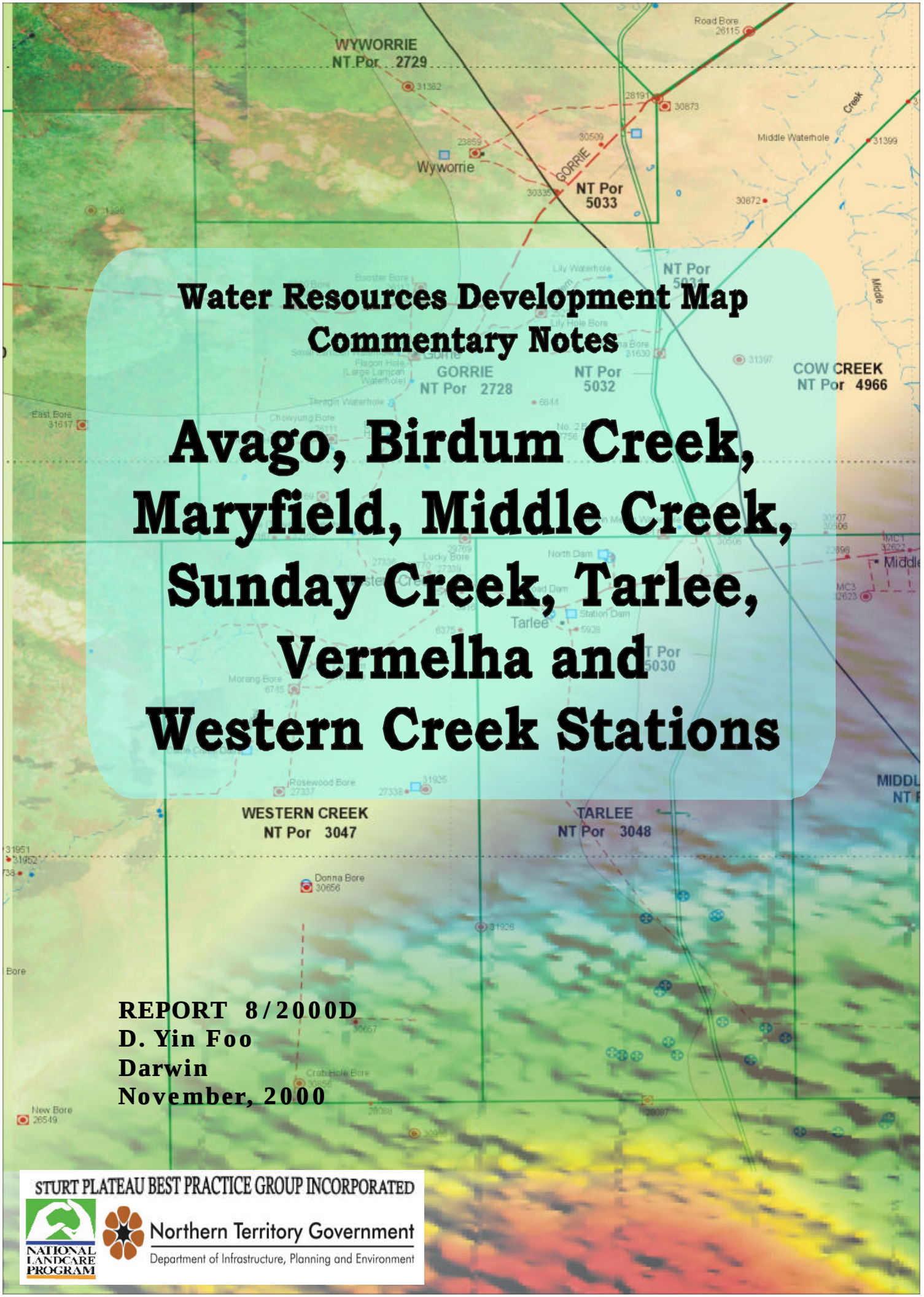

Water Resources Development Map Commentary Notes

Avago, Birdum Creek, Maryfield, Middle Creek, Sunday Creek, Tarlee, Vermelha and Western Creek Stations

REPORT 8/2000D
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Darwin
November, 2000

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LIST OF ABBREVIATIONS

m	-	metre
m^3	-	cubic metre
km	-	kilometre
L/s	-	litres per second
mg/L	-	milligrams per litre
ML	-	megalitre (million litres)
mm	-	millimetre
µS/cm	-	microsiemens per centimetre
pH	-	acidity and alkalinity index
RN	-	Registered Number
TDS	-	total dissolved solids

LIST OF CONVERSIONS

1 mm (millimetre)	=	0.04 inches (4 points)
1 m (metre)	=	3.3 feet
1 km (kilometre)	=	0.6 miles
1 L (litre)	=	0.22 gallons
1 ML (megalitre)	=	220,000 gallons
1 L/s (litre per second)	=	800 gallons per hour

SUMMARY

This Water Resources Development map is designed as a guide in determining the most appropriate type of water supply for an area.

Groundwater throughout the Sturt Plateau is mainly derived from aquifers developed in the fractures and cavities of a limestone formation. The limestone is layered between surface sediments up to 60m thick and a basalt basement. The basalt is non-water bearing, except where fracturing is present. The thickness of limestone, and therefore the groundwater availability, varies with the undulations and other structural features of the basement. Within the region covered by this map, the groundwater potential ranges from excellent east of the Stuart Highway, to poor along the central region where the limestone layer thins and the basalt rises to near surface.

Surface water development options within the map region are also generally good. However, experience with dams elsewhere in the Top End has shown that hazards posed by the wet season need to be considered. An effective dam must resist potential flood damage, have viable capacity and harvest adequate sheet flow from the catchment. On the Sturt Plateau, there are difficulties associated with flat topography and low runoff potential. There is usually sufficient clay in the soil for a viable construction. Evaporation is high and deeper dams with adequate storage to persist through the dry season may not always be an option. In such instances, shallower tanks or dams are still viable and will permit a greater area of pasture to be used for at least the early part of the dry season.

1.0 INTRODUCTION

This map and accompanying notes represent one in a series of four covering the Sturt Plateau region. The intention was to provide station managers with a map tool containing up to date information on water resources. In conjunction with other natural resources maps, planning and management at property scale will be feasible.

The Sturt Plateau Best Practice Group (SPBPG) provided the initiative for this project. The Northern Territory Government and the National Landcare Program took carriage of, and jointly funded this project. The water resources in the Sturt Plateau region, comprising 23 properties and land trust areas, was studied between May 1997 and June 2000.

The Sturt Plateau region covers approximately 30000 km^2 and defines an area which extends between Mataranka in the north and Dunmarra in the south. The eastern boundary is featured by an upland area parallelling the Stuart Highway. It is bounded to the west by the Buntine Highway. Road access is good throughout the region. During the wet season, the main roads are generally accessible by light vehicles, although many station tracks may be impassable.

Plate 1 - Main access road to Sunday Creek and Avago Stations

The availability of stock water is a major influence on stock management. Nearly all of the annual rainfall, which averages about 800mm, occurs in the short hot monsoonal wet season between December and March. Little rainfall is experienced during the remainder of the year. Recharge to groundwater systems occurs at this time. Evaporation rates of water bodies such as dams or waterholes are between 5 and 11 millimetres per day (average about 8 mm per day or 2.8 metres per year). This ensures that water levels in creeks, dams and tanks decline rapidly. Air temperatures are high throughout the year. The average monthly maxima range from about 29 degrees in June to 37 degrees in December. The corresponding average monthly minima are 13 and 24 degrees. Climatic data for Larrimah, at the centre of the Sturt Plateau, are presented in Table 1.

In this map sector of the Sturt Plateau, bores currently supply the vast majority of stock water needs with the remainder coming from waterholes. Where bores are used, steel tanks and turkey nests are popular as temporary storages. During the wet and the early dry season, most of the surface water that is accessible is used, but as the dry season progresses, these sources become depleted. A few large, shallow waterholes are known

to persist throughout the year. These exist within the Western Creek and Birdum Creek systems, while other smaller but deeper waterholes exist in the upland region on the eastern flanks of Vermelha and Maryfield.

TABLE 1 CLIMATIC AVERAGES for LARRIMAH

	Rainfall (mm)	**Rain Days**	**Daily Min. Temp (⁰C)**	**Daily Max. Temp (⁰C)**	**Daily Evap. (mm)**
January	201	15	24.0	35.5	10.4
February	191	15	23.6	34.3	7.9
March	154	11	22.5	33.7	7.5
April	33	3	19.6	33.8	8.6
May	14	1	16.2	31.4	6.1
June	5	1	12.8	29.2	5.0
July	4	1	12.0	29.0	6.0
August	0	0	14.7	32.1	7.2
September	5	1	17.9	34.7	6.9
October	27	3	21.6	37.0	8.6
November	65	7	24.1	37.7	11.4
December	113	10	24.3	36.9	8.3
Total	812	67			

2.0 WATER SUPPLY DEVELOPMENT

The accompanying Water Resources Development Map gives a broad view of the most likely and suitable development option for stock watering. The map classifications are based on a combination of information on groundwater occurrence, soil types and topography. Local conditions, such as soil types can vary considerably, so the maps should not be taken as a definitive guide to cover every situation. Detailed on-ground investigations are recommended when considering specific developments.

For an explanation of the colour codes on the main map, refer to the legend entitled "Water Resources Development Option". Four categories of "preferred options" have been mapped:

OPTION 1 - Where natural waterholes exist, piping from these features is the most appropriate development option. Man made surface water developments are not suitable and the area is not likely to produce adequate stock supplies from bores.

OPTION 2 - Within this area, surface water development, particularly dams or excavated tank constructions, are viable and the area is not likely to produce adequate stock supplies from bores.

OPTION 3 - Groundwater is a viable option within this area. Surface water developments are not suitable.

OPTION 4 - Water supply development is viable using either groundwater or surface water sources.

Some of the main features of the development map are:

- groundwater availability is good for the majority of the map. In some areas, geophysical information will aid in successful site selection.

- most areas are suitable for surface water development. The construction of drainage-line excavated tanks are preferred due to the flat nature of the landscape.

- the area to the east of Vermelha and Maryfield Stations is featured by uplands comprising sandstone ridges and escarpment country. Man-made surface water development options do not appear prospective mainly due to sandy soils, shallow rock and generally inaccessible terrain.

- the central region of the map is underlain by shallow basalt basement. Man-made development options are not preferred due to sandy soils, shallow rock and poor groundwater prospects.

3.0 GROUNDWATER

Groundwater prospects across the area have been assessed using information on geology, ground and airborne geophysical surveys and from existing boreholes. Assessment of this data has enabled a more detailed side map entitled the Groundwater Resources Map, to be produced. 'The Thickness of Limestone Below the Water Table' and 'The Depth to Water Table' side maps should be used as guides to minimum bore depths and indicative pumping depths and are applicable to areas within the limestone basin.

Technical information on bores in the area is held on the Natural Resources Division's files and is available on request. Chemical analyses of groundwaters from all bores and guideline limits for common uses are listed in Appendix 2 and Appendix 3 respectively.

Plate 2 - Karstic weathering

Within the study area, the vast majority of bores exploit an aquifer within an extensive limestone formation. These systems are termed karstic - a term which describes a landscape resulting from dissolution and weathering of limestone, and usually noted for cavern development. Sinkholes often develop on the ground surface due to a collapse of the formation. An aquifer thus formed comprises a myriad of interconnected cavities and fractures developed within the horizon of the host rock, which allows movement of groundwater through it. Successful bores intersect submerged cavities, voids and fractures in the formation.

Three categories, representing 'expected or likely bore yields', ranging from less than 0.5 L/s (poor success rate) to more than 5 L/s (high success rate), are referred on the Groundwater Resources side map. For stock watering, bores yielding above 0.5L/s are generally regarded as successful.

Plate 3 - Sinkhole at Avago Station

Consider a typical case of a paddock holding 1000 head of cattle (each consuming 50 litres per day). Adequate stock watering is represented by a pumping regime yielding a minimum of 0.5 L/s continuously. This equates to a bore yielding 1L/s to run two days out of four. A bore yielding more than 2L/s to top up storages intermittently would provide a good safe margin.

The expected yield is based on knowledge of the type of aquifer, and in some cases, the submergence characteristics. For example, consider a limestone aquifer. Where the aquifer submergence is greater than 20m, a bore intersecting a cavity or fractured rock will likely yield in excess of 5L/s. Where the submergence is less than 20m, but more than 5m, a yield of between 0.5 and 5L/s may be expected. In an area where the submergence is less than 5m, the likelihood of intersecting a cavity or fracturing in the formation within this interval, is low. Therefore it is considered as a poor prospect because there is a high risk of failure.

Plate 4 - 'Bulwaddy bore' at Avago Station

Water quality from all aquifers across this region of the Sturt Plateau is suitable for stock. Appendix 2 tabulates the available water analyses from bores in the area. Higher, although still acceptable salinity, is noted from bores intersecting basalt aquifers.

The three zones shown on the groundwater map are now described:

3.1 Areas of Poor Likelihood of Success

Although there is limited data across the undeveloped central region of the map, several bores drilled indicate that the water table is approximately co-incident with the top of the basalt basement. Groundwater occurrences will therefore depend on intersecting fractures in the basalt which may yield 1 to 2 L/s. However, there is difficulty in locating fractures as they are generally masked by a cover of sediments up to 50m thick. Bores intersecting the weathered surface of the basalt occasionally yield about 0.3 L/s. Under this scenario, the prospect for locating stock supplies is considered low.

About 30 bores on the Sturt Plateau have been drilled specifically to investigate groundwater in the basalt. These have met with a total of seven successes. This includes three bores drilled through the basalt into an underlying aquifer.

The use of geophysics currently presents the most cost-effective option in locating a viable aquifer within this zone. An appropriately designed investigation should aim to locate fractures in the basement, which can then be targeted with drilling. Costs will mainly depend on the technique used.

The basalt aquifers usually occur as isolated and independent aquifers and hence water qualities from different bores vary. However, within the map area, they are usually of satisfactory water quality for stock and hardness

levels bear a general similarity to the limestone waters. That is, hard to very hard and scale forming. Where higher salinities are observed, it is usually due to the presence of sodium chloride (NaCl).

Bores on the Sturt Plateau which have been drilled through the basalt have intersected an aquifer in sandstone. These bores indicate that there is considerable variation in thickness of the basalt (from 3m to 200m) and water quality ranged from good to saline. With this limited information, the extent of the resource, its recharge mode, water quality variations and resource sustainability cannot be adequately assessed.

3.2 Areas of Moderate Likelihood of Success

The Groundwater Resources side map identifies two environments in which there is a moderate likelihood of success. These aquifer types are the sandstone and the limestone aquifers. Bore yields can be expected to range from nil to more than 5 L/s.

Within the limestone aquifer, variation in success and yield from bores within this category can be attributed to at least four factors.

Firstly, natural variations in the properties of the rock and in the development of dissolution features of the limestone mean that variation also occurs in groundwater yields. Also, where cavities or fractures exist, they need to be intersected by a borehole – usually 200mm in diameter before a successful yield is obtained.

Plate 5 - Drilling on the Sturt Plateau

Secondly, bore yields also depends on the aquifer's submergence characteristics. This term describes the location of the aquifer in relation to the water table. Submergence will vary with the undulations of the ground surface and by virtue of the random nature of aquifer occurrence within the limestone.

Bore construction, and the drillers' skill may also influence bore yields. Drilling in the limestone environment of the Sturt Plateau is difficult. Cavities usually exist above the water table as well as below it, and these can determine how drilling progresses and also the outcome of the hole. The driller's assessment of the strata, the depth to the aquifer and the possible yield from the bore depends on uphole returns of drilled cuttings and intersected water. Where cavities exist, and the returns are 'lost' into them, this data

becomes ambiguous. The bore is eventually constructed based on the drillers' perception of the available data and sometimes his experience. Although a potential for error is recognised here, in most cases, bores producing at stock supply rates have a good tolerance level for errors in judgement, and many have been successfully constructed.

Another significant reason for the variability in bore success rates across the Sturt Plateau is the presence of a structural feature within the basalt basement which affects the groundwater system in the western half of the map. It is relevant particularly to Western Creek, Tarlee, Avago and Sunday Creek Stations. The feature is a system of parallel ridges and troughs trending north-west / south-east. The higher ridges intersect or approach the water table in the majority of cases. This affects groundwater conditions and creates corridors which are non-prospective for groundwater.

The use of airborne geophysics has enabled these features to be mapped (Reference 1). Where these features are prominent, bore site selection can be critical. It is important that the troughs be targeted to intersect an adequate thickness of limestone and optimise aquifer submergence. A map showing these basement features is considered an essential tool in bore site selection within the affected areas, and is available from the Natural Resources Division upon request.

Sandstone outcropping as ridges and low hills forms the upland country extending along the eastern flank of Vermelha and Maryfield Stations and is noted for difficult access to some parts. Aquifers occur in weathering features and fractured areas associated with faulting. Although there is limited information from the few bores in the region which have intersected this sandstone (including four on Vermelha), they are generally successful in obtaining stock supplies. Site selection for stock bores does not appear to be critical.

The limestone aquifer within the map area is distinguished in the east and west by different water qualities. This is possibly due to the influence of local recharge conditions. However, in all cases the water quality is considered to be suitable for stock. A measure of salinity, known as the total dissolved solids (TDS), is considered the primary indicator of water quality. The desirable limit for human consumption is 500mg/L, although up to 1500mg/L is acceptable. Cattle will tolerate a TDS of up to 10000mg/L (refer Appendix 3).

Typical TDS values in the western map area including Avago, Western Creek and Sunday Creek Stations are less than 600mg/L while in the vicinity of Maryfield and Vermelha, TDS levels are approximately in the range of 700mg/L to 1100mg/L. The higher salinities in the eastern area result from a combination of carbonates, and sulphate and sodium chloride salts.

The waters are very hard (total hardness over 400mg/L) and scale forming. Measures can be taken to minimise the occurrence of scale development on

elements of the reticulation. These include control of thermal variation of the reticulated water and limiting the aeration of the water.

3.3 Areas of High Likelihood of Success

Mapping of these zones is based on areas where aquifer submergence exceeds 20m. This will occur where the basalt basement deepens. There is a high likelihood of success for stock bores with yields in excess of 5 L/s.

Within the map region, the primary area of potential high yield is featured in the western parts of Maryfield and Vermelha (refer Groundwater Resources Map). Near the Stuart Highway, the limestone extends to depth as a result of geological faulting of the formation (refer Cross-Sections A-B and B-C). This fault is regionally extensive and has been tracked from as far north as the Nenen/Manbulloo boundary to the south as far as the Buchanan Highway, and approximately aligns with Birdum Creek. The vertical displacement associated with the fault in the vicinity of Larrimah is in the order of 200m. The limestone thins to the east until it diminishes adjacent to the uplands area near the Strangways River.

It is important to note that although the aquifer in this area may produce high yielding bores, there is currently a low level of information available on which to assess the sustainability of the resource. Issues of resource sustainability, environmental impact and allocation need to be addressed in these areas if large scale water usage (eg. horticulture) is considered.

Plate 6 - New Leaf bore at Sunday Creek Station

4.0 SURFACE WATER

Few man made surface water storage constructions exist on the Sturt Plateau. The flat topography, low runoff potential of the area and high evaporation rates may make excavated tank and dam construction unattractive as primary water source options. However, regardless of the difficulties that these factors pose, surface water development options do exist for most areas and formal and purposeful design will provide these options. Even if preferred as secondary options, shallow tanks or dams need to be considered and will permit a greater area of pasture to be used for at least the early part of the dry season.

The major river systems that drain this map area are the Western Creek and Birdum Creek/Sunday Creek systems, and Cattle Creek and the Strangways River to the east. The former two systems drain to Elsey Creek and eventually the Roper River in the north-east of the Sturt Plateau. The land is described as broad, flat to gently undulating plains and is typical of the Sturt Plateau. Of particular note is the lack of well-defined drainage paths across much of the country.

Flow records exist for Daly Waters Creek in the upper Birdum Creek catchment and Elsey Creek at Warloch Ponds. These records are indicative of the general runoff characteristics over the Sturt Plateau where only a small percentage of rainfall (less than 10%) eventually contributes to sheet flows. Flow only occurs during the wet season after the catchment has been adequately wet or following significant rainfall events. Initial wetting of the catchment may account for up to 40% of the total seasonal rainfall each year. See map side graphs for Elsey Creek flow data and indicative regional rainfall figures.

Plate 7 - Birdum Creek at Western Creek Road culvert (April, 2000)

In the uplands area of eastern Maryfield and Vermelha, the Strangways River captures runoff from the ridge and rocky, sometimes sandy, undulating and dissected country. This area is distinguished as a different catchment type, and although runoff from this area is good, the generally difficult nature of the terrain and presence of shallow rock makes it unsuitable for cost-effective tank excavation and dam construction.

Typically, the drainage systems on the Sturt Plateau deplete to form isolated pools in the rivers, and waterholes on the relict channel (black soil) areas of the flood plain. The majority of these are dry by about August or September.

The region's suitability for surface water development has been assessed by broadly adapting the land systems classifications and supplementing this information with field testing. The Land Systems Classifications (Reference 2), which integrate factors including topography, soil and vegetation types provide an approximation to relative runoff characteristics. Field investigation at a number of localities has allowed assessment of site suitability in terms of depth and clay content and enabled comment on the water retention characteristics of various soils. The results are presented as the Surface Water Resources Map, one of the side maps accompanying the Water Resources Development Map. However, it should be noted that the broad scale of this map is primarily for planning purposes and does not preclude the need for site specific investigations.

4.1 Surface Water Storage Types

By its nature, monsoonal rainfall in the Top End gives rise to discrete, sometimes significant flow events in local drainage systems. Dam construction types, which are sympathetic to this regime but enable effective and adequate harvest of surface water, are limited. As well, the general lack of defined drainage courses on the Sturt Plateau further limit options.

Three types of excavated tanks are suitable for the generally flat to gently sloping plains of this map region. They are on-stream tanks, off-stream tanks, and drainage-line tanks (see Figure 1 below). An on-stream tank is one that is constructed in a well-defined stream channel. Off-stream tanks are constructed away from the main channel but are connected to it by an excavated inlet channel. The third type, the drainage-line tank is the preferred option and is one that is sited along a broad poorly defined watercourse.

The on-stream excavated tank requires a high standard of design and construction and is prone to erosion and silting because of its location in a fast flowing main stream channel. The off-stream design (see Figure 2) reduces these problems by using a man-made channel to divert water from the stream to the tank. This is an improvement on the on-stream design, but has excessive excavation costs because to take advantage of short duration stream flows, the tank level must be below that of the natural stream bed.

The drainage-line tank or hillside storage is constructed in flat to moderately sloping areas where there are no clearly defined incised creeks. This type of construction is considered the most suited to the environment of this area. The tank itself is of the same design as the off-stream one, but without an inlet channel (see Figure 3). Sheet flow on the plains, with its low silt load, may be harvested. Catch drains or wing walls directing flow towards the dam may be used to enhance interception capacity.

Some common problems experienced with excavated tanks include the following:

- inadequate spilltail channels do not direct water away from bunding
- erosion of wing walls
- silting of catch drains

Regular maintenance is required before the wet season to correct these problems.

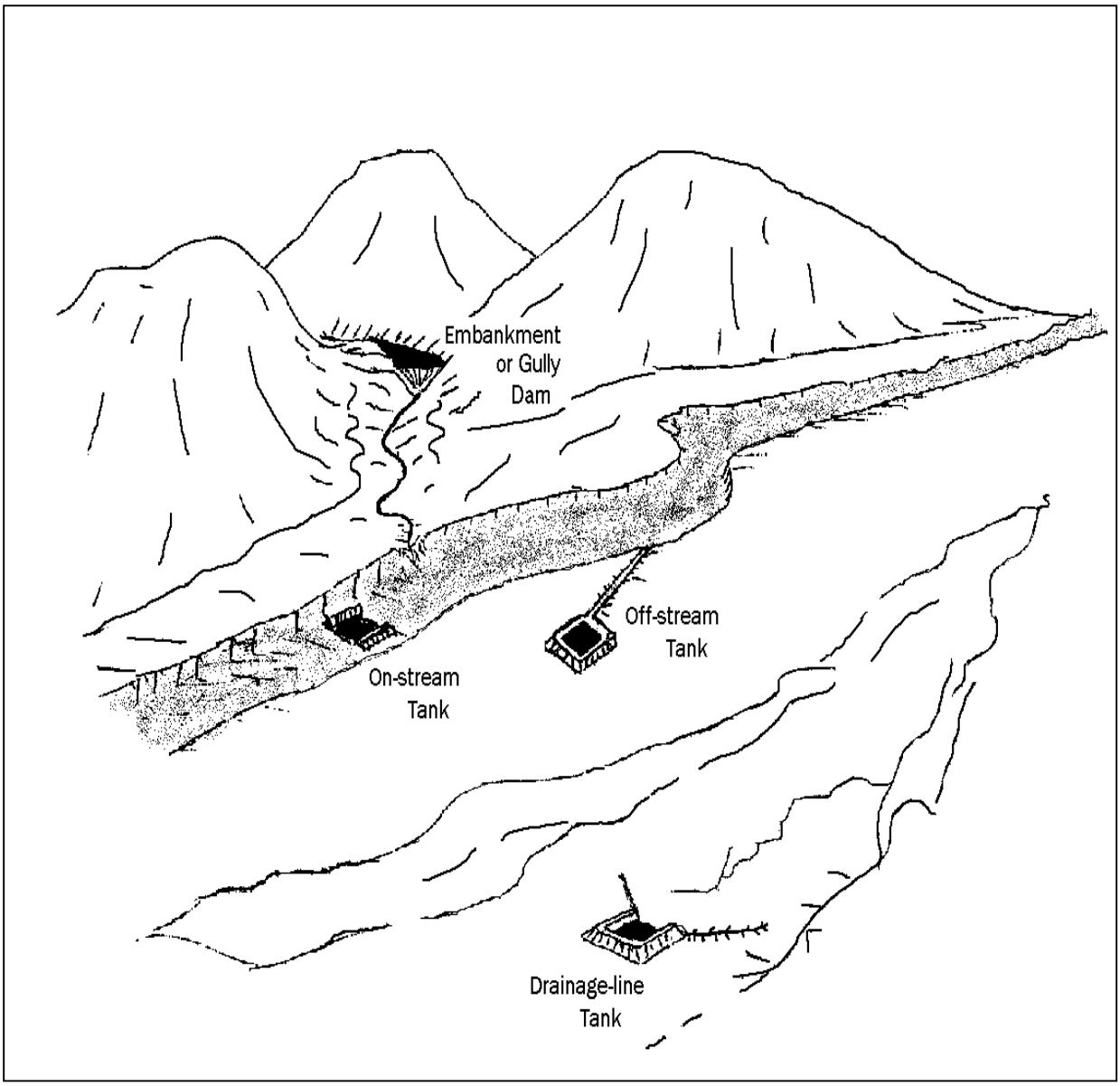
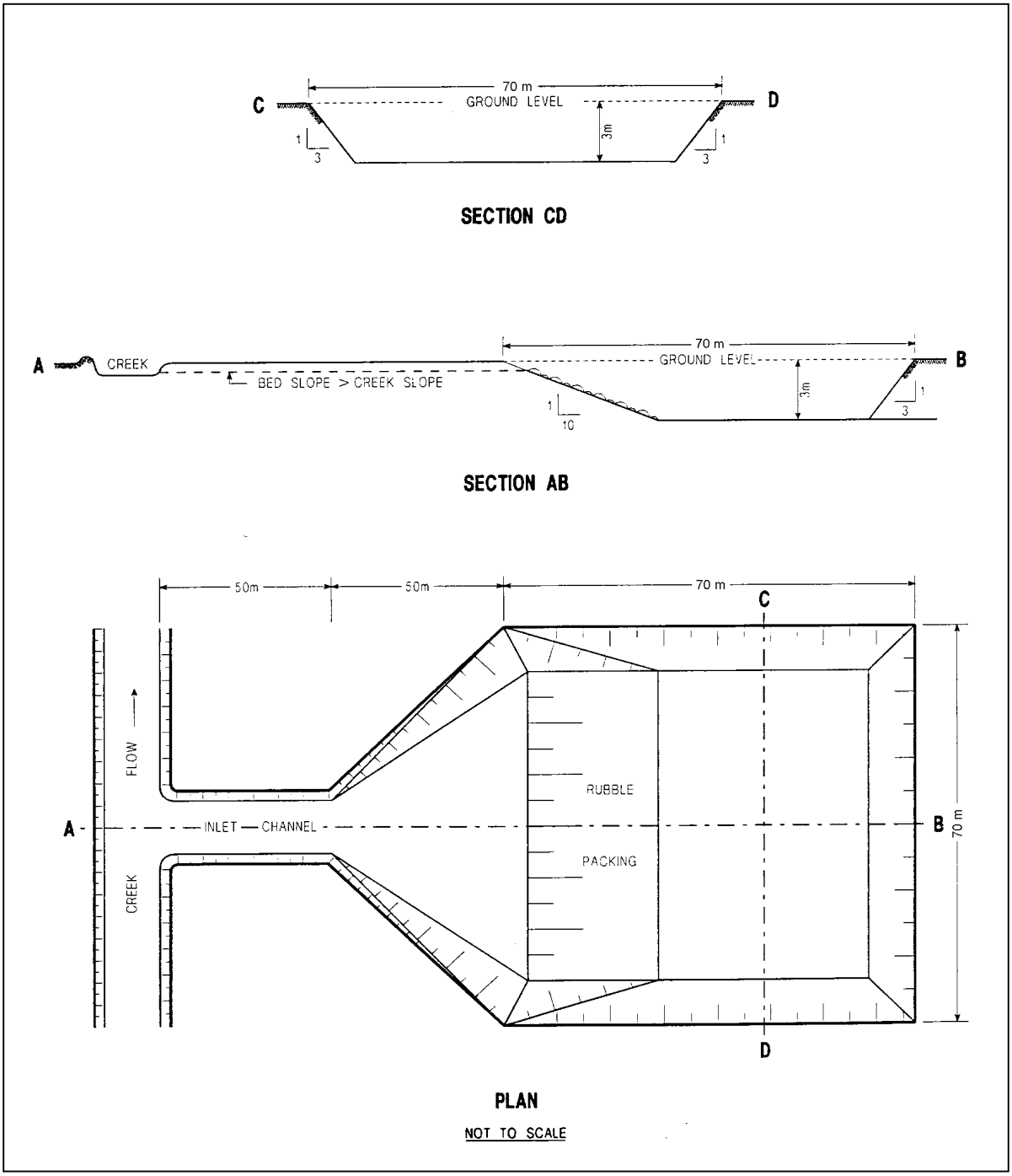


Figure 1 Types of Tanks and Dams

Another type of dam, the gully or embankment dam, is suited for undulating to hilly country and consists of an embankment built across a drainage line. It should be noted that structural failures are high amongst gully dams, as they require a high standard of design, construction and management. Within the map region, this type of construction would only be suited to the low hilly country to the east, however, probably not economically viable due to the sandy and rocky nature of the country.

Figure 2 Typical Off-Steam Excavated Tank



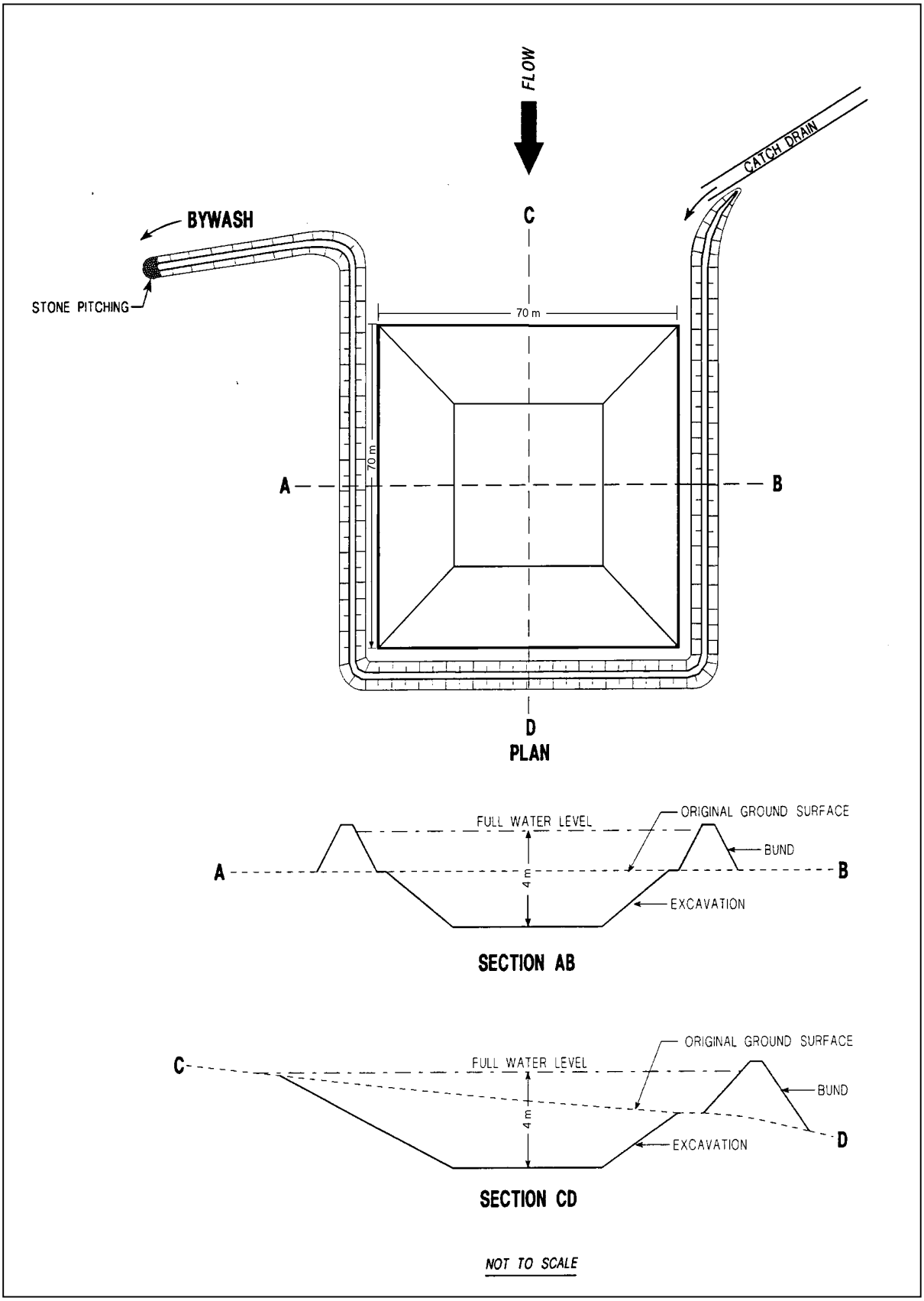


Figure 3 Typical Drainage-Line Excavated Tank

Construction of gully dams involves potential high costs in dealing with the foundations and mitigation of flood flows with diversion through an adequate by-wash or spillway. It is recommended that appropriate planning and design be undertaken, particularly for construction on rock foundations.

The "Earth Movers Training Course" booklets 9 and 10 (Reference 3), provides an excellent background guide to dam building and design. However, it is important that the information be considered in conjunction with local knowledge as many of the dam types are only applicable to the less extreme conditions experienced in southern climates.

4.2 Selection of Sites for Excavated Tanks

The availability of runoff and depth of impermeable soil are usually the determining factors in site selection for excavated tank construction. Conditions appear to be favourable across the major part of the map area as it comprises gently undulating plains to low hills. The soil appears to have adequate clay content and sufficient depth.

In areas mapped with cracking clay (black) soils, such as the relict drainage paths of Western Creek, the clay may extend to depths of about two metres in most places and will be suitable for excavated tanks. However it should be noted that this is unlikely to be sufficient depth to be economical, and hence underlying soil conditions should also be investigated to confirm viability.

Plate 8 - Soil sampling with a small auger rig

A drainage-line tank is best suited to this country where there is flat or gently sloping ground. Excavation will be minimised where the tank site has some slope, say about 1:100, to allow bunds constructed from excavated material to add to the storage volume of the tank. Drainage-line tanks may also be feasible in areas immediately adjacent to the low hilly country on rippable laterite horizons if there is sufficient depth of clayey soils.

A few areas have been mapped where ferricrete is predominant on the surface. This rock, in its 'in-situ' form is highly permeable and would appear to be non-prospective as a foundation for shallow dam or tank construction. However, Avago and Hidden Valley have conducted informal trials in such areas using small holding dams, and report that success has been achieved over a short period of time, simply by allowing animals to 'work' the soil in the dams. After the soil is 'pugged in', a seal is effected. A number of landholders, through personal communication, report a similar

result is commonly noted in sinkholes, where once freely draining 'holes' are 'pugged' when animals are allowed access into them.

Areas mapped with variable soils are minor, but they may also be suitable for excavated tanks. In these areas, there is a likelihood of encountering dispersive or sandy profiles, or high permeability zones and these should be avoided. Remedial work such as installing a clay liner brings added expense, but would be necessary.

4.3 Design and Construction of Excavated Tanks

In this section, empirical calculations are used for example purposes only. However, it serves to demonstrate typical dimensions which may be encountered on the Sturt Plateau.

The design dimensions for an excavated tank are determined by the number of stock in the paddock to be watered. This is often governed by the carrying capacity of the country and grazing radius. On the Sturt Plateau, this would be typically between 400 and 800 head. Based on a consumption of 50 litres per head per day, the corresponding water requirement is between 6 ML and 12 ML for the 9 month period from April through to December. With a depth of about 4m, which is the minimum preferred for good reliability and 1:3 batters, the larger tank would measure approximately 70m square at the top.

Following from this example, a storage of 12 ML (if neglecting evaporation and leakage losses) as a drainage-line dam would need a minimum catchment area of about 1 km^2 for the typical environment. This figure assumes an average annual rainfall of 700mm, a runoff threshold of 60% of rainfall and a runoff coefficient of 5%. For tank sizes of larger or smaller storage capacity, the required catchment area would need to be varied correspondingly to capture the required amount of runoff.

The proposed design is indicated in Figure 3 and is relatively simple. Excavated soil can be dumped to waste or used to build a bund on three sides of the tank. Bund and wing walls will increase the storage capacity of a drainage-line tank where there is a moderate slope on the natural ground surface. The excavated volume in this example is large for the proposed design dimensions (approximately 10,000 m^3) so construction costs will be high (usually in the order of $\$1/m^{3)}$. The cost will also be influenced by ground conditions. Tank construction is described in more detail in Appendix 5.

An off-stream tank shown in Figure 2 is similar and with 12ML capacity. However, its 'filling' capability is controlled by the elevation of the inlet channel in relation to the creek bed and the nature and frequency of flow in the creek. The hydrology of the creek would therefore need to be examined to enable a viable tank to be designed.

4.4 Waterholes

In the dry season, natural waterholes are found in depressions in streambeds and in the black soil areas of relict floodplains. Most are shallow and become dry a few months after the end of the wet season. Excavation of the base (Appendix 5), but only where clay or a rippable and impermeable rock underlies the site may increase the available capacity of such waterholes. The storage capacity of well confined waterholes with high banks could be increased by construction of a bund at its downstream end. The bund would need to be designed and constructed to withstand flood flows.

Plate 9 - "'Rocky Hole' in the eastern uplands area

Examples of waterholes in the study area exist mainly in the Western Creek and Birdum Creek systems and adjacent floodplains. Some are perennial, however, are shallow by the end of the dry season. The larger, deeper waterholes on the Western Creek system appear to have been influenced by the development of large sinkholes.

Other waterholes exist in the rocky uplands area of Vermelha. As perennial waterholes, such as Rocky Hole, they are generally smaller, but deeper.

4.5 Piping of Surface Water

Surface water may be piped from borrow pits into turkey nests and this practice is effective as an alternative low cost option where possible. The use of turkey nests is a good option as losses to evaporation can be minimised. 50mm polythene pipe, buried where possible, can be used to pipe water to about four kilometres in flat country. The distance can be increased by using larger diameter pipes and higher capacity pumps. It is desirable to bury polythene pipe to protect it from

Plate 10 - 'Marang bore' and ground tank at Western Creek Station

physical damage (eg. grass fires or stock trampling) and because its strength is reduced if subjected to elevated daytime temperatures.

Piping is a recommended option for a large portion of Cow Creek where the basalt basement is shallow or the veneer of surface soil is sandy. Water may exist in shallow natural waterholes immediately following the wet season and piping to turkey nests should be considered.

4.6 Supply of Stock Water from Tanks

Turkey nests are required as a balancing reservoir between the tank and stock watering troughs. Dimensions for turkey nests providing three days water for various stocking rates are given in Appendix 5. The basic equipment to transfer water from an excavated storage tank to a turkey nest is a pump, with a choice of three energy sources - diesel, wind or solar. The initial cost of a windmill or solar powered pump is high but running costs are low. The low cost and availability of a relatively cheap diesel motor and centrifugal pump makes diesel the preferred option even though running costs are high. The advantages are mobility and ease of maintenance.

Plate 11 - Bore and turkey nest at Vermelha

5.0 RECOMMENDATIONS

- The water resources development map should be used during the conceptual planning stage to determine the type of water supply most appropriate to the development of specific areas on the property. In areas where a number of options are available, economics will normally determine the final development type selected.
- Groundwater is available over much of the region.
- Surface water development options have been indicated to be viable over a large part of the map area.
- The provision of reliable water supplies with a maximum grazing radius of six kilometres should be a priority, in order to reduce over-grazing and soil erosion.
- Advice should be sought from geotechnical engineering consultants when considering the construction of larger excavated tanks.

Specific recommendations are considered under three headings: distribution, groundwater, and surface water.

5.1 Water Supply Distribution

Over-grazing will severely reduce ground cover and eventually, initiate soil erosion. A major adverse effect is the degradation of pasture quality by allowing non-beneficial species and weeds to become dominant. Apart from the number of cattle present, the distribution of watering points is a major factor affecting grazing pressure. A rule of thumb commonly adopted for planning the location of watering points is that they should be located so that cattle can graze the whole paddock without having to walk more than six kilometres for water. Where possible, tanks or bores should be located to give a maximum spacing of twelve kilometres between watering points. Otherwise the water can be piped to steel tanks / turkey nests or directly to troughs in appropriate locations. The piping of water away from supplies sited in the corners of paddocks may decrease the grazing pressure by keeping the cattle spread over a greater area. Figure 4 is an example layout showing the potential increase in the size of the grazing area due to improved water reticulation from a bore or tank.

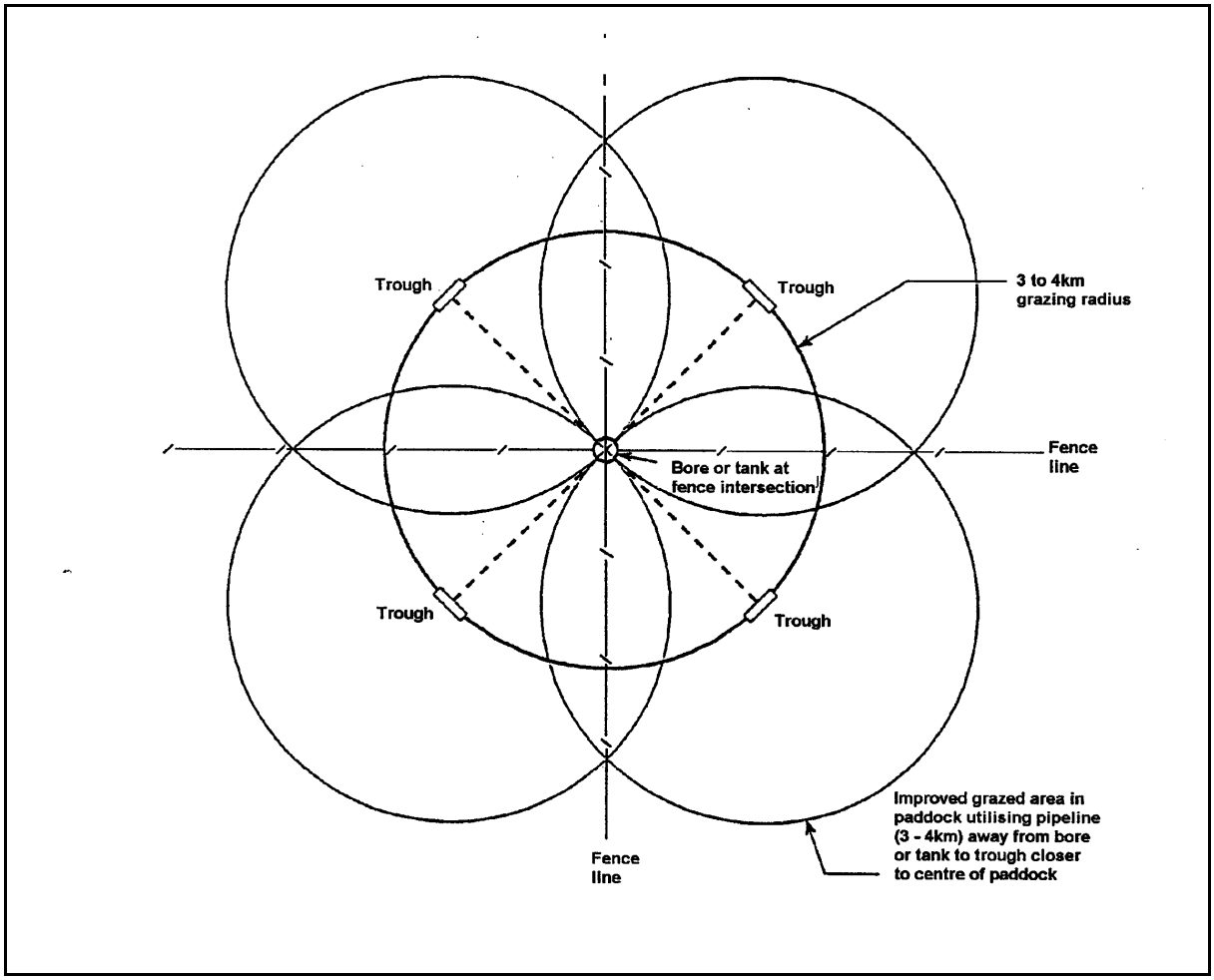


Figure 4 Sketch showing increased size of grazing area due to improved water reticulation from bore or tank

5.2 Groundwater

The prospect for obtaining a groundwater supply in the map area is highly dependent on location and therefore the 'Groundwater Resources' side map should be consulted in the first instance.

Adequate stock water supplies may be obtained from aquifers in the limestone formation underlying a large part of the region. 'The Depth to Water Table' and 'Thickness of Limestone Below the Water Table' side maps should be used as a guides to minimum and maximum bore depths and indicative pumping depths.

Bore siting is critical in the limestone aquifers to the west. The basement variations described in Section 3.2 will affect groundwater prospects in parts of Avago, Western Creek, Tarlee and Sunday Creek Stations. The Natural Resources Division may assist in further defining target areas using available aeromagnetic mapping, however, ground geophysics may be needed to optimise the specific siting of bores.

In areas where groundwater prospects are mapped as poor, water supplies are usually only available in basalt aquifers. If groundwater options are to be pursued in these areas, geophysical or other aids should be utilised to locate specific targets for drilling.

5.3 Surface Water

The 'Surface Water Resources' side map accompanying the main map provides an indication of the potential for dam and excavated tank construction over the area. However, this is based on broad scale mapping and intended for planning purposes only. Site specific investigations will need to be conducted to ascertain the viability of particular sites.

Drainage-line and off-stream type excavated tanks are recommended for areas suited to development. These construction types are less susceptible to washout during seasonal flooding, and more effective in harvesting the low runoff available from the catchments on the Sturt Plateau.

Generally, the sub-soils are suitable for dam construction. Where clayey soils are shallow or there is underlying shallow rock, small capacity excavated tanks should still be considered. The supply may not be sustained throughout the year, however, a greater spread of grazing will possible for the initial part of the dry season.

6.0 ACKNOWLEDGMENTS

The author would like to thank the managers, families and staff of all stations involved for their time, assistance and fruitful discussions during the study.

The work of Anthony Knapton contributed largely to the outcomes of this project. His assessment and analysis of the geophysical components, particularly airborne magnetics, laid the cornerstone for the current understanding of the basement structure.

Technical advice and guidance from Peter Jolly and Gary Humphreys throughout the survey has been much appreciated.

Acknowledgment and thanks is also extended to Paul Schober who assisted in the geophysical and ground surveys, Jeff Fong of the GIS unit who drafted the maps and figures for the report, and the drilling and bore testing crews of the Technical Services Group.

7.0 REFERENCES

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2. Day, K.J., Sivertsen, D.P. and Torlach, D.A., “Land Resources of the Sturt Plateau, Northern Territory – A Reconnaissance Land System Survey”, Land Conservation Unit, Conservation Commission of the Northern Territory, Darwin (1985).

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8.0 GLOSSARY

AMG EASTING	The east-west coordinates of the bore in metres from the grid's origin. It refers to the grid lines on the map.
AMG NORTHING	The north-south coordinates of the bore in metres from the grid's origin. It refers to the grid lines on the map.
AQUIFER	A body of rock that is sufficiently permeable to transmit groundwater and to yield economically significant quantities to bores and springs.
BATTER	Slope expressed as a ratio of horizontal to vertical distance.
BERM	Flat area between excavated area of tank and bund.
BORE	Lined hole constructed with a drilling rig and which is used to extract groundwater.
BORE DIAMETER	The minimum internal bore diameter in millimetres
BORE REGISTERED NUMBER (RN)	A number assigned by the Natural Resources Division to each registered bore.
BUND	Bank constructed of compacted fill used to contain water.
CASING	Tubing used to line boreholes. The length of casing in the hole is expressed in metres and its internal diameter in millimetres.
DEMAND	The volumetric flow rate required for stock watering therefore the rate at which water would be supplied if available.
DEPTH DRILLED	The total depth of the bore in metres below ground level.
DISSOLUTION	The process where rock has been dissolved by water and the component parts are carried in solution.
GROUNDWATER	Water contained in rock below the water table.
KARSTIC	Term which denotes the characteristic scenery of a limestone region.
OFF-STREAM TANK	Excavated tank built near creeks and connected to the creek by a channel to tap the creek flow.

ON-STREAM TANK	Excavated tank built in the bed of a well defined stream.
PERENNIAL	Lasting throughout the year, or through many years.
PUMPING RATE	The recommended pumping rate in litres per second.
PUMP SETTING	The recommended depth below ground level at which the pump intake should be set.
SLOTS	The apertures located in the casing adjacent to the aquifer. An interval over which they exist is usually expressed between depths in metres below ground level.
SPILLWAY	A structure designed to overflow excess water out of a dam.
SPILL TAIL CHANNEL	A channel built downstream of the spillway to direct excess water back into the creek.
STANDING WATER LEVEL (SWL)	The level below the ground surface to which groundwater will rise in a bore or well.
STORAGE CAPACITY	The volume of water that can be stored in a tank up to its full supply level.
TOTAL DISSOLVED SOLIDS (TDS)	A measure of water salinity based on the quantity of solids left after evaporation of a litre of the sample.
WATER TABLE	The surface resulting when the standing water levels in adjacent bores in the same aquifer are connected.
WATER STRUCK	The depth in metres below ground level at which the main water bearing zone was encountered.
YIELD	The amount of water obtained in litres per second by airlifting usually during drilling of the hole.

APPENDIX 1

BORE TEST REPORTS

Test reports for bores within the region are included in this Appendix. Further details of the bore tests and other bore information is available from the Natural Resources Division in Darwin.

1. General Recommendations for Finishing, Operating and Protecting Groundwater Bores.

Attention to the following points will prolong the life of the bore supply and help prevent pollution of the groundwater resources.

a. Construct a concrete apron around the borehead to prevent surface flow and any spillage from entering the bore.

b. Seal the space between casing and pump equipment to prevent entry of small animals, insects, dirt and pollutants.

c. Maintain pumping equipment in good order to prevent pollution. Avoid spillage of fuel and oil on the ground around the bore.

d. Keep stock away from the bore head. Discourage domestic activity at the bore and store fertiliser and other chemicals at least 50 metres distant.

e. Pumping the bore at higher than recommended rates may cause sand intrusion and lead to instability or pump problems. Seek advice from this office or other qualified source.

f. When bore is not equipped or no longer required it should be securely capped. If the bore is to be abandoned, the casing may need to be removed, the bore backfilled and cement plugs placed.
NB. This requires the services of a registered driller

Please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number, RN, is the Natural Resources Division's only reference to the scientific and engineering data on this bore and hence important to this Division’s records for advice to bore owners.

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT – RN 6744

Bore Location: Birdum Creek Station
Map: LARRIMAH 1:100,000 Sheet: 5566
Grid Reference: 304468 - 8274199

Client: Birdum Creek Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 4 L/s **Pump Setting: 37m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 6744** Palmerston NT 0831

****

Bore Data:
Finished depth: 44.2 m Completion date: 19.10.69
Standing Water Level: 30.0 m on 9.6.98
Construction Details:

Test Date: 24.5.84
Test Rate: 4.5 L/s
Test Duration: 8 hours

Interval	Description
0 - 21.3 m	**203 mm ID steel casing**
0 - 38.1 m	**152 mm ID steel casing**
38.1 - 42.6 m	**152 mm ID steel casing, slotted**
42.6 - 44.2 m	**152 mm ID steel casing**

Notes: 1. Top of casing when tested was 0.12 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test up to 4.5 L/s for 8 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was clean and clear throughout testing.
4. Obstruction at 39.13 m on 9.6.98

****

WATER ANALYSIS:
Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 26366

Bore Location: Birdum Creek Station
Map: LARRIMAH 1:100,000 Sheet: 5566
Grid Reference: 303600 - 8273400

Client: Birdum Creek Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.4 L/s **Pump Setting: 70m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 26366** Palmerston NT 0831

****

Bore Data:
Finished depth: 89.0 m Completion date: 29.6.89
Standing Water Level: 42.57 m on 6.7.89
Construction Details:

Test Date: 6.7.89
Test Rate: up to 0.7 L/s
Test Duration: 3 hours

Interval	Description
0 - 6.5 m	**219 mm ID steel casing**
0 - 56.0 m	**168 mm ID steel casing**
56 - 73.0 m	**168 mm ID steel casing, oxy slotted**
73 - 76.0 m	**168 mm ID steel casing**
76 - 82.0 m	**168 mm ID steel casing, oxy slotted**
82 - 89.0 m	**168 mm ID steel casing**

Notes: 1. Top of casing when tested was 0.48 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:
1. The above recommendations are based on an extended step drawdown test up to 0.7 L/s for 3 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. Discharge was clean and clear throughout testing.

****

WATER ANALYSIS:
Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 26367

Bore Location: Birdum Creek Station
Map: LARRIMAH 1:100,000 Sheet: 5566
Grid Reference: 303550 - 8271900

Client: Birdum Creek Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.5 L/s **Pump Setting: 51m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 26367** Palmerston NT 0831

****

Bore Data:
Finished depth: 83.0 m Completion date: 30.6.89
Standing Water Level: 49.7 m on 7.7.89
Construction Details:

Test Date: 10.11.99
Test Rate: up to 1.4 L/s
Test Duration: 3 hours

Interval	Description
0 - 22.0 m	**203 mm ID steel casing**
0 - 34.0 m	**168 mm ID steel casing**
34 - 46.0 m	**168 mm ID steel casing, slotted**
46 - 52.5 m	**168 mm ID steel casing**
52.5 - 83.0 m	**203 mm open hole**

Notes: 1. Top of casing when tested was 0.4 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on an extended step drawdown test up to 1.4 L/s for 3 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was clean and clear throughout testing.

****

WATER ANALYSIS:

Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 24616

Bore Location: Birdum Creek Station
Map: LARRIMAH 1:100,000 Sheet: 5566
Grid Reference: 304468 - 8274199

Client: NT Gas
Purpose: Construction
Water Supply

****

RECOMMENDATIONS: Pumping Rate: 6 L/s **Pump Setting: 35m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 24616** Palmerston NT 0831

****

Bore Data:
Finished depth: 81.6m Completion date: 25.6.92 (deepened) Test Date: 26.11.87
Standing Water Level: 29.95 m on 27.11.87 Test Rate: up to 10 L/s
Construction Details: Test Duration: 19 hours

Interval	Description
0 - 12.0 m	**203 mm NB PVC casing**
0 - 45.0 m	**150 mm NB PVC casing**
41 - 45.0 m	**150 mm NB PVC casing, slotted**
45 - 81.6 m	**140 mm open hole sump**

Notes: 1. Top of casing when tested was 0.1 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 140 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 140 mm.

****

COMMENTS:

1. The above recommendations are based on an extended step drawdown test up to 10 L/s for 19 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was clean and clear throughout testing.

****

WATER ANALYSIS: 87/88/0854

Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30494

Bore Location: Vermelha Station
Map: LARRIMAH 1:100,000 Sheet: 5566
Grid Reference: 0315590 - 8281268

Client: Brazil Enterprises Pty Ltd
Purpose: Irrigation

****

RECOMMENDATIONS: Pumping Rate: 60 L/s **Pump Setting: 58 m**

For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30494** Palmerston NT 0831

****

Bore Data:

Finished depth: 91.4 m Completion date: 18.4.98 Test Date: 25.5.98
Standing Water Level: 50.15 m on 21.5.98 Test Rate: 93 L/s
Construction Details: Test Duration: 24 hours

Interval	Description
0.0 - 6.0 m	**314 mm ID steel casing**
0.0 - 58.0 m	**260 mm ID steel casing**
58.0 - 70.0 m	**260 mm ID steel casing, 3mm slots**
68.9 - 91.1 m	**206 mm ID packer and steel casing, 3mm slots**
91.1 - 91.4 m	**206 mm ID stainless steel sump with J latch**

Notes: 1. Top of casing when tested was 0.59 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 206 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 260 mm.

****

COMMENTS:

1. The above recommendations are based on a constant discharge test at 93 L/s for 24 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. This bore is capable of higher yields but long term pumping data is required to enable analysis of aquifer performance.
4. Production pump may be set lower if NPSH is critical however it is not recommended practice to pump within slotted or screened areas. Refer Natural Resources for revised pumping rates and pump settings.
5. Under the NT Water Act 1992 an extraction permit is required for yields above 15 L/s.
6. This bore will produce a small amount of fines at recommended rate.

****

WATER ANALYSIS: 712 12/6/98s #16 Lab register # 695

Prepared by: P Rees
4.6.98

Checked by: B Thatcher
6.7.98

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30655

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 274660 - 8211846

Client: K Holzwart
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 2 L/s **Pump Setting: 76 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30655** Palmerston NT 0831

****

Bore Data:
Finished depth: 84.0 m Completion date: 11.6.96
Standing Water Level: 65.58 m on 14.8.96
Construction Details:

Test Date: 15.8.96
Test Rate: 2.5 L/s
Test Duration: 8 hours

Interval	Description
0 - 5.8 m	**208 mm ID PVC casing**
0 - 77.5 m	**152 mm ID steel casing**
77.5 - 84.0 m	**152 mm ID steel casing, 3mm slots**

Notes: 1. Top of casing when tested was 0.30 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test at 2.5 L/s for 8 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Further advice can be obtained from Natural Resources Darwin.

****

WATER ANALYSIS: 1736

Prepared by: D Hill
28.8.96

Checked by: B Thatcher
29.8.96

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30656

Bore Location: Western Creek Station
Map: WESTERN CREEK 1:100,000 Sheet: 5466
Grid Reference: 242156 - 8248029

Client: Western Creek Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 10 L/s **Pump Setting: 65 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30656** Palmerston NT 0831

****

Bore Data:
Finished depth: 84.0 m Completion date: 1.6.96 Test Date: 20.8.96
Standing Water Level: 55.71 m on 20.8.96 Test Rate: 14 L/s
Construction Details: Test Duration: 8 hours

Interval	Description
0 - 5.8 m	**208 mm ID PVC casing**
0 - 77.5 m	**152 mm ID steel casing**
77.5 - 84.0 m	**152 mm ID steel casing, 3 mm slots**

Notes: 1. Top of casing when tested was 0.30 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on an constant rate test up to 14 L/s for 8 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was clean with a few fines for the duration of testing.

****

WATER ANALYSIS: 1737

Prepared by: D Low
28.8.96

Checked by: B Thatcher
28.8.96

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT – RN 30856

Bore Location: Western Creek Station
Map: WESTERN CREEK 1:100,000 Sheet: 5466
Grid Reference: 241758 - 8235616

Client: Western Creek Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.2 L/s **Pump Setting: 76m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30856** Palmerston NT 0831

****

Bore Data:
Finished depth: 84.0 m Completion date: 14.6.96 Test Date: 19.8.96
Standing Water Level: 63.05 m on 19.8.96 Test Rate: 0.2 L/s
Construction Details: Test Duration: 5 hours

Interval	Description
0 - 5.8 m	**208 mm ID PVC casing**
0 - 77.5 m	**152 mm ID steel casing**
77.5 - 84.0 m	**152 mm ID steel casing, 3 mm slots**

Notes: 1. Top of casing when tested was 0.30 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on an extended step drawdown test up to 0.2 L/s for 5 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was cloudy with fines throughout testing.

****

WATER ANALYSIS: 1739
Prepared by: D Low 28.8.96
Checked by: B Thatcher 28.8.96

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30710

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 273927 - 8222597

Client: K Holzwart
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.7 L/s **Pump Setting: 73m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30710** Palmerston NT 0831

****

Bore Data:
Finished depth: 78 m Completion date: 28.5.97
Standing Water Level: 63.17 m on 11.9.97
Construction Details:

Test Date: 10.11.99
Test Rate: up to 0.9 L/s
Test Duration: 1 hours

Interval	Description
0 - 6.1 m	**208 mm ID steel casing**
0 - 68 m	**152 mm ID steel casing**
68 - 78 m	**152 mm ID steel casing, 3mm slots**

Notes: 1. Top of casing when tested was 0.35 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on an step draw-down test up to 0.9 L/s for 1 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was discoloured with fines throughout the duration of testing.

****

WATER ANALYSIS: 719
Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION

TEST REPORT - RN 30714

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 633 - 280

Client: K Holzwart
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate 1.5 L/s **Pump Setting: 82 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30714** Palmerston NT 0831

****

Bore Data:
Finished depth: 101 m Completion date: 14.6.97
Standing Water Level: 72.63 m on 9.9.97
Construction Details:

Test Date: 10.9.97
Test Rate: up to 2 L/s
Test Duration: 6 hours

Interval	Description
0 - 5.8 m	**208 mm ID steel casing**
0 - 88.0 m	**152 mm ID steel casing**
88 - 96.0 m	**152 mm ID steel casing, 3mm slots**
96 - 101 m	**152 mm ID steel casing**

Notes: 1. Top of casing when tested was 0.37 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a extended step test up to 2 L/s for 6 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 679, 680 & 823

Prepared by: D Hill
29.9.99

Checked by: B Thatcher
29.9.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30986

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 0248010 – 8232444

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate 2.5 L/s **Pump Setting: 64 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30986** Palmerston NT 0831

****

Bore Data:
Finished depth: 76.8 m Completion date: 25.8.99
Standing Water Level: 58.33 m on 30.8.99
Construction Details:

Test Date: 28.9.99
Test Rate: up to 3 L/s
Test Duration: 6 hours 40 mins

Interval	Description
0 - 5.5 m	**202 mm ID steel casing**
0 - 59.0 m	**152 mm ID steel casing**
59 - 63.0 m	**152 mm ID steel casing, 4 mm slots**
63 - 73.6 m	**152 mm ID steel casing**

Notes: 1. Top of casing when tested was 0.70 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test at 3 L/s for 6 hours 40 mins and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Note: Recommended pump setting is below slots.
4. Casing is suspended by annular ring.

****

WATER ANALYSIS:
Prepared by: D Hill
29.9.99

Checked by: B Thatcher
29.9.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30987

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 247734 - 8229574

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate 5 L/s **Pump Setting: 70 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30987** Palmerston NT 0831

****

Bore Data:
Finished depth: 103.3 m Completion date: 26.8.98
Standing Water Level: 61.43 m on 9.10.98
Construction Details:

Test Date: 10.10.98
Test Rate: up to 5 L/s
Test Duration: 7 hours

Interval	Description
0 - 5.5 m	**202 mm ID steel casing**
0 - 91.9 m	**155 mm ID steel casing**
91.9 - 103.3 m	**open hole**

Notes: 1. Top of casing when tested was 0.55 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 155 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 155 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test up to 5 L/s for 7 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. This bore is capable of higher yields. For further advice contact Natural Resources.
4. Casing is suspended by an annular ring.

****

WATER ANALYSIS: 1306
Prepared by: D Low
5.1.99

Checked by: B Thatcher
5.1.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30988

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 247293 - 8221984

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate 1.2 L/s **Pump Setting: 69 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30988** Palmerston NT 0831

****

Bore Data:
Finished depth: 97.8 m Completion date: 28.8.98
Standing Water Level: 63.19 m on 30.8.99
Construction Details:

Test Date: 31.8.98
Test Rate: 1.5 L/s
Test Duration: 9.5 hours

Interval	Description
0 - 65.0 m	**155 mm ID steel casing**
65 - 67.0 m	**155 mm ID steel casing, slotted**
67 - 70.0 m	**155 mm ID steel casing**
70 - 72.0 m	**155 mm ID steel casing, slotted**
72 - 83.6 m	**155 mm ID steel casing**
83.6 - 97.8 m	**200 mm open hole**

Notes: 1. Top of casing when tested was 0.5 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 155 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 155 mm.

****

COMMENTS:
1. The above recommendations are based on a constant rate test at 1.5 L/s for 9.5 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. Note: Recommended pump setting below slotted casing.
4. Casing is suspended by an annular ring.

****

WATER ANALYSIS:
Prepared by: D Hill
29.9.99

Checked by: B Thatcher
29.9.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30989

Bore Location: Avago Station
Map: MIDDLE CREEK 1:100,000 Sheet: 5465
Grid Reference: 246546 - 8214321

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate 2.5 L/s **Pump Setting: 90 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30989** Palmerston NT 0831

****

Bore Data:
Finished depth: 109.3 m Completion date: 29.8.99
Standing Water Level: 81.69 m on 4.9.99
Construction Details:

Test Date: 2.9.99
Test Rate: 2.5 L/s
Test Duration: 24 hours

Interval	Description
0 - 95.0 m	**152 mm ID steel casing**
95 - 109.3 m	**150 mm open hole**

Notes: 1. Top of casing when tested was 0.75 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 150 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test at 2.5 L/s for 24 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS:
Prepared by: D Hill
29.9.99

Checked by: B Thatcher
29.9.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT – RN 31925

Bore Location: Western Creek Station
Map: WESTERN CREEK 1:100,000 Sheet: 5466
Grid Reference: 248628 - 8254260

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.5 L/s **Pump Setting: 63m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 31925** Palmerston NT 0831

****

Bore Data:
Finished depth: 72.84 m Completion date: 17.8.98
Standing Water Level: 46.56 m on 6.11.98
Construction Details:

Test Date: 4.11.98
Test Rate: up to 0.6 L/s
Test Duration: 6.6 hours

Interval	Description
0 - 5.70 m	**203 mm ID steel casing**
0 - 63.38 m	**154 mm ID steel casing**
63.38 - 69.90 m	**154 mm ID steel casing, 2 mm slots**
69.90 - 72.84 m	**154 mm ID steel casing**

Notes: 1. Top of casing when tested was 0.44 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 154 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

2. The above recommendations are based on a multi-rate test up to 0.2 L/s for 5 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 1487

Prepared by: D Spencer
24.2.00

Checked by: B Thatcher
24.2.00

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31926

Bore Location: Western Creek Station
Map: WESTERN CREEK 1:100,000 Sheet 5466
Grid Reference: 251623 - 8245528

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.5 L/s **Pump Setting: 75 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 31926** Palmerston NT 0831

****

Bore Data:
Finished depth: 96.87 m Completion date: 19.8.98 Test Date: 7.11.98
Standing Water Level: 66.95 m on 5.11.98 Test Rate: up to 1 L/s
Construction Details: Test Duration: 160 mins

Interval	Description
0.0 - 4.70 m	**203 mm ID steel casing**
0.0 - 77.51 m	**152 mm ID steel casing**
77.51 - 84.02 m	**152 mm ID steel casing, oxy slots**
84.02 - 88.88 m	**152 mm ID steel casing**
88.88 - 96.87 m	**157 mm open hole**

Notes: 1. Top of casing when tested was 0.56 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:
1. The above recommendations are based on a constant rate test at 1 L/s for 5 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped

3. This bore will produce sand at higher rate.
4. Casing is suspended by an annular ring.

****

WATER ANALYSIS: 1488
Prepared by: D Spencer
6.1.99

Checked by: B Thatcher
6.1.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31965

Bore Location: Maryfield Station
Map: WESTERN CREEK 1:100,000 Sheet 5466
Grid Reference: AGD 66 53 L 0347056 - 8255588

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.8 L/s **Pump Setting: 67.5 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 31965** Palmerston NT 0831

****

Bore Data:
Finished depth: 115.5 m Completion date: 16.8.00 Test Date: 24.09.01
Standing Water Level: 47.85 m on 22.09.01 Test Rate: up to 1 L/s
Construction Details: Test Duration: 7.5 hours

Interval	Description
0.0 - 5.6 m	**202 mm ID steel casing**
0.0 - 68.5 m	**154 mm ID steel casing**
68.5 - 75.0 m	**154 mm ID steel casing, 10 mm oxy slots**
75.0 - 115.0 m	**open hole**

Notes: 1. Top of casing when tested was 0.68 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 154 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test at 1 L/s for 7.5 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped

3. This bore will produce sand at higher rate.
4. Casing is suspended by an annular ring.

****

WATER ANALYSIS: Lab Register # TBA
Prepared by: Bob Setchell
24.9.01

Checked by: Dennis Low
3.10.01

APPENDIX 2

CHEMICAL ANALYSES OF GROUNDWATERS

The following table lists chemical analyses of bores sampled in this area of the Sturt Plateau. See Appendix 3 for quality guideline limits for stock and domestic consumption.

Table 2 Water Quality Data

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
553	01/11/55				642	554	1427	97	265		76		11	175	155	1.6			
553	03/10/68	1900	7.7	348	212	585	1060	75	315	8	87		14	190	170	0.8	0.7	49	pumped
554	01/11/55				354	285	790	8	165		64		3	115	81	0.5			
554	08/02/68	1000	7.7	440	268	500	706	90	100		68		10	60	50		0.4	35	pumped
554	03/10/68	900	7.3	322	196	338	540	42	98	1	44		6	65	58	0.7	0.1	31	pumped
2186	08/10/56				522	513	1124	101	190		63		14	125	101				
2186	15/01/69	1450	7.2	498	304	585	960	145	180		52		13	138	104	1.3	0.2		
5492	25/07/66	1552	6.8	544	332	640	1312	205	266		30.7		34	212	20	0.3	0.26		
5492	08/02/68	1950	7.5	436	266	520	1130	70	280		60		33	225	178	1	0.2	43	pumped
5492	06/07/82	2150	7.6	554	676	615	1350	146	270	440	61	3	46	222	198	0.9	0.3	42	2.2L/s, 55.3m
5877	01/09/67	1450	7.8	470	288	585	810	105	45		77	3	24	130	100		0.4		
5877	02/09/67	1500	7.8	478	291	610	922	102	45		83		23	125	100		0.2		
5877	05/10/67	1450	7.6	484	294	556	879	95	50		76	3.5	3	140	100		1.5		
5877	30/10/80	1780	6.9	481	586	580	960	135	190	305	59	4	13	131	128	0.2	0.1	43	pumped
5877	19/09/85	1550	7.3	436	531	530	940	120	176	290	56		12	121	131	0.2	0.3		
5928	09/07/92	845	6.7	467	570	490	520	135	20	34	37	3	4	6	20	0.1	1.6	37	1.2L/s, 53m, pumped
5929	20/07/99	1730	6.9	376	459	531	1060	124	218	359	54	5	27	245	180	0.5	0.1	37	pumped as equipped
6744	01/11/69	1150	7.9	299	364	368	940	69	172		52	1	15	121	116	0.4	9.2	41	43m, pumped
22858	19/06/84	1860	7.5	374	456	474	1120	88	290	473	62	3	24	201	198	0.3	3.9	42	1L/s, 78m, airlift
22859	21/06/84	1360	7.8	295	359	377	770	44	170	285	65	1	10	137	150	0.3		14	2L/s, 66m, airlift

Table 2 Water Quality Data (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
6744	13/05/84	1630	6.8	484	590	552	930	134	180	300	53		18	134	124	0.3			
6744	23/05/84	1580	6.7	483	589	576	970	140	170	277	55		17	134	135	0.3	2.9		4.5L/s, 37.5m
6744	24/05/84	1600	6.7	485	591	576	980	140	180	293	55	2	17	135	135	0.3	2.7	43	4.5L/s, 37.5m
6745	01/11/69	700	7.7	482	588	416	550	112	12		44		5	12	15	0.2	0.1	38	
6745	03/06/98	831	6.4	459	560	463	493	126	5	8	36	1	4	8	24	0.3	0.1	39	1.5L/s, pumped as equipped
8513	22/10/74	520	7.9	267	326	258	270	26	5	8	47	1	3	8	11	0.4	12	33	2.3L/s, 91m
8514	20/10/74	1070	7.8	312	380	462	690	76	68	120	64	2	6	43	176	0.5	6	23	1.1L/s, 73m, airlift
8514	07/06/98	1107	6.5	437	533	530	707	138	39	64	45	1	5	45	164	0.3	1.2	46	2L/s, pumped as equipped
8684	02/03/79	2100	6.8	545	665	630	1286	148	270	445	66	6	40	215	205	0.6	0.2	44	pumped as equipped
8699	08/07/75	1330	7.8	290	354	361	780	56	159	262	54	3	15	128	124	0.2	2.7	40	4.5L/s, 73m, airlift
8699	08/07/75	1610	7.7	299	365	381	780	62	186	307	55	4	16	137	124	0.2	1.6	40	4.5L/s, 73m, airlift
8699	15/04/81	1750	7.1	490	598	584	960	140	186	306	57	4	15	124	126	0.3	0.1	43	pumped as equipped
8699	17/04/84	1610	7.4	479	583	572	950	135	180	293	57	4	15	128	148	0.2	0.2	42	pumped as equipped
21117	30/09/81	680	7.6	405	494	362	420	62	7	12	51	1	4	11	19	0.4	21.5	31	0.9L/s, 114m, airlift
21117	28/10/81	900	8.0	220	268	108	520	24	125	203	11	1	3	156	51	0.8	0.3	20	0.5L/s, 107m, pumped
21783	22/08/83	960	7.8	442	539	475	600	118	55	91	44	1	7	38	52	0.2	3.3	25	6L/s, pumped
21783	07/06/98	1015	6.5	437	533	456	584	115	58	96	41	2	6	40	56	0.1	0.1	32	3L/s, pumped as equipped
22669	24/08/83	1830	7.9	276	336	357	1040	46	270	440	59	6	40	224	207	0.6		42	1.1L/s, 67m, airlift
22670	25/08/83	1970	7.6	317	387	416	1180	58	310	510	66	5	41	246	234	0.6		46	1.2L/s, 67m, airlift
22860	23/06/84	1780	7.6	405	494	429	1090	70	248	409	62	5	22	196	181	0.2		43	3L/s, 66m, airlift
22860	20/07/99	1460	7.1	402	490	530	897	130	149	246	50	2	18	113	150	0.4	0.1	34	pumped as equipped

Table 2 Water Quality Data (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
22861	02/07/84	700	7.4	321	392	316	410	67	36	58	36	1	4	27	35	0.1	5	32	2.5L/s, 52m, airlift
22861	02/07/84	720	7.4	322	393	321	400	69	36	59	36	1	5	28	34	0.1	8	31	2.5L/s, 52m, airlift
22861	20/07/99	829	7.1	319	389	441	492	114	18	30	38	1	4	13	29	0.1	0.1	27	pumped as equipped
23662	20/07/99	1940	7.0	443	540	606	1190	144	252	415	60	5	22	185	190	0.3	0.4	40	pumped as equipped
24616	29/05/86	1410	7.8	365	445	441	860	106	180	293	43	2	18	145	139	0.2	10	42	4.8L/s, 80m, airlift
24616	27/11/87	1570	6.9	100	120	560	630	75	180	295	40	2	10	80	140	0.2	0.5	45	8L/s, 37.2m, pumped
25209	13/01/95	862	6.5	486	592	520	494	139	10	16	42	1	3	8	18	0.2	1.9	31	3L/s, 115m, airlift
26314	20/07/99	1200	7.2	413	503	548	751	142	74	122	47	1	8	56	120	0.3	1	30	pumped as equipped
26315	20/07/99	1660	7.2	390	475	542	1030	130	196	323	53	4	23	148	170	0.5	0.2	36	pumped as equipped
26316	20/07/99	1760	7.0	427	520	575	1090	135	215	354	58	3	18	158	160	0.2	0.2	39	pumped as equipped
26366	06/07/89	1595	7.0	510	622	589	1005	142	179	295	57	3	15	142	140	0.3	2.6	47	0.7L/s, 64.3m, pumped
26367	07/07/89	2720	7.5	129	157	313	1560	94	795	1310	19	1	10	456	11	1	0.5	22	1.7L/s, 51.9m, pumped
27330	20/07/99	1250	7.0	461	562	515	763	132	94	155	45	1	10	66	120	0.3	0.2	28	pumped as equipped
27332	20/07/99	1560	7.0	500	609	551	936	135	163	269	52	2	18	115	150	0.4		32	pumped as equipped
27337	03/06/98	853	6.4	476	580	479	510	126	6	10	40	1	4	9	30	0.3	0.1	42	1.5L/s, pumped as equipped
27337	28/05/99	831	7.8	464	566	443	500	110	5	8	41	1	4	10	31	0.2	0.1	43	2L/s, pumped
28082	28/05/92	1615	7.0	491	598	588	975	143	183	301	56	4	16	129	142	0.4	0.2	43	10L/s, 54m, pumped
28087	02/07/92	825	7.5	445	543	432	480	112	12	20	37		4	15	19	0.3		38	65m, bailed
29013	15/01/94	2310	7.2	546	666	664	1360	157	282	465	66	4	37	242	232	0.4	0.1	48	10L/s, 51.5m, pumped
29014	14/01/94	1570	7.0	484	602	609	961	155	165	272	54	3	16	128	138	0.2	0.1	44	10L/s, 63.5m, pumped
29537	04/09/97	1371	6.6	238	290	307	818	59	204	336	39	6	14	144	159	0.4	3.8	29	3.3L/s, 73m

Table 2 Water Quality Data (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
29537	04/09/97	1475	7.1	308	376	357	884	56	216	356	53	6	18	158	166	0.4	0.4	37	3.3L/s, 73m
29537	19/07/99	1250	7.3	504	614	541	776	131	82	135	52	1	8	58	110	0.4	0.1	43	pumped as equipped
29706	23/08/97	993	6.4	251	306	316	592	46	101	166	49	1	10	75	139	0.5		32	5L/s, 83m
29706	22/07/99	1330	7.3	496	605	540	819	134	101	166	50	1	11	72	130	0.4	0.1	30	pumped as equipped
29707	24/08/97	1146	6.4	260	317	299	679	41	154	254	48	1	18	113	135	0.5		32	2L/s, 72m
29707	22/07/99	1480	7.3	494	602	515	888	124	151	249	50	2	18	110	130	0.4	0.1	32	pumped as equipped
29708	25/08/97	1301	6.7	283	345	333	772	51	182	300	50	1	15	128	145	0.5		29	2L/s, 77m
29708	19/07/99	1590	7.3	505	616	535	963	127	183	302	53	3	15	129	130	0.5	0.1	36	pumped as equipped
29769	02/09/94	741	7.1	424	517	442	450	116	3	5	37	1	3	11	14	0.2	0.1	46	5L/s, 78m, airlift
29769	28/05/99	869	7.5	509	620	462	520	111	2	3	45	1	3	12	20	0.2	0.1	48	pumped
30494	18/04/98	1581	8.0	332	405	390	935	61	208	343	58	4	26	159	183	0.4	0.8	45	20L/s, 91.4m, airlift
30494	26/05/98	1756	6.3	511	623	609	1057	142	204	336	62	4	25	162	176	0.4	0.2	39	93L/s, 65m, pumped
30498	22/04/98	842	8.0	277	338	332	522	54	71	117	48	1	7	46	98	0.4		46	3L/s, 60m, airlift
30654	10/06/96	516	7.6	262	319	254	290	26	10	16	46	2	5	14	23	0.2		33	0.5L/s, 76m, airlift
30654	13/08/96	911	7.1	522	636	508	532	113	6	10	55	1	4	10	26	0.3	2.1	46	0.3L/s, 76.8m, pumped
30655	11/06/96	678	7.4	344	419	319	375	52	14	23	46	1	6	14	27	0.2		47	2L/s, 79m, airlift
30655	15/08/96	834	7.2	454	553	438	498	95	11	18	49	1	5	12	26	0.3	0.1	51	2.5L/s, 77.4m, pumped
30656	01/06/96	451	7.1	236	288	237	250	62	6	10	20	1	2	5	17	0.3	3	24	3L/s, 77m, airlift
30656	21/08/96	797	7.0	429	523	423	474	128	8	13	25	1	3	7	27	0.2	0.2	31	14L/s, 77.4m, pumped
30710	28/05/97	660	7.1	341	416	366	380	71	16	26	46	1	5	15	24	0.3	0.2	45	1.3L/s, 67m, airlift
30710	12/09/97	849	6.8	482	588.2	438	479	98	6	10	47	1	5	25	23	0.5	2.3	34	0.7L/s, 73.6m, pumped
30714	10/9/97	553	8.1	244	297	27	338	6	36	59	3	1	2	122	19	2.0	0.3	27	2L/s, 82.9m, pumped

Table 2 Water Quality Data (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
30714	14/8/00	618	8.2	235	286	28	363	8	4	7	2	1	2	121	17	1.6	0.1	22	2L/s, pumped as equipped
30869	01/08/96	1472	7.6	333	406	399	888	71	194	320	54	3	23	143	166	0.5	2.9	36	4.5L/s, 61m, airlift
30869	21/07/99	1740	7.1	492	600	520	1040	121	218	359	53	4	26	161	170	0.4	0.1	34	pumped as equipped
30710	28/05/97	660	7.1	341	416	366	380	71	16	26	46	1	5	15	24	0.3	0.2	45	1.3L/s, 67m, airlift
30710	12/09/97	849	6.8	482	588.2	438	479	98	6	10	47	1	5	25	23	0.5	2.3	34	0.7L/s, 73.6m, pumped
30714	10/9/97	553	8.1	244	297	27	338	6	36	59	3	1	2	122	19	2.0	0.3	27	2L/s, 82.9m, pumped
30714	14/8/00	618	8.2	235	286	28	363	8	4	7	2	1	2	121	17	1.6	0.1	22	2L/s, pumped as equipped
30869	01/08/96	1472	7.6	333	406	399	888	71	194	320	54	3	23	143	166	0.5	2.9	36	4.5L/s, 61m, airlift
30869	21/07/99	1740	7.1	492	600	520	1040	121	218	359	53	4	26	161	170	0.4	0.1	34	pumped as equipped
30915	19/07/99	1430	7.2	393	479	577	895	144	129	213	53	1	14	95	140	0.4	0.1	36	pumped as equipped
30987	26/08/98	654	7.7	358	436	327	390	57	10	16	45	1	5	8	14	0.2		34	4L/s, 92m, airlift
30987	10/10/98	873	7.3	497	606	467	479	113	9	15	45	1	5	6	29	0.2	0.4	36	5L/s, 88m, pumped
30989	29/08/98	583	7.7	321	391	299	356	64	6	10	34	1	4	7	14	0.2		25	1L/s, 109m, airlift
31606	11/05/98	546	6.6	282	344	272	337	63	15	25	28	1	4	16	4	0.1	6.7	24	2L/s, 78m, airlift
31606	26/08/99	716	7.4	395	482	391	433	112	8	13	27	1	3	8	16	0.1	0.1	37	0.7L/s, 64m, pumped
31742	21/07/98	1232	8.0	234	285	294	729	39	164	270	48	1	21	133	154	0.4		36	3L/s, 70m, airlift
31742	19/07/99	1590	7.2	499	608	528	969	126	171	282	52	3	20	128	150	0.4	0.1	34	pumped as equipped
31861	10/10/98	1390	7.5	199	243	310	872	78	327	539	28	2	4	166	19	1.4		27	0.1L/s, 77.2m, pumped
31862	19/07/99	1360	7.1	500	610	554	832	138	109	180	51	1	11	75	130	0.1		31	pumped as equipped
31862	19/07/99	1360	7.1	500	610	554	832	138	109	180	51	1	11	75	130	0.1		31	pumped as equipped
31921	05/08/98	568	8.1	213	260	83	341	15	47	77	11	1	4	83	25	0.3		37	0.3L/s, 72.8m, airlift
31921	05/08/98	490	8.4	204	241	64	302	11	38	63	9	1	3	79	13	0.3		30	0.3L/s, 66.8m, airlift

Table 2 Water Quality Data (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
31921	05/08/98	477	8.0	206	251	62	296	10	31	51	9	1	2	81	32	0.3		31	0.3L/s, 60.8m, airlift
31921	05/08/98	670	8.5	209	247	96	397	17	69	114	13	1	6	101	48	0.8		21	0.3L/s, 60.8m, airlift
31925	17/08/98	513	7.6	260	317	269	306	70	6	10	23	1	3	7	18	0.2		27	0.5L/s, 73m, airlift
31925	04/11/98	686	7.4	383	467	184	406	39	3	5	21	1	2	3	17	0.2	3.3	27	0.5L/s, 87m, pumped
31926	19/08/98	679	7.7	358	437	351	449	88	9	15	32	1	4	8	31	0.3	11.9	35	0.5L/s, 97m, airlift
31926	06/11/98	777	7.4	434	529	246	461	46	7	12	32	1	3	8	19	0.2	1.6	35	1L/s, 88.9m, pumped
32037	22/07/99	1770	7.3	334	407	441	1070	83	257	424	57	1	3	215	240	0.3	1.1	38	pumped as equipped
32039	20/07/99	2100	7.5	556	678	618	1300	144	224	369	63	5	30	212	210	0.5	0.1	42	pumped as equipped

APPENDIX 3

WATER QUALITY STANDARDS FOR STOCK AND DOMESTIC USE

1. WATER QUALITY STANDARDS FOR STOCK USE

SUBSTANCE	GUIDELINE VALUE
pH range	6.5 - 8.5
Total dissolved solids	10000mg/L
Sodium chloride	Not more than 75% when total dissolved solids near limit
Sulphate	2000mg/L
Nitrate	400mg/L
Fluoride	2.0mg/L
Magnesium	300mg/L

The composition of mineral supplements to stock feed must be considered when stock waters are near to the guideline limits, especially for fluoride and sulphate. Further information is available from the Chief Veterinary Officer, Northern Territory Department of Primary Industry and Fisheries.

2. WATER QUALITY STANDARDS FOR DOMESTIC USE (NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL, AUSTRALIAN DRINKING WATER GUIDELINES 1996)

Analyses of water intended for human consumption should lie within the guidelines listed below. Discussion relating to the quality of domestic water should be addressed to the Northern Territory Department of Health and Community Services.

SUBSTANCE	GUIDELINE VALUE	
pH range	6.5 - 8.5	*
Total dissolved solids	500mg/L	#
Chloride	250mg/L	#
Sulphate	250mg/L	#
Nitrate	50mg/L	+
Fluoride	1.5mg/L	
Hardness (as Calcium Carbonate)	200mg/L	*
Sodium	180mg/L	*

(*) Values outside of the guidelines for pH and hardness may result in either build-up of scale in pipes or corrosion of pipes but they do not pose a health problem.
(#) Above these limits the taste may be unacceptable but they do not pose a health problem.
(+) For nitrate, a limit of 50mg/L is recommended for babies less than 3 months old, 100mg/L is the guideline for older children and adults.

APPENDIX 4

EXCAVATED TANK SITE INVESTIGATIONS

Having determined a catchment capable of supplying stock quality water for the required stock numbers, site investigations must be undertaken to confirm that the proposed tank site is suitable. The site investigation guidelines presented here are based on a booklet entitled "Design and Construction of Small Earth Dams" (Reference 4). The key investigation method is to auger a series of investigation holes. In an excavated tank situation this helps to:

- determine the extent of impermeable soils and the presence of any layers which are likely to present leakage problems
- show if there is any impermeable and soft rock present, such as rippable hard clays or laterite
- ascertain whether shallow groundwater is present, and if so, is it suitable for stock
- provide information on the soils to ensure the tank sides will be stable

If an on-stream tank is proposed, then spillway conditions will also require investigation. If it is too sandy it will erode and wash away or if it is in rock, excavation could be very expensive.

A hand operated 100 mm earth auger capable of drilling to between 5 and 6 metres is the basic tool for the sub-surface investigations. Auger holes are sunk in soil to one metre deeper than the tank design depth, with minimum 500 gram samples taken wherever there is a change in soil. A plan of the soil changes down each hole should be kept to compare variations from hole to hole. Excavated tanks require a minimum five test holes, one in the centre and the other 4 positioned at the mid point of each corner slope of the proposed tank (Figure 5). For the modification of an existing waterhole, auger holes are sunk at 50 metres apart along the centre of the bed, and 100 metres apart along the edges of the bed.

The site for proposed excavation must fulfil three main conditions :

- the loss by seepage must be relatively low
- the sides must be stable
- silting must not be excessive

1. Seepage Loss

In most areas, the water table will be deeper than the proposed 3 to 4 metre tank depth. Hence leakage of stored water through the sides and base of the tank is possible.

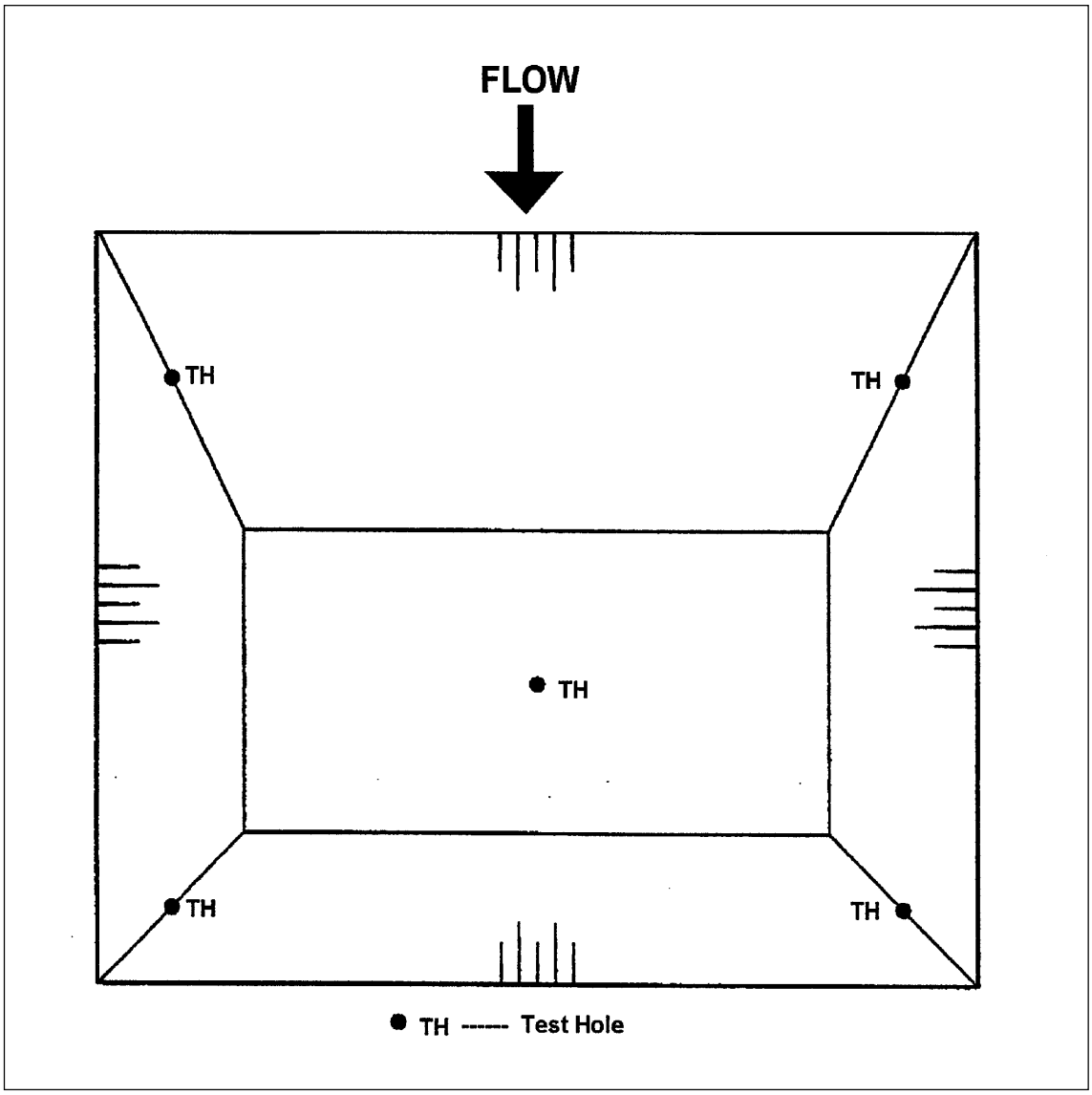

Figure 5 Test hole plan for an excavated tank

A simple permeability test can give an indication of potential leakage from the tank using the series of auger holes used for soil sampling. The following procedure is proposed but is only indicative:

- Pre-soak each hole for at least 1 hour before starting the test by filling the hole to exactly 0.5 metres below ground level. Maintain the water at this level by topping up as necessary.
- The test is a measurement of the amount of water needed to maintain the water level at 0.5 metres below ground level for one day. Once the test is commenced, the amount of water added is recorded. This should continue for one day.

If the water added exceeds 30 litres per hour, then the site is too permeable for an excavated tank. If it is between 3 and 30 litres per hour then the site is considered doubtful. Some work would be needed to limit the water loss rate or to increase the sealing capacity of the tank floor (eg. use plastic liner or clays). Seepage rates less than 3 litres per hour indicate that leakage will not be a serious problem.

2. Tests on Soil Samples

Soils commonly consist of particles ranging in size from coarse gravels, through sands and silts, to very fine clays. Gravels and sands can be readily identified by appearance and feel, and unless they are mixed with finer silts and clays, will be prone to leakage. Clays and silts are indistinguishable when dry. While clay is one of the most useful soils in dam building, silt, when wet, is the most troublesome. It tends to be unstable in the presence of water, often collapsing when saturated.

Generally, a favourable site investigation result will confirm the presence of non-dispersive clays that bind together any coarser particles to create a water holding material. Accurate classifications of soil types can be undertaken by sending at least 100 gram of sample to a soil laboratory to provide confirmation of soil suitability. However, simple field tests can give a good indication for the likely behaviour of the soils.

- A simple test to differentiate clay from silt is to moisten the sample and feel it. Clay should be sticky. Pinch a sample between the thumb and forefinger; if it is clay it should be possible to form a flexible ribbon about 1.5 mm thick and at least 40 mm long.

- If the presence of clay is established, then the water holding potential of the soil can be tested using the "bottle test". The bottom of a one litre plastic drink bottle is cut off. The bottle is inverted and one-third filled with the soil to be tested. The bottle is filled with water. If no water seeps through the soil in 24 hours, it has good water-holding properties.

- All clays should be tested for dispersion. Some clays break down in water to form a suspension of clay particles throughout the water. This is dispersion and has been the cause of many dam failures. To test for dispersion, take 5 to 10 grams of air dried soil crumbs and drop them into 100 ml of distilled water in a cup. Allow it to stand for at least one hour without shaking. If the water appears cloudy then dispersion has occurred and special care will be needed if building tanks in these materials. The presence of deep erosion gullies suggests markedly dispersive soils and that these sites should be avoided.

If site investigations show that there is likely to be problems with any of these factors then professional advice should be sought, and remedial measures may be possible. However it may also be necessary to abandon the proposed site.

APPENDIX 5

CONSTRUCTION DETAILS OF EXCAVATED TANKS, TURKEY NESTS AND MODIFIED WATERHOLES

Assume preliminary investigations (Appendix 4) have been conducted and indicate that suitable conditions exist for the proposed construction. The integrity of the structure now hinges on the construction methods utilised.

1. Drainage-Line Excavated Tanks

The site is first cleared of vegetation and the planned tank laid out on the ground using marker pegs. Excavation is commonly carried out using scrapers or bulldozers. If the tank is in an area with some slope (say greater than 1 in 100), excavated material can be used to construct bunds around three sides of the excavation to increase the storage capacity. The bund should have a minimum berm width of 5 metres (Figure 3). Topsoil with potential for leakage must be removed down to an impervious layer before the bund is built, and compaction may be undertaken using the available machinery. The ideal time to achieve optimum compaction is early in the dry season when soils are still slightly moist.

Three sides of the tank are excavated with a slope of 1 in 3, and flow enters the tank through the side with a mild slope, as low as of 1 in 10. The inflow side may be rubble packed to prevent erosion. Where the excavation is in rock, with little chance of erosion, the inlet batter may be increased to 1 in 4 to decrease the volume of material to be removed. The recommended slopes allow for machinery to enter the tank, excavate, turn and exit with ease.

Catch drains can also be constructed (eg. using a tilted grader blade) to effectively increase the interception capacity of sheet flow towards the tank.

2. Modifying Waterholes

Modifying a waterhole usually means constructing a narrow excavated tank within the waterhole to increase its storage capacity. Site investigations are critical. If the subsoil is impermeable, non-dispersive, and there is no rock within two metres depth, then excavation should be possible using a scraper. The presence of rock will usually require the use of rippers for excavation. The longitudinal batter could be 1 in 3 or less, while the cross sectional batter should not be more than 1 in 2.

3. Turkey Nests

The current design and construction techniques for turkey nests are quite sound although special attention should be paid to:

- removal of leaky topsoil from the base before construction
- the selection of a non-dispersive soil as the construction material
- compaction at optimum moisture content. This can be achieved if construction is undertaken early in the dry season while the soil is still moist. Every 100 mm layer of loose soil should be compacted.

The table below gives examples of recommended dimensions, sized for turkey nests of a three day water supply capacity.

Number of Cattle	Inner Diameter At Base (m)	Inner Diameter at Top (m)	Total Height of Turkey Nest (m)	Draught (m)
250	4	13	1.8	0.8
400	6	15	1.8	0.8
600	6	16	2.0	1
1000	6	18.5	2.5	1.5

These figures are based a slope of 1 in 2.5 for the inner sides. The capacity of the tank (in terms of number of cattle) allows for leakage, the overflow standpipe to be 0.5m below the top of the tank and the outlet pipe supported 0.5m above its base. The draught is the depth of available water in the tank and is effectively the tank's storage capacity.