MARTIDJA BANYJIMA

ACHM
AUSTRALIAN CULTURAL HERITAGE MANAGEMENT

Rio Tinto

Rockshelter Excavations in the East Hamersley Range, Pilbara Region, Western Australia

edited by

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foreword by

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Editor's Preface

Too often, the results of consulting archaeology projects disappear into the filing cabinets and bottom drawers of desks, never to be seen again. This reality is especially tragic when substantive field research is not disseminated to the general community. In this volume, we have endeavoured to make the results of the Hope Downs 1 excavations an exception to this fate, and we are fortunate to have the support of the Martidja Banyjima, Innawonga Bunjima, Rio Tinto Iron Ore Pty Ltd, and Australian Cultural Heritage Management to produce this document. Early on, we recognised that the findings of the Hope Downs 1 investigations are significant and important to the local Aboriginal community, and this research should be properly document and published for the Banyjima community and interested researchers alike. This document has taken years collate, and we have endeavoured to keep it up to date with recent literature, so we offer our apologies for any new regional findings that have been inadvertently overlooked or have been published in more recent times. We hope that this document will find a place in the Pilbara archaeological literature and serve the Banjima community in the years to come.

Acknowledgements

This monograph represents the work of many parties involved with the Aboriginal heritage salvage operations at the Hope Downs 1 mine. The editors wish to acknowledge and pay respect to the many Martidja Banyjima and Innawonga Banjima traditional owners that were involved with this extensive field project. The Federal Court recognises you together as the Banyjima People Native Title Group (WAD6096/1998), and we hope that this research volume will stand as a tribute to your long and enduring cultural legacy. The editors wish to express their gratitude to all of the excavators, field workers, and specialists that contributed to this project. We also thank Karijini Developments Pty Ltd and Rio Tinto Iron Ore for their assistance with project logistics and access to heritage documents. Furthermore, we sincerely thank Australian Cultural Heritage Management Pty Ltd for providing the opportunity to manage and participate in the direction of this large project. Completion of this project would not have been possible without the encouragement of heritage staff and management at Australian Cultural Heritage Management, Karijini Developments, and Rio Tinto Iron Ore. We thank all parties involved for your continuous support and your good faith efforts that have allowed us to produce this final publication. Funding for the Open Access publishing and the colour print hard copies of this monograph were generously provided by Rio Tinto Iron Ore.

Reporting of Dates

Dates are an important aspect of archaeological research, and the standards used for discussing dates must be clearly outlined. In this monograph, only radiocarbon dates are reported with the suffix 'BP' or 'cal BP', while dates obtained through means other than radiocarbon methods (*e.g.*, thermoluminescence or optically stimulated luminescence) are reported in calendar years rounded to the nearest century, and they are identified by the suffix 'ka' (thousand years before present) or 'mya' (million years ago before present). Uncalibrated radiocarbon dates are presented in years before present and are identified by the suffix 'BP'; calibrated dates represent calendar years before present and they are identified by the suffix 'cal BP'. Calendar ages were calibrated at 2-sigma (95.4%) accuracy using IntCal09 (Reimer *et al.* 2009) and OxCal v4.1 (Bronk-Ramsey 2010). Median values of the calibrated radiocarbon dates were calculated using OxCal v4.1. SHCal04 was not used to calibrate the dates as it is not recommended for calibration of dates beyond 11,000 cal BP without the use of an offset (McCormac *et al.* 2004: 1091), and this offset cannot be applied in programs such as OxCal v4.1. To provide consistency among the calibrated dates, IntCal09 was used to calibrate all dates in the document. IntCal09 is the first calibration dataset ratified by the 14C community to extend the calibrated timescale back to 50,000 cal BP; however, the 14C community recommend caution for the calibration of early dates (for a discussion see Reimer *et al.* 2009). When dates are discussed in the text as broad ranges or in general terms as 'years ago' (*e.g.*, 40,000 years ago) it should be understood that these dates are regarded as calendar years before present.

Abbreviations and Conventions

Term	Meaning
AAR	Acute angle retouch (<60°)
ACHM	Australian Cultural Heritage Management Pty Ltd
ACMC	Aboriginal Cultural Material Committee
AHA	*Aboriginal Heritage Act 1972 (WA)*
aka	Also known as
AMSL	Above mean sea level
Artefact Dimensions	Length-x-width-x-thickness
AU	Analytical unit
Avg	Average
BIF	Banded iron formation
BL	The largest of the four relevant categories of transverse fragments that are also broken longitudinally (excluding medial fragments) in the MNF calculation
BP	Conventional radiocarbon years before present (AD 1950)
C	The number of complete flakes in the MNF calculation
cal BP	Calibrated radiocarbon years before present
CHMP	Cultural Heritage Management Plan
CL	The greater of left or right longitudinal fragments without transverse breakage in the MNF calculation
cmbd	Centimetres below datum
cmbs	Centimetres below surface
DGPS	Differential global positioning system
DAA	Western Australian Department of Aboriginal Affairs
Frag	Fragment (*i.e.*, artefact fragment)
GDA	Geocentric Datum of Australia
GIS	Geographic information system
GIUR	Geometric index of unifacial reduction; ratio of the retouch scar thickness (t) to the flake thickness (T), where GIUR = t/T
GPS	Global positioning system
HDIO	Hope Downs Iron Ore Pty Ltd (a subsidiary of HPPL)
HDMS	Hope Downs Management Services (a subsidiary of HPPL)
HPPL	Hancock Prospecting Pty Ltd
IB	Innawonga Banjima
ka	Thousand years ago
Layer	Excavation layer; generally an arbitrary 5cm excavation layer (see Chapter 4 for further details)
LGM	Last Glacial Maximum
LCS	Longitudinal cone split
MHA	McDonald, Hales and Associates Pty Ltd
MIB	Martidja Banyjima Native Title Group
MIS	Marine Isotope Stage
MNF	Minimum number of flakes; where MNF = C + T + CL + BL
mya	Million years ago
n	Number of specimens
PAD	Potential archaeological deposit
PNTS	Pilbara Native Title Service (now Yamatji Marlpa Aboriginal Corporation)
PRI	Perimeter retouch index; ratio of the sum of the retouch length (RL) to the perimeter length (PL), where PRI = ΣRL/PL
Quad	Quadrant (0.5-x-0.5m)
Rockshelter Dimensions	Opening width-x-depth from dripline-x-height
ROM pad	Run-of-mine pad
RTIO	Rio Tinto Iron Ore (a subsidiary of Rio Tinto Ltd)
SAR	Steep angle retouch (>60°)
Section 16	Section 16 of the *Aboriginal Heritage Act 1972 (WA)*
Section 18	Section 18 of the *Aboriginal Heritage Act 1972 (WA)*
SD	Standard deviation
SL	Stratigraphic layer
T	The largest category of transverse fragments that are longitudinally complete (excluding medial fragments) in the MNF calculation
UTM	Universal Transverse Mercator
WA	Western Australia

Foreword

Go with a Clear, Open and Accepting Spirit, and the Country Will Not Treat You Badly

Maitland Parker and Slim Parker

Elders of the Martidja Banyjima Aboriginal Community

"Wirlankarra yanama. Yurlu nyinku mirda yurdarirda."

> - Go with a clear, open and accepting spirit, and the country will not treat you badly.

We, the Martidja Banyjima, (also known as the Fortescue Banyjima) are a strong and resilient people.

Our roots are embedded deep in the soil and rock of our lands. Our ancestors walk with us every day through the mountains, valleys and plains of our country. Those ancestors and our land give us our identity, strength and lore. Our culture is very alive, strong and vibrant as it was before the Europeans arrived.

The arrival of Europeans almost 150 years ago set in motion chains of events that changed our lands and our people forever. Many of us are old enough to remember the time before mining companies and archaeological excavations. Many things have changed in our land, but what has not changed is that we are still here, with our people, our lore ceremonies and our traditional cultural kinship and Language.

The Hope Downs project was significant for Banyjima people in several ways. But it is one of the examples that has been very devastating with regards to its impacts on our country and the very significant cultural Dreamtime sites of our Wardidba and Milgu song lines.

Firstly, Banyjima people were empowered to drive the research agenda and outcomes of this project far more directly than is now common. Secondly, the field work involved a large number of Banyjima people over three years, reconnecting many people with Djadjiling, Weeli Wolli Creek and the surrounding country.

Thirdly, the results of the archaeological excavations and analysis documented here demonstrate our people were using these places up to 47,000 years ago or more. That clear and ongoing connection to our old people spans more than 1,000 generations. This work is a repository of knowledge and culture reaching out to us across the ages.

We the Martidja Banyjima people have shouldered the responsibility of having to make the decisions to see this process through. We have fought as hard as possible to preserve our culture within the confines of legal processes and agreements, and we as a people will always continue the struggle to protaect the sacred and secret sites within our traditional country or Yurlu.

We are reliably informed that nothing like this has ever been produced for the Pilbara. It is a thorough description of the sites excavated at Hope Downs, including detailed site drawings, photographs, and specialist studies.

We commend this monograph for its protection of the memories and the historical and cultural significance of the heritage lost in the creation of this work.

Photo by Clive Taylor, A.C.S.

PART 1: INTRODUCTION AND BACKGROUND

Chapter 1

An Introduction to the Rockshelter Excavations at Hope Downs 1

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Between 2007 and 2010, Australian Cultural Heritage Management Pty Ltd (ACHM) carried out investigations of 31 rockshelters at the Hope Downs 1 Mine in the east Hamersley Range, Western Australia (Figure 1-1). The excavations were conducted as part of a larger archaeological salvage program prompted by the development of the Hope Downs 1 iron ore mine. This monograph is the culmination of the collaborative efforts of a large team of Traditional Owners, archaeologists, specialist researchers, and mining personnel. Six rockshelters are the focus of this monograph, including sites with both Pleistocene and Holocene archaeological sequences. The sites documented here were selected because they offer new data regarding the antiquity of Aboriginal occupation, past environmental conditions, Aboriginal subsistence and daily life, lithic technology, and site formation processes.

Four rockshelters with Pleistocene occupational sequences are detailed in this monograph, including Jundaru (HN-A9), HD07-3A-PAD13, HS-A1, and Djadjiling (HD07-1A-04). Together, these rockshelters demonstrate that there is a repeated pattern of early Aboriginal occupation of the east Hamersley Range from 41,000 years ago and possibly as early as 47,000 years ago. Prior to this series of excavations, the earliest rockshelter occupations in the inland Pilbara had been dated to between 28,000 and 31,000 cal BP, as reported for Newman Rockshelter (30,897±372 cal BP, SUA-1510; Brown 1987) and Mesa J24 Rockshelter (28,317±415 cal BP, Wk-2514; Hughes *et al.* 2011). The excavations at Djadjiling rockshelter provided the first indication that the Aboriginal occupation of the inland Pilbara was some 10,000 years earlier than previously reported (Law *et al.* 2010; Law and Cropper 2012; Law *et al.* 2008). Subsequent excavation at HD07-3A-PAD13 and HS-A1 confirmed the early occupation and even extended it slightly. While Jundaru was found to be occupied from a slightly later date (*ca.* 35,978±653 cal BP), it was found to have an incredible density of artefacts along with a rich faunal assemblage and series of well-preserved combustion features. These sites are not only important for establishing the antiquity of occupation,

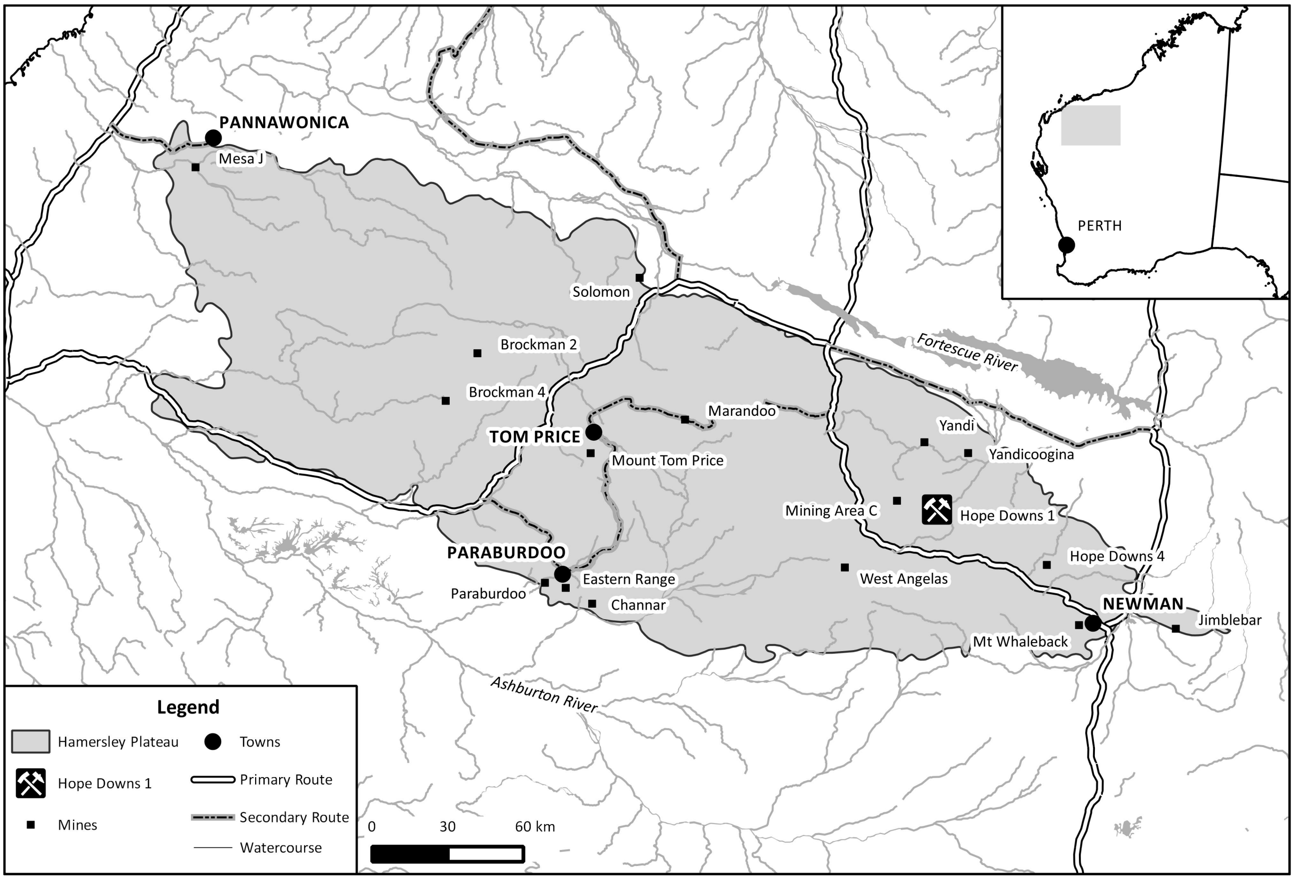

Figure 1-1 Map showing the regional location of the Hope Downs 1 mine

but they offer valuable insight into the intensity of occupation through time and provide data for evaluating the timing of the use of formalised retouched artefacts and grinding implements.

This monograph also includes the excavation and analytical results of two significant Holocene sites, PAD 3 and HD07-3A-03. PAD 3 was initially identified as a rockshelter having a potential archaeological deposit. Excavations at this site revealed an occupation spanning the Holocene. What is remarkable about PAD 3 is the series of exceptionally preserved combustion features in combination with the abundant faunal and macrobotanical remains. PAD 3 also provides the best chronological resolution for the initial appearance of backed artefacts at Hope Downs 1. Four backed artefacts recovered from a combustion feature dated to 4686±78 cal BP, and one additional backed artefact was found below this feature, suggesting that these artefacts were manufactured even earlier. HD07-3A-03 is included in this monograph because of its extremely high density of artefacts that is only paralleled at one other site investigated at Hope Downs 1, Jundaru. This site provides a rare large artefact assemblage through which it is possible to consider technological changes in artefact manufacture from the mid-Holocene through to the recent past. The site boasts one of the largest samples of tulas and backed artefacts from excavated contexts at Hope Downs 1. The context of the formalised retouched artefacts indicates that tulas and burrens appeared in the archaeological record much more recently than backed artefacts.

The well-preserved Holocene occupations at PAD 3 and HD07-3A-03 and the long occupational sequences at Djadjiling (HD07-1A-04), Jundaru (HN-A9), HS-A1, and HD07-3A-PAD13 provide the opportunity to explore local environmental changes and subsistence strategies through specialist studies. These studies include macrobotanical analysis, usewear analysis of stone artefacts, archaeomagnetic analysis of sediment samples, pollen and sediment analysis, phytolith analysis, faunal analysis, OSL analysis, geomorphology, and sediment analysis. These specialist studies offer invaluable contextual data for the archaeological sequences and make it possible to investigate correlations in settlement patterns and technological changes with palaeoenvironmental conditions.

The chapters in this monograph can be divided into four groups. The first four chapters provide background information that contextualises the excavation results. These chapters include an overview of the project and the environmental setting, reviews of the archaeological and ethnographic setting, and the research aims and methods. The second group of chapters documents the results of the excavations and analyses for the six rockshelters that are the focus of this monograph. The third group of chapters includes the results of the specialist analyses that have been carried out on materials from the six key rockshelters, including archaeomagnetic, pollen, phytolith, faunal, usewear, optically stimulated luminescence, and geomorphic analyses. Finally, the outcomes of this research are summarised in Chapter 18.

1.1 PROJECT BACKGROUND

The Hope Downs 1 mine (AM70/00282) is located approximately 75km northwest of Newman, in the east Pilbara region of Western Australia (Figure 1-1). The mine is an unincorporated joint venture between Rio Tinto Ltd (Rio Tinto) and Hancock Prospecting Pty Ltd (HPPL). The development and ongoing operation of the mine is managed by Rio Tinto Iron Ore (RTIO), a division of Rio Tinto responsible for iron ore operations. The Hope Downs 1 mine covers an area of approximately 42.5 square kilometres and includes the Hope North and Hope South project areas (Figure 1-2 and Figure 1-3). These project areas are roughly 5km apart and generally follow the large ranges that dominate the north and southeast areas of the lease. The mine is situated near several other iron ore mines, including Mining Area C (BHP Billiton Iron Ore [BHPBIO]; adjacent to Hope Downs 1), West Angeles (RTIO), Yandicoogina (RTIO), and Yandi (BHPBIO).

The Hope Downs 1 mine is in the traditional land of the Banyjima People native title holders (National Native Title Tribunal file no: WC11/6-1; Federal Court no.: WAD6096/1998). The excavations at Hope Downs 1 preceded the Banjima People Native Title Claim. During the fieldwork there were two overlapping native title claims areas over the mining lease: the Martidja Banyjima (MIB) Native Title Claimants and the Innawonga Bunjima (IB) Native Title Claimant areas. Representatives from each claimant group are identified as such throughout this monograph, reflecting the native title claims as they were when the fieldwork was undertaken.

In Western Australia, places of Aboriginal heritage are protected under the *Aboriginal Heritage Act* 1972 (AHA). Section 17 of the act states that it is an offence to damage any Aboriginal site whether it has been previously recorded or not, unless doing so under a Section 16 (excavation of Aboriginal sites) or Section 18 (consent to certain uses) authorisation. Since 1992, numerous heritage surveys were commissioned for the Hope Downs mine in order to identify heritage sites on the lease (Murphy *et al.* 1992; Edwards *et al.* 2001; Jackson *et al.* 2003; Jackson *et al.* 2007; Green 2001; Law *et al.* 2009; Mott *et al.* 2006; Mott and Liebelt 2006). As a result of this work, 164 heritage sites were identified on the mine lease, including both archaeological sites, sites with potential archaeological deposits, and ethnographic sites.

Development of a mine is classified by the DAA (2013) as an activity causing major disturbance, and in the case of Hope Downs 1, this occurred within a largely unaltered environment. As a requirement of the AHA, land users must apply for and be granted a Section 18 consent to impact an Aboriginal site, and excavation of Aboriginal sites requires a Section 16 consent. These authorisations are issued with specific conditions regarding the management of these sites, and these conditions must be adhered to by the proponent before any site impacts occur. In 2002, a Section 18 permit was granted to 'conduct open iron ore mining, and to construct associated infrastructure at the Hope Downs North and South Deposits' (Carpenter 2002). At the time the permit was granted, only 16 heritage sites were known to be on the mining lease, but numerous sites have since been identified on the Hope Downs 1 lease. These additional sites are also covered by the 2002 Section 18 permit, as 'blanket' permission had been granted to use the land on the mining lease. In accordance with the 2002 Section 18 permit, Pilbara Iron (on behalf of RTIO and HPPL) applied for Section 16 permits to undertake mitigative salvage and test-pitting at sites in the mining lease (Permits 416, 421, 423, 428, and 432).

ACHM was contracted to carry out the salvage investigations at Hope Downs 1 mine for sites scheduled to be impacted by the mining development (either directly or indirectly). ACHM was engaged by Karijini Development Pty Ltd, which represents the MIB Native Title claimants, who now form part of the Banjima People Native Title claim with IB. Over the course of 23 field trips between April 2007 and September 2010, ACHM investigated 31 rockshelters, salvaged 13 open artefact scatters, recorded three man-made structures, documented 11 culturally modified trees (including the salvage of five specimens), and conducted extensive laboratory work in collaboration with Traditional Owners. Numerous additional field trips were conducted during this time for ethnographic consultation. The full results of this archaeological research are presented in three separate reports that are divided according to the stages of archaeological fieldwork (Cropper 2013; Cropper and Law 2012; Law and Cropper 2011).

The Hope Downs 1 Mitigative Salvage Project encompasses heritage fieldwork that was conducted in three stages, which are defined according to priority areas identified by RTIO.

1. **Hope North Stage 1** (MIB25): includes areas impacted by the development of the northeast pit number 2, the northwest pit, the southeast waste dump, the northwest waste dump, and the waste dump associated infrastructure.

2. **Hope South Stage 2** (MIB50): includes the development and mining of an initial mining area in the Hope South orebody. Contrary to the project name, it also includes mining and waste dump areas in the southern and eastern fringe of the Hope North orebody.

3. **Hope Downs 1 Mitigative Salvage Program** (MIB40): includes areas in Hope North and Hope South scheduled for the construction of infrastructure and mine development.

The Hope North Stage 1 Salvage Program (MIB25)

The Hope North Stage 1 salvage program was carried out over four field trips between March and July 2007. Thirteen archaeological sites were investigated, including two rockshelter sites (Hope 1-24 and Hope 1-43), five rockshelters with potential archaeological deposits (PADs 2B, 3, 4, 5, and 6), one man-made structure (Hope 1-47), and six stone artefact scatters (Hope 1-02, Hope 1-23, Hope 1-34, Hope 1-35, Hope 1-36, and HN-A4). All of the archaeological sites investigated during the Hope North Stage 1 salvage operations have been disturbed by the Hope 1 North mining development. The sites flagged for the Stage 1 salvage were impacted by the infrastructure construction, pit excavation, and/or waste dumps associated with the mine. The locations of the sites nominated for salvage were widespread across the Hope North orebody; although, a small concentration of rockshelters with potential archaeological deposits (PAD 2, PAD 3, PAD 4, PAD 5, and PAD 6) and a man-made structure (Hope 1-47) were concentrated in the run-of-mine (ROM) pad gully near the primary iron ore crusher, which was under construction during the investigation of these sites.

The excavations conducted as part of the Hope North Stage 1 program resulted in the documentation of several sites with Holocene occupational sequences. Excavations in one rockshelter identified as a potential archaeological site, PAD 3, revealed a series of well-preserved combustion features spanning from the early to late Holocene. The PAD 3 investigations demonstrated that rockshelters formed in banded iron formations can contain well-preserved cultural features with complex stratigraphic relationships, despite the fact that the deposit is comprised of a high proportion of exfoliated rock. Research at PAD 3 has also extended the antiquity of backed artefacts in the Hamersley ranges, with evidence for their use conservatively estimated between 4825 and 4569 cal BP.

PAD 3 is one of five rockshelters with potential archaeological deposits excavated during the Hope North Stage 1 salvage program. Work at these sites demonstrated that most rockshelters with potential archaeological deposits are likely to have buried cultural material. Admittedly, some rockshelters yielded few artefacts, but there is no way to predict the extent of the archaeological record in these places without proper test excavations. The most significant sites in the Hope North Stage 1 project were discovered in this manner, and they have yielded substantial information on Aboriginal subsistence, lithic technology, and past human-environment interactions.

The Hope South Stage 2 Salvage Program (MIB50)

The Hope South Stage 2 (MIB50) salvage program included the recording, collection and documentation of 14 archaeological sites between July 2007 and March 2008 (with a subsequent laboratory trip in April 2008). The sites investigated during the salvage program include five rockshelters (HD07-1A-02, HD07-1A-03, HD07-1A-04 (aka Djadjiling Rockshelter), HD07-1A-07, and HD07-1A-22), one rockshelter with a potential archaeological deposit (PAD 7), five open artefact scatters (HD07-1A-01, HD07-1A-08, HD2006-6, Hope 1-03, and Hope 1-33), two culturally modified trees (Hope 1-04 and Hope 1-05), and one man-made structure (Hope 1-14). With the exception of Djadjiling (HD07-1A-04), HD07-1A-07, and HD07-1A-22, all of the aforementioned sites were disturbed by the Hope North and Hope South mining development. The mine planners were able to re-design the impact footprint so that Djadjiling Rockshelter could be preserved. Sites HD07-1A-07 and HD07-1A-22 are located in an area that is not scheduled to be directly impacted by the mine development; however, the sites were included in the Stage 2 salvage program as nearby blasting may cause vibrations that destabilise the rockshelter and result in roof collapse. The remaining sites flagged for the Stage 2 salvage will be impacted by infrastructure construction, pit excavation and/or waste dumps associated with the mine.

Of the six rockshelters that were excavated as part of the Hope South Stage 2 program, one highly significant site was identified. Excavations at Djadjiling Rockshelter documented a Pleistocene occupational sequence, demonstrating Aboriginal occupation of the Hamersley Ranges 41,000 years ago. At the time of its discovery, this site pushed back the known initial settlement of the inland Pilbara by 10,000 years, as previous archaeological investigations suggested the region was first occupied by approximately 28,000 to 31,000 cal BP, as reported for Newman Rockshelter (30,897±372 cal BP, SUA-1510; Brown 1987) and Mesa J24 Rockshelter (28,317±415 cal BP, Wk-2514; Hughes *et al.* 2011). Djadjiling was most intensely occupied during this early occupational phase, and this has been demonstrated through artefact densities, archaeomagnetic analysis, and phytolith analysis. The long occupational sequence at Djadjiling allowed for the investigation of local environmental changes over time through specialist studies, including macrobotanical, archaeomagnetic, palynological, and phytolith analyses. These studies provide invaluable contextual data for the archaeological sequence that allow us to investigate correlations in settlement patterns and technological changes with palaeoenvironmental conditions, particularly when considered alongside the specialist studies undertaken for PAD 3. The usewear analysis of artefacts from Djadjiling has shown that many stone tools were utilised for woodworking, hinting at the possibility of a broad assemblage of wooden artefacts that has not been preserved. Moreover, several of the Pleistocene retouched artefacts show evidence of hafting, demonstrating the established use of this technology during the earliest phases of occupation.

Table 1-1 Sites investigated during the Hope Downs 1 Mitigative Salvage Project

Project Stage	Site Name	DAA ID	Site Type	Location	Salvage Start	Salvage End
Hope North Stage 1 (MIB25)	HOPE 1-02	24032	AS	Hope North	25-Jul-07	26-Jul-07
	HOPE 1-23	24033	AS	Hope North	01-Jul-08	01-Jul-08
	HOPE 1-24*	24034	RS	Hope North	30-Jun-07	30-Jun-07
	HOPE 1-34	24035	AS	Hope North	27-May-07	27-May-07
	HOPE 1-35	24036	AS	Hope North	27-May-07	27-May-07
	HOPE 1-36	24037	AS	Hope North	27-May-07	27-May-07
	HOPE 1-43	24038	RS	Hope North	01-Jul-07	04-Jul-07
	HOPE 1-47	25234	MMS	Hope North	16-Apr-07	16-Apr-07
	PAD 2B		PAD	Hope North	16-Apr-07	18-Apr-07
	PAD 3		PAD	Hope North	19-May-07	30-Jun-07
	PAD 4		PAD	Hope North	14-Apr-07	19-May-07
	PAD 5		PAD	Hope North	14-Apr-07	16-Apr-07
	PAD 6		PAD	Hope North	14-Apr-07	16-Apr-07
Hope South Stage 2 (MIB50)	HD07-1A-01		AS	Hope South	17-Oct-07	17-Oct-07
	HD07-1A-02		RS	Hope South	18-Oct-07	12-Dec-07
	HD07-1A-03		RS	Hope South	13-Dec-07	13-Dec-07
	HD07-1A-04 (Djadjiling)		RS	Hope South	18-Oct-07	07-Mar-08
	HD07-1A-07		RS	Hope South	13-Dec-07	17-Dec-07
	HD07-1A-08		AS	Hope South	18-Jul-07	19-Jul-07
	HD07-1A-22		RS	Hope South	18-Dec-07	18-Dec-07
	HD2006-6		AS	Hope South	19-Oct-07	19-Oct-07
	HOPE 1-03	25214	AS	Hope North	20-Oct-07	20-Oct-07
	HOPE 1-04	25052	CMT	Hope North	21-Oct-07	22-Oct-07
	HOPE 1-05	25053	CMT	Hope North	21-Oct-07	22-Oct-07
	HOPE 1-14	25059	MMS	Hope North	21-Oct-07	21-Oct-07
	HOPE 1-33	25230	AS	Hope North	20-Oct-07	20-Oct-07
	PAD 7	25195	PAD	Hope North	20-Oct-07	22-Oct-07
Hope Downs 1 Mitigative Salvage Program (MIB40)	HD07-3A-01		AS	Hope South	16-Sep-08	20-Oct-08
	HD07-3A-03		RS	Hope South	13-Jan-09	19-Jan-09
	HD07-3A-13		RS, MMS	Hope South	19-Oct-08	20-Oct-08
	HD07-3A-17		RS	Hope South	16-Nov-08	18-Nov-08
	HD07-3A-18		CMT	Hope South	14-Sep-08	14-Sep-08
	HD07-3A-PAD05		PAD	Hope South	15-Sep-08	15-Sep-08
	HD07-3A-PAD07		PAD	Hope South	20-Oct-08	21-Oct-08
	HD07-3A-PAD13		PAD	Hope South	08-Nov-08	13-Sep-10
	HD2006-5	26893	CMT	Hope North	15-Sep-08	15-Sep-08
	HN-A12	18715	MMS	Hope North	12 Aug- 08	12 Aug-08
	HN-A7	18712	RS	Hope North	06-Sep-08	11-Sep-08
	HN-A9 (Jundaru)	18195	RS	Hope North	20-May-08	20-Aug-08
	HOPE 1-09	25054	CMT	Hope North	13-Sep-08	19-Sep-08
	HOPE 1-10	25055	CMT	Hope North	12-Sep-08	12-Sep-08
	HOPE 1-11	25056	CMT	Hope North	12-Sep-08	12-Sep-08
	HOPE 1-12	25057	CMT	Hope North	12-Sep-08	12-Sep-08
	HOPE 1-13	25058	AS	Hope North	20-Oct-08	20-Oct-08
	HOPE 1-15	25060	CMT	Hope North	13-Sep-08	13-Sep-08
	HOPE 1-16	25061	RS	Hope North	12-Sep-08	13-Sep-08
	HOPE 1-17	25199	RS	Hope North	12-Sep-08	13-Sep-08
	HOPE 1-22	25200	RS	Hope North	03-May-08	03-May-08
	HOPE 1-39	25201	RS	Hope North	28-Apr-08	30-Apr-08
	HOPE 1-40	25202	RS	Hope North	25-Apr-08	26-Apr-08
	HOPE 1-41	25203	RS	Hope North	26-Apr-08	04-May-08
	HOPE 1-42	25205	CMT	Hope North	02-May-08	02-May-08
	HOPE 1-44	25206	CMT	Hope North	03-May-08	03-May-08
	HOPE 1-45	25233	AS, CMT	Hope North	02-May-08	03-May-08
	HOPE 1-46	25207	RS	Hope North	01-May-08	02-May-08
	HS-A1	18716	RS	Hope South	11-Oct-08	20-Oct-08
	HS-A2	18717	RS	Hope South	08-Nov-08	16-Nov-08
	PAD 1	25194	RS	Hope South	24-May-08	01-May-08

Key: AS - artefact scatter, RS - rockshelter, MMS - man-made structure, CMT - culturally modified tree, PAD - potential archaeological deposit.
*Hope 1-24 is a rockshelter with surface artefacts, but no deposit.

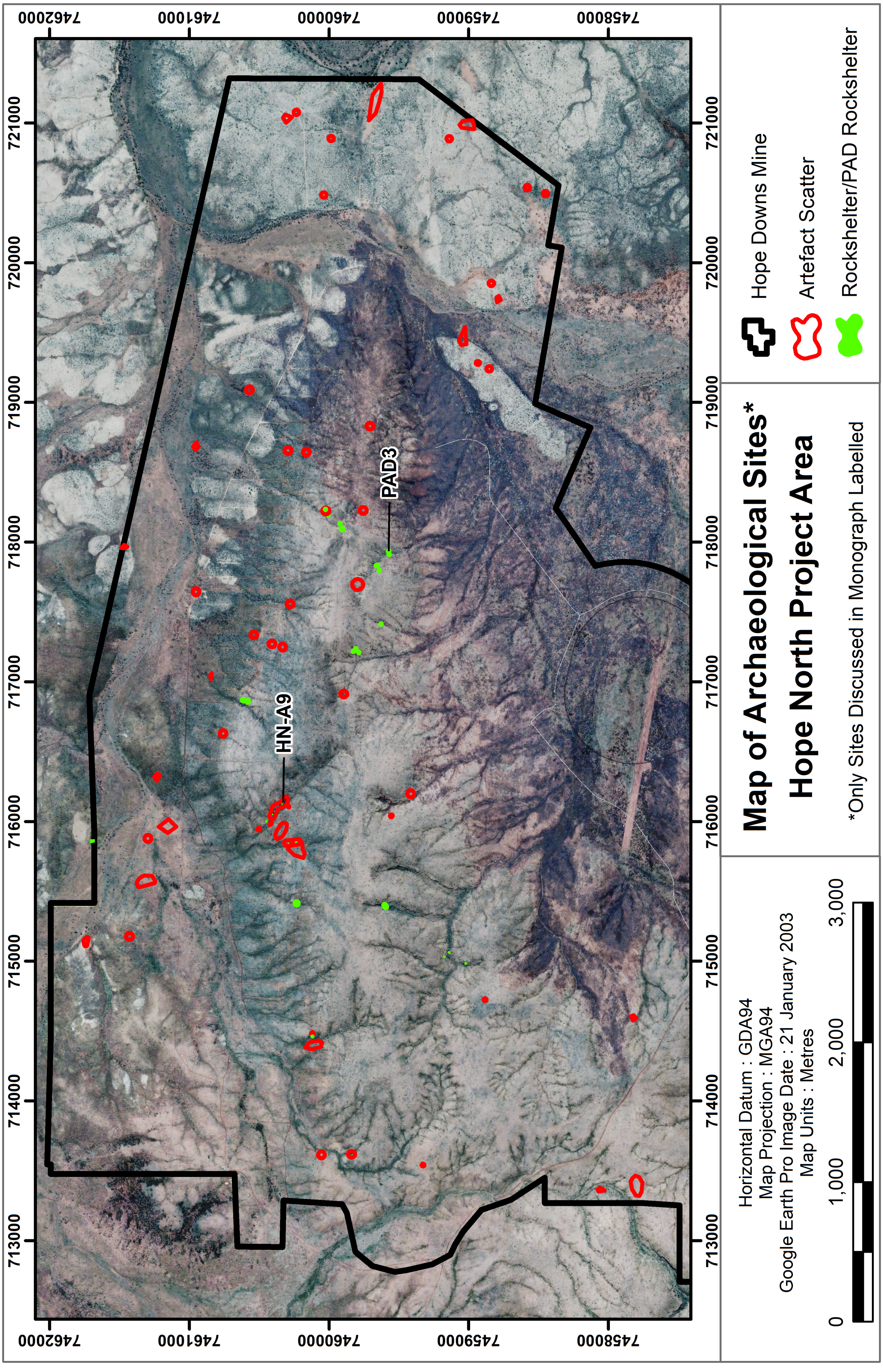

Figure 1-2 Archaeological sites in Hope North

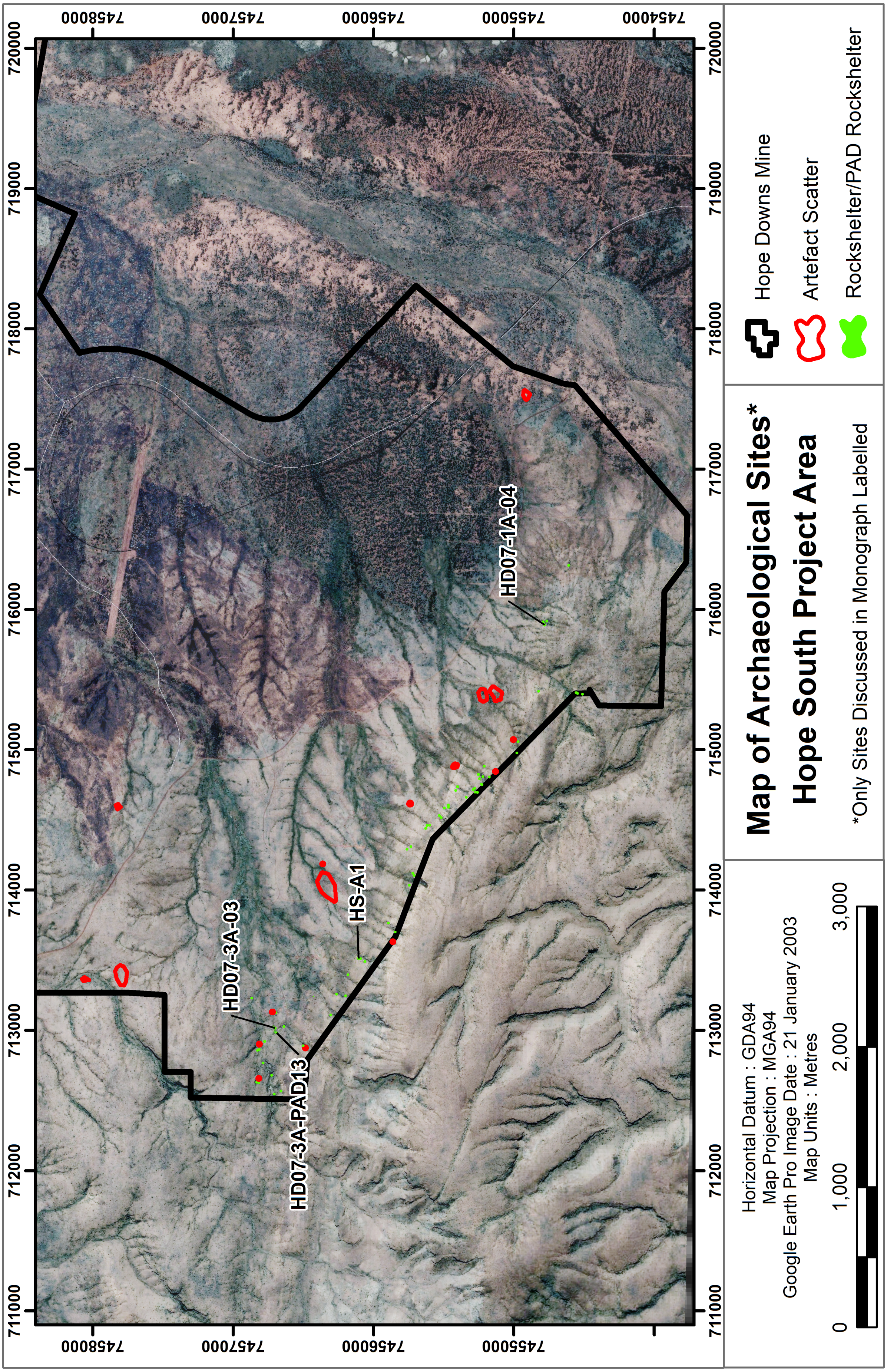

Figure 1-3 Archaeological sites in Hope South

The Hope Downs 1 Mitigative Salvage Program (MIB40)

The Hope Downs 1 Mitigative Salvage Program (MIB40) was carried out over 15 field trips between April 2008 and September 2010, and it included the recording, collection, and documentation of 31 sites prior to the impacts (direct or indirect) of mining activities. The sites investigated included 14 rockshelters (three with man-made structures), four rockshelters with potential archaeological deposits, three open artefact scatters (one with culturally modified trees), nine culturally modified tree sites, and one man-made structure site. All of the archaeological sites investigated during the MIB40 program were subject to mitigative salvage measures before they were disturbed by the Hope North and Hope South mining development. Two sites (Sites HS-A1 and HD07-3A-PAD13 are) are located on the edge of the Hope South mine pit, and they have not been impacted. It has been recommended that measures should be taken to avoid directly impacting these sites, as both are significant Pleistocene sites.

A key outcome of the MIB40 program was the identification of Pleistocene occupational sequences at four rockshelters: Jundaru (HN-A9), HS-A1, HD07-3A-PAD13, and Hope 1-41. These sites further confirm the early occupation of the local area as was first demonstrated at Djadjiling. Well-preserved combustion features were identified at Jundaru and HS-A1, and a rich assemblage of cultural material was recovered from Jundaru. The excavation at HD07-3A-PAD13 showed that its deposit formed under very different conditions to most other rockshelters at Hope Downs 1, and the OSL ages obtained from HD07-3A-PAD13 further substantiate the pre 41,000 cal BP radiocarbon dates for the initial occupation the region. Only a limited Pleistocene assemblage was identified at Hope 1-41, and the site has been affected by bioturbation. The long occupational sequences at Jundaru (HN-A9), HS-A1, and HD07-3A-PAD13 provide the opportunity to explore local environmental changes and subsistence strategies through specialist studies, including the macrobotanical analysis, usewear analysis of stone artefacts, archaeomagnetic analysis of sediment samples, pollen and sediment analysis, phytolith analysis, faunal analysis, OSL analysis, geomorphology, and sediment analysis.

In addition to the Pleistocene sites investigated as part of the MIB40 program, excavations also revealed HD07-3A-03 as an important Holocene site. HD07-3A-03 was found to have an extremely high density of flaked stone artefacts, dating from approximately 5716±64 cal BP and continuing until the recent past. The density of artefacts at this site is rivalled only by Jundaru.

1.2 ENVIRONMENTAL SETTING

The Hope Downs 1 mine lies within the rangelands of the Hamersley Plateau, in the eastern Pilbara region of Western Australia. The inland Pilbara is geographically remote and sparsely populated. The physiographic and ecological systems of the Pilbara are the consequence of a long geological and evolutionary history. Understanding the mechanisms that shaped these systems, and the natural resources contained within them, is vital to our understanding of the Aboriginal archaeological record. The following sections briefly describe the landforms, geology, and climatic history of the inland Pilbara. Also described is the native flora and fauna that occupy the land systems.

Landforms and Geology

Hope Downs 1 is located in a physiographic region known as the Hamersley Plateau, which stretches across large portions of the southern inland Pilbara and incorporates the Hamersley Range. The Hamersley Plateau covers an area of over 39,000 square kilometres, stretching from Newman in the east to Pannawonica in the west. The Fortescue valley and Chichester Range lay to the north, and the Augustus Ranges are to the south and west.

The land surfaces in the Hamersley Plateau are predominately erosional hills and ridges with low to very high (30-450m above mean sea level [AMSL]) topographic relief (Payne 2004: 72). Amongst these areas of relief are very low lying (9-30m AMSL) stony plains formed primarily by colluvial wash deposits and dissected by narrow drainages (Payne 2004: 73). Although uncommon, extremely low lying rivers (<9m AMSL) cut through this massive, weathered landscape (Payne 2004: 75).

There are seven land systems characteristic of the Hamersley Plateau that occur within the mining lease. These land systems are described by Payne (2004) as the Newman, Platform, Pindering, Boolgeeda, Calcrete, Oakover, and River land systems (Figure 1-4). The Newman land system is the most widespread and common land system at Hope Downs 1. It is an upland land system, easily identified by the rugged plateaux, ridges and mountains expanding across the lease. The Newman system is an erosional land surface, with vertical escarpments, steep scree slopes, and well-incised gullies and gorges (Payne 2004: 298). Soils are stony and shallow, with some residual, loamy red earths. The geological age of the land surface dates to the Lower Proterozoic, which formed approximately 2600 mya (Thorne and Tyler 1997). Rockshelters are a common feature throughout this upland system, offering protected locales for undisturbed soil aggradation and potentially, stratified archaeological deposits. Artefact scatters and similar open archaeological sites in this land system will be resting atop of the ground surface with little or no soil deposition.

At Hope Downs 1, the Newman land system is part of the Hamersley geological group, and the Marra Mamba Iron Formation is the most prominently featured unit (Thorne and Tyler 1997). The Marra Mamba Iron Formation is the oldest unit of the Hamersley Group, and it is the iron ore rich formation that is economically important to the mine. The Marra Mamba formation is divided into three members: the Nummuldi Member (lowest), the MacCleod Member (middle), and Mount Newman Member (upper) (Kneeshaw 1984; Blockley *et al.* 1993). The formation is siliceous, with alternating layers of yellow to yellow-brown chert, brown to black banded ironstone, interlayered thin shales, and pelite. Often, the contact between the Nammuldi Member and the MacLeod Member is marked by a distinctive elongated and lenticular-shaped chert layer know by geologists as the 'potato bed' (Thorne and Tyler 1997: 11). Chert outcrops from this formation were once a significant raw material resource for Aboriginal stone tool manufacture.

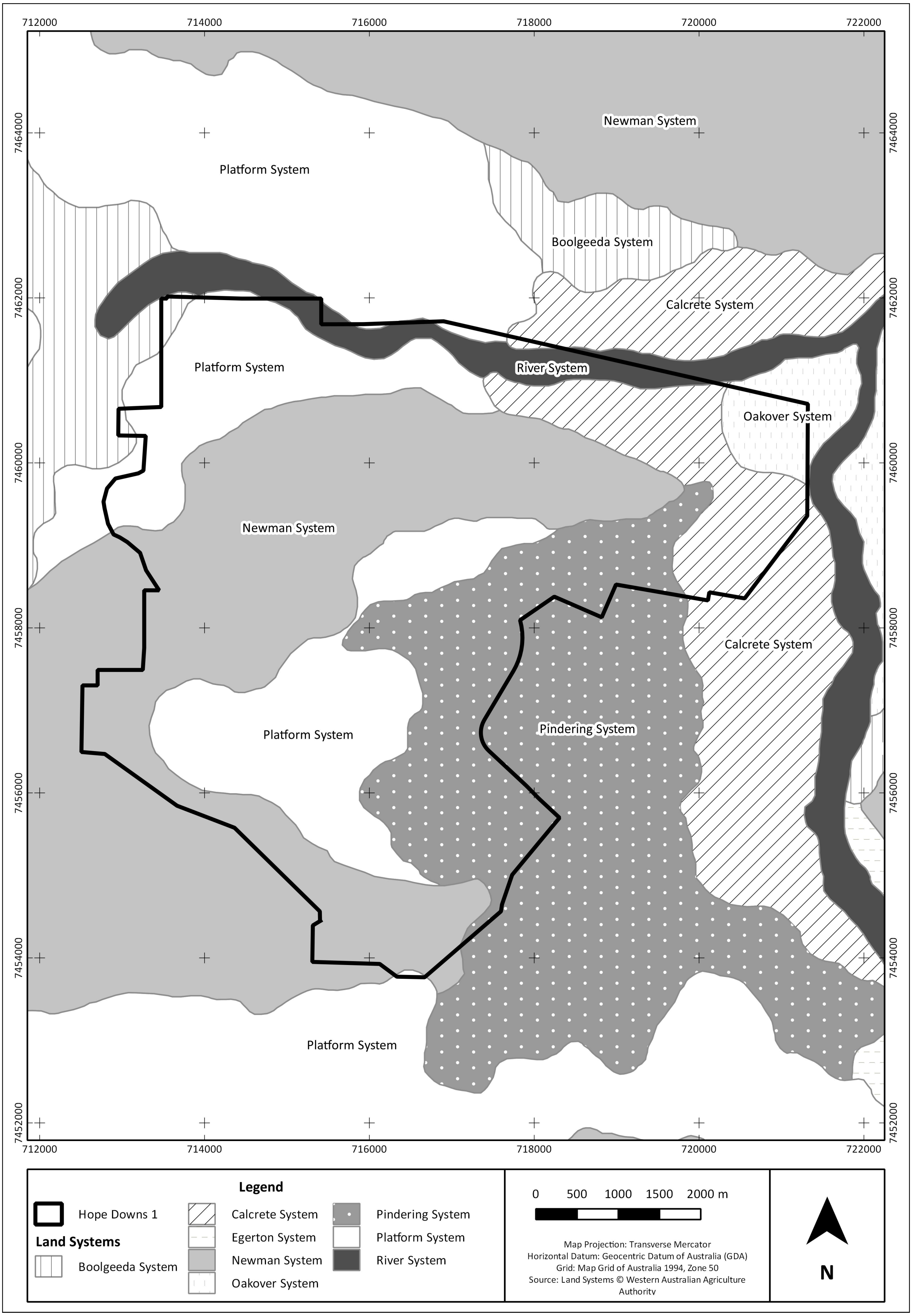

Figure 1-4 Land systems at the Hope Downs 1 mine

The Platform land system is a colluvial landform resting along the toeslope of the Newman system (Payne 2004: 320). The land system consists of partially consolidated Tertiary age (65-1.8 mya) colluvium, deriving from the upper Newman land surface. Most of the land system is dissected by gently inclined erosional slopes with closely spaced dendritic or sub-parallel drainage systems. Soils, if present, are red shallow loams and stony soils with no prominent stratigraphy. Archaeological sites located in this land system will be surficial and most likely degraded due to the gradually sloping and weathered nature of the land system.

The Boolgeeda and Pindering land systems occupy the stony lower slopes and plains beneath the Newman and Platform systems (Payne 2004: 196). The Boolgeeda and Pindering are depositional landforms, formed by Tertiary and Quaternary colluvial sheet wash (Thorne and Tyler 1997). The uppermost relief of these land surfaces is very gently inclined and becomes more level further downslope. The Boolgeeda drainage system is closely spaced, with dendritic and sub-parallel narrow drainages dissecting the land surface (Payne 2004: 196). Drainage lines of the Pindering land system are linear and arranged at right angles to the surface sheet flow (Payne 2004: 318). The stony ground surface is composed of unconsolidated soil, quartz, and ironstone fragments, locally derived from upland scree and talus slopes. The presence of spinifex grasses make these systems prone to bush fires. Open archaeological sites in this weathered and slowly aggrading land system are unlikely to be deeply buried, stratified, or *in situ*.

The Calcrete and Oakover land systems rest in the plains of the east and northeast lease area, between the Pindering and River systems (Payne 2004: 205-206, 306-307). The principal difference between the Calcrete and Oakover land systems is topography. The Oakover is a rangeland system comprised of mesas, plateaux, breakaways, and calcareous plains. It overlies the Calcrete land system, which is primarily low calcrete platforms and plains. Inside the lease, it is extremely difficult to differentiate between the two landforms; however, outside the lease, the differences are more topographically distinctive. The foundation of these land systems is Tertiary age calcrete, which occurs as a mosaic of low rises and platforms (up to 10m) above the surrounding plains. A loamy Quaternary alluvium has been deposited between prominent calcrete platforms via low energy water movement. Although soils are shallow, there is a possibility for buried cultural deposits to be present in lowland areas, and the low energy water movement increases the likelihood that these materials may be *in situ* or undisturbed.

An uncommon but important land system is the River land system (Payne 2004: 328), which abuts the north and east Hope Downs mining lease boundary. This system is a depositional landform clearly associated with Weeli Wolli Creek, which runs in a northeast direction from the lease to Weeli Wolli Spring. The soils of this system are Quaternary age alluvium, deposited by regular overbank flood events. Flood plains and river terraces are the most common land units of the River land system, with periodically washed sandy levees, stony plains, and water channels composing the remaining associated units (Payne 2004: 328-329). Red sandy soils are common along the upper terraces of the drainage, while loamy red soils and red/brown non-cracking clays occupy much of the flood plains and lower terraces.

It is possible that Aboriginal river terrace encampments were periodically inundated by flood waters in the archaeological past, and Aboriginal sites buried by low energy, sediment-rich waters have the potential to be stratified and well preserved. The terraces along Weeli Wolli Creek are therefore an important landform for archaeological investigation, as significant subsurface cultural deposits may be buried beneath alluvium.

Modern Climate and Palaeoclimatic History

The Hope Downs 1 Mine is in the Australian arid zone, a hot and dry climatic region where annual potential evaporation exceeds annual precipitation. Rainfall variability, often expressed by extensive droughts and occasional flooding rains, is the dominant climatic element for Australia's arid regions (Morton *et al.* 2010). The project area belongs to the desert-summer rain bioclimatic region of the inland Pilbara, a region characterised as regularly having up to 12 months of dry weather and high temperatures with occasional rainfall (Beard 1990). Rain usually occurs in the form of summer thunderstorms, and rainfall is heavily influenced by the Indo-Australian summer monsoon and associated cyclonic events. Pilbara summers are very hot, and winters are generally cool and mild. The local mean summer daytime temperature at the Newman weather station is recorded as 39.6°C (January data; Bureau of Meteorology 2009). In winter, mean daytime temperatures is 22.3°C (July data; Bureau of Meteorology 2009), and the night time winter temperatures at Newman rarely drop to 0°C.

Annual precipitation is extremely varied, and the region rarely receives an 'average' rainfall year unless it has high frequency of cyclone events (Leighton 2004: 21). The mean annual rainfall recorded at the Newman station is 310.2mm (Bureau of Meteorology 2009), and more than half of the annual rainfall comes during the summer months of December, January, and February. Historically, the wettest month in the Pilbara has been February, while September and October were the driest (Leighton 2004: 26).

The extreme climatic patterns of the inland Pilbara have not always been as they are at present. The regional climate has varied considerably over the past 50,000 years, and Aboriginal populations have continuously adapted to these climatic fluctuations. Unfortunately, there is very sparse palaeoclimatic data available on the Pilbara region itself; consequently, data from other areas of the Australian arid zone must be considered when modelling the palaeoclimatic record of the inland Pilbara.

Between 50,000 and 35,000 years ago, climatic conditions across the Australian arid zone were likely warmer, wetter, and more seasonally predictable than present, and there is evidence suggesting that summer monsoons penetrated the continental interior at regular intervals (Magee *et al.* 2004: 1151; Johnson *et al.* 1999). Inland freshwater playa lakes were more plentiful across the region at this time (Cohen *et al.* 2011), and in some areas of southern central Australia palaeoshorelines expanded and joined together to form mega-lakes (De Deckker *et al.* 2011). These favourable climatic conditions formed the backdrop for the original Aboriginal settlement of the inland Pilbara, which has recently been demonstrated as being prior to 41,000 cal BP (Law *et al.* 2010). Between 42,000 and 33,000 years ago, this lacustral climatic phase gradually transitioned towards the increasingly xeric conditions of the Last Glacial Maximum (LGM) (De Deckker *et al.* 2011: 49).

In comparison to the present day, the LGM was a climatic period characterised by decreased, unpredictable rainfall patterns and decreased terrestrial temperature across inland Australia. In some arid zone areas there is evidence for increased wind strength during the LGM, as demonstrated by aeolian dune-building activity; however, it is unclear if dune aggradation was encouraged by an increase in wind strength or a decrease in dune-stabilising vegetation (Hesse and McTainsh 1999: 343). Palaeoclimatic research from northwest Australia indicates that the LGM covers the time interval between 35,000 and 14,000 years ago (Williams *et al.* 2009: 2410). Of course, there was climatic variability across Australia at this time, which makes the precise timing of the LGM period debatable, and it requires periodical revision as new data is collected. Recent research indicates that hyperaridity became markedly pronounced in the arid zone between 23,000 and 19,000 years ago, a period sometimes referred to as the 'LGM proper' (Mix *et al.* 2001: 636; Williams *et al.* 2009: 2400). Food and water resources during the LGM were diminished and more limited than today, and it is argued that the arid zone experienced colder winters than present (Harrison 1993: 223; Hesse and McTainsh 1999: 347; Williams *et al.* 2009: 2410).

Around 14,000 years ago, at the tail end of the Pleistocene, arid conditions ameliorated with the re-initiation of the northern summer monsoon cycle across northern Australia (Wyrwoll and Miller 2001: 127). Climatic conditions progressively warmed, and vegetation communities stabilised as surface water became more widely available. This more climatically predictable and wetter period most likely continued throughout the terminal Pleistocene and into the early Holocene (10,000-6000 years ago) (Wyrwoll and Miller 2001: 127; Quigley *et al.* 2010: 1099; De Deckker *et al.* 2011: 49). In central Australia, for example, increased effective precipitation has been measured at 11,500 cal BP and 8000 to 5000 cal BP, with peak moisture recorded between 7000 and 6000 years ago (Quigley *et al.* 2010: 1093).

In the mid-Holocene (6000-3500 years ago), many researchers contend that the arid zone experienced a comparatively dry climatic phase between 6000 and 4000 years ago (*e.g.*,Quigley *et al.* 2010; Dimitriadis and Cranston 2001; McCarthy and Head 2001). Of particular relevance to the Pilbara is recent climatic data from Shark Bay, located on the mid-north Western Australia coastline (Nott 2011). The Shark Bay study demonstrates that there is 1700 year gap in storm surge shell ridge building activity, leading Nott (2011: 722) to conclude monsoonal activity ceased between 5400 cal BP and 3700 cal BP, and the region became drier than present. During this time, Nott (2011: 722) hypothesises that the Shark Bay region experienced a mega drought that may have persisted for more than 1000 years. Similar research immediately to the east of the Pilbara, in the Lake Gregory Basin, indicates that a significant episode of sand dune building occurred around 5000 years ago, adding further evidence of a mid-Holocene hyperarid event (Fitzsimmons *et al.* 2012: 476). Although this recent research shows that rainfall became less frequent and more unpredictable during the mid-Holocene, it is evident that the dry climatic conditions were not as severe as those of the LGM.

For the last 2000 years, climatic conditions of the inland Pilbara have been much like the present climate. The late Holocene palaeoclimate has been considerably wetter than the drier mid-Holocene period, and it has been more climatically variable and less predictable than the early Holocene (McCarthy and Head 2001: 687). Seasonal rainfall has become more frequent than the mid-Holocene, but it is still not as regularly cycled as in the early Holocene.

Flora

The distribution of plant communities on the Hamersley Plateau is intrinsically connected to the geography and geology of the region. The Hamersley Plateau is considered to be one of the four subregions for the Pilbara biogeographical region (the Fortescue River Plains, Chichester Ranges, and Roebourne Coastal Plains comprise the remaining subregions). Thackway and Cresswell (1995) characterise the vegetation communities of the Hamersley Plateau as low mulga woodland over bunch grasses on fine textured soils and snappy gum over spinifex hummock grasses on skeletal sandy soils in upland ranges. The diversity and distribution of Pilbara plant communities is much more complex than this generalised description, and at Hope Downs 1, the distribution of plant communities is easily attributed to the surrounding landform and soils. The flora of the Hope Downs area was surveyed and mapped by Mattiske Consulting Pty Ltd (2009), which identified 18 vegetation communities within the mining lease (Table 1-2).

The vegetation communities identified at Hope Downs 1 can be divided broadly between those present in the creek lines and drainage areas and those characteristic of the ranges, hills, and hillslopes. Each vegetation community is linked with the geomorphology and land systems of each area. Table 1-2 provides a comparison of the dominant vegetation communities within the previously described land systems.

The uplands at Hope Downs 1 are dominated by hummock grasslands, which Mattiske Consulting Pty Ltd (2009) have defined as hummock grassland of *Triodia* species with an overstorey of isolated to scattered eucalypts, mulga, and shrubs. Within the two prominent upland land systems, the Newman and Platform land systems, there are a range of hummock grassland communities (Newman – S1, S2, S3, and S4; Platform S1, S2, and S3), which support slightly different ranges of species (Table 1-2). Dominant hummock grassland species include *Triodia epactia,* limestone spinifex (*Triodia wiseana*), echidna spinifex (*Triodia brizoides*), hard spinifex (*Triodia basedowii*), and occasionally soft spinifex (*Triodia pungens*) (Mattiske Consulting Pty Ltd 2009: Table 6). Woody species are dominated by eucalypts and acacia species, but there are also numerous species of scattered shrubs and flowering plants, such as *Senna*, *Ptilotus*, Wickham's grevillea *(Grevillea wickhamii)*, crimson turkey brush (*Eremophila latrobei*), native poplar (*Codonocarpus cotinifolius*), and *Indigofera monophylla* (Mattiske Consulting Pty Ltd 2009: Table 6).

Low woodlands are typically present within the lower-lying Boolgeeda (S1, S2, M2, and M4) and Pindering (M1 and M2) land systems; although, hummock grasslands continue to be a dominant vegetation community in the Boolgeeda land system (Mattiske Consulting Pty Ltd 2009: Table 6-7). The low woodland vegetation communities are dominated by *Acacia* species, with mulga (*Acacia aneura*) being predominant (Mattiske Consulting Pty Ltd 2009: Table 6). The stony slopes and lowland plains at Hope Downs 1 are dominated by plain hard and plain soft spinifex grasslands (Van Vreeswyk and Payne 2004). The dominant hummock grassland species of the lowlands vary, but *Triodia* epactia and soft spinifex are the dominant grasses (Mattiske Consulting Pty Ltd 2009: Table 6). The grass layer may potentially cover 60% of the ground surface, depending upon the timing of the last bushfire (Van Vreeswyk and Payne 2004). Trees and shrubs are infrequent, but when they do occur, they may form a prominent stratum.

Table 1-2 Vegetation communities present in the Hope Downs 1 lease (adapted from Mattiske Consulting Pty Ltd 2009: Tables 6-7)

	Code	Description	Dominant in Land System
Creek Lines and Drainage Areas	C1	Low Woodland of *Eucalyptus xerothermica* and *Eucalyptus victrix* over *Acacia citrinoviridis, Acacia maitlandii*, *Gossypium australe*, *Melaleuca lasiandra, Petalostylis labicheoides, Rulingia luteiflora* over *Triodia epactia, Chrysopogon fallax* and *Triodia pungens* on minor creeklines with sandy soils.	River
	C2	Low Woodland of *Eucalyptus xerothermica* and *Eucalyptus victrix* over *Acacia citrinoviridis, Acacia maitlandii*, *Gossypium australe*, *Melaleuca lasiandra, Petalostylis labicheoides, Rulingia luteiflora* over *Triodia epactia, Chrysopogon fallax* and *Triodia pungens* on minor creeklines with sandy soils.	River
	C3	Tall Shrubland of *Acacia arida*, *Acacia bivenosa*, *Acacia ancistrocarpa, Acacia maitlandii, Acacia monticola* with occasional emergent *Corymbia deserticola* subsp. *Deserticola, Eucalyptus gamophylla* and *Eucalyptus leucophloia* over *Gompholobium polyzygum, Indigofera monophylla, Rulingia luteiflora* over mixed *Triodia* species on sandy-loam soils in minor gullies.	None
	C4	Open Woodland of *Eucalyptus victrix, Eucalyptus camaldulensis* var. *obtusa, Melaleuca argentea* over *Acacia citrinoviridis, Acacia coriacea* subsp. *Sericophylla* and *Melaleuca lasiandra* over *Cyperus vaginatus* on major creeklines with pools with sandy soils.	River
	X3	Tall Shrubland of *Acacia bivenosa, Acacia monticola, Acacia marramamba, Petalostylis labicheoides* with occasional emergent *Eucalyptus leucophloia* over *Triodia pungens* and *Triodia basedowii* on calcrete soils in minor gullies.	Calcrete
	M1	Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia catenulata* subsp. *Occidentalis, Acacia rhodophloia, Grevillea berryana* with an occasional emergent *Eucalyptus leucophloia* and *Eucalyptus gamophylla* over *Psydrax latifolia, Keraudrenia nephrosperma*, *Acacia distans, Eremophila fraseri*, *Acacia tetragonophylla, Eremophila forrestii* subsp. *Forrestii, Solanum lasiophyllum* over *Chrysopogon fallax, Triodia pungens* and *Triodia epactia* and a range of annual species on sandy-loam flats and broad plains.	Pindering
	M2	Low Woodland of *Acacia aneura* var. *aneura* to a Tall Shrubland of *Acacia pyrifolia, Acacia bivenosa, Acacia ancistrocarpa* and *Acacia maitlandii* with occasional emergent *Eucalyptus xerothermica, Corymbia aspera, Psydrax latifolia* and *Acacia citrinoviridis* over *Gompholobium polyzygum, Rulingia luteiflora, Themeda triandra, Triodia epactia* and *Triodia pungens* on sandy soils on flats on edges of major creeklines.	River, Boolgeeda, Pindering
	M4	Low Open Woodland of *Acacia rhodophloia* and *Acacia tetragonophylla* with occasional *Eucalyptus gamophylla* and *Eucalyptus xerothermica* over *Acacia hilliana, Acacia maitlandii* over *Triodia pungens, Triodia basedowii, Aristida* species and a range of annual species on flats and broad valley floors.	Boolgeeda
	M5	Low Woodland of *Acacia aneura* var. *aneura* to a Tall Shrubland of *Acacia pyrifolia, Acacia bivenosa, Acacia ancistrocarpa* and *Acacia maitlandii* with occasional emergent *Eucalyptus xerothermica, Corymbia aspera, Psydrax latifolia* and *Acacia citrinoviridis* over *Gompholobium polyzygum, Rulingia luteiflora, Themeda triandra, Triodia epactia* and *Triodia pungens* on sandy soils on flats on edges of major creeklines.	None
	M7	Low Open Woodland of *Acacia aneura* var. *aneura, Acacia pruinocarpa* over *Acacia bivenosa* and *Triodia pungens* and a range of annual species on open sandy-loam flats and broad plains.	
Ranges, Hills, and Hill slopes	B1	Hummock Grassland of *Triodia basedowii, Triodia wiseana* and *Triodia pungens* with emergent patches of *Eucalyptus leucophloia, Acacia citrinoviridis, Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia synchronicia* over *Eremophila latrobei* subsp. *Glabra, Senna glutinosa* subsp. *Glutinosa, Solanum lasiophyllum, Eriachne mucronata* and species of *Maireana* and *Triodia* on narrow breakaways and rocky slopes on edges of hills and ranges.	None
	S1	Hummock Grassland of *Triodia epactia* with pockets of *Triodia basedowii* and *Triodia pungens* with emergent *Corymbia hamersleyana*, *Eucalyptus gamophylla*, *Eucalyptus leucophloia* over *Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia rhodophloia, Codonocarpus cotinifolius, Psydrax latifolia* and *Grevillea berryana* over *Acacia adoxa* var. *adoxa, Acacia arida, Acacia tenuissima, Acacia tetragonophylla, Acacia bivenosa, Acacia distans, Acacia hilliana, Eremophila latrobei* and *Eremophila forrestii* subsp. *Forrestii* over range of annual species on gravely soils on lower slopes.	Boolgeeda, Newman, Platform
	S2	Hummock Grassland of *Triodia basedowii, Triodia* aff. *Wiseana and Triodia epactia* with emergent *Acacia pruinocarpa, Acacia inaequilatera, Corymbia deserticola* subsp. *Deserticola, Corymbia hamersleyana, Eucalyptus leucophloia* and *Eucalyptus gamophylla* over *Eremophila latrobei, Acacia adoxa* var. *adoxa, Acacia arida, Acacia bivenosa, Eremophila exilifolia, Acacia spondylophylla, Acacia ancistrocarpa, Acacia bivenosa, Acacia inaequilatera, Acacia hilliana, Indigofera monophylla* and a range of annual species on gravelly soils on mid and upper slopes of small ranges.	Boolgeeda, Newman, Platform
	S3	Hummock Grassland of *Triodia wiseana* with emergent *Eucalyptus leucophloia, Corymbia hamersleyana* over *Acacia adoxa* var. *adoxa, Acacia hilliana, Acacia marramamba, Codonocarpus cotinifolius*, *Indigofera monophylla*, *Hakea lorea* subsp. *Lorea* over *Goodenia stobbsiana* and mixed *Senna* and *Ptilotus* species on gravelly soils on mid and upper slopes of ranges.	Newman, Platform
	S4	Hummock Grassland of *Triodia basedowii* and *Triodia pungens* with emergent *Eucalyptus leucophloia, Hakea lorea* subsp. *Lorea, Grevillea wickhamii, Acacia ancistrocarpa, Acacia bivenosa, Acacia inaequilatera* over a range of annual species on low hills and ranges.	Newman, Oakover
	X1	Hummock Grassland of *Triodia wiseana w*ith emergent *Eucalyptus socialis, Eucalyptus trivalva* and *Corymbia hamersleyana* over *Acacia tenuissima, Petalostylis labicheoides, Santalum lanceolatum, Senna artemisioides* subsp. *Oligophylla* x *helmsii*, *Rulingia luteiflora, Acacia bivenosa, Acacia inaequilatera, Acacia maitlandii* (narrow form) and a range of annual species on calcrete soils on mid to upper slopes.	None
	X2	Hummock Grassland of *Triodia wiseana w*ith emergent *Eucalyptus socialis* over *Melaleuca eleuterostachya*, *Senna artemisioides* subsp. *Oligophylla, Acacia maitlandii* (narrow form), *Calytrix carinata* and *Acacia bivenosa, Themeda triandra* and a range of annual species on calcrete soils on lower slopes.	Calcrete
	X4	Hummock Grassland of *Triodia basedowii, Triodia wiseana* and *Triodia pungens w*ith emergent *Eucalyptus leucophloia* and *Corymbia hamersleyana* over *Acacia adoxa* var. *adoxa, Acacia tetragonophylla, Mirbelia viminalis, Acacia victoriae, Eremophila cuneifolia, Acacia hamersleyensis, Petalostylis labicheoides, Senna glutinosa* subsp. *Glutinosa* and *Acacia bivenosa* and a range of annual species on calcrete soils on lower slopes.	Calcrete, Oakover

The calcrete soils present in the Calcrete and Oakover land systems give rise to hummock grasslands (X1, X2, and X4), as well as tall acacia shrublands (X3) within minor gullies (Mattiske Consulting Pty Ltd 2009: Table 6). Limestone spinifex is the most common *Triodia* species in the hummock grasslands, but soft and hard spinifex is also present (Mattiske Consulting Pty Ltd 2009: Table 6). There are occasional trees and shrubs (predominantly *Eucalyptus spp.* and *Acacia spp.*), as well as annual species (Mattiske Consulting Pty Ltd 2009: Table 6).

The narrow drainages, flood plains, and river channels of the River land system offer a comparatively diverse overstorey of trees and shrubs due to their proximity to water, particularly along channel banks. Low *Eucalyptus* woodlands (C1 and C2) occur along minor creek lines and have *Eucalyptus xerothermica* and smooth-barked coolabah (*Eucalyptus victrix*) over low shrubs, grasses, and flowering plants (Mattiske Consulting Pty Ltd 2009: Table 6-7). Open woodland (C4) occurs along Weeli Wolli Creek, the only major creek line in the project area, and this vegetation community is characterised by its large trees, including river red gum *(Eucalyptus camaldulensis), Eucalyptus victrix,* and silver-leaved paperbark (*Melaleuca argentea*) (Mattiske Consulting Pty Ltd 2009: Table 6-7). In addition, low mulga woodland to tall acacia shrubland (M2) is present along the edges of major creek lines (Mattiske Consulting Pty Ltd 2009: Table 6-7). While the C4 communities are restricted to Weeli Wolli Creek, M2 communities are more widely dispersed and occur alongside the larger tributaries of Weeli Wolli Creek (Mattiske Consulting Pty Ltd 2009).

Fauna

The native terrestrial fauna of the Hamersley Plateau include a wide variety of mammal, bird, and herpetofauna species that are important to the traditional diet of Aboriginal people. A faunal survey of vertebrate species within the Hope Downs 1 lease indicates that the species richness compares favourably with other areas of the inland Pilbara such as Karijini National Park, Yandicoogina, Woodstock-Abydos Reserve, and the Marandoo tenement (Ecologia 1997). It is important to note that the diversity of marsupial species has significantly decreased in the past century due to habitat loss and the introduction of non-native fauna.

Kangaroos and wallabies are important wild game to indigenous Australians, but smaller-sized marsupials were also targeted by Aboriginal peoples in the past. Several large macropod species subsist throughout the plateaux, including the red kangaroo (*Macropus rufus*), the euro or wallaroo (*Macropus robustus*), and the rock wallaby (*Petrogale rothschildii*) (Brown 1987: 10; Longbottom 2004: 54). Medium-sized marsupials occupying the ranges consist of the northern brushtail possum (*Trichosurus arnhemensis*), bilby (*Macotis lagotis*), mulgara (*Dasycercus cristicauda*), and the northern quoll (*Dasyurus hallucatus*). Smaller marsupial species documented on the lease include the western pebble mouse (*Pseudomys chapmani*), Pilbara ninguai (*Ningaui timealeyi*), delicate mouse (*Pseudomys delicatulus*), and common rock rat (*Zyzomys argurus*). The short-beaked Echidna (*Tachyglossus aculeatus*) is the only monotreme found in the region.

The dingo (*Canis familiaris dingo*), although not native to the Australian continent, has survived in the Pilbara since the mid-Holocene, approximately 4000 to 5000 years ago (Johnson and Wroe 2003). Through predation and competition, the dingo has been implicated in the demise of many native terrestrial fauna. Three prominent marsupial species that disappeared from mainland Australia are the Thylacine (*Thylacinus cynocephalus*), Tasmanian devil (*Sarcophilus harrisii*), and Tasmanian native hen (*Gallinula mortierii*) (Archer 1974; Baird 1991; Corbett 1995). Until recently, it is believed that these species only survived in Tasmania because the dingo was never introduced to the island; however, a recent argument suggests that humans may have hunted these animals to extinction on the mainland (Johnson and Wroe 2003).

The Hamersley Plateau is inhabited by hundreds of bird species, many of which were economically important to local Aboriginal people. Some economically important large bird species include the emu (*Dromaius novaehollandiae*) and bush turkey (*Ardeotis australis*). These birds were (and continue to be) an import component of the traditional Aboriginal diet, and many parts of the animal carcass were utilised as components of other material culture items (*e.g.*, bone awls, clothing, and headdresses). Other notable bird species include spinifex pigeon (*Geophaps plumifera*), galahs (*Cacatua roseicapilla assimilis*), and birds of prey such as the brown goshawk (*Accipiter fasciatus didimus*) and brown falcon (*Falco berigora berigora*) (Brown 1987).

Lizards and similar herpetofauna also inhabit the region and were frequently consumed by past Aboriginal populations. In particular, the large goanna (*Varanus giganteus*) and similar *Varanus* lizard species comprised an important part of the local diet.

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