# Hydrological Report on Burra Creek Catchment

## CONTENTS




***ABSTRACT***

This report examines the Burra Creek catchment hydrological processes. The catchment has been through numerous changes, both physically and environmentally. On-going dry conditions due to a recent severe drought in Australia has had a significant impact on the area. In addition, the natural landscape of the catchment has undergone rural urban development. The ongoing development along the catchment has generated soil degradation, resulting in acceleration of soil erosion processes. The catchment has a significant geological feature, namely a fault line running down its centre, brought about by tectonic activity during faulting, generating rock deformation through slaty cleavage outcrops due to low grade metamorphism.

A set of rainfall and discharge data events have been examined for this report. The data shows two significant rainfall and discharge high peaks on the hydrological graph on the 20th and 28th of January 1995. These high peaks indicate that the Burra Creek catchment was not able to absorb the majority of the rainfall, resulting in a significant discharge. The water quality data for these events shows high levels for phosphorus, nitrogen, ammonia, turbidity and suspended solids, along with high (but possibly normal for this area) electrical conductivity. The source of the these nutrients and other parameters are likely to be artificial fertiliser use, septic seepage and overgrazing along the catchment. Exposed soil surfaces due to temporary loss of grass cover through overgrazing has promoted active soil erosion, resulting in runoff during heavy rainfall events, depositing high volumes of sediments and nutrients into the creek, affecting Canberra's water quality.


***KEY WORDS:*** Burra Catchment, Phosphorus, Dams, Land Use, Agriculture, Farms.

## I. INTRODUCTION

Irrespective of the size of a catchment, according to Charman et al (2001), it has very complex land characteristics and land uses. The main components of a catchment includes its geology, vegetation, slopes, drainage patterns, soils and land forms. The characteristic of the catchment dictates its hydrological processes.

The Burra Creek catchment certainly has its share of geological complex structures showing environmental changes over time. Large portions of the catchment have been developed into rural urban centres where large properties were subdivided into small properties leading to low density housing.

Since the European settlement, land use practices such as tree clearing to give way to pasture land and increasing pressure to increase productivity from the agriculture industry has lead to heavy cultivation and high usage of fertilisers, which has resulted in massive soil degradation and high nutrient output to the water ways. Australia has a very old landscape therefore it is very susceptible to soil degradation such as erosion.

According to Chaman et al (2000), there are major contaminants that affects the quality of the water. These are:

- agriculture chemicals and heavy metals;
- salinity;
- sediments;
- nutrients; and
- organic matter and microbes.

Agriculture chemicals and heavy metals are forms of water contaminants and the potential sources of these contaminants are from pesticides, herbicides and fertilisers that are being used by farmers for cropping growth. Runoff from industrial sites and roads are also one of the potential sources. Salinity is one of Australia's current major land problems, and is quite severe in highly irrigated areas. Salinity is also occurring in dry land areas due to land practices such as land clearing, but there are some studies which state that salinity is also actively occurring in fault lines or fractures areas, as in a study conducted in Cootamundra [ERIC, 2001]. This data from "Baseline Mapping for Cootamundra Shire" shows that the movement of the salt in the Shire is occurring along the fault lines or fractures. Their data shows a strong relationship between soils with high electrical conductivity

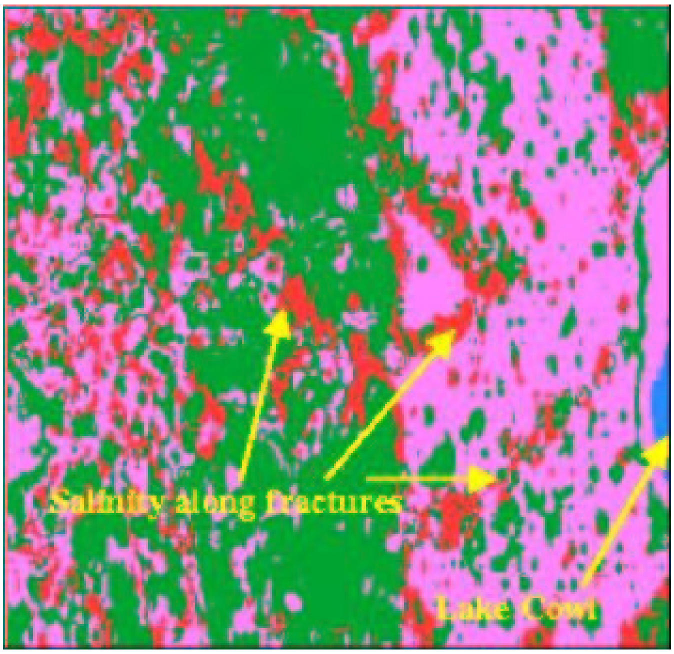


Figure 1. ERIC's map image of salt in fracture zone (fault line)

and geological fracturing (faults), see Figure 1. Nutrients such as nitrogen and phosphorus have the potential to severely affect the aquatic ecology on streams, creeks and wetlands, and organic matter and microbes are contaminants that come from sewage treatment, septic systems, and plant remains [Charman and Murphy, 2000].

Field visits in the catchment have seen some evidence of numerous livestock grazing in a small paddock resulting in overgrazing. The catchment landscape is very dry and there are areas that have no vegetation cover. Active land degradation such as soil erosion is a common sight across the catchment region.

This report will attempt to explore land use activities in the catchment. The impact of agriculture practices will also be examined. A set of rainfall and discharge data events of Burra Catchment will be explored and water quality data for selected rainfall and discharge events will be examined in an attempt to analyse how the catchment responded.

## II. Description of Catchment

### A. Terrain

The catchment of Burra Creek is composed of hills and plains. The catchment areas are a mixture of farmlands, small properties (hobby farms) and native forest areas, as shown in Figure 2 for a typical small property and Figure 3 for native forest. The headwaters of Burra Creek are in the Tinderry Mountains [Wade et al, 2002]. The creek flows are heading due north through dense native forest ranges. The landscape where Burra Creek flows as it descends is along agriculture areas. There are several tributaries of Burra Creek, and Holden's Creek is considered to be the major one [Wade et al, 2002]. Field visits into the catchment have identified very dry conditions in some creeks. Aquatic plants

Figure 2. Native forest in the Burra Creek catchment; unvegetated understory.

Figure 3. Small properties in Burra Catchment

are growing excessively along the creek, resulting in restriction of water flow. Brackish water conditions can be seen in some isolated ponds along the creek, as shown in Figure 4. Active farming activities such as grazing are evident along the Burra Creek catchment.

### B. Geology of the Burra Catchment

The Burra Creek catchment region is composed of Ordovician meta-sediments, Silurian granite and porphyritic volcanic rock. The topography of the catchment areas are a mixture of plains and steep slopes, especially along the ranges at the head of Burra Creek. The catchment area has a major fault line that approximately cuts through the centre of the catchment as demonstrated in the geological map of the catchment. The evidence of faulting and shearing activities can be seen through highly deformed rock beds along the creek (slaty cleavage due low grade metamorphism), as evidenced in Figure 6. Distinct sedimentary layers are also amongst the features on Burra

Figure 4. One of several isolated ponds in Burra Creek catchment as a result of water depletion.

Figure 6. Highly deformed rock bedding.

Figure 5. Distinctive sedimentary layers

Figure 7. Small paddock with numerous cattle grazing, the vegetation in this paddock is very poor.

Creek's bank. The sediment layers may be due to several deposition events, such as flood plains flooding, that occurred over time through environmental change in the region, see Figure 5.

### C. Land Use

Observation made during the field trip to the Burra Creek catchment region revealed a high level of agriculture activities. These agriculture areas are a mixture of small properties, including residential dwellings as shown in Figure 3. These small properties are supporting large variety of livestock such as cattle, goats, horses, sheep and lamas. The environment surrounding the catchment is under severe stress through over use, evident through the small properties which are utilised as hobby farms. Field observation shows over stocking on a number of small hobby farm properties, resulting in overgrazing, which has lead to soil degradation such as soil compaction and erosion as shown in Figure 7. There is evidence of environmental stress throughout the landscape along the catchment.

The removal of vegetation cover due to over grazing make it susceptible to loss of top soil, see Figure 8. Farming activities around the Burra Creek catchment region involve the use of some fertilisers. The common component of these fertilisers is nitrogen, which is used for crop growth. Some of the nitrogen is consumed for soil fertility and the rest is lost to either the atmosphere or soil surface run-off and ground water, resulting in an increase in concentration of soluble nitrogen in the waterways in the catchment [Davie, 2002]. Phosphorus is also a common component of crop fertilisers that farmers use. Phosphorus that is in bound into the soil is also carried to the waterways through soil erosion [cRcReef, 2003]. Australia has experienced severe droughts and extreme dryness, and the effect of this is evident through the condition of the grass and other vegetation in the Burra Creek catchment area.

The water of Burra Creek flows into the Googong Dam, a

Figure 8. Very dry, low vegetation soil in Burra Creek catchment.

Figure 9. This picture shows a typical grazing activities in the catchment and eroded creek bank.

source of Canberra water. Farm dams have been constructed on numerous small properties in the catchment for their water needs and to support their live stock and crops. Reduction of water flow on the Burra Creek and into the Googong reservoir is a direct impact of these farm dams.

Unprotected soils will also become prone to soil erosion. The water content in numerous creeks in the catchment areas is minimal and in some creeks it is very dry. This is mostly due to ongoing dry conditions, but farm dams are certainly playing a major role in the current water content conditions amongst tributaries and Burra Creek itself.

### D. Soil

Soil has an important role in the catchment, especially for its interaction with rainfall for water supply and quality which is highly important for domestic use. Good water quality is also quite vital to the aquatic habitat and for industrial and irrigation purposes [Charman and Murphy, 2000]. Soils that are susceptible to runoff are the hard setting soil, and shallow soils. These soils are mostly covered with vegetation on the upper part of the slope. Sodic soils are the second category and tend to generate soil loss due to their silty texture. This soil type is mostly found in heavy cultivated areas and generate dirty (high sediment and nutrient content) runoff during intense rainfall events. The last category are those soils that are very fertile and deep. These soils will readily absorb water during heavy rainfall events.

The majority of the soil condition of the Burra Creek catchment region is mainly dry and land use along the region are mostly grazing. As previously mentioned, sodic soil types are highly susceptible to erosion and evidence of this active erosion is highly visible along the catchment area especially along creek banks as shown in Figure 9, along with an example of gully erosion at Figure 10. Sodic soil generates massive top soil loss during intense rainfall, resulting massive deposition of sediments in the waterways, which is undoubtedly occurring in Burra Creek and its numerous tributaries. The transported sediment contains phosphorus and nitrogen. A study by Talbot

Figure 10. Active erosion processes in the catchment

et al (1998) of the impact of land use practices such as land clearing in the Great Barrier Reef catchment region indicates that the above land use practices have these negative impacts on the catchment [Talbot et al, 1998], and is a major source of nitrogen and phosphorus discharge in both dissolved and percolated forms.

### E. Water Quality

Heavy rainfall events promote runoff and eventually floods into water ways. River or stream waters have a higher level of suspended sediment due to active erosion processes in the catchment and high velocity river flow. The fine sediments that are carried and deposited into the stream or river contain (attached) nitrogen and phosphorus. According to cRcReef (2001), pesticides and heavy metals are mostly attached to soil particles. The role and the health of the catchment is important in order to maintain the quality of water, and the stability of the entire aquatic ecosystem in Burra Creek depends on the maintenance of this water quality. As some areas of the catchment have highly erodible sodic soil (Ordovician meta-sediments), the capacity exists for depositing massive sediments into the Burra Creek system, impacting negatively on the quality of the water.

Eroded materials such as sediment and nutrients deposited into the Burra Creek waterways eventually affect the quality of the water. These water contaminants promote high turbidity in the water, which can trigger instability of the aquatic fauna and flora. Deaths of species that can not tolerate high turbidity will occur causing instability and alteration of the habitat in the creek. Any salinity in the catchment area may also be due to land use and farming practices. The geological structure of the catchment also contributes to any salinity in the area; the fault line in the centre on the catchment is potentially leaching salt in some areas of the catchment, which will eventually leach into the creek through runoff during heavy rainfall events.

Figure 11. Excessive growth of plants in the creek

### F. Nutrient Impact

Due to the nature of the land use and agriculture practices in Burra Creek catchment, the use of an artificial fertilisers amongst farmers is unavoidable except for organic farmers. The main components of these fertilisers are nitrogen and phosphorus. Heavy use of fertilisers will lead to an increased nutrient level input into the streams in the catchment. The guideline for Aquatic ecosystem has clearly emphasised that high concentrations of nutrients can lead to the excessive growth of aquatic plants (phytoplankton, sea-grasses, filamentous and attached algae) in both marine and fresh water [ANZECC, 2002]. This nuisance growth of aquatic plants is already occurring in most creeks in the catchment, see Figure 11. These weeds are clearly restricting the flow of the water in the stream resulting alteration of community balance within the creek and are promoting the growth of algae, as shown in Figure 12. The biodiversity of the stream ecosystem will also be affected by death amongst species that were unable to adapt to the new habitat. Excessive growth of these weeds will also increase the input of organic matter into the creek, resulting in depletion of dissolved oxygen, which will also lead to the death of some aquatic organisms [ANZECC, 2002].

Figure 12. Algae growth in Burra Creek

### G. Stream flow

The flow along Burra Creek and its numerous tributaries has been very minimal and in some cases, due to massive aquatic plant growth, water flow is not occurring. Farmers in the catchment have been modifying the environment through planting exotic plants (e.g. Willow tree) along the riparian section of the creeks. Willow trees drop their leaves into the creek, promoting changes in the creek morphology and increased organic input into the system.

### H. Rainfall and Discharge

Rainfall activity along Burra Creek catchment is currently quite minimal. The landscape of the Burra Creek catchment region is very dry and the dryness can be seen through the condition of the vegetation along the catchment. Rainfall data events for the catchment for the last fourteen years show some significant peaks. There are significant high peaks for the period of March 1989 to April 1989 and in January/1995. *See the next section for a more detailed analysis of the rainfall and discharge events at Burra Creek catchment.*

Average monthly rainfall statistics for the area are shown in Figure 13.

## III. Data Analysis

### A. A. General and Typical Conditions

Figure 14 shows the average of measured water quality events between 1994 and 1997. This graph was used to select the period in time to examine. There are two high peaks, occurring in January 1995 that are of interest. So the month of January 1995 will be examined in further detail.

Figure 15 shows a typical high rainfall and discharge event that occurred in Burra Creek catchment. This graph shows several high peaks of rainfall and discharge. The discharge response to these events shows a lag of a day after the rainfall

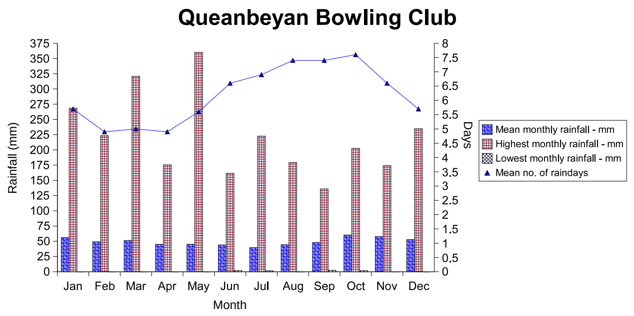


Figure 13. Average monthly rainfall for the Queanbeyan Bowling Club

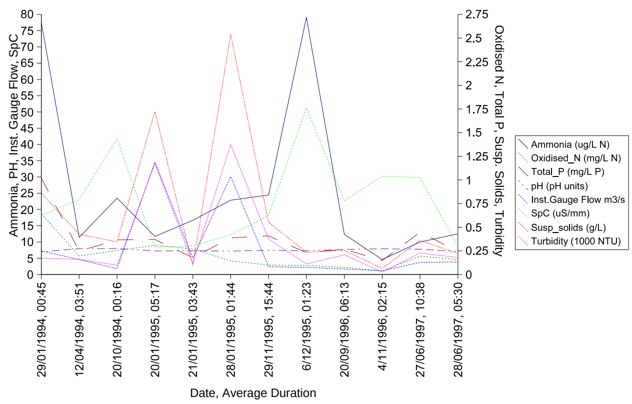


Figure 14. Graph for 1994 to 1997 average for water quality

starts and proceed two days later. The discharge response rate is slower than the rainfall rate.

Field observation has seen evidence of overgrazing on some small properties; one property which is located closely to the riparian section of the creek was occupied by 14 head of cattle. The amount of the grazing area was very small (less than a hectare) for the number of cattle grazing. The vegetation cover was minimal and there were active erosion processes along the creek bank. The ongoing dry condition in Australia has been reflected here in the Burra Creek catchment, where the landscape is very dry and showing environmental stress.

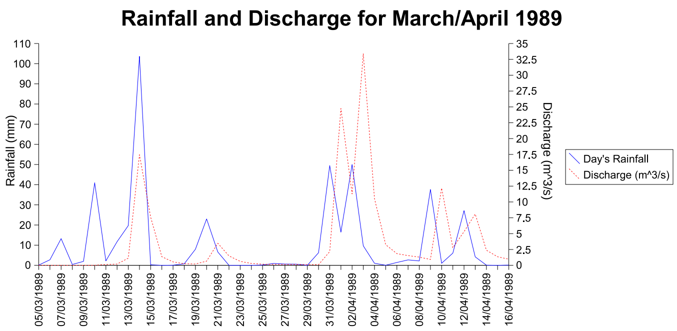


Figure 15. Rainfall and Discharge during a high rainfall period


Figure 16. Rainfall and Discharge during January 1995

Figure 16 shows the rainfall and discharge events for the selected month of study, January 1995.

## B. First Event (20 January, 1995)

### 1) Rainfall

On the 20th of January, the rainfall peak at 112mm. This is about twice as much as the January monthly average and are third the maximum since 1870. The heavy rainfall started on the 20/1/1995 and the discharge commenced on the same day, after some minor rainfall events some days before (16th, 17th, and 19th).

### 2) Stream Flow

On this occasion, discharge occurred almost immediately providing there was sufficient moisture in the soil. The discharge release rate proceeded for only one day after rainfall ceased. The immediate response may be due to dry, hard and compacted ground or lack of vegetation cover, whereas the 1989 rainfall and discharge response may be due to the ground being less compacted and more vegetated. Soil moisture and vegetation cover may be related to previous rainfall levels.

### 3) Water Quality

The discharge event correlates with the water quality data, with the results being displayed graphically in Figure 17. The turbidity and suspended solids graph lines show a close relationship with the discharge. The level of turbidity is 80 times the upper trigger value from the Aquatic Ecosystem Guidelines [ANZECC, 2002]. This is also the case with the suspended solid level, which peaked at 3g/L. The pH level was constant throughout the event and was quite neutral (averaging at 7.3).

The level of suspended solids for the 20/1/95 rainfall event peaked at 2.9g/L. For the turbidity graph results, the graph also corresponded with the high discharge event data.

The level of the Nitrogen rose and remained relatively constant through to the next day, varying between 0.12mg/L and 0.37mg/L. However, the ammonia rose from an undetectable level at the events peak then dropped after the turbidity subsided for a period of three hours, then rose again.

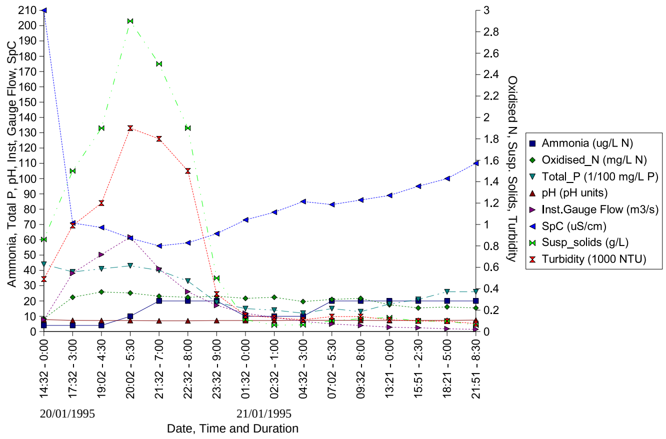


Figure 17. Water quality on the 20th of January, 1995

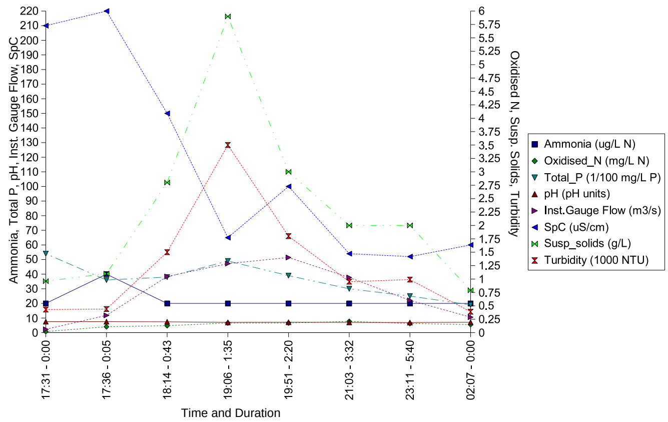


Figure 18. Water Quality on the 28th of January, 1995

The total phosphorus for this event was high at the beginning of the event then it started to drop in sympathy with the ammonia, then rose again to 50% of its previous level during the peak of the event.

- The SpC electrical conductivity (EC) reading was approximately 210$\mu$s/cm and dropped rapidly to 60$\mu$s/cm during the event and very gradually rose after the event. Dilution by fresh water from the rainfall will be the likely reason for the reading.
- Oxidised Nitrogen level rose and remained relatively constant through to the next day. However, the ammonia rose at the event's peak then dropped after the turbidity subsided for a period of three hours, then rose again.
- Likewise, total phosphorus level was approximately 43mg/L throughout the event then dropped to 12mg/L, then rose again to just under 50% of its previous level during the peak of the event.

The other water quality parameter that was examined from the graph was the electrical conductivity (EC), a measure of the salt content (calcium and possibly sodium in this case) of the water from the creek during the 20/1/95 water quality graph. The results show an immediate drop in response to the high discharge event and gradually rose after the event had occurred.

### C. Second Event (28th January 1995)

#### 1) Rainfall

The rainfall level was approximately 42mm, nearly the average monthly for January. The graph of the rainfall and discharge shows that there was a break in rainfall between the 20th until the 28th of January. Then rainfall occurred on the 28th of January, and the data also shows that there was no rainfall on the 29th, although, there was still some discharge occurring from the rain of the 20th.

#### 2) Stream Flow

The discharge level was 2.27m$^3$/s at the commencement of the event record, peaking at 51.4m$^3$/s half way through the event and dropping to 10.58m$^3$/s; the rainfall and discharge graph in Figure 16 shows an immediate response to the rain just as with the 20th of January rainfall, in spite of the previous soil softening rain. This high response is very interesting given that the soils still have the moisture from the 20th rainfall event and presumably contain some young growth. It is also interesting to note that the peak gauge flow is just 10 m$^3$/s less than on the 20th.

#### 3) Water Quality

The water quality graph at Figure 18 shows a more centred and widespread response than the 20th of January rainfall.

- The turbidity level ranged between 390 NTU and 3500 NTU, peaking at not quite double that of the 20th;
- The suspended solids ranged between 790 mg/L and 5900 mg/L, peaking at over double that of the 20th;
- Ammonia level was generally 0.02 mg/L, appearing to have continued on at that level from the rains of the 20th, and was 0.04 mg/L at the second sample, where SpC peaked
- The oxidised nitrogen ranged between 0.02 mg/L and 0.21 mg/L, generally lower than the 20th;
- Phosphorus level ranged between 54mg/L down to 19 mg/L, an average that was somewhat higher than the 20th; and
- The SpC (EC) level started at a high level at 210$\mu$S/cm, peaked at 220$\mu$S/cm and declined to dip at 52$\mu$S/cm.

The pH was relatively constant throughout the event (neutral), ranging from 7.5 down to 6.9. The ammonia level rose until the suspended solids (turbidity) started to rise when it declined to the original level and levelled off prior to suspended solids reaching its peak. The oxidised Nitrogen rose and peaked when suspended solids peaked and plateaued at the point. The Phosphorus level declined until the suspended solids started to rise, were it level off and then started to steadily decline when the suspended solids reached its peak.

#### 4) Field Trip EC Test

A number of Electrical Conductivity (EC) tests were conducted during the field trip for this course. The first test was obtained at the rain gauge station at the Burra Creek and the EC reading taken at this site was 560$\mu$s/cm. The second EC reading result was 570$\mu$s/cm at site 2 (see Appendix for Burra Creek Catchment map). The third EC reading, taken at site 3, was 440 $\mu$s/cm, a bit lower in comparison to the second reading. The water content in the creek seems to have better flow at site three than the previous site (site 2). The meta-sediments in this area are of Ordovician, resulting in a high rate of erodibility. Distinctive sedimentary layers in the creek bank may be due to different deposition events over time. The dark layer and the muddy texture of the sediments is possibly due to a flooding event that must have occurred in the area, as shown in figure 5.

## IV. Discussion

### A. Soil Compaction and Erosion

The Burra Creek catchment region has been transformed from its natural environment into a highly modified rural urban area. The impact of these modifications are quite visible through stress conditions of the landscape and vegetation along the catchment.

The environmental stress condition of the area can also be seen along the native vegetation areas. There is no vegetation under story (grass or small shrubs) beneath the native forest, resulting in susceptibility to soil erosion (gully, etc.) during heavy intense rainfall events. The rainfall data that were taken from the catchment show some significant rainfall events. The March to April in 1989 rainfall and discharge data have shown numerous high rainfall and discharge peaks with 220mm falling. The characteristics of the discharge peaks demonstrate a typical dry condition in the catchment during these events. The discharge response occurred a day after the rainfall starts and progressing two days later. Dry soils will readily absorb water as long as its has an undisturbed structure (not compacted).

In contrast to the 1989 rainfall and discharge data, the 1995 hydrograph has shown an immediate discharge response during heavy rainfall event. The discharge graph shows that the discharge response occurred one day after the rainfall has ceased. This result is a typical reflection of the type of land use activity, namely agriculture, in the area. Overgrazing by hobby farmers promotes high soil erosion activity in the catchment resulting temporary loss of vegetation cover, meaning massive runoff during heavy rainfall. Soil compaction from overgrazing was possibly one of the major contributors of the immediate and high discharge response that occurred for the 20/1/95 event. Compacted soils will resist absorbing moisture or water during a rainfall event. Apart from loss of vegetation due to overgrazing, the native forest area was probably another source of runoff during the heavy rainfall events, as a result of the minimal vegetation cover.

### B. Suspended Solids and Turbidity

The high discharge event for the 20/1/95 corresponds with the water quality parameters. The first water-quality parameters analysed are the suspended solids and turbidity. Suspended solids are one of the key measurements for water quality [Davie, 2002]. The amount of suspended solid in the river system is very critical for the aquatic fauna. High sediment deposits in the river system will affect the breeding cycle of invertebrates and fishes. According to Davie (2002), as with suspended solids, turbidity is also one of the key parameters for the measurement of water quality. The amount of suspended solids such as sediments will dictate the cloudiness of the water. Light penetration is also important to some aquatic flora and fauna that are dependent to amount of sunlight reaching into the bottom of the water.

On the 20th of January, there was 2.5 times the rainfall and discharge to that on the 28th of January but the water flow was still high. This may be due to massive runoff from the exposed soil surface in the catchment region due to land use activities. This also goes with the turbidity and the suspended solid levels that were double from those of the 20th at their peaks; interesting given the much lower level of rainfall. The previous rainfall has probably accelerated the erosion process causing massive deposition of sediments in the system, resulting in double the amount of suspended solids from the previous rainfall event. Overflow from farm dams could also be a sediment source of these massive amount of suspended solids.

The Burra catchment data graph result for the turbidity level for the 20/1/95 was 80 times the upper trigger value of the Aquatic ecosystem guidelines. This turbidity result will have a significant impact on the aquatic ecosystem of Burra Creek not to mention the affect on the quality of the water in the creek. The Burra Creek is one of the major tributaries of the Googong Dam reservoir, and this dam is one of the main source for Canberra drinking water during dry the summer period [Wade et al, 2002].

The Wade et al (2002) report states that the large amount of calcium in the limestone creek at Burra Creek catchment acts as a natural water filtration system for the Googong Dam reservoir. However, this natural water treatment process is threatened by the increasing development at the catchment area. The high turbidity and suspended solids graph results have demonstrated the seriousness of this concern. Records for the initial development activities in the catchment were unfortunately unavailable, therefore it is hard to speculate that the period of the rainfall and discharge data in conjunction with the water quality data for 1995 are due to the development and changes in land use practices in the catchment. The discharge response for the 20/1/95 is a typical signature for a very stressed catchment landscape.

### C. Salts

The declination of the EC reading is possibly due to the large amount of fresh water input from the rainfall resulting a dilution process during the event. The gradual increasing activity of the EC may be due to a delayed input of salts from up stream, and increasing re-charge activity may also promote an increase in ground water level, resulting salt rising to the surface, which ends into the creek system. This salt could possibly be sodium based, calcium based or a combination of both. It is more likely to be predominantly calcium due to the presence of limestone in the catchment. The fault line in the catchment is likely to be the main source of any sodium based salt discharge in the catchment [Wade et al, 2002]. This theory of sodium based salt discharge from the fault line was confirmed by previous research by ERIC (2001) on salinity risk at the Cootamundra Shire. Their findings indicate that salt laterally moves in the B2 horizon due to the geological fracture structure. The salt level in the soil class which sunk during the faulting event is considerably higher in comparison to the uplifted areas.

The conductivity (SpC) level started dropping when suspended solids started to rise, dipping when the suspended solids reached its peak. It then rose again until suspended solids started to taper in decline, where it dropped again and levelled out. This suggests a delayed response from calcium ground water sources and perhaps from gradual accumulation of water within the fault line slowly discharging. Faulting events can generate complex rock bedding folding structures which could result flow restriction along the fault line.

### D. Fertilisers and Organic Nitrogen Sources

Hydrograph results for the nitrogen and ammonia strongly reflect the agricultural practices in the catchment area of Burra Creek. The dramatic increase of the level of ammonia can only be due to the runoff from the agriculture areas (high usage of fertilisers, e.g. ammonium nitrate) in the catchment, probably just prior to the event. The increase in ammonia level after three hours, in conjunction with the declination of the turbidity may be due to:

- the amount of sunlight penetration on the water resulting chemical reaction which generates the formation of ammonia [Davie, 2002]; and
- delayed slow discharge from the up land areas of the catchment (maybe a steady light rainfall activity resulting ammonia discharge into the system).

The hypothesis for the phosphorus profile is that the initial high levels during the event were due to runoff and the later high levels were due to seepage with the gap being due to the delay between deluges and seepage.

The pH result may be due to the rainfall activity that occurred on the 27th, which can be seen through the rainfall and discharge data graph in Figure 16.

The reduction of ammonia level as the turbidity and suspended solids peaked may be due to less concentration of ammonia from the discharge due to the previous (20/1/95) rainfall event. The majority of fertilisers and other ammonia sources must have already been washed out, resulting in less ammonia concentration from the runoff. The rise of the P level as the suspended solids started to rise is undoubtedly due to runoff from the agriculture areas in the catchment possibly including from animal manure. Residential input of detergent into the streams is also probably one of the contributors to the phosphorus level, and although the peak of the suspended solids and turbidity did seem to cause an increase in P level, but it's steady declination may be due to fresh water input.

### E. Overall Environmental Impact

Farming activities around the catchment, if not controlled, may lead to the acceleration of already over grazed pasture resulting increasing temporary loss of grass cover to Burra Creek catchment region. Removal of vegetation accelerates soil erosion and loss of nutrients from the land.

The health of the Burra Creek catchment is very important in order to maintain water quality for the Queanbeyan and Canberra district. Development in the catchment is rapidly generating high density housing. Household septic systems (due to no sewage treatment in the area) are in no doubt a source of pathogen contamination of Burra Creek and eventually into the Googong Dam reservoir. A future study could examine the possibility of including the monitoring of pathogenic input at the hydrological monitoring station.

## V. Conclusion

The overall results of the data from the rainfall, discharge and for water quality indicates that the Burra Creek catchment is very susceptible to heavy rainfall events. Field observation shows environmental stress across the catchment streams and landscape. Small properties along the catchment are actively undertaking farming activities resulting some overgrazing in some parts of the catchment. Soil degradation such as soil erosion is actively occurring along the riparian section of Burra Creek and other tributaries in the catchment. Changes in land practices since European settlement, such as deforestation, has been the main cause of the salinity in the catchment areas. Tectonic activity has resulted in a fault line in the centre of the catchment which may also be contributing to salinity problems in the catchment. This research backs up other research [Wade et al, 2002] that the natural filtration system through Limestone Creek is under threat due to land development in Burra Creek catchment.

## References


[ANZECC, 2002] ANZECC, 2002. National Water Quality Management Strategy. Guidelines for freshwater quality, Section 3 Pp 3.3-10 - 3.3-28.

[Charman and Murphy, 2000] Charman P. E. V. and Murphy B. W. 2000. Soils - Their properties and management. Oxford University Press. 253 Normanby Road, South Melbourne (Pp403-404).

[cRcReef, 2003] cRcReef Research Centre. 2003. Land Use and The Great Barrier Reef. CURRENT STATE OF KNOWLEDGE. June 2003 (revised edition). `http://www.reef.crc.org.au/publications/brochures/index.html` and `http://www.barrierreef.org/publications/files/CRC_Reef_run-off_brochure.pdf`.

[Davie, 2002] Davie, T. 2002. Fundamentals of Hydrology. Routledge, 11 New Fetter Lane, London.

[ERIC, 2001] ERIC Pty Ltd. 2001. Application of Radiometrics to Identify Salinity Risk in the Cootamundra Shire. `http://www.naturalintelligence.com.au/resourceintelligence/portfolio/salinity.php`.

[Talbot et al, 1998] Talbot F., Gilmore A., Birtles A., Morris R. 1998. Land Clearing, agriculture and pastoral land-use. `http://www.reef.crc.org.au/aboutreef/costal/waterquality_consensus.html`.

[Wade et al, 2002] Wade, A. Huett, D. Page, D. 2002. Base flow and Groundwater Investigation of Burra Valley and Implications for Runoff Water Quality. ActewAGL Distribution and ECOWISE Environmental.