Water management systems in colonial South Australia

PAMELA A. SMITH

Colonists who took up land in the new colony of South Australia following its proclamation in 1836 introduced water management technologies from their homelands, generally the United Kingdom and Europe. The aim of this paper is to present some archaeological evidence of nineteenth-century water management strategies identified in field surveys undertaken by the Hills Face Zone Cultural Heritage Project. This evidence includes nineteenth-century strategies to conserve water, control water flow and to irrigate orchards and crops. The analysis of the GIS data collected through field studies, together with several case studies, showed how some irrigation and water control methods were effective, whilst others were found to be unsuitable for the Australian environment and resulted in the destruction of property and degradation of the environment by occasional severe floods.

INTRODUCTION

When Colonel William Light, the Surveyor-General to the new colony of South Australia, surveyed the site for Adelaide in 1836 it was believed that there would be sufficient water to support the colony for many years. Certainly, in its promotion of the new colony the South Australian Company gave only glowing accounts of the climate and the prospects of those who ventured there (Angas n.d.). For example, John Morphett, who accompanied Colonel Light, reported more than favourably on the water resources of the western hills face:

> Mount Lofty bears nearly east, and the whole of this side of the range is intersected with gullies, ravines and water courses, of the deepest kind, bearing evident marks of being acted on by powerful torrents. All of the hilly country along the coast has a similar character, but in no place is it so conspicuous as here. The facilities for damming up, and the creation of water power, are greater than I have seen in any country in an equal area. (Morphett 1837:12)

Many of the first colonists would have read reports such as this and arrived in South Australia with expectations that supplies of water would be well in excess of their needs and similar to those of their homeland. The year of 1836 must have been particularly wet, as ten years later the *Emigrants Friend or Authentic Guide to South Australia* (Anonymous1848) provided intending colonists with a very different description:

> ... there is another circumstance equally important to internal comfort and to health, as to which Adelaide is singularly deficient—that is the want of good water—the river is of course, salt, and all the water available for drinking and for domestic purposes, is obtained either by catching the rain water, or from deep wells, with which the city is furnished, and the making of which entails much expense upon the newly-allotted resident in most parts of the Colony. (Anonymous 1848:9)

Certainly colonists were forced to confront the reality that the climate of this new land differed considerably from the cooler and wetter climates of Great Britain and Europe. Although the streams flowing from the Mount Lofty Ranges (approximately 10 km east of the new settlement of Adelaide) flooded across the Adelaide Plains in winter, the colonists

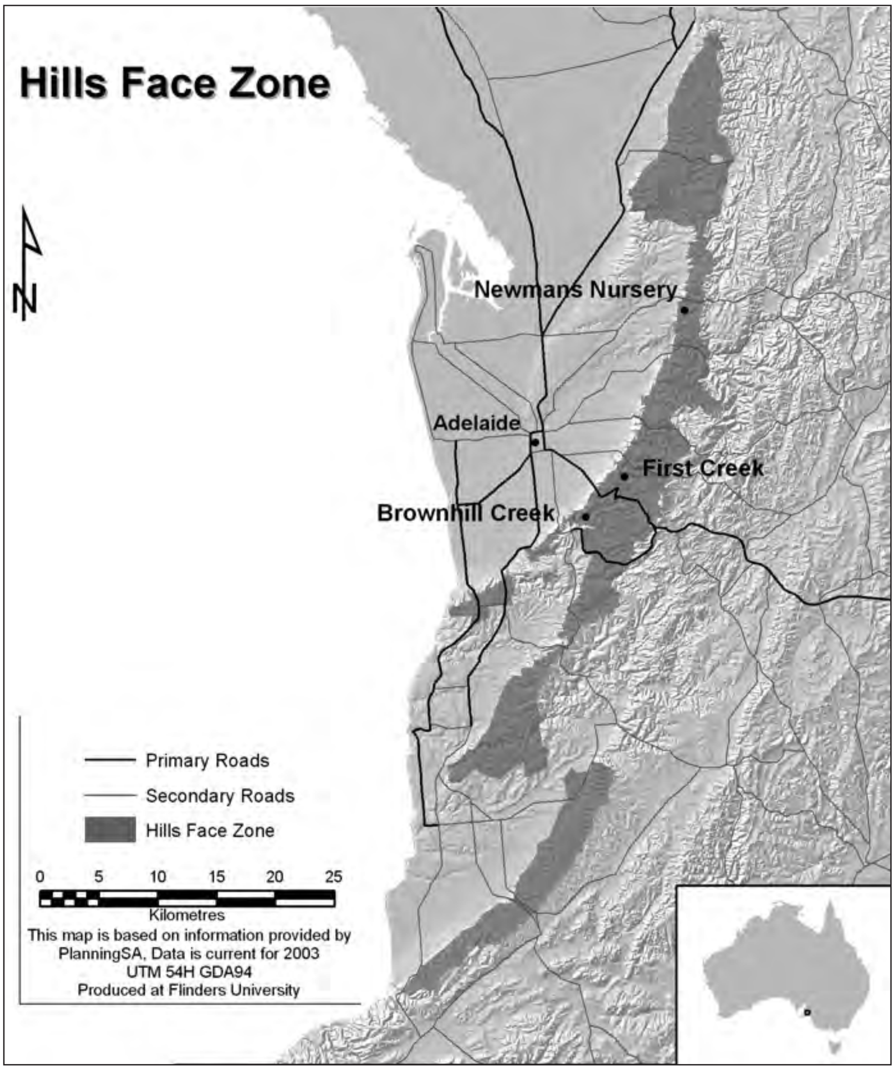

Fig. 1: Map of the Adelaide Plains showing the location of the city of Adelaide and the Hills Face Zone (shaded). R. Keane, GIS consultant

soon realised that the permanent springs in the ranges were the only reliable sources of water during the long dry summers. It was, therefore, crucial for the survival of the colony that water management strategies be developed for the reticulation of water to the developing town of Adelaide and to the several small new villages. The steep west-facing valleys of the Mount Lofty Ranges to the east of the Adelaide Plain with their deep black soil and many natural springs were also quickly identified as providing the best environment for orchards and market gardens.

THE HILLS FACE ZONE CULTURAL HERITAGE PROJECT

The Hills Face Zone Cultural Heritage Project (HFZCHP) was undertaken between 2002 and 2005 and was funded by the Australian Research Council, Flinders University and ten Industry Partners. The aims and outcomes of the project are found on the project's website (Hills Face Zone Cultural Heritage Project 2005). The field work and research were undertaken by staff and students from the Department of Archaeology, Flinders University and by community volunteers. The Hills Face Zone is defined by the western face of the Mount Lofty Ranges and extends for approximately 90 km from Sellicks Hill, south of Adelaide, to Gawler, north of Adelaide. The region is entirely within the Adelaide metropolitan area (defined in the *Metropolitan Development Act* 1993).

The close proximity of essential natural resources, that is, timber, stone, water and fertile soil, to the new settlements meant that the valleys along the western face of the Mount Lofty Ranges played an important role in the economic development of Adelaide and were settled within the first decades following the proclamation of the new colony. Now, in 2007, the western face of the ranges has been protected from subdivision and intensive agriculture and horticulture for almost 45 years by the 1967 Hills Face Zone provisions in the 1962 Metropolitan Development Plan. As a consequence, many new parks and reserves have been declared within the zone during this period. The intention of the government was to preserve the region's outstanding natural heritage values but inadvertently a rare model of nineteenth-century European colonisation was also protected and these parks now provide a window through which we have been able to interpret South Australia's colonial past.

The landscape archaeology paradigm used by this project was derived from earlier systems-based approaches to human landscape use developed in relation to settlement pattern and human ecology studies (Binford 1980, 1982; Clark 1952; Willey 1953, 1956; Steward 1955). As archaeologists are now primarily concerned with understanding the meanings underlying culturally determined phenomena, these earlier approaches to the interpretation of spatial and diachronic changes across landscapes have been revolutionized over the past two decades and are now applied to a wide range of landscape situations (examples include: Jacques 1995; Plachter and Rössler 1995; Roberts 1996; Yamin and Metheny 1996; Ashmore and Knapp 1999; Ucko and Layton 1999). In addition, archaeologists are constantly experimenting with Geographic Information System (GIS) and computer models that quantify social change and refine predictive modelling (Crumley and Marquardt 1990; Kvamme 1999; Gillings et al. 1999; Bell and Bevan 2006). In this project GIS landscape models were used for quantifying data, predictive modelling and as an inventory containing over 900 nineteenth-century colonial features and/or sites to be used as a management tool for future cultural heritage management (Adelaide's Hills Face Heritage GIS Database 2005).

Methods in landscape archaeology and GIS were used to identify and interpret the cultural 'baggage' that the colonists to South Australia brought with them and determined how they initially viewed, settled, and used the new and unfamiliar landscape. This 'baggage' included industrial and domestic building technologies, social mores, agricultural and horticultural practices and culturally determined settlement patterns. Through the archaeological field surveys we identified evidence of how the colonists adapted to the very different environment and the ways in which landuse changed through time. The approach developed by the project team was also influenced by settlement ecology methods (Anschuetz et al. 2001:177). Using this approach to interpret the archaeological data we were able to better understand the complex ways in which the colonists transformed this landscape and how their activities were determined by the environment, the economic imperatives of the time and by the symbolic and social mores they brought with them.

The aim of this paper is to present some archaeological evidence of nineteenth-century water management strategies identified by field surveys undertaken by the Hills Face Zone Cultural Heritage Project. This evidence includes nineteenth-century strategies to conserve water, control water flow and to irrigate orchards and crops using technologies the colonists brought with them from England and Europe, Through case studies it is demonstrated how some technologies appear to have worked well, while others ultimately proved unsuitable for the Australian environment.

WATER MANAGEMENT TECHNOLOGIES

Water and stone, two natural resources in the Mount Lofty Ranges, were essential for the economic development of the new colony. During the first decades of the colony irrigation and water management systems were constructed from stone and allowed water from the many permanent springs to be controlled. Many of these irrigation systems were used well into the twentieth century, and although the lower prices of iron pipes in the latter half of the nineteenth century ensured the gradual replacement of water-races and stone channels for irrigation, several examples of water channels and races used to control water remain and were recorded by this project.

Most colonists had emigrated from Great Britain and of those who took up market gardening and horticulture few had any previous experience in irrigation and water conservation technologies. The small acreage under irrigation in England in the nineteenth century used flooded grasses in water-meadows to increase yields of cut grass for hand-feeding livestock. In 1876 it was estimated that the extent of water-meadows in England was not more than 100,000 acres (40,468 ha), mostly confined to the south and west (*Chambers' Encyclopaedia* 1876:249). In England, it was the need to drain the land of water and so to expand the area available for agriculture that was a priority. Williamson (1996) in his discussion of the evolution of the English landscape refers to the introduction of the ceramic or terracotta pipe for underground drainage in wetlands, such as the Fens, in the 1840s as one of the major technological changes in nineteenth-century agriculture.

Market gardeners, horticulturalists and farmers settling in the steep-sided valleys of the hills east of Adelaide found it necessary to adapt the technologies and knowledge brought with them to a very different environment. The long dry summers and infrequent torrential rains demanded at least two significant technological adaptations. In the era before modern pumps the many permanent springs in the valleys provided the only reliable sources of water which was conserved in chains of small dams, in wells and stone water storage tanks constructed along the creeks. These conservation measures and the increased use of water resulted in an unpredicted depletion of water resources within the first 50 years of the colony, as described by E.H. Hallack in 1893:

> Of the creeks between the Sturt and the Torrens there are six which start from the western slopes of the Mount Lofty Ranges. In the early days their waters used to run through the Adelaide Plains for the greater part of the year. Boys bathed in them and children gathered flowers from their shady banks long before many of the present suburbs were dreamt of. But since the development of the hills gardening industry the sight of a running stream for more than four months in the year is a novelty, and what used to mark the confines of running brooks are now ugly, open channels … (*Adelaide Observer* 6 May 1893:9)

These essential conservation strategies exacerbated competition for water resulting in frequent disputes over water rights (pers. comm. Geoffrey Bishop and Andrew Tilley) and Letters to the Editor, similar to the following complaint, appeared regularly in Adelaide newspapers during the second half of the nineteenth century:

> For the last two or three years the people of Norwood and Kent Town, through whose land the creek (called I believe, First Creek) used to run at this time of year, have had to deplore its premature dribble and final exhaustion … From Howitt's Mill downwards, the water is dammed up by one and another until the immense evaporation of summer exhaust[s] its overflow, and what might and ought to be a blessing to thousands is monopolised by a few without let or hindrance. One gentleman, whose name I need not mention, dams up the water after it leaves the mill until the flood irrigates a large piece of land, and insures him a fine crop of grass or grain, when others not so favoured are parched up … another irrigates his nursery garden, and is by this means enabled to grow vegetables of fine quality on comparatively poor soil, swells his horticultural production and enjoys a fine bath whenever he pleases … (*Register* 2 February 1856)

The second essential technological adaptation was in response to the severe flood cycle. Destructive torrential downpours occurred infrequently and up to 20 or 30 years apart and flood management skills were learned through years of experience and loss of investments. It is estimated that 94 per cent of houses in the study area built between 1836 and 1870 were within 150 m of a creek and 61 per cent were within 50 m of a creek (Smith 2006:71). Most of these cottages were the homes of market gardeners, orchardists or farmers and many were flooded or destroyed during these severe floods. People gradually learnt to anticipate these events and accommodate to them. Protective retaining walls were built along the tops of agricultural terraces and industry-related infrastructure and access tracks were constructed on hillsides rather than through the floor of the valley.

Approximately 113 nineteenth-century stone features associated with water management were documented during heritage surveys and entered into Adelaide's Hills Face Heritage GIS Database (2005). These features are categorised by type in Table 1.:

The GIS data has also enabled us to interpret the spatial patterns of water-related infrastructure within the colonial landscape, to calculate their distance from water sources and their relationships to each other. All of this information has been brought together in this paper to reconstruct examples of mid nineteenth-century water management systems and to interpret examples of relict landscapes that demonstrate how water was managed during the nineteenth century in order for the colony to develop and prosper.

Table 1: Stone features related to water management in the Hills Face Zone dating from 1836 to 1900.

Feature type	Estimated date	No.
Stone lined water channel – former creek	1836-1900	11
Drain or channel – fragments only	1836-1870	12
	1870-1900	2
	unknown	1
Stone dam wall or weir	1836-1870	5
	1870-1900	5
	unknown	4
Stone irrigation channel/water race	1836-1870	9
Well	1836-1870	11
	1870-1900	21
	unknown	13
Tank/tank stand	1836-1870	10
	1870-1900	5
	unknown	2
Water wheel	1836-1870	2

Reservoirs

The colonists who settled in Adelaide and on the plains found that water was expensive and often in short supply. They initially obtained water by carting it from the River Torrens, from wells they sunk and from rainwater tanks. As the population grew, water carriers carted water from the river and sold it to householders for 1 shilling 6 pence to 3 shillings per 50 gallons (227.3 litres), depending on the distance carted. By the late 1840s and 1850s these water supplies had diminished to the point where they could barely meet the demands of the growing population and colonists became all too aware of the need for a more reliable and pure water supply.

Several suitable sources of permanent water to supply the growing population on the plains had been identified in the Mount Lofty Ranges and three of these, the River Torrens, First Creek and Ellison Creek in the Brownhill Creek catchment, were considered as a possible site for a large reservoir. To complicate this increasingly pressing issue, wealthy settlers with their own sources of water, or those who could afford carting charges, opposed or delayed the development of water supply projects in order to profit from their own enterprises (*Observer* 14 December 1850).

The Brownhill Creek catchment was considered a possible site for a reservoir as early as 1847 when the formation of a water company was proposed (*Register* 13 November 1847). This plan appears to have been abandoned because of the high cost involved, although in 1848 George Green, a retired engineer, developed a second plan for supplying water to Adelaide from Brownhill Creek:

> The reservoir at Brownhill Creek will be found just above the boundary of Mitcham, and will be 174 feet above the highest part of Adelaide. The conduit main will be 6 inches in the bore and will bring in 300,000 gallons (1,400,000 litres) of water daily to the closed cast iron receiver fixed in the centre of the reservoir. From the closed receiver the Company's mains are charged for supplying the City, and the water escapes from the regulating valve at the top, which is loaded with a weight equal to 17 $^{1}/_{4}$ pounds per square inch, or the pressure capable of supplying the water in the Company's pipes to a height of 40 feet (12.19 m) above the highest part of the City. The water after passing through this regulating valve is made to supply a fountain, and then falls into the outer and open reservoir. And from this reservoir always containing

1,000 gallons (1,546 litres), pipes are taken for supplying water to carts so that all parts of the city where the company finds that mains cannot be laid at a profit will still have the advantages of a cheap and abundant supply of pure filtered water. The required outlay for the entire works as far as Victoria Square will not exceed as per estimate. (*Register* 11 November 1848)

Prior to a decision on this proposal, a letter in the *Observer,* 14 December 1850, promoted an alternative plan for a water scheme on First Creek in Waterfall Gully. The formation of a private water company was proposed but the project failed to raise sufficient capital and lapsed. It was not until 1860 that the Thorndon Park reservoir was eventually constructed along the River Torrens and from it the first reticulated water supply to Adelaide was supplied (Gargett and Marsden 1996:24). The city was, however, experiencing variable seasons and the summers were frequently dry, long and very hot and so, despite the new supply the government continued to struggle to meet the demands of the colonists for water. In 1872 a second River Torrens reservoir was constructed and the reticulation system was progressively extended to most suburbs (Gargett and Marsden 1996:25).

The Mitcham Water Works—A Reservoir Case Study

Meanwhile, the village of Mitcham, 6 km southeast of Adelaide, was rapidly expanding along Brownhill Creek, but the volume of water, which had also been expected to provide a permanent water supply, was diminishing. The village was at a higher elevation than Adelaide and could not be supplied with water by gravity flow from either of the new reservoirs. In anticipation of the Mitcham Water Works becoming a reality, the District Council of Mitcham had constructed an access road to Section 1076 on Ellison Creek in order to promote the selection of the site for the new reservoir. Notice of the council's intention to construct the road was published in 1858 in the *South Australian Government Gazette* (9 December 1858:935). Although their council's first bid was unsuccessful, the residents of Mitcham continued to lobby the State Government for a permanent water supply and during 1877 and in 1878 Parliament agreed to construct a water supply system on Ellison Creek, in the Brownhill Creek catchment area.

The proposed site was sufficiently upstream to ensure good quality water would be available, as further downstream along Brownhill Creek the water had already been polluted by market gardens. Work began on the construction of the water storage and reticulation scheme in 1879, although the water works site on Section 1076 was not acquired by the Commissioners of Waterworks until 1880, when it was purchased from C. B. Hardy who had acquired it from John Grainger earlier the same year (Mitcham Heritage Research Centre archives, Mitcham Water Works file). A brick-lined water storage well, a stone-lined valve well, a dam wall and a settling pond were constructed in the bed of the creek. A six-inch cast iron pipe, imported from Scotland, carried water through the Ellison Creek and Brownhill Creek valleys to the base of McElligott's Quarry. Here the pipeline ran up the side of the valley and across what is now the end of Fullarton Road to the Mitcham Tank with a 270,000 gallon (1,026,000 litre) storage capacity (Fig. 2). From here the water was piped to the Mitcham village and in times of water shortages to Unley and Adelaide, with the route of the pipeline readily identified by cast iron water fountains for public use.

The Mitcham Water Works was officially opened on November 25, 1879. The pipeline followed the route shown on the Section map of the district and the water flowed by gravity, the pressure in the system being a function of the respective heights above sea level of the brick well on Ellison Creek and the Mitcham tank. The elevation of the Mitcham tank was 150 feet (45.72 m) lower than that of the well. However, it was still sufficiently elevated to enable water to flow by gravity to Mitcham and on to Adelaide. The system was officially discontinued in 1930, although it is highly likely that it had not been in use for several years.

Although references to the water works appeared in local history records and archival documents (Fig. 3) the locations

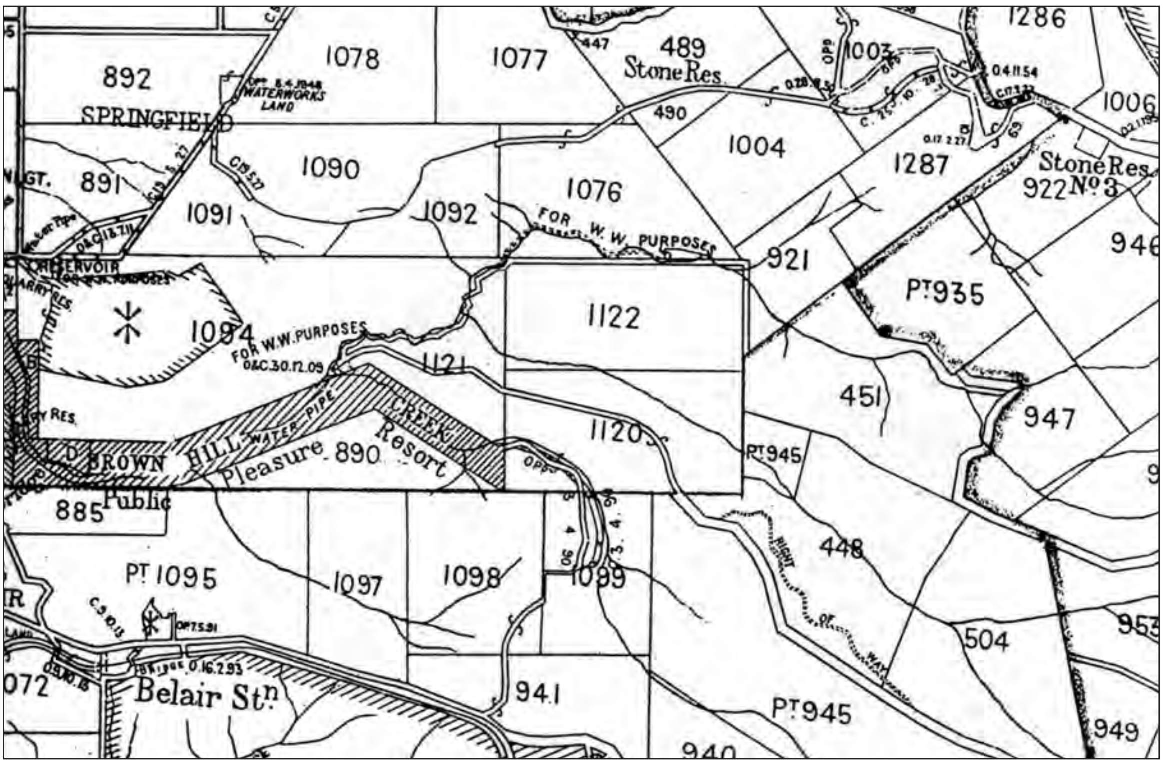

Fig. 2: Section Map of Brownhill Creek and Ellison Creek area showing the route of the water pipeline. Mitcham Village is off the western edge of the map. Public plan, withdrawn in 1906, Department of Lands, Adelaide. Mitcham Heritage Research Centre

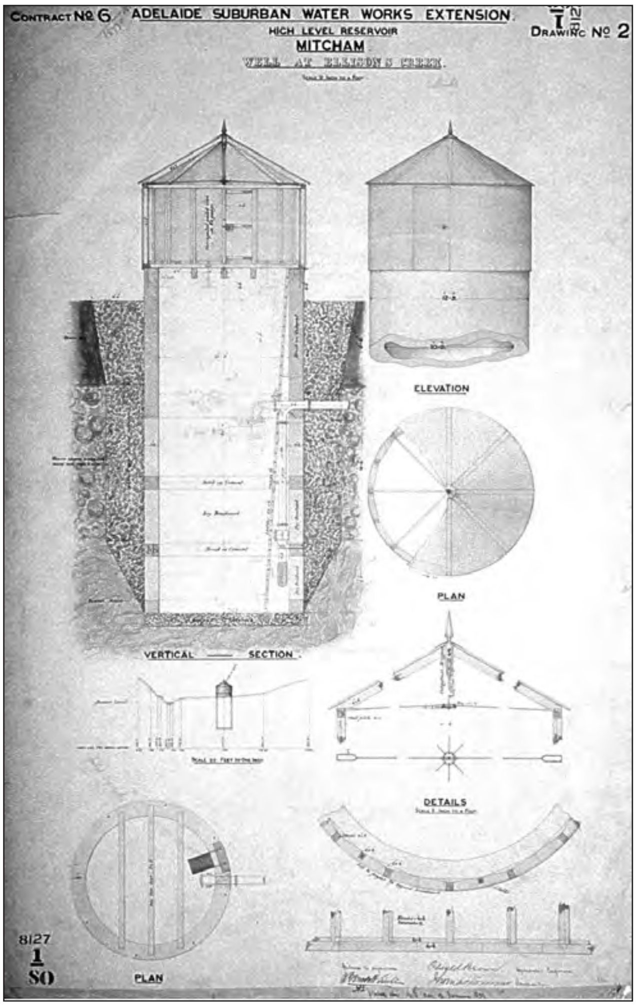

Fig. 3: The original 1879 drawings for the Mitcham High Level Reservoir well at Ellisons Creek. Contract no. 6, Drawing no. 2. 1878. Engineering and Water Supply Department n.d. (a)

of many of the features associated with the Mitcham Water Works had been forgotten despite hints, such as the surviving water fountains described above. Between 2002 and 2004 each feature was gradually identified and documented by persistent field survey teams. The field survey is fully described in Lane et al. (2006).

The small dam wall, settling pond, circular brick well and square stone-lined valve well were all eventually discovered under dense thickets of blackberries. In addition to the dense undergrowth all structures were buried by sediment eroding from an upstream 1960s quarry and only the open top of the brick well was visible after the removal of the undergrowth.

The length of the pipeline was explored and mapped by Aidan Ash as a student project. Six exposures of the pipeline were identified between the Mitcham Tank and the water works on Ellison Creek. The pipe was approximately two miles (3.21 km) long and, where it is exposed, the fabric of the six-inch (15.24 cm) diameter cast iron pipe appeared in reasonable condition. Each exposure was recorded by GPS and photographed. No exposures of the pipeline were recorded along Brownhill Creek between the Chapel Footbridge and White's Bridge or along the section of pipeline located with a metal detector between the end of Fullarton Road and the drinking fountain. This drinking fountain is the only one remaining along Brownhill Creek and is located at the southeastern end of the caravan park before White's Bridge. A second drinking fountain is reported to have been located adjacent to the Chapel Footbridge.

The pipeline from Ellison Creek terminated at the Mitcham Tank at the end of Fullarton Road, above McElligott's Quarry (now a council reserve). This tank, known also as the Mitcham High Level Reservoir tank, was commissioned in 1879 (Fig. 3). This circular brick tank has a flat metal roof with five air vents which today is at ground level. The tank is 22 m in diameter with a trap-door entrance and the original six-inch (15.24 cm) water pipe connection on the northern side.

The rediscovery and recording of the Mitcham Water Works revealed an intact example of nineteenth-century water management technology that had lain forgotten for most of the twentieth century. Its capacity and the expectation of the engineers who built it provides rare data about stream flows in the second half of the nineteenth century and insights into the technology used at this time. It is currently being nominated for inclusion on the South Australian State Heritage Register by the City of Mitcham.

Irrigating Market Gardens and Nurseries

Today the solid stone-lined channels carrying the waters of the larger creeks follow roads and are familiar sights to local residents. These include, First Creek through Waterfall Gully, Third Creek in the vicinity of Norton Summit, Fifth Creek along the Montacute Road and the upper sections of Brownhill Creek—to mention only a few. But few people are aware of the network of stone structures along the smaller tributaries or the extent of irrigation systems and retaining walls in the narrow valleys.

Unlike the dry-stone walling used to construct fences and farm buildings, most examples of dry-stone walling used in water management structures were built as random or uncoursed walling using undressed or minimally dressed stone. It has been suggested that the stone walls of the Adelaide Hills are the legacy of Scottish immigrants but there is no evidence to support such a regional influence. Title searches of the properties surveyed show they were settled by colonists from all areas of Great Britain, Ireland and from Germany and it was concluded that each family group introduced skills in stone masonry from their homeland into the colony.

Peter Cunningham, Surgeon R.N., author of *Hints for Australian Emigrants* (1841) was well travelled and recorded and published agricultural methods, including irrigation systems, that he felt were suited to the Australian environment. He described irrigation systems he observed in the Mediterranean region and in Peru and Chile (Cunningham 1841). These included extensive irrigation areas in Lombardy, the south of France and Spain introduced during the occupation by the Roman Empire 2000 years earlier.

Cunningham recommended nine models of irrigation systems for use in the Australian colonies which he illustrated and described in detail. Each model was designed to manage water in a particular situation or to water a particular crop. For example:

- 'A' represents the mode of laying out vineyards, orange, and other fruit groves, and consists of a series of hollows for the plants, with shallow connecting channels between, the irrigating water filling each series of hollows in succession, until the whole of the field has been irrigated.
- 'B', 'C' represent a series of ridges and furrows (like those of the turnip and potato husbandry) with alternate spurs shooting out from each ridge, the openings at the ends of which are successively closed by spades of earth … Indian corn, potatoes

and various kitchen vegetables, are grown in these ridges in Chili and Peru.

- 'D' represents an aqueduct leading from the tank to fields below, and other aqueducts are shown leading laterally to fields in these directions … when water is raised by a wheel, they (the embankments) are usually of wood or stone … (see Cunningham 1841:94–102 for illustrations of each of these examples).

Water races were common and essential components of irrigation systems in the study area and evidence of in-ground channels, usually stone lined, were associated with most market gardens and orchards. Several examples were similar in design to Cunningham's example D, although the water was more likely to have been supplied from flowing natural springs or raised from a stream by a water wheel. There is also anecdotal evidence of wood pipes or fluming. The fate of wooden pipes, or fluming, in England was described in 1876 as follows:

> Formerly wooden pipes were extensively used for conveying water and for draining; but so great an improvement has been effected of later years in the manufacture of metal and earthenware pipes that they have become exceedingly rare, and will soon disappear. (*Chambers' Encyclopaedia* 1876 VII:553)

Only hints of these colonial irrigation systems were described by nineteenth-century chroniclers of horticultural endeavours. E. H. Hallack (1987) referred to irrigation systems, but provided few details. He did, however, provide a glimpse of a horse-powered system for pumping water (Fig. 4).

Fig. 4: Horse raising water from a well at Montacute. Hallack 1987

Ebenezer Ward (1862), who described crops and landscapes in the Adelaide Hills and plains in the mid-nineteenth century, also made only fleeting references to irrigation systems. For example, when describing Sunnyside, the residence of the Hon. William Milne, M.P. and now an urban subdivision, this is the only information he gave:

> Mr Milne has already found a means of irrigating his vines to an extent which, combined with the natural winter soakage, he considers sufficient for the purpose. On the highest portion of his vineyard he has constructed a reservoir into which the storm water from the higher hills is conducted by races cut at their base, and the water is afterward disseminated over the vineyard by surface drainage. (Ward 1862:26)

Irrigation systems such as these were also the first water management features to become redundant when iron water pipes became readily available after the 1860s and over the following 50 years or so the open water races gradually disappeared from the landscape.

Archaeological evidence of irrigation systems using water races, stone-lined channels, open stone tanks and even iron drums sunk into creek beds, were identified. This evidence varies from a scatter of stones providing a hint of what had once been there, to extensive relict landscapes that were able to be reconstructed and interpreted using Adelaide's Hills Face Heritage GIS Database (2005). In addition, evidence of water management structures such as weirs, wells and sluice gates were documented. By reconstructing these historic landscapes we also know that wooden water races were used in conjunction with in-ground stone lined races, particularly where there was a rock face or the terrain was steep and it was not possible to trench an in-ground race (pers. comm. Andrew Tilley and Ken Preiss). These wooden structures have now disappeared.

The Eagle Terraces—A Case Study

The Brownhill Creek catchment was quickly identified by the colonists as one of the most fertile of the catchments close to Adelaide (Fig. 5). It is defined by Waverley Ridge, Crafers to the east, the South-Eastern Freeway to the north, the Adelaide Plain to the West and the Sheoak Road ridge, Belair, to the south. The three largest creeks within the catchment are Brownhill, Ellison and Tilleys Creeks, and it was in these fertile valleys that some of the best examples of nineteenth-century water management technologies were identified by archaeological field surveys.

The historic market gardens along Brownhill Creek are well known but the colonial market garden area at the headwaters of Ellison Creek and Brownhill Creek below Crafers was also highly regarded during the nineteenth century and Ellison Creek was considered to be one of the most reliable sources of permanent water. It was in this valley that one of the best examples of colonial technology used to irrigate terraced slopes was documented; it is this irrigation system that also best resembles the method D described above by Cunningham (1841).

Prior to the redevelopment of the former Eagle Quarry as a mountain bike park the Office of Recreation and Sport requested the HFZCHP project to undertake a field survey of the park. A cluster of features was identified on a northeast facing slope that included terraces cut into the hillside, a dry stone retaining wall, a drain and a water race. Following a site survey and the excavation of the stone-lined water race (that had been filled with sediment and appeared to be a path) it was possible to understand the function of each feature as a part of a gravity-fed irrigation system. The name, the Eagle Terraces, was given to the site by this project. Subsequent research into the history of the property revealed that it had been visited and described by E. H. Hallack, a nineteenth-century journalist, in 1893 and that the property had been called Mount Eagle and was adjacent to the better known property, the Eagle's Nest.

The following details by Hallack have been extracted from his account of John Mack's orchard and the small vegetable garden on the southern slope now referred to as the Eagle Terraces:

> The area under cultivation, taking the undulating character of the country into consideration, does him

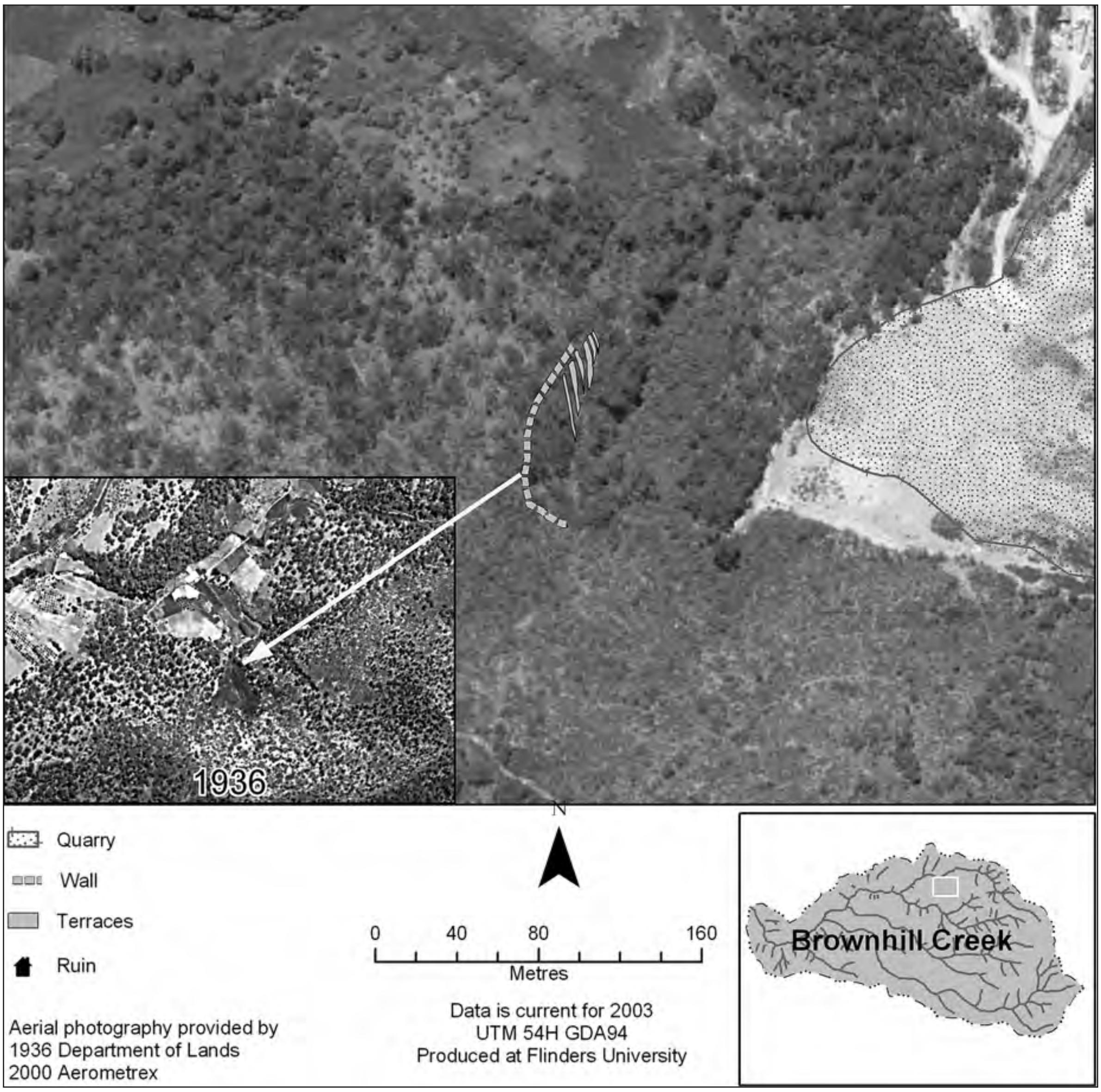

Fig. 5: GIS map of the Eagle Quarry showing the survey area, contour lines and the location of the Eagle Terraces; the 1936 aerial photograph is inset.
R. Keane, GIS consultant

> great credit … There is also a spring on the southern slope of the hill, the water from which is used for tomato plots in the spring and vegetables in the autumn. Heavy crops of the latter are invariably obtainable by Mr Mack, the systematic use of all kinds of manures being undoubtedly the secret of his success as a grower … (*Adelaide Observer* 13 May 1893:3)

Title searches confirmed that the property owned by John Mack was on Section 304 (Title Volume 5407 Folio 605), shown in two aerial photographs (Fig. 5). The aerial photograph taken in 1936, inset below, was taken before extensive quarrying destroyed much of the adjacent landscape and reveals a house and orchards in the valley along Ellison Creek. The Eagle Terraces (highlighted) are on the southern side of the valley. The larger map illustrates the same area today, with the Eagle Quarry on the right hand side of the image and the Eagle Terraces in the middle. The farm house is now buried under sediment eroding from the quarry and the area below the terraces is overgrown with dense thickets of blackberries. The heritage survey of Section 304 is fully documented in Smith et al. (2006:78–69).

Prior to 1963 Section 304 comprised Sections 922, 935, 946, 947 and 1287 (Fig. 2). Title searches and the archaeological evidence indicate that this was once a significant market garden and orchard area along Ellison Creek, although there is little evidence of this activity today. Section 922 was granted to Mr Stephens in 1850 who built a stone house which he named the Eagle's Nest. The other sections were granted to John Grainger, also in 1850. Grainger leased Section 1287 and other downstream sections to Samuel Ellison in 1853, although Ellison, who gave his name to the valley, is reputed to have been in the area prior to 1844 when he had a dairy and grew wheat, barley and potatoes (pers. comm. Roger Grigg). He built his home on Section 1004 and is also thought to have had a small market garden, although no evidence of either the house or his market garden has been identified.

The next lessee of these Sections was John Mack from the early 1870s (City of Mitcham 1979). Mack is also known to have irrigated a small market garden in the lower valley with water from the Grainger Mine (Section 1287), which he purchased in 1885, although the Certificate of Title was issued in 1887. As described above, he was a successful market gardener and was the Secretary of the SA Market Gardeners' Co-operative Society and the Market Gardeners' Horticultural Society; he is also reputed to have exported lemons to South Africa, and became one of the first to export produce from South Australia (pers. comm. J. McDonald).

Today much of Mount Eagle has been buried by sediment from the Eagle Quarry, including the house and orchards in the valley. This damage was not apparent however, when visited by Claude Thorpe, a descendant of John Mack, in 1974. He later described the property in his memoirs and refers to timber fluming remaining on the hillside:

> My uncle Arthur Mack has written for me the following excellent description of the family property near the Eagle-on-the Hill. 'The property known as Mount Eagle consisted of 80 acres (including 14 acres of rich agricultural soil, the remainder being hillside land good for grazing and fruit growing). There were permanent springs and a creek which flowed through to Brown Hill Creek near Mitcham … Although my parents left the property it did not pass out of their possession. One or other of my brothers worked it until 1925 when I bought it from my Mother. I sold out to G. Kuhlmann in 1932.'
>
> In 1974 in the company of my cousin 'Bonny' (christened Muriel Mack, daughter of Alf Mack) I visited Mount Eagle. We were well received by the wife of the present owner and were delighted to find that the kitchen part of the original Mack home had been preserved by being incorporated in a modernised house. The original walls were thick, apparently built from rough stones (out of the creek?) and plastered over. The plaster by now stays in place only with difficulty … Ancient cherry trees still survived on the steep slopes visible through the kitchen window. Across the creek I saw where wooden fluming was used to bring water from up the valley somewhere to water fruit trees or vegetables on the gentler slope. (Thorpe n.d.)

The Eagle Terraces were documented during two archaeological field surveys in 2004. The first element of the irrigation complex to be identified was a wet area where a small creek ran across the pathway and the water was still flowing despite the fact that it was late summer and was a year of average rainfall. The series of seven narrow agricultural terraces covered by regenerating Acacia and Eucalypt species and a dry stone wall were recorded a short distance beyond the spring. Each feature is identified in Figure 6. The illustration at the top right is a reconstruction of the Eagle Terraces complex as we believe they were constructed in the mid-nineteenth century, with a recent track alignment removed. A 3-dimensional view of the terraces is illustrated in the bottom left image and the image at bottom right locates the Eagle Terraces within the Brownhill Creek catchment.

Terracing

Agricultural terracing is widely used throughout the world for cultivating crops on hillsides and it was predicted at the commencement of the field surveys that evidence of terracing would be found in the market gardening areas of the Hills Face Zone. Terraced hillsides collect soil and nutrients eroding from above, they hold water and they prevent erosion—

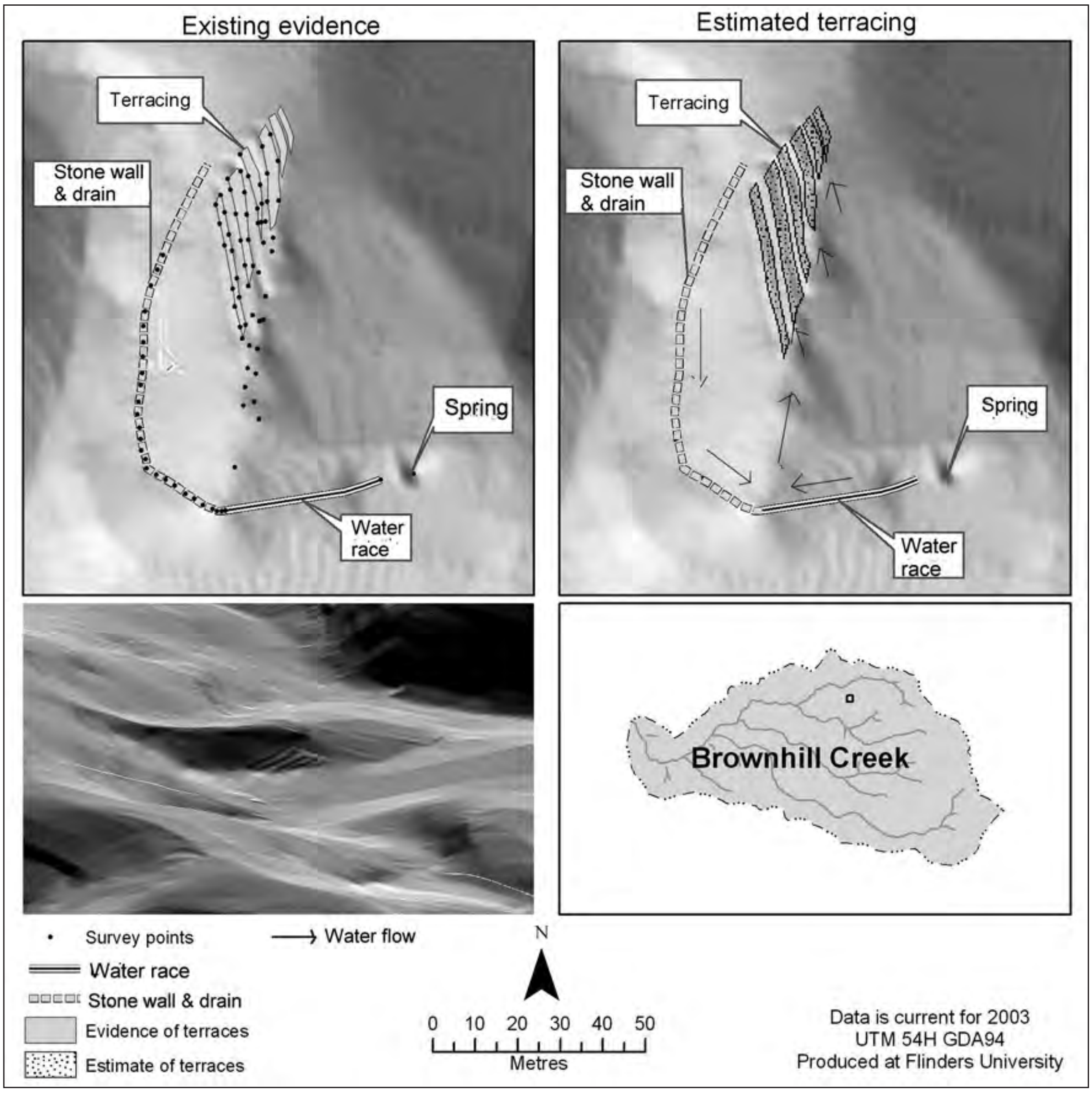

Fig. 6:
i. A 3-dimensional images of the Eagle Terraces c.2005.
ii. A reconstruction of the Eagle Terraces.
R. Keane, GIS consultant

particularly when stabilised by dry-stone walling. When terracing is used in conjunction with irrigation systems, they provide ideal situations for growing a variety of crops, as described by Cunningham:

> ... terraces are formed by a series of dry-stone walls of sufficient height to secure a broad belt of ground for cultivation, by throwing downward the earth from the portion of the hill above the terraces, the latter consequently rising from the base to the top of the hill, like steps. (1841:43–44)

The field surveys of hillsides undertaken for the HFZCHP, including those in areas noted for their orchards and market gardens such as at Norton Summit, Montacute, and in Brownhill Creek Catchment, revealed less use of terracing than had been predicted. Where relict terraces were identified there was little use of stone retaining walls. The evidence for these terraces also varied. Most terraces without supporting dry stone walls had almost vanished after 150 years of weathering and were best seen in the late afternoon or early morning, whilst the locations of others were identified from aerial photographs taken by the Australian Army in 1936. Although there were few dry stone walls supporting the Eagle Terraces they were protected from run-off by a dry-stone wall and drain above them and there is no doubt that this design contributed to their preservation.

The seven terraces of the Eagle Terraces followed the contours on the northeast facing slope and each terrace was between 50 m and 60 m long (Fig. 6). The width of the terraces ranged from <550 mm at terrace 1, to 1200 mm at terrace 6 and the height of each terrace also varied, although all were under 0.5 m. Terrace 1, the uppermost and narrowest terrace, was the only one supported by a dry-stone retaining wall. It is likely that the lower slopes closest to the creek had also been terraced, but we found the area inaccessible with dense thickets of blackberries. A walking track, probably an earlier cart track, had been cut across terrace 5 and incorporated terrace 6 at the northwestern end.

Dry Stone Wall and Drain

The terraces were protected from heavy water runoff by a substantial dry-stone wall and a drainage ditch above terrace 1. The wall and ditch ran the full length of the terraces dropping slightly downhill at either end to allow the water to flow away from the wall. Both the wall and the drain were 100 m long. The southeastern end terminated in a small steep gully, as does the in-ground water race which approaches the same gully from the opposite direction. The dry-stone wall has collapsed at several points and is now in a fragile condition. It was constructed as coursed stonework, although it is not of a high quality and appears to be random in some sections. The original dimensions of the stone wall were: <300 mm thick, that is two stones wide, by <950 mm high. The dimensions of the ditch are: <500 mm deep x <1000 mm wide. No other example of an agricultural terrace being protected in this way was identified in the Hills Face Zone.

Water Races

Timber fluming and an in-ground water race carried water from the spring to the terraces. On the northern side of the in-ground water race a low stone retaining wall with stones laid on edge provided a clue that the flat ‘pathway’ was in fact a water race filled with sediment. The usual method for constructing a retaining dry stone wall is to lay the stones flat to give greater support. This method of constructing a dry stone wall for an irrigation channel had previously been identified in Tilleys Gully (pers. comm. A. Tilley).

The excavation of the water race is described in the survey report (Smith et al. 2004:14). The excavation confirmed that this had been an in-ground water race used to transport water and that it had later filled with sediment. The water race itself had been dug along the northern edge of a narrow terrace cut into the hill and a dry-stone retaining wall was constructed by placing the stones in a vertical position. The terrace along which the water race had been excavated almost followed the contour of the slope but had sufficient fall for the water to flow downhill.

The excavation exposed 1 m of a box race 255 mm wide by 450 mm deep filled with water-borne sediment. The sediment was light brown to pink and clearly differed from the surrounding soil matrix of olive brown, but was the same as the sediments around the spring. This race had been used to transport water for irrigation from the spring to the agricultural terraces. Decaying fragments of *Xanthorrhoea sp.* in EU4 at the bottom of the square race supported our conclusion by confirming that this had once been a wet environment and had transported water from the spring, where *Xanthorrhoea sp*. was the dominant plant species. Overall the water race was 37 m long and 255 mm wide. The western end of the race terminated in the same small gully as the eastern end of the ditch and dry stone wall (Fig. 6). Stone work associated with the water reticulation system distributing water to the terraces had been disturbed and it was difficult to reconstruct.

The eastern end of the water race terminated within 8 m to 10 m of the spring. The terrain at this point is steep and the underlying rock face is exposed. In these situations it was common to use timber fluming as a water race, as described above by Charles Thorpe. No evidence of the wooden race remains, although at a very similar situation in the adjacent Tilleys Gully it is known that a square cut into stone at the top of a water fall accommodated timber fluming which carried water across a small outcrop of rock to an in-ground stone-lined race (pers. comm. Andrew Tilley). It is likely a similar situation existed at Eagle Terraces.

Missing elements of the irrigation scheme are the smaller stone channels linking the water flowing from the main water race to the terraces. The ground is covered by small stones in this area and there are a number of points at which it is possible to speculate that they once formed channels which have since been destroyed by floodwaters. Although archaeological evidence for stone water races associated with irrigation and water management systems were identified throughout the study area, they should not be confused with the similar stone-lined channels used to control the flow of water along creeks.

Natural Springs

The spring, described by Hallack in 1893, was the source of water for the irrigation system. The spring today is surrounded by dense vegetation and is inaccessible. *Xanthorrhoea sp.* (Kraehenbuehl 1996) is the dominant plant in the vicinity of the spring and decaying fragments of the same species were identified at the bottom of EU2 following the excavation of the stone channel. Although we cannot say positively that it was a permanent spring, it was certainly still flowing in February 2004 at the end of a summer with average rainfalls. Over the past century many permanent springs have dried up or their water flow has greatly decreased. This has been largely due to over use of ground water, and because the Kaurna, the Traditional Owners, are no longer able to access and maintain them. At the time of writing historical evidence of the number and locations of natural springs in the study area is being compiled by the Patawalonga and Torrens Water Catchment Management Boards.

The Eagle Terraces complex illustrated in Figure 6 is a rare example of an early colonial landscape in which agricultural terraces complete with a dry-stone wall drainage system and irrigation system have survived for approximately 150 years. The preservation of this historic landscape is largely an outcome of the protection afforded by the Hills Face Zone legislation and the location of the Eagle Terraces within the buffer zone around the former Eagle Quarry. The Eagle Terraces are now within the new Eagle Mountain Bike Park and steps are currently being taken to ensure their protection.

Newman's Nursery—A Case Study

Charles Newman (formerly Neumann) migrated from Germany with his parents and siblings in 1844 or 1847 and by 1854 had purchased land in Water Gully and had commenced construction of a home, extensive hothouses and the structures necessary for what became a flourishing plant nursery and orchards (Fig. 7). After almost 70 years and several major floods the family were forced to abandon their extensive horticultural enterprise in 1932 and move to a less flood-prone location. For example, during the two most severe floods in 1913, one in the autumn and one in the spring, six glass houses were damaged and a ten foot wall, a 400 gallon tank and between 4,000 and 5,000 pot plants were swept away. See Swinbourne (1982) and Piddock (2006) for detailed descriptions of the archaeology and history of Water Gully.

Advice on market gardening and horticultural practices appropriate for the Australian climate was readily available to colonists coming to South Australia and drew on 50 years of experience in the eastern colonies where the 'scorched earth of a drought would seldom let rain penetrate more than an inch' and the retention of moisture in the soil was essential (Cunningham 1841:11). From experiences in the eastern states it was also known that floods were common and that severe floods may occur every 20 to 30 years. Despite this, all infrastructure related to Newman's enterprise had been constructed at the junction of two creeks, and although this had certainly compounded his difficulties, it was his use of European land-use management practices that ultimately led to the ruin of his and similar enterprises.

Archaeological surveys of the study area found that the methods used by Newman to manage water in the steep valleys of the hills were common from the earliest days of the colony, and that the losses experienced by the Newman family were common throughout the study area when houses and other structures were built close to creek lines. The nursery is illustrated in Figure 8. This GIS map of Water Gully shows the nineteenth-century features as they were reconstructed following two field surveys. All hot houses, wells and stone water storage tanks are located in the floor of the valley at the junction of two creeks where they were most vulnerable to the irregular floods.

<u>Water Channels</u>

The central feature in Figure 8 is a slate-capped box drain along the eastern side of the valley. Newman had intended this drain to carry all the water flowing through the valley to the stone water storage tanks, brick wells sunk into the creek bed and the small reservoirs downstream from the hot houses.

Travellers through the Adelaide Hills today barely notice that the meander of almost every creek has been straightened and the course of the water determined by drains supported by dry-stone walling. These were constructed along sections of almost every valley in the survey area and the same planning pattern was repeated with few variations: a channel was constructed on one side of the valley floor, usually the least fertile, and the creek was diverted into the channel. This water management strategy was used by most market gardeners and orchardists, although the drains were usually open and only two examples of slate-capped box drains were recorded. This strategy allowed the fertile flood plains to be used for irrigating crops by reticulating the water through irrigation channels and often assisted by small water wheels.

Although the practice of realigning and straightening creeks had several advantages and may have been successful in the Newman's home in central Europe, the disadvantages often out-weighed the advantages in the Mount Lofty Ranges. Meanders are important in slowing down the flow of water, particularly during floods and allow eroding sediments from the hillsides to be deposited in the floor of the valley. It was

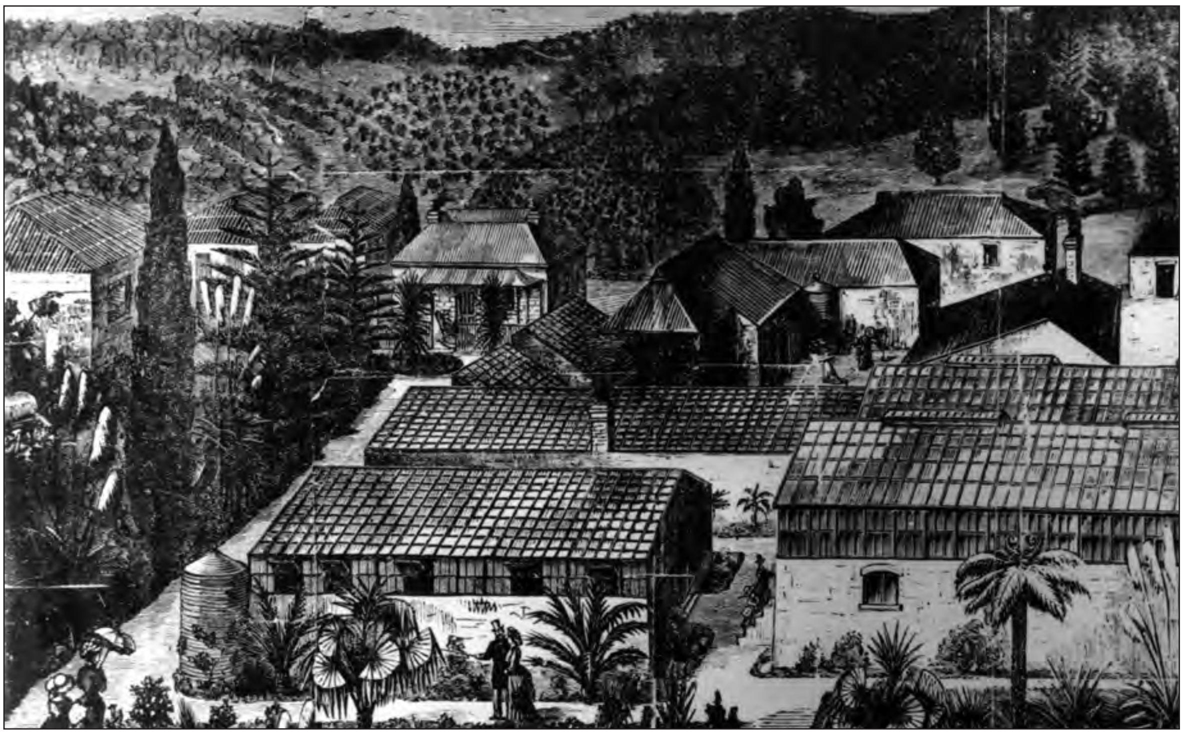

Fig. 7: Newman's Nursery, 1860. Reproduced courtesy of the State Library of South Australia SLSA B16015

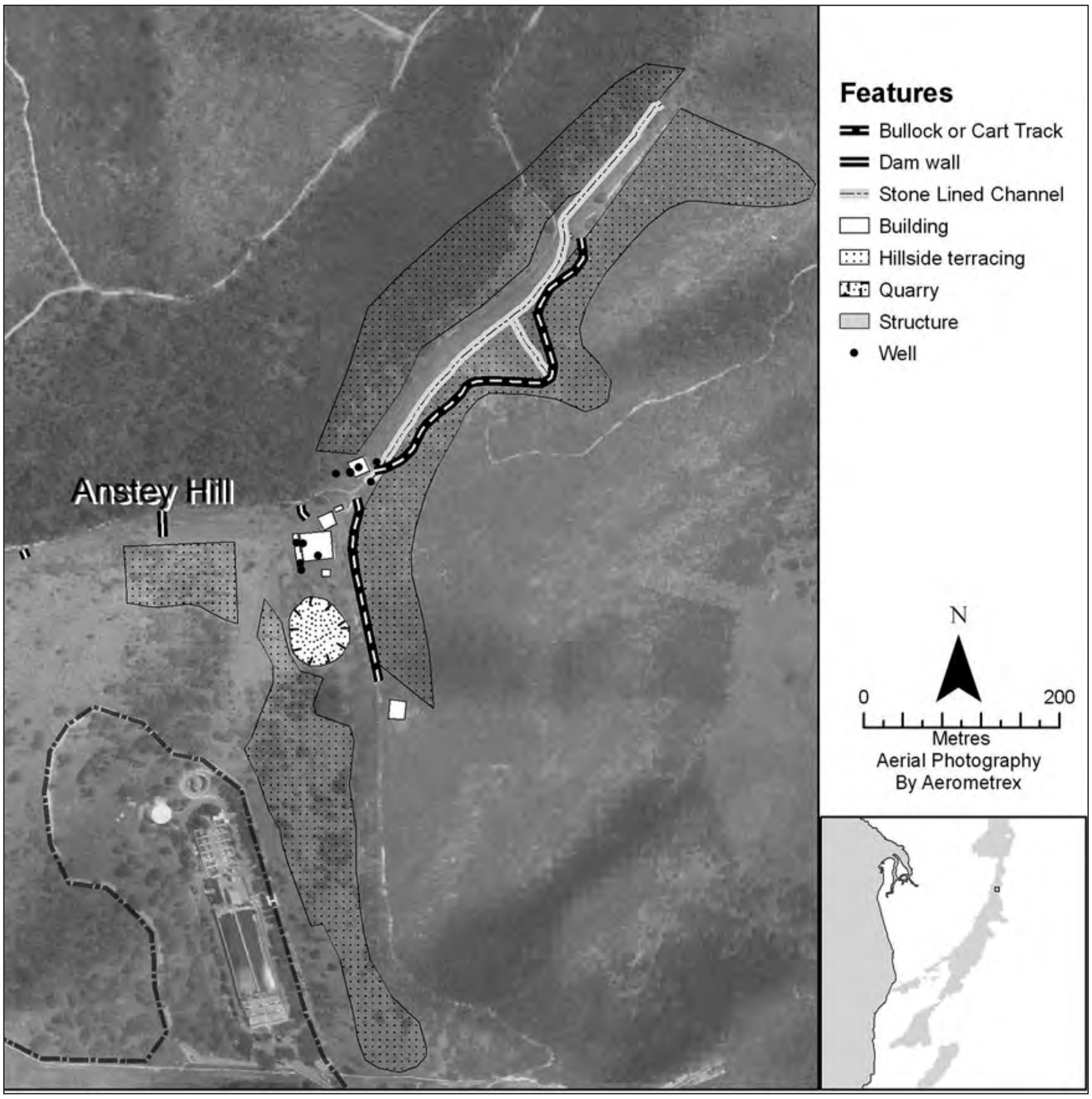

Fig. 8: GIS reconstruction of Water Gully and the Newman Nursery complex. Robert Keane, GIS consultant

this action that had created the fertile valleys so valued by nineteenth-century horticulturalists and market gardeners. The strategy of straightening the creek resulted in a loss of top soil, decreasing soil fertility and a dramatic increase in the damage caused by floods when water channels, particularly the closed drains in Water Gully, became blocked and the flooding water was free to flow untamed by either meander or channel.

Wells, Water Tanks and Dams

Many wells and water storage tanks were documented throughout the HFZCHP study, with the highest concentrations of water storage tanks along water courses in the market garden areas where there were many natural springs. These are shown on Adelaide's Hills Face Heritage GIS Database (2005). The greatest concentrations of water storage tanks and wells were recorded below Waverley Ridge, the headwaters of the four main tributaries of Brownhill Creek and in Water Gully where Mr Newman had his nursery. Figure 8 shows a cluster of wells and water storage tanks around the hot houses at the junction of the two creeks. These wells were all brick lined, although examples of stone-lined wells were also recorded across the study area. Most tanks were constructed from stone and mortar, although those from the late nineteenth century were usually constructed in concrete. (It is possible that the several square stone tanks may have originally had timber rooves, in which case they could be described as enclosed cisterns).

As described above, many privately owned dams were constructed across waterways in the hills and provided a common means of storing water, although they often reduced the water available to those downstream. In Water Gully three small dams were tiered (shown as short black lines on Fig. 8) below the glasshouses.

Tracks

Access tracks in such irrigated Hills valleys usually followed ridges or were high above the fertile valley floor so it could be fully used for crop production. There is evidence of two main access tracks into Water Gully on both the eastern and western sides of the valley (Fig. 8).

Summary

Newman's Nursery is an example of the several similar well preserved water management systems identified by field surveys. Others of note were Tilley's market garden (Tilley 2006), Mr Hodge's Small Garden in the Brownhill Creek catchment (Smith 2006) and Mr Emery's garden (Smith 2006). These irrigation systems represent a time when people laboured hard for small gains and utilised all available fertile soil. For example, the retaining wall of the smallest terrace in Mr Hodge's Small Garden was only 2600 mm long and 780 mm high (Smith 2006). Ultimately, the strategy of straightening and channelling the creeks at Newman's Nursery, and the construction of all houses and infrastructure in the floor of the valley, at the junction of two creeks, resulted in the destruction of the whole enterprise. With the meander removed from the creek the water flowed faster and the larger floods stripped the top soil, decreased soil fertility and increased the damage caused by floods, particularly when the closed drains in Water Gully, became blocked and the flooding water was free to flow untamed by either meander or channel.

Additional Water Technologies

Water Wheels

Although not present in the case studies cited, water wheels have been reported as being essential components of irrigation systems along creeks in the Adelaide Hills and were used for lifting water from creeks into the irrigation channels (pers. comm. K. Preiss; D. Fenton). Few now recall that Gawler, north of Adelaide, was a centre for small foundries manufacturing a multitude of iron agricultural implements during the nineteenth century, including water wheels, but no records have been identified of how many water wheels were manufactured there or where they were located (pers. comm. G. Fenton).

Two iron water wheels were recorded by this project, one along First Creek in Waterfall Gully and one on Sixth Creek at Castambul. Despite a literature search, no references to similar water wheels in South Australia has been found and the water wheel on First Creek, which was used for lifting water from First Creek to irrigate land owned by Sir Samuel Davenport, is possibly the only remaining water wheel of its type in South Australia (Fig. 9).

It is a vertical overshot water wheel fitted directly onto the side of the water channel by a shaft. The simple design does not incorporate gears and the metal vanes are sloped to receive water from above (see International Water History Association).

A second and historically significant water wheel was recorded on private property on Sixth Creek at Castambul (Fenton and Fenton 2004:28). Again, it is probable that it is the last remaining water wheel of this type in South Australia, as no others appear on the South Australian State Heritage Register or the local heritage registers of councils in the hills. It was used during a brief period to harness water power for the engine used to cut timber for the construction of the Gorge Road along the River Torrens. This is a larger vertical water wheel also manufactured entirely from iron. It is more complex than the water wheel on First Creek and lifted water from a concrete water race constructed parallel with Sixth Creek.

Fig. 9: A small iron water wheel on First Creek, Burnside. HFZCHP 2003

Sluice Gates

The flow of water along the irrigation channels was frequently controlled by small sluice gates. These varied in their construction from a complex lifting system to one or two large stones placed across a channel. Several examples of sluice gates were recorded in conjunction with irrigation systems. Those that have survived have been stronger more recent sluice gates that included concrete in their construction and are located on the main creek channels. Examples recorded by field survey included those along Ellison Creek and Tilleys Gully in the Brownhill Creek catchment (Tilley 2006), the Field River catchment, First Creek and Walkers Creek in the Shepherds Hill Recreation Park.

Water management systems were also essential for mines and quarries. The best example of large stones acting as sluice gates to control water flow was recorded at the water storage system above the Delabole Quarry (1840s), Willunga. Although the largest slates have been pilfered, it is still possible to see where they had been inserted into the slate-lined water channel.

DISCUSSION

The archaeological evidence for nineteenth-century water management strategies described in this paper provides information about the technologies introduced by the colonists from their homelands, and the degree to which some were successful and others were unsuccessful. The need to provide a permanent water supply to Adelaide and the new villages of Unley and Mitcham became urgent within two decades of the founding of the colony and at the same time the significance of the permanent springs in Adelaide's Hills Face was recognised, particularly at the end of the hot dry summers. The identification of the Mitcham Water Works during field surveys revealed colonial reservoir technology that had lain buried for many decades. It also demonstrated how quickly the water works became inadequate and was completely abandoned after only 50 years, apparently because of reduced flows that did not meet the expectations of the engineers.

Most colonists would have been aware of the ways in which the Australian climate varied from Europe and England, particularly from the experiences of colonists in the eastern states. The major climatic differences impacting on market gardeners and orchardists were the extreme floods every 20 or so years, the need to conserve water in tanks and wells during summer and to protect the thin topsoil on the slopes of the hills to avoid erosion.

The archaeological evidence from the two case studies demonstrating irrigation technologies provided information about why some water management strategies failed and other succeeded. In the example of the Eagle Terraces, John Mack had protected his agricultural terraces from flood waters rushing down the hillside by building a stone wall above the terraces and a drain that directed the water onto the terraces through channels. Not only would this have prevented erosion by the flood water, but eroded sediments would have been deposited on the terraces. The fact that the terraces were noted by Hallack in the 1890s and by Claude Thorpe in 1974 is evidence of their long use and the success of this irrigation technology.

The technology used by Charles Newman in Water Gully that included straightening creeks and forcing them into stone-lined drains was found to have been widely used throughout the study area. The removal of the meander from creeks freed the fertile valley floors for crop production and many market gardeners and orchardists enjoyed abundant harvests. This also meant that the sediments stripped from the hillsides during floods were carried down to the Adelaide Plains and not deposited in the valleys. The flow of water also increased with the potential to damage anything in the way, particularly when structures were built in the floor of the valley. It was this that ultimately resulted in the failure of Charles Newman's extensive enterprise in Water Gully and forced the family to abandon the enterprise in the 1930s and move to a new location where they still operate their business today. Newman had not taken heed of the potential for floods to destroy his buildings and he had built his home and extensive stone hot houses in the floor of the valley. All that remains of these buildings today are the stone ruins scattered through a quiet valley in the Anstey Hill Recreation Park. These are only a few examples of the colonial water management strategies identified by the Hills Face Zone Cultural Heritage Project. Today the productive valleys of the nineteenth-century orchardists and market gardeners are no longer economically viable and this colonial landscape is protected by the Hills Face Zone provisions of the 1962 *Metropolitan Development Act*. Implemented to protect the natural heritage of the zone, the region has now also been identified as a significant historic and cultural landscape.

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PERSONAL COMMUNICATIONS

Geoffrey Bishop
D. Fenton
G. Fenton
Roger Grigg
J. McDonald
Ken Preiss
Andrew Tilley

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