks found in the wetlands.

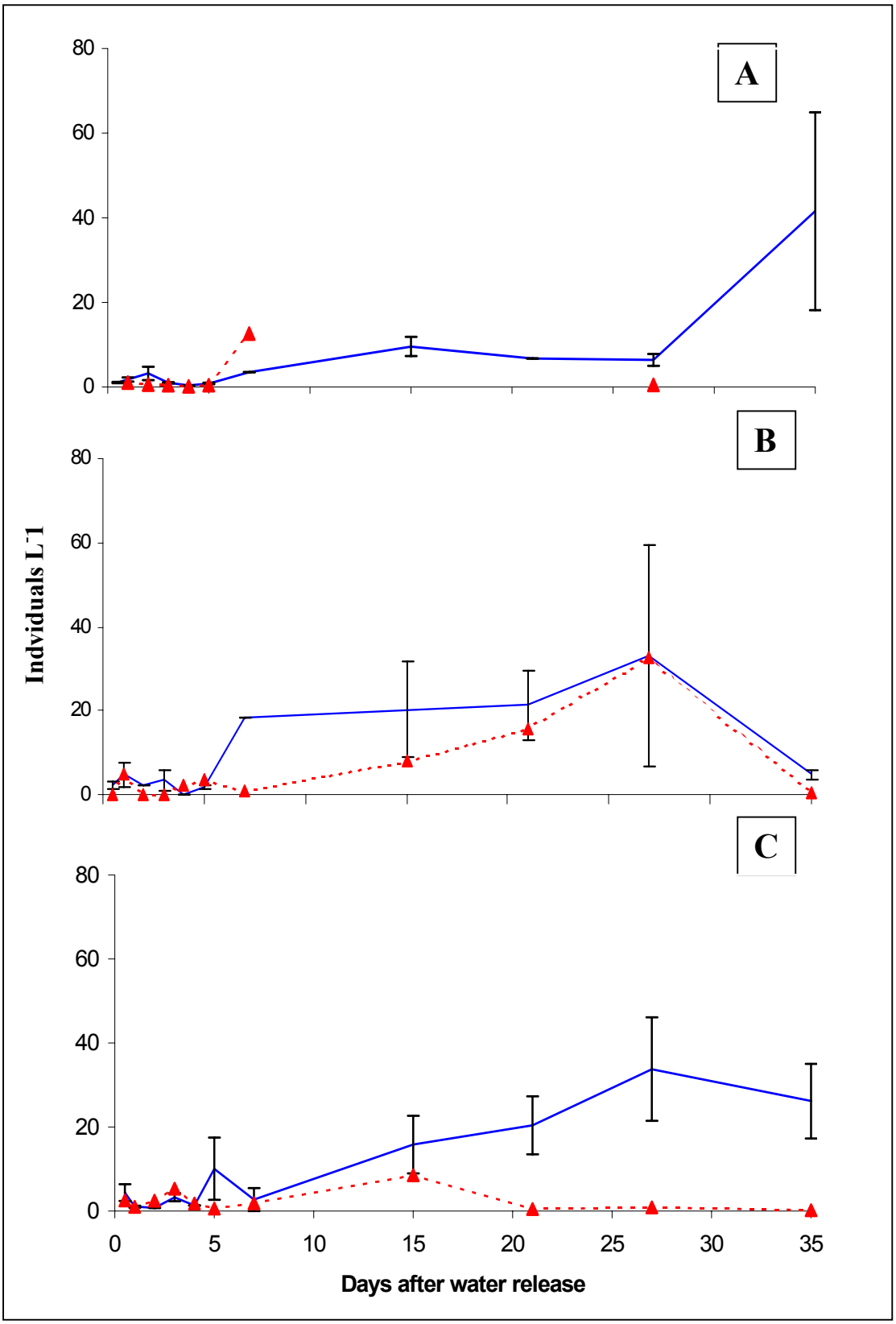

Figure 13: Microcrustacea (individuals L^{-1}) in a) Forest Creek, b) Greenacres and c) Lynnbrae.
(Mean ± SE of 3 replicate wetland sites ——; Channel site ------)

The microcrustacean community plays an important role in the wetland food web in regulating both the biomass of phytoplankton in the water column and epiphyton on submersed aquatic macrophytes through grazing, and as food items for other organisms, particularly macroinvertebrates and planktivorous fish. Microcrustacea are a crucial component in a complex food web affecting a series of interacting organisms (Zrum and Hann 1997). The differences found in species composition between the wetlands could be attributed to numerous factors including a difference in wetland ecology and physiology and different flooding regimes including the timing, duration, frequency and intensity of flooding and the source of water (including connectivity to the main river channel) (Boulton and Jenkins 1998).

Low numbers of microcrustacea were recorded in the inflowing water for the majority of the sampling period and probably had little effect on wetland population densities. Species composition was the same in each channel as in the adjoining wetland. Three peaks of microcrustacea were found during the sampling period in the Forest Creek wetland (days 2, 15 and 27), however numbers did not begin to significantly increase until day 27. As very low numbers of individuals were recorded to have come in from the channel, the increase in numbers during the end of the sampling period was probably attributed to individuals (eggs), which were already in the wetland in their resting stages. The microcrustacean eggs were undergoing a resting and maturing phase in the initial three weeks following inundation after which they begun to emerge in higher numbers. The initial peak on day 2 was composed of 8 different taxa with the dominating species being Bosminidae and Centropagidae. The peak on day 15 showed an increase in the number of taxa with 13 taxa being recorded. Highest numbers of Moinidae, Cyclopidae, Centropagidae and Daphniidae were found at this peak. Twelve taxa were found at the final peak on day 35 with the peak being dominated by Daphniidae and Cyclopidae that tended to increase in numbers with ongoing time in the wetland.

The Greenacres and Lynnbrae wetlands showed very similar trends in relation to timing of peaks and dominating species found at the peaks. Two peaks were recorded in each wetland during the sampling period on days 5 and 27 with eleven different taxa recorded in each of the peaks. The peak on day 5 in the two wetlands may have been due to an original pulse explosion, however this peak quickly dropped by day 7 before beginning to gradually rise again until the second peak on day 27. The sudden drop in microcrustacea numbers after the initial peak on day 5 may have been due to a change in physio-chemical conditions including a shift from a flowing to a non-flowing environment and/or low food availability due to low concentrations of algae present on day 5 in both Greenacres and Lynnbrae wetlands (Figure 12).

Interestingly, the dominating species during the two peaks also demonstrated a very similar pattern between Greenacres and Lynnbrae. The day 5 peak was dominated by Cyclopidae, Centropagidae and Bosminidae in the two wetlands, whilst the second peak on day 27 had highest numbers of Cyclopidae, Centropagidae, Moinidae and Daphniidae. The second peak may therefore have been attributed to the increase in two other taxa - Moinidae and Daphniidae and to the decrease in macroinvertebrate predators.

Discussion of model

The continual interaction between organisms over different temporal scales within a community and the environment forms a complex trophic web that must be clearly understood for effective wetland management (Ingram *et al.* 1997). Bacteria are decomposers, they are involved in the breakdown of organic material to their mineral component thus making nutrients available to primary producers. The primary producers (photosynthesizes) are represented by algae (phytoplankton and periphyton) and other aquatic plants. They are the source of food and energy for all other aquatic animal life. Primary consumers, the herbivores, graze on the primary producers, which in turn are preyed on by secondary consumers such as copepods, rotifers, and juvenile fish (Ingram *et al.* 1997).

Past studies demonstrate the succession of blooms and crashes that bacterial, phytoplankton and zooplankton communities undergo in the development of a community following a filling period of a water body such as an aquaculture pond (Culver 1988; Culver and Geddes 1993). However, little is known about these relationship patterns in wetlands and the 'response time' of these peaks in wetland environments after inundation.

Figure 14 illustrates the conceptual model described by Ingram et al. (1997) and Culver and Geddes (1993) to demonstrate the succession of trophic responses after lake filling. This suggests that after filling, an initial nutrient pulse is followed by a peak in the primary producers (algae), and in turn followed by a peak in primary and secondary producers (zooplankton).

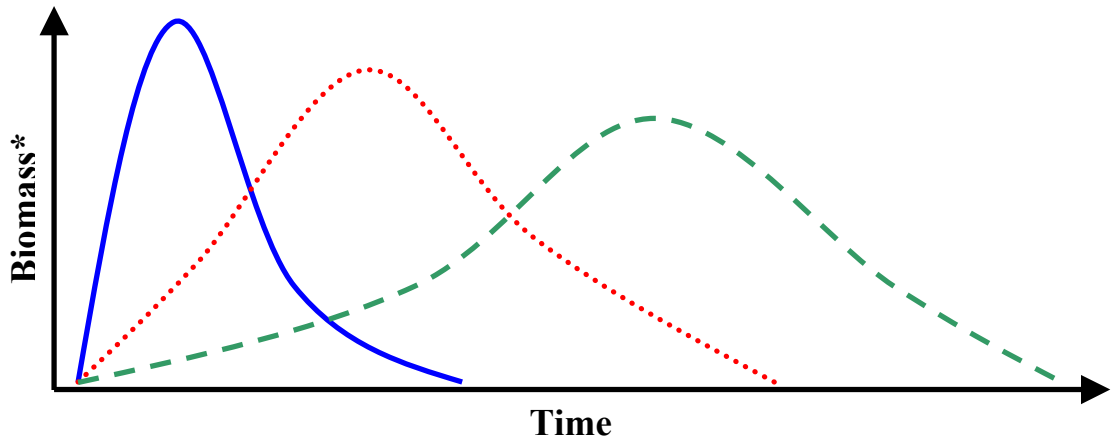

Figure 14: Conceptual Model of the post flood successional development in wetlands
(Nutrients _____, Phytoplankton ....., Zooplankton ---------)
(*Vertical scales cannot be compared).

The pattern of the peaks in the three Deniliquin wetlands examined (Forest Creek, Greenacres and Lynnbrae) generally conform to this conceptual model with the nutrient peak initially occurring due to the initial flood pulse into the wetland and sediment releases. This was followed by an algae peak (occurring due to an absence of higher predators and grazers) and finally the zooplankton peak due to the emergence of hatchlings (Baldwin and Mitchell 2000; Qiu and McComb 1995).

The design of this study therefore was set up to test whether the strongly linked functioning community groups, bacteria, phytoplankton and zooplankton followed this model in the Deniliquin wetlands and to ascertain the response times of each community after inundation. Two hypotheses were therefore examined – 1. The success ional sequence in the conceptual model is valid; 2. All wetlands have the same timing response. Samples and recordings taken in the channel site acted to determine what was coming into the wetland and what was coming out of the sediment in the wetland to enable for a more accurate representative of the peaks in the wetland sites.

Graphs of Nutrients (NOx and TN), Phytoplankton and Microcrustacea were overlayed for each wetland to illustrate the relationship between the peaks in each of these parameters over time and determine whether the conceptual model illustrated in figure 14 is supported by these findings. As FRP and TP follow very similar trends to NOx and TN in relation to timing of peaks in the wetlands, NOx and TN were used to represent nutrients in the overlayed relationship graphs. (Graphs of FRP and TP concentrations in the three wetlands can be viewed in Figure 11).

Forest Creek

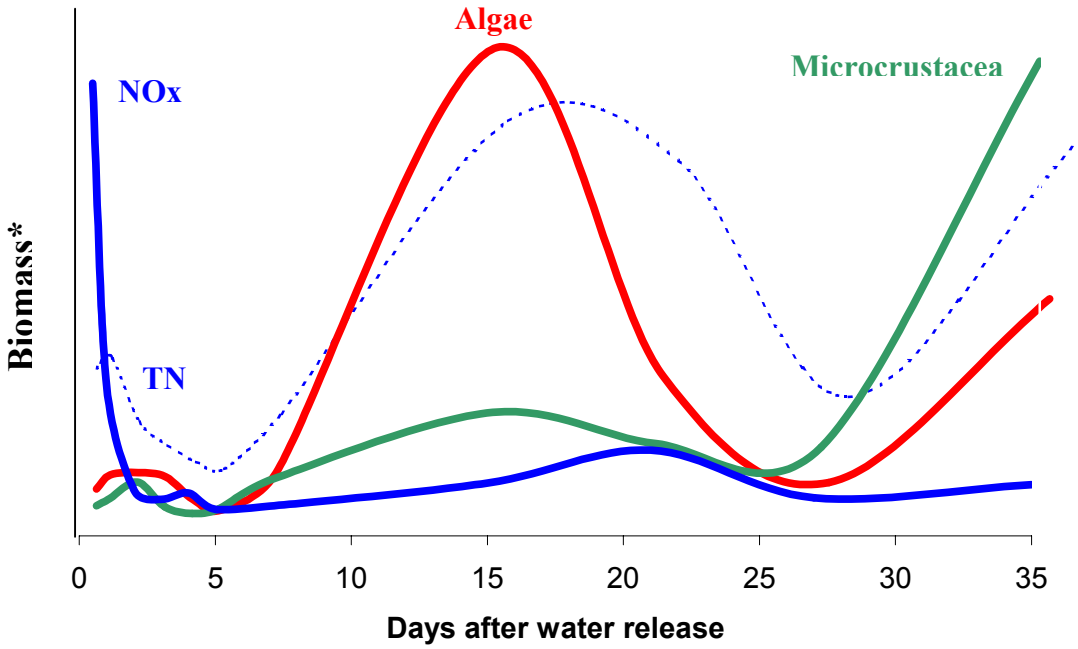

Figure 15: Overlayed graphs illustrating the relationship between nutrients, chlorophyll and microcrustacea over time in the Forest Creek Wetland.
(Nutrients NOx_____ TN --------, Phytoplankton_____, Microcrustacea_____)
(*Vertical scales cannot be compared).

The initial peak in nutrients in the Forest Creek wetland showed a very short response time and occurred within a few hours of inundation and dropped after approximately 5 hours after which they remained low and stable for the duration of the sampling period. A second peak in total nutrients (TN and TP) occurred on day 16 of sampling. A response time of 15 days and 35 days was recorded for chlorophyll and microcrustacean communities, respectively.

Greenacres

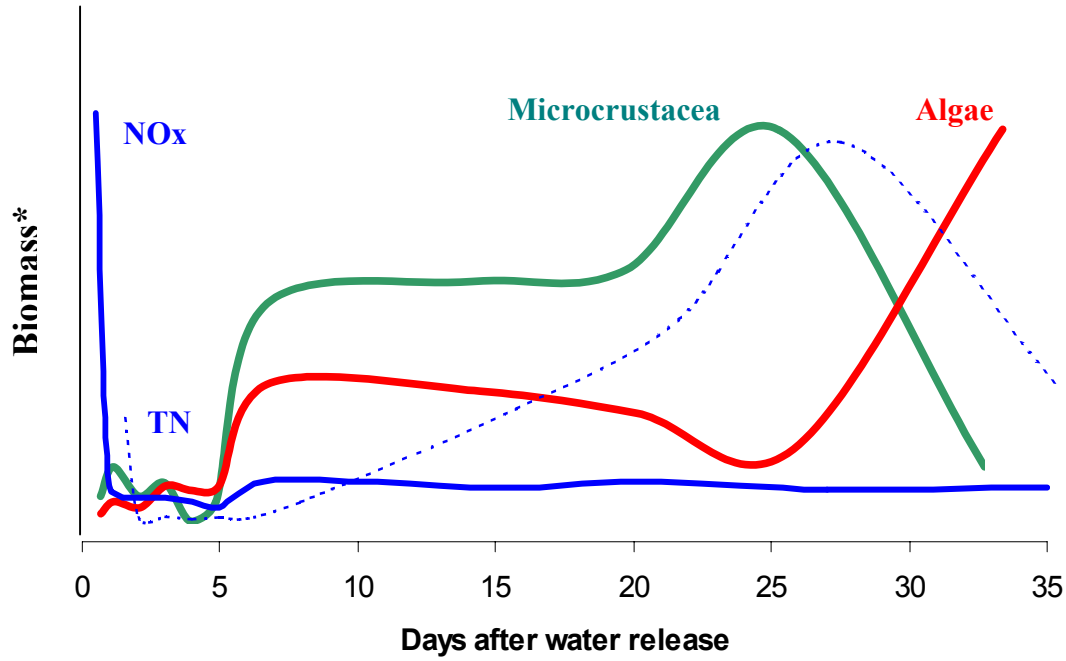

Figure 16: Overlayed graphs illustrating the relationship between nutrients, chlorophyll and microcrustacea over time in the Greenacres Wetland.
(Nutrients NOx_____ TN --------, Phytoplankton_____, Microcrustacean_____)
(*Vertical scales cannot be compared).

The Greenacres wetland demonstrates a very quick response time in nutrients following flooding of the wetland with a peak occurring within a few hours of inundation. As with the Forest Creek wetland, this peak dropped markedly by the afternoon of the first day and remained at a stable low level for the duration of the sampling period. The microcrustacean community showed an initial response time of 5 days following inundation and a further, larger peak was also recorded on day 27. A short response time of 7 days was recorded for the initial peak in chlorophyll, however this was a small peak and a larger peak was recorded at the end of the sampling period on day 35.

Lynnbrae

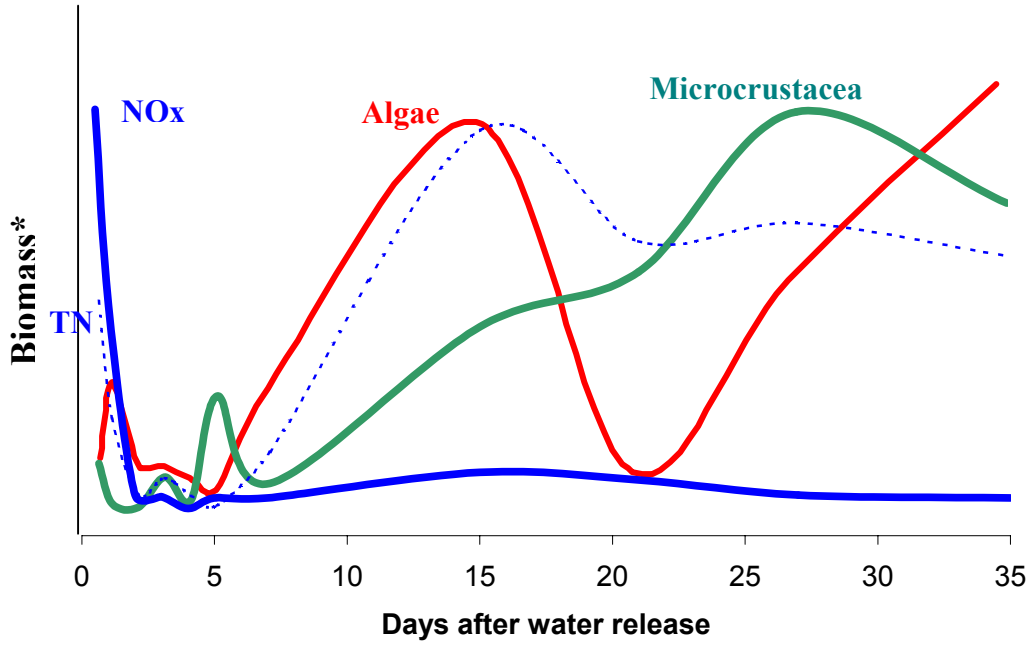

Figure 17: Overlayed graphs illustrating the relationship between nutrients, chlorophyll and microcrustacea over time in the Lynnbrae Wetland.
(Nutrients NOx_____ TN --------, Phytoplankton_____, Microcrustacea_____)
(*Scales cannot be compared).

The initial peak in nutrients in the Lynnbrae wetland showed a very short response time and occurred within a few hours of inundation and dropped by the evening of day one after which it remained low and stable for the duration of the sampling period. A second peak in total nutrients (TN and TP) occurred on day 16 of sampling. A response time of 15 days and 27 days was recorded for chlorophyll and microcrustacean communities, respectively.

Forest Creek and Lynnbrae Wetlands

The relationship in response times between nutrients, chlorophyll and microcrustacean communities over time in the Forest Creek and Lynnbrae wetlands follows closely the model depicted in Figure 14. The initial peak in nutrients showed a very short response time and occurred within a few hours of inundation, however this peak lasted a very short time period and dropped markedly by the evening of the first day after inundation. These large initial nutrient flushes have also been reported for re-wetted soils and sediments in past literature (Birch 1960; Haynes and Swift 1989; Qiu and McComb 1995; Sparling and Ross 1988; West *et al.* 1988) as a consequence of drying induced microbial-cell lysis (Baldwin and Mitchell 2000). Although a second peak in total nutrients (TN and TP) is seen on day 16, this could have been attributed to the peak in chlorophyll seen just one day before the nutrient peak in both wetlands as total nitrogen is a measure of the potential pool size of available nitrogen and so the algae would also have also been taken up in this sample.

A response time of 15 days can be seen for the peak in the phytoplankton community. This ties in well with the peak in microcrustacea which does not occur until the end of the sampling period on day 35 in the Forest Creek Wetland and day 27 in the Lynnbrae wetland. The initial low numbers of predators for both the chlorophyll and microcrustacean communities indicate that the response of these groups is primarily nutrient/food limited further indicating that their abundance or response is strongly linked to the flooding of the wetlands.

Similar phases and response times were also illustrated in research conducted on ponds at the MAFRISC (Geiger *et al.* 1985). Upon filling of the ponds, an initial peak of chlorophyll *a* concentration developed within two weeks of filling, whilst the zooplankton biomass peaked two to four weeks after filling. This correlates well with the chlorophyll response time of two weeks after inundation in the Forest Creek and Lynnbrae wetlands and the response time of 4 – 5 weeks in the microcrustacean community. The difference between the findings at the MAFRISC ponds and in the Deniliquin wetlands in zooplankton response times (i.e. 2-4 wks in MAFRISC ponds and 4-5 weeks in Deniliquin wetlands) may have been attributed to rotifers not being examined in the Deniliquin wetlands. As rotifers generally peak within the second week after inundation (Walsh, R. pers. comm.), the two-week zooplankton peak in the MAFRISC ponds may have been attributed to the rotifer peak, however this peak was not picked up in the Deniliquin wetlands as only microcrustacea and no rotifers were examined.

The NSW Fisheries ponds demonstrated further smaller secondary peaks in chlorophyll *a* concentration, and zooplankton biomass 5-7 weeks after filling (Arumugam and Geddes 1987). This was also seen in the Forest Creek and Lynnbrae wetlands five weeks after filling and a peak in chlorophyll was also seen in the Greenacres wetland at week five.

Greenacres

The Greenacres wetland demonstrated a slightly different pattern to the one found in the Forest Creek and Lynnbrae wetlands, however still followed the model in figure 14 to a lesser degree. The short response time of a few hours for nutrients followed the same trend however this was followed by a small peak in microcrustacea, a small peak in chlorophyll, again a larger microcrustacea peak and finally a chlorophyll peak at the end of the sampling period. The initial response times for the microcrustacean and chlorophyll communities in the Greenacres wetland was 5 days and 7 days respectively. Figure 13 illustrates that whilst only 2 individuals/L were recorded in the channel site on day five, a mean of 19 individuals/L where recorded in the wetlands sites. This demonstrates the microcrustacea were not coming into the wetland from the channel site as may be expected with this short response time, but instead would have hatched and emerged from the sediment at an earlier stage than seen in the other two wetlands.

The difference in response times may have been attributed to an environmental stimulus, perhaps in temperature and/or possibly in water depth. Temperature is thought to be the main stimulus for the release from eggs or diapores (Walsh, R. pers. comm.). Figure 5 illustrates an increase in temperature on day 5 in the Greenacres

wetland that did not occur in the Forest Creek and Lynnbrae wetlands. This may have encouraged the hatching of certain microcrustacea taxa within the Greenacres wetland.

The dominating species composition between the three wetlands in the initial peak was very similar with the peaks being dominated by Bosminidae and Centropagidae in all three wetlands and with an addition of Cyclopidae in the Greenacres wetland. The taxa Cyclopidae was recorded as the most dominant taxa in the Greenacres wetland in the initial peak with more than twice the number of Cyclopidae present as Bosminidae and Centropagidae. The addition of this taxa only in the Greenacres wetland coupled with the environmental stimulus of higher temperature on day 5 may have contributed to the shorter response time in the Microcrustacean community in the Greenacres wetland.

Canfield and Watkins (1984) found a significant positive relationship between chlorophyll *a* concentrations and total zooplankton abundance during their summer sampling periods. Although this relationship was seen in Forest Creek and to a lesser extent in Lynnbrae, the Greenacres wetlands followed a slightly different trend with peaks in chlorophyll recorded a few days after peaks in microcrustacea were found (figure 12). The phytoplankton community in the Greenacres wetland demonstrates an interesting response time of 7 days for the initial peak in concentrations. This closely follows the initial peak of the microcrustacean community, which peaks on day 5 and drops by day 7. From the results of the Forest Creek and Lynnbrae wetlands, the model in figure 14 and previous literature (Culver 1988; Culver and Geddes 1993; Geiger *et al.* 1985; Ingram *et al.* 1997) it would be expected that the peak in microcrustacea would occur after the peak in chlorophyll as the latter would be providing the source of food supply to the microcrustacean community, however as seen here, this was not the case.

The decrease in microcrustacea and so predators by day 7 may have encouraged the increase in chlorophyll concentration to occur. However with the dominating species being the blue-green algae *Anabaena* sp. in the day 5 peak (figure 12), the reason behind the initial increase would have been attributed to environmental indicators including an increase in temperature, drop in water levels, low dissolved oxygen levels and/or an increase in the nutrient load, particularly in Phosphorus. An increase in water temperature (figure 5), low dissolved oxygen levels (figure 9) and an increase in FRP nutrient levels (figure 11) which generally increases algal growth and total algal biomass (Harris 1994) was seen on day 5 in the Greenacres wetland which all make up highly favorable conditions for the blue-green algae.

Blue-green algae begin to dominate Australian algal communities in water temperatures around 20^{o}C, therefore the increase in temperature to 22^{o}C by day 5, coupled with increased FRP levels which provide a measure of the amount of soluble phosphorus present that is readily available for algal growth and lastly low dissolved oxygen levels which only the blue-green algae can tolerate present on day 5 may have made up the right conditions for the peak and therefore shorter response time of the phytoplankton community in the Greenacres wetland.

This wetland therefore may not have followed the 'Model' pattern of the previous two wetlands as the response times may have been governed to a greater extent by environmental stimuli and perhaps to a lesser extent by the effects of the other communities in the ecosystem.

Conclusion

Despite national and even international agreement on priorities and frameworks for wetland conservation, many natural wetlands and the species that depend upon them continue to be threatened, degraded or lost through human actions, both direct and indirect (Finlayson *et al.* 1999; Mitsch 1994). There is an urgent need for basic and directed information that is contained within an integrated information management system that can be used to monitor the changing status of the global wetland resource, and a need to make it available for those undertaking national and regional planning of wetland conservation (Finlayson *et al.* 1999).

As a large proportion of wetlands occur on private property, many wetlands are left unmonitored and despite Government policy, landowners do not have the simple and reliable monitoring tools available to assess the influence of their land-management actions on wetlands (Spencer *et al.* 1998)

This study has provided vital information of the flooding affects on various parameters in the three private Deniliquin wetlands. From the preceding results and discussions, the succession of events which unfold after a wetland becomes inundated can be clearly seen. This includes changes in water quality/chemistry, nutrients, phytoplankton and microcrustacea over time after filling.

The response time after inundation and relationship between three strongly linked functioning community groups - nutrients, phytoplankton and zooplankton - followed the trend set in a conceptual model described in previous literature to a high degree in the Forest Creek and Lynnbrae wetlands and to a lesser extent in the Greenacres wetland. Following inundation an initial strong pulse and short response time of a few hours was seen in nutrients in all wetlands, followed by a response time of 15 days for phytoplankton and 35 days for microcrustacea in the Forest Creek and Lynnbrae wetlands.

From this it can be concluded that hypothesis one was supported as the successional sequence in the wetlands followed the sequence in the conceptual model. However, whilst the same timing responses were found in the Forest Creek and Lynnbrae wetlands, Greenacres demonstrated a different timing response and thereby did not support the second hypothesis.

Recommendations

Wetlands are highly valuable environments for fish breeding, however post flood responses of macroinvertebrates and fish remain poorly studied in such shallow wetlands. The shallowness of the wetlands may have prevented fish from entering and reproducing in the wetlands. Although a small number of fish larvae were found on the first 3 days of sampling, these were mainly found in the channel sites and any found in the wetland were over 3 days of age and therefore also were bought in from the channel. The water depth when the wetland is filled may need to be considered in future flooding events if fish are to be able to use the wetlands for recruitment and reproduction. It would then be vital to monitor not only the species entering the wetland through the channel but also the survival, recruitment and possible reproduction in the actual wetlands over time.

Little is known regarding the influence that timing of inflows may have on post flood responses. Future filling of the wetlands performed on a natural time scale should also include the monitoring of water quality/chemistry, nutrients, phytoplankton and micro and macroinvertebrates to determine the possible change in response times and effects in concurrent wetting cycles. Also experimental filling of different wetlands at different times would provide valuable seasonal data of post flood responses. Longer post flood monitoring should be conducted to capture the macroinvertebrate and fish responses.

Further research in these key areas will make a significant contribution to the provision of the information necessary for the successful management of wetlands and the timing and duration of associated wetting cycles.

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APPENDIX I

Total Microcrustacea Found

Cyclopidae: *Mesocyclops sp.*
Acanthocyclops cf vernalis
Apocyclops sp.
Australocyclops australis
Eucyclops sp.
Metacyclops cf mortoni
Microcyclops sp.
Thermocyclops sp.

Centropagidae: *Boeckella sp*.
Boeckella triarticulata
Calamoecia ampulla.

Daphniidae: *Daphnia carinata.*
Daphnia lumholtzi
Simocephalus elizabeatha.
Simocephalus victoriensis.
Ceriodaphnia sp.
Scapheloberis kingi
Bosminidae: *Bosmina meridionalis*
Chydoridae: *Chydorus sp.*
Leydigia sp.
Alona sp.
Moinidae: *Moina spp.*
Sididae: *Latonopsis sp*.
Diaphanosoma sp.

Limnocytheridae: *Limnocythere sp*
Notrodromadidae: *Newnhamia* cf *fenestrata*
Cyprididae: *Diacypris sp.*
Cypridopsis sp.
Ilyocyprididae: *Ilyocypris sp*

APPENDIX II Forest Creek Microcrustacea

Site Number	B	C	Ch	A	B	C	Ch	A	C	Ch	A	B	C	Ch	A	Ch	A	B	C	Ch	C	A	B	C	Ch	B	Ch	A	B	C	A	B	C
Days after water release	0.5	0.5	1	1	1	1	2	2	2	3	3	3	3	4	4	5	5	5	5	7	7	15	15	15	21	21	21	28	28	28	35	35	35
Crustacea:Copepoda																																	
Cyclopidae: *Mesocyclops sp.*				42		27		45														54	60	60			5	50	42		390		
Acanthocyclops cf vernalis																						366	120	70				60	36	38		36	171
Apocyclops sp.						9																											
Australocyclops australis												1								128	32									36	400	3600	
Eucyclops sp.																																	
Metacyclops cf mortoni								45									13	2															
Microcyclops sp.																																	
Thermocyclops sp.																																	
Calanoida																																	
Centropagidae: *Boeckella sp .*																																	
Boeckella triarticulata	14	30	30	33	54	27	9	117	2	14	20	16	14	11	18	22	14	27	16	768	142	312	84	194			27	100	96	36	150		18
Calamoecia ampulla.		11	18	5	9	9	14		3		4	41			8			14	1	48	24	132	36	40			5	50	42	6	100		
Crustacea:Cladocera																																	
Daphniidae: *Daphnia carinata.*																						6		10									
Daphnia lumholtzi																																	
Simocephalus elizabeatha.		6	7	18				18	1		4						7	1				24	72	4				110	96	80	220	4	27
Simocephalus victoriensis.																	1														180	5	36
Ceriodaphnia sp.		1		3	9																	24		2				50	6	14	760	1116	45
Scapheloberis kingi																												20	18		210	1620	99
Bosminidae: *Bosmina meridionalis*	74	18	26	10		126	17	135	113	16	44	30	37			6	22	36	20		66	6	48	10					6				
Chydoridae: *Chydorus sp.*	4	1		7					1		1	5						2				24		2			2	120					
Leydigia sp.																																	
Alona sp.																												10					
Moinidae: *Moina spp.*																						66	294	14				70	120	90			9
Sididae: *Latonopsis sp .*																																	
Diaphanosoma sp.																								10									
Crustacea:Ostracoda																																	
Limnocytheridae: *Limnocythere sp*													1				2																
Notrodromadidae:																2				2			2								30	1	1
Cyprididae: *Diacypris sp.*																				3		1						10	3		90	1	5
Cypridopsis sp.																												9				23	1
Ilyocyprididae: *Ilyocypris sp*																						1	3	2				10					

APPENDIX III Greenacres Microcrustacea

Site Number	Ch	A	B	C	Ch	A	B	C	Ch	C	Ch	A	B	C	Ch	C	Ch	A	B	C	Ch	C	Ch	A	B	C	Ch	A	B	C	Ch	A	B	C
Days after water release	0.5	0.5	0.5	0.5	1	1	1	1	2	2	3	3	3	3	4	4	5	5	5	5	7	7	15	15	15	15	21	21	21	21	28	28	28	28	35	35	35	35
Platyhelminthes:Turbelleria																																					1	
Tricladida: Dugesiidae:																																						
Crustacea:Copepoda																																						
Cyclopidae: *Mesocyclops sp.*																											9											
Acanthocyclops cf vernalis										17														324														
Apocyclops sp.																																						
Australocyclops australis	3	11		2	40		40						23		22		70	55	18		17		327	360	24	156	333	45	666	720			1476	10	40	108	135	45
Eucyclops sp.								72																														
Metacyclops cf mortoni			22																	2880																		
Microcyclops sp.				43				336				3		162								582																
Thermocyclops sp.																																						
Calanoida																																						
Centropagidae: *Boeckella sp .*																																						
Boeckella triarticulata	6	42	61	103	2	45	86	60	3	103	7	4	76	216	91	11	81	61	76	1080	30	300	63	1044	78	804	234	126	153	648	216			366	1	45	18	291
Calamoecia ampulla.			17	45	12	9	22		6	37	4	3	25	72	35	3	58	36	3	1800	10	264	45	654	16	30		162	72	180	36			80		9	9	99
Crustacea:Cladocera																																						
Daphniidae: *Daphnia carinata.*																				108		6	3			198		13	45					12				
Daphnia lumholtzi																																		2				
Simocephalus elizabeatha.		4	5	5		9	13	48	1		1	1	7	9	12		25	7	10		17		111	252		6	180	90	126		36		2052	6			81	
Simocephalus victoriensis.																	1																					
Ceriodaphnia sp.	1	4	35	58	4		30	72		6			1	63	1		4		1	180		6		72			108		108	72								
Scapheloberis kingi																																						
Bosminidae: *Bosmina meridionalis*	4	1	12	17	320		2	180		7			3				9		2	1260		138		36														
Chydoridae: *Chydorus sp.*		1	3	11			12	12						9	1		5		1																		
Leydigia sp.			3																																			
Alona sp.							1																															
Moinidae: *Moina spp.*			2	2				12				2	1						2	648		36	45	252		72	180		567	144	2088		900	14	2	99		108
Sididae: *Latonopsis sp .*				1						1																											
Diaphanosoma sp.													1	72			1			288		54		36		156	126		99	756	72			12				
Crustacea:Ostracoda																																						
Limnocytheridae: *Limnocythere sp*			6				11							18			3																				
Notrodromadidae:																											1										3
Newnhamia cf fenestrata																																						
Cyprididae: *Diacypris sp.*																								36	2	4	1				3		3	1	3	4	7	
Cypridopsis sp.																															5		14	2		8	2	

APPENDIX IV Lynnbrae Microcrustacea

Site Number	Ch	A	B	C	Ch	A	B	C	Ch	B	Ch	A	B	C	Ch	A	Ch	A	B	C	Ch	B	Ch	A	B	C	Ch	A	B	C	Ch	A	B	C	Ch	A	B	C
Days after water release	0.5	0.5	0.5	0.5	1	1	1	1	2	2	3	3	3	3	4	4	5	5	5	5	7	7	15	15	15	15	21	21	21	21	28	28	28	28	35	35	35	35
Crustacea:Copepoda																																						
Cyclopidae: *Mesocyclops sp.*																		36	2	7						36		180		36	12		234	63		882		
Acanthocyclops cf vernalis																								90	162	108		234	378			270						
Apocyclops sp.																																						
Australocyclops australis																					6	46	292			72				54		288	225	72			549	468
Eucyclops sp.																																						
Metacyclops cf mortoni																	2																					
Microcyclops sp.																																						
Thermocyclops sp.												2																										
Centropagidae: *Boeckella sp.*			1																																			
Boeckella triarticulata	18	207	14	13	42	45	34	30	71	16	257	160	127	98	103	55	37	576	147	131	66	216	21	138	45	451	7	216	108	351	31	180	36	36	2	36	27	144
Calamoecia ampulla	33	63	16	28	22	18	16	6	47	8	70	65	36	20	26	19	2	450	23	24	62	92	96	210	9	163	3	108	9	216	6	18	45	369		198	18	
Crustacea:Cladocera																																						
Daphniidae: *Daphnia carinata*																			2	1			3		9					2		18		36		378	9	3
Daphnia lumholtzi																																						
Simocephalus elizabeatha						9					2	7	1	2			2	54		9			69	12	54	63	15		27		6	108	117	216	4		45	414
Simocephalus victoriensis																								6					18	27						27	198
Ceriodaphnia sp.	18	90	10	19				3	14	4	5	23	4	4	5	2	2	100	6	2		14		120	54	18		693	243		1	1512	216			36	27	108
Scapholeberis kingi																																						
Bosminidae: *Bosmina meridionalis*	120	270	112	145	11	27	42	6	52	27	67	120	59	5		25	2	630	12	22	6	32	3															
Chydoridae: *Chydorus sp.*				1											1				1			6				9												
Leydigia sp.																																						
Alona sp.																																						
Moinidae: *Moina spp.*														1				18	2	3		2	156	546		1188	8	1134	270	288	8	1980	594	945	7	1584	81	630
Sididae: *Latonopsis sp.*																																						
Diaphanosoma sp.																																						
Crustacea:Ostracoda																																						
Limnocytheridae: *Limnocythere sp*																																						
Notodromadidae																																	18	1				
Cyprididae: *Diacypris sp.*																														2				1		18	3	
Cypridopsis sp.																																		1				
Ilyocyprididae: *Ilyocypris sp*																																		1				