

Standing Committee on Environment and Public Affairs

Your ref: A703078, Petition No. 074 – Submission

All documents and correspondence referenced in this submission have been provided to the committee clerk:

Petition No. 074 addresses three issues regarding the Dampier Archipelago.

1. As a matter of urgency, the petitioner reiterates the call for Dampier Archipelago to be nominated for World Heritage Listing at the State Government's earliest opportunity.
2. The petitioner opposes further development of heavy industry on Murujuga and by inference, recommends all future heavy industry be placed on the Maitland Heavy Industry Estate.
3. The petitioner declares the need for evaluation of the cumulative airshed of pollutants and all emissions that impact on Murujuga (the Gazetta's of the Burrup Peninsula and Dampier);¹ which, along with 43 other islands, constitutes the Dampier Archipelago as covered by the National Heritage listed area No. s 127.^{2 3}

1. World Heritage Listing of the Dampier Archipelago

Burrup (Murujuga) World Heritage Listing chronology of nominations.

1. In 1980, a delegation of members of the Academe of Humanities, on behalf of Australian Heritage Commission, visited the Burrup for consideration for World Heritage nomination.
2. The region was identified as potential World Heritage in Australia's Wilderness Heritage, World Heritage Areas, Kevin Weldon, reprinted 1989, 1992. Figgis, Penelope (Penny) and Mosley, J.G., 1988
3. On the 12 July 1994, Hon Robert Tickner MP received a request for Nomination of the Burrup to World Heritage status from the International Federation of Rock Art Organisations.
4. In 2002, the Australian Conservation Foundation submitted a request for Nomination of the Burrup to World Heritage status.
5. On 26 March 2003, Hon Dr. David Kemp MP, Commonwealth Minister for the Environment and Heritage, sought comment from the West Australian State Government on World Heritage Nomination for the Dampier Archipelago.⁴ He indicated the opportunity of including the rock engravings of the Burrup in said a World Heritage Nomination. There was no positive response to Minister Kemp in support of the nomination, though in a reply letter dated 15 May 2003, Hon Judy Edwards, West Australian Minister for the Environment, advised that the Traditional Owners of the Burrup were in support of the concept of World Heritage listing,⁵ thereby triggering

¹ 1979-05-10 Dampier Peninsula Named-Hamersley News

² 2007-07-03 S127 Gazette Notice NHL.pdf

³ 2007-07-03 S127 Gazette Map Place ID 105727.pdf

⁴ 2003-03-26 Kemp Letter to Edwards

⁵ 2003-05-15 Letter to Kemp.doc

clause 12.1 to 12.5 of the Additional Deed of the Burrup and Maitland Industrial Estates Agreement (ADBMIEA).^{6 7 8 9 10}

6. On 30 May 2003, I (Robin Chapple), after discussion with named parties of the Burrup and Maitland Industrial Estates Agreement (BMIEA), referred the rock engravings on the Burrup Peninsula and other islands to the (then) Federal Minister for the Environment and Heritage, for inclusion in a World Heritage serial nomination of Aboriginal rock art properties.
7. 16th June 2003: Chrissy Grant, Director of Indigenous Heritage Section: Australian and World Heritage Division, and Dave Collett of the Federal Department of Environment and Heritage, in cooperation with Western Australian Department of Conservation and Land Management (CALM) to organise the first meeting with Traditional Owners of the Burrup region. The group was called the 'Burrup Heritage Committee'. The Traditional Owners who attended the meeting expressed interest in the proposed World Heritage serial nomination for Aboriginal rock art. This was further confirmed with a meeting of the National Trust.
8. Freedom of Information Applications (FOIs) indicate a flurry of concern that the process established under clauses 12.1 to 12.5 of the ADBMIEA should not continue. No further meetings of the 'Burrup Heritage Committee' were ever convened.
9. The National Trust of Australia called for both the Federal and State Governments to nominate the Dampier Rock Art Precinct as Australia's first World Heritage Landscape on the 20th of December, 2006. This call was restated in November 2007, when the National Trust nominated the Dampier Archipelago in the top ten of Australia's most endangered heritage areas. In 2008, this request was again reiterated with the inclusion of the Dampier Rock Art Precinct in the National Trust "Our Heritage at Risk" list.
10. During the 2017 State General Election both the (then Government) and the Opposition stated they would seek world heritage listing for the Burrup Peninsula and Dampier Archipelago.
11. On 27th August 2018 all parties but one agreed (via a letter) to progress a nomination of the Burrup Peninsula and Dampier Archipelago for World Heritage recognition to the Federal Minister for Environment. It is unknown whether the letter has been dispatched. If it has not, there is no reason dispatch should be delayed as all the contracting parties have repeatedly supported World Heritage listing. Signatories include Yaburara deed party members, Audrey Cosmos, Valerie Holborow and Kevin Cosmos.

Recommendation: the Committee establish whether the nomination of the Burrup Peninsula and Dampier Archipelago for World Heritage recognition has been sent to the Federal Minister for Environment. If it has not, the Committee should encourage the Government to do this at their earliest convenience.

2. Curtailing further industry on Murujuga (the Burrup Peninsula and Dampier) and development of the Maitland Heavy Industrial Estate

⁶ 2003-01-16 BMIEA Additional Deed.

⁷ 2003-06-05 Ministerial Action Sheet 20239

⁸ 2003-06-06 Daniel Smith to DG on 20239

⁹ 2003-06-13 Advice to Minister 20239

¹⁰ 2003-07-03 Brown to Hockey on Kemp

At the outset, it is vital to understand why the areas of the Dampier Archipelago were identified as the primary space suitable for heavy industry development. An explanation of how and why Maitland was considered and then opposed for further development will follow.

Port facilities to export iron ore began to be conceptualised after the discovery of the Mount Whaleback deposit in 1957. At this stage, the Government preferred Depuch Island for the site of an industrial port. The desire to develop Depuch Island as the site of an industrial port forced a heritage assessment of the island. This assessment was carried out by a party from the WA Museum commencing on 26th May, 1962.¹¹

Having only surveyed Depuch Island, and with no other foundations, the 1964 WA Museum Special Publication No 2 WDL Ride (IM Crawford, GM Storr, RM Berndt & RD Royce) declared the number of engravings at sites throughout the region (see Table 1).

TABLE 1
Numbers of Engravings on Depuch Island, compared with other sites in Western Australia.

<i>Depuch</i>	<i>5,000</i>
<i>Kimberley</i>	<i>Few only</i>
<i>Port Hedland</i>	<i>800*</i>
<i>Woodstock Station Area</i>	<i>Over 500</i>
<i>Dampier Archipelago</i>	<i>200</i>
<i>Hamersley Ranges</i>	<i>Unknown</i>
<i>N.W. Cape Area</i>	<i>20</i>
<i>Desert</i>	<i>Few reports</i>

However, it is now known the Dampier Archipelago contains approximately 2 million petroglyphs, with more than a million on the Burrup Peninsula and Dampier (Murujuga) alone.

It was, in part, the tabling of this report that led the government to conclude that, from an archaeological perspective, the Dampier Archipelago was a more suitable location for industry. This notion is exemplified by the Press Release from E. H. M. Lewis, Minister for Education and Native Welfare on 23rd December, 1964.¹²

At the same time, one of the first State Agreements, the *Iron Ore (Mount Goldsworthy) Agreement Act 1964*¹³, which covered Depuch Island was assented to. Indeed it was the same day that this State Agreement was assented to that the Minister for Education and Native Welfare tabled the aforementioned report, identifying that Depuch Island should not be used for an industrial port. When the Goldsworthy mine was developed by Utah Development Co. in 1965, the port facilities were constructed at Finucane Island, Port Hedland.

Establishing small ports was in contrast to the plans by Lang Hancock who on the 10th June 1964, presented the State Government with a plan on behalf of National Bulk carriers mining company, Sentinel mining. The 'Ludwig Plan' was an integrated design for the railing and shipment of iron ore out of the Pilbara. Lang Hancock supported the National bulk Carriers proposal for a much larger port than Port Hedland, Dampier, and Cape Lambert, to be constructed on Ronsard Island near Depuch Island. It proposed a complex of network of rail connections to culminate in one port and rail operation for the proposed iron ore production of BHP, Cleavland Cliffs, Hamersley Iron, and Amax.

¹¹ 1964 WA Museum Special Publication No 2

¹² 1964-12-23 Press Release on Dampier, Port Hedland and Depuch

¹³ 1964-12-23 Iron Ore (Mount Goldsworthy) Agreement Act 1964

This design would reduce the requirement of rail tracks from 625 miles to about 425 miles. In addition, only one port would have been required, as opposed to the three that were constructed. Should this plan have been enacted by the government at that time, there was potential for an estimated \$150 million of capital savings. However, due to conflict that existed at that moment between the Government and Lang Hancock, this proposal was rejected.

The first major plan for the Burrup and surrounding regions was 'The Concept'¹⁴ developed by HE Graham, Minister for Development and Decentralisation. In this report, Graham championed industrial development on the Burrup Peninsula, the mainland and Port Robinson (now named Ankertell). The area on the mainland zoned for development, (see map on page 8 of 'The Concept') shows a parcel of land between the salt leases and the rail and infrastructure corridor leading to the Burrup. It is a far more suitable place for industry than on the Burrup Peninsula. Whilst West Intercourse Island was also identified for future industry, there was no connection with the industrial land on the mainland. It is important to note that the report did mention the need for adequate protection of aboriginal artefacts but made no further comments on the matter.

The next study to look at the area was the 1974 'The Pilbara Study'¹⁵ this referred to the land area as Dampier, the study did include West Intercourse Island as an industrial location and again referred to the same parcel of land on the mainland for further in mainland industrial development as described in 'The Concept' (see map page 41 of 'The Pilbara Study'). This report did not make any mention of Aboriginal heritage.

The Land and Port Planning Burrup Peninsula document of 1980¹⁶ makes no mention of industrial land on the mainland, it did however identify that the proposed industrial land was some 8 km away and identified that a port on West Intercourse Island would be costly to develop. It also states that there was need "to retain any areas of special interest (e.g. Aboriginal sites)", and that "Records to date indicate the area to be rich in Aboriginal sites, particularly the northern part of the Peninsula. Detailed surveys of all development areas would require to be undertaken to locate these".

The next report to look at the area generally was the 1992 'Pilbara 21' report.¹⁷ This report is largely informed by the background paper, 'Pilbara 21, A Land Use Strategy for the Burrup Peninsula: A Discussion Paper'.¹⁸ Whilst both of these documents make reference to aboriginal heritage, it is seen as an impediment and something that needs to be relegated to certain areas irrespective of their value or location. They make a number of observations that are now deemed to be incorrect. Neither document indicates industrial zones on the mainland or the use of West Intercourse Island for industry or porting.

In 1993 the 'Pilbara Heavy Industry Site Evaluation Karratha Area'¹⁹ presents the first plans for the industrial development of West Intercourse. It predicated the research and development of the mainland industrial estate on the Governments preferred option of initial development of West Intercourse Island.

"The primary requirement for a suitable heavy industrial site is a large, clear, flat space upon which site works can be achieved with minimal cost. The preliminary survey identified six such mainland sites (which are considered here) and two sites in the Dampier Archipelago (West Intercourse Island and the Burrup Peninsular)."

¹⁴ 1973 The Concept

¹⁵ 1974-06 The Pilbara Study

¹⁶ 1980-01 Land and Port Planning Burrup Peninsula SLAM

¹⁷ 1992-06 Pilbara 21 Final Strategy Report

¹⁸ 1992-01 Pilbara 21 A Land Use Strategy for the Burrup Peninsula A Discussion Paper

¹⁹ 1993-08 DRD Pilbara Heavy Industry Site Evaluation Karratha Area

This document examined six areas on the mainland that would be suitable for heavy industry. It was concluded that areas 4, 5 and 6 (Maitland) in Figure 1 were most suitable; site 4 being the same area identified in 'The Pilbara Study'²⁰ and 'The Concept'²¹ (see comparative maps²²). The paper also ascertained that "Gas is available through the site [4] and the Hamersley Power Line runs along the eastern end." It is also adjacent to the access corridor to the Port of Dampier and is closer to the Port of Dampier than Maitland Industrial Estate. Drilling investigations of both sites 4 and 6 were carried out in 1994, and no particular obstructions were found at either site.²³

The EPA has assessed the Maitland Industrial Estate in 1997.²⁴ And stated in 1998 "This (Maitland) Estate has been assessed by the EPA, but currently there are no plans for projects to be established there. --- the EPA looks forward to the time when the Maitland Estate becomes an attractive alternative to the Burrup"²⁵.

In discussing the suitability of the Maitland Estate for industrial development, it has always been predicated on the primary development of West Intercourse Island and the costs²⁶ associated with such joint development.²⁷ This is predicated on the idea, not fact, that Maitland can only be developed by first developing West Intercourse Island.

In 1994, the 'Review of Aboriginal Heritage: Karratha and Port Hedland Heavy Industry Estates' it is identified, albeit with little survey work, that West Intercourse island was densely covered in rock art.²⁸ Later studies of West Intercourse Island confirmed that it is home to a plethora of petroglyphs. Dr Patricia "Pat" Vinnicombe, a member of the Western Australian Government's 'Rock Art Monitoring Management Committee',^{29 30} has, on a number of occasions, ruled out West Intercourse Island for development due to its archeological value. Additionally, on the 5th of April 2006 Fred Riebeling MLA, Speaker of the Western Australian Legislative Assembly confirmed in a press release that West Intercourse island was densely covered in rock art and could not be used as part of the Maitland Industrial Estate.

*"The Maitland Industrial Estate has been proposed as the alternative to further developing the Burrup Peninsula by some people who don't understand the distribution of Rock Art. This is not an option as rock art is widespread on West Intercourse Island and this would prohibit its use as the port for the Maitland Industrial Estate".*³¹

Developing a mainland industrial site

One of the most prolific fallacies is the cost of developing the Maitland Industrial estate which has always included the additional cost of developing West Intercourse Island.³² In 1994, the cost of developing the Maitland Industrial Estate was estimated to be \$151.8 million of which \$137 million was for the Onshore Causeway \$59.6M, Channel Causeway \$11.2M, Bridge \$27.6M, West Intercourse Island Corridor \$27.0M and 2000 TPH Conveyor at \$31.5M. This left only \$14.1 million for the development of the Maitland Industrial Estate comprised of Storm water Diversion Drains

²⁰ 1974-06 The Pilbara Study

²¹ 1973 The Concept

²² Preferred site 4 1973-1993

²³ 1994 Results of Drilling Investigations at the Proposed Heavy Industry Site Karratha

²⁴ 1997-05 Maitland Heavy Industrial Estate Karratha EPA

²⁵ 1998-99 EPA Annual Report

²⁶ 2006-07 Dampier Archipelago Burrup Peninsula, Heritage and Rock Art, Questions

²⁷ 2006-07-26 Pilbara Region Burrup - Maitland Industrial Estates

²⁸ 1994 Review of Aboriginal Heritage Karratha and Port Hedland Heavy Industry Estates

²⁹ 2002-08-21 Interview on Maitland with Vinnicombe

³⁰ 1997 SITE EVALUATION

³¹ 2006-04-05 PR National Heritage Listing-Fred Riebeling

³² 1994-09 DRD Karratha Heavy Industry Site Engineering & Environment

\$0.8M, 132kV Power Line (21km) \$10.2M, 100mm Above Ground Water Line (25km) \$1.9M, Access Road (200m) \$0.1M and Levee Bank at \$1.1M. In summation, this means that the actual cost of developing Maitland (in 1994) was only some 9% of the figures being quoted. If one was to include the estimated cost of dredging to the new Port Development of potentially \$194M then the cost of developing Maitland was only some 4% of the original estimated costs.

Maitland, having been fully environmentally assessed, can be developed effectively by the use of corridors either to the North or South of the Dampier Salt ponds. Another option for industrial development on the mainland is the aforementioned parcel of land identified in the Concept³³, the Pilbara Study³⁴ and the DRD Pilbara Heavy Industry Site Evaluation Karratha Area³⁵. This parcel of land is part of Temporary Reserve 70/5461 and has a Ministerial Purpose for the Industrial Development of the Roebourne and Karratha Area and this area is a Ministerial Reserve to provide for orderly development in and around Karratha and Roebourne. The area is traversed by the gas pipeline and the Heavy Transmission Line and has to its eastern edge the Rio Tinto Rail easement. Additionally, it also has, at the end of its site, connection to the infrastructure corridor that leads to the Dampier Port. It is important to note that Maitland is 25km from Dampier Port whilst this Ministerial reserve is only 16km.

In January 2000, the State of Western Australia notified its intention to acquire land for the construction of heavy industrial estates on the Burrup Peninsula and adjacent Maitland area, along with any native title rights and interests that the native title parties may have had. At that time there were three registered native title claims covering the proposed acquisition area, all of which claims were part heard in the Federal Court. The first claim, by the Ngarluma Yinjibarndi, had been lodged in 1994. Two other groups, the Yaburara Mardudhunera and the Wong-Goo-To-Oo, lodged claims in 1996 and 1998 respectively. Being registered native title claimants these groups had the right, under the Native Title Act 1993, to negotiate with the Western Australian Government.

BMIEA³⁶ provides that in exchange for the native title parties' agreement to the surrender and permanent extinguishment of native title on the Burrup and Maitland Estates industrial land and the land required by the State for residential and commercial purposes in Karratha. In July 2003, after the signing of BMIEA, the Federal Court found that non-exclusive native title rights still existed over parts of the land the subject of the native title claims but that native title no longer existed over the Burrup Peninsula. This agreement contained an objectionable clause (4.8) which states that on and from the Satisfaction Date, the Contracting Parties [traditional owners] agree that the Contracting Parties will not, in their capacity as owners of the Burrup Non-Industrial Land, lodge or cause to be lodged any objection to development proposals intended to occur on land within the Industrial Estate. This clause in my view breaches Article 8, 11, 12 and 13 of the *United Nations Declaration on the Rights of Indigenous Peoples*.

3. The need to evaluate and reduce the cumulative airshed of pollutants and all emissions that impact on the Gazettal's of the Burrup and Dampier

Current Assessment of the Impact of Pollution on Murujuga Rock Art

The petroglyphs of Murujuga are unique in the world. The Dampier Archipelago is the only known place where at least 45,000 thousand of years of human culture and spiritual beliefs through a changing environment and an Ice Maxim are captured in rock engravings.

³³ 1973 The Concept

³⁴ 1974-06 The Pilbara Study

³⁵ 1993-08 Pilbara Heavy Industry Site Evaluation Karratha Area

³⁶ 2003 Burrup and Maitland Industrial Estates Agreement

The main reason for the carvings retention over such a lengthy period is that they are carved on Granophyre, whilst Granophyre spalls (ie over time loses its corners) it does not exfoliate (ie over time loses its face) as per other granitites. Conventional granites lose their face after approximately 3,500 years. Recent studies across the Australian land mass have indicated that the types of carvings that exist on the Burrup were carried out right across the Australian continent, the “archaic faces” document links with an art and ritual tradition dispersed widely across the north and centre of the continent, occurring almost always in remote valleys in impressive ranges (the Cleland Hills, the Calvert Ranges, the Durba Hills) but it is only on the Burrup due to the nature of the Granophyre that the carvings remain.

Granophyre AyG and AyGr is the upper unit of Gidley Granophyre succession and makes up most of Burrup Peninsula with outcrops on the north-western side, Dolphin, West Intercourse, Angel, Gidley and outcrops also on East Lewis, Enderby and Eaglehawk and some of the smaller islands. This granophyre is fine- to medium-grained, massive, homogeneous, well jointed, dark reddish green to dark blue-grey or purple-grey. It consists almost entirely of finely intergrown quartz and alkali feldspar.

Murujuga is also the location for a major petrochemical industrial complex which is served by one of the largest bulk handling ports in the world. Emissions from industry have increased acidity of rock surfaces at some rock art sites by more than 1000-fold from near neutral pH of 6.8 ± 0.2 pre-industry to as low as 3.8 ± 0.15 in 2017³⁷. Maintaining integrity of the outer rock is essential for survival of the petroglyphs. The ‘patina’ or ‘rock varnish’ on the outer rock is formed at an extremely slow rate of around 10 microns per 1000 years under neutral to weakly alkaline conditions of desert environments. Acid dissolves the oxides in the rock varnish. Therefore, research is needed urgently to show whether the combined emissions from industry, shipping and the environment are dissolving the outer rock. In the meantime, the Western Australian Government should invoke the Precautionary Principle from the Environmental Protection Act 1986 by restricting further industrial development on Murujuga and by setting regulations that limit industrial emissions to near zero.

Significance of rock art (petroglyphs) on Murujuga

The Dampier Archipelago, which includes the island Murujuga (‘Burrup Peninsula’), is estimated to contain more than one million rock art images in the form of petroglyphs (JMCD CHM 2011). These petroglyphs capture at least 45,000 thousand years of human culture and spiritual beliefs through a changing environment (Bednarik 1979; Donaldson 2009; JMCD CHM 2011; McDonald and Veth 2009; Mulvaney 2011). The rock art is believed by some to contain the oldest known representation of the human face (Mulvaney 2015). Other petroglyphs include elaborate geometric designs, extinct mammals such as megafauna, the fat-tailed kangaroo and Thylacines, as well as existing animals, birds and sea creatures (Bird and Hallam 2006; JMCD CHM 2011; Mulvaney 2009, 2013, 2015; McDonald 2015). The Murujuga inhabitants created this rock art until 1868, when the Yaburara indigenous population was almost exterminated in the ‘Flying Foam Massacre’³⁸. The petroglyphs on Murujuga are a priceless, irreplaceable, historical and archaeological treasure of global significance.

Industrial development of Murujuga

Murujuga is also the site of a large industrial complex, beginning in the 1960s with an iron ore export terminal (1964). From then, a salt production facility (1970), natural gas processing facilities (early 1980s), liquefied natural gas (LNG) production plants (1995 and 2007), an ammonium fertiliser plant (2006) and an ammonium nitrate production facility (2017) have all been established on Murujuga.

³⁷ 2017-02-21 Black, MacLeod, Smith - Theoretical effects of emissions on rock art-JASREP

³⁸ 2018-03-29 Flying Foam Massacre Report-Chapple RH

Pollution from industry on Murujuga

The National Pollution Inventory (NPI) shows that in 2016-17 Woodside Energy Limited Burrup gas plants produced 8000 tonnes (t) oxides of nitrogen, 97t of sulphur dioxide and 16000t of volatile organic compounds. The NPI also shows that the Yara Pilbara ammonium fertiliser plant produced 13600t of sulphur dioxide equivalents in 2014. There are not yet annual figures available for the Yara ammonium nitrate plant. The Port of Dampier is one of the busiest bulk-handling ports in the world. According to the Pilbara Ports Authority, 3173 vessels entered the port during 2017-18. A single bulk cargo ship burning high-sulphur fuels has been estimated to release 5200t of sulphur oxides into the atmosphere annually (Vidal 2009).

Sulphur dioxide emissions are coming four-fold from the shipping, liquefied gas, fertiliser and ammonium nitrate plants, all of which are in close proximity to the deeply significant rock art found on Murujuga. This heavy pollution impacts the rock art significantly because sulphur dioxide combines with water in the air to form sulphuric acid and, as aforementioned, acid dissolves the outer rock, damaging the rare and invaluable ancient petroglyphs.

Murujuga rocks and petroglyph formation

To assess the potential impact of industrial emissions on the petroglyphs, it is important to understand the nature of the rocks on Murujuga and the way the petroglyphs were formed. Rocks on Murujuga are igneous and crystallised at high temperatures to produce extremely hard granophyre and gabbro types (Hickman 2001; Donaldson 2011). The rock faces degrade extremely slowly (Pillans and Fifield 2013), producing an orange/yellow coloured weathering rind that can attain a thickness of 5 -10 mm in 30,000 years depending on the rock type (Bednarik 2007; Donaldson 2011). The weathering rind is overlaid by a hard, thin dark, red/brown/black, 'patina' or 'rock varnish' from <1 to 200 microns thick (Liu and Broecker 2000). The petroglyphs are created on the flat surfaces by breaking through the patina to expose the underlying pale weathering rind, which results in a colour and contour contrast (Vinnicombe 2002). Therefore the integrity of the 'patina' or 'rock varnish' is crucial for preservation of a petroglyph.

Changes to the acidity of Murujuga rock surfaces since industry establishment

Rocks collected pre-industrialisation from Murujuga and stored at the Western Australian Museum were found to have a rock surface with circum-neutral pH (pH of 6.8 ± 0.2 ; MacLeod 2005³⁹). MacLeod (2005) found that the pH of rock surfaces at 30 sites across Murujuga ranged from 4.25 to 5.74 when measured in 2003/4. More recent measurements in 2017 of the same rocks showed continuing decline in pH with individual sites being as low as 3.81 ± 0.15 . The lowest individual measurement was pH 2.89. At the extreme, these measurements suggest the acidity of rock surfaces has increased by more than 1000-fold following industrialisation of Murujuga.

Potential effects of emissions on petroglyphs

Electrochemical theory dictates that lowering of pH will promote dissolution of the manganese and iron oxides from the patina (Black et al. 2017b). Nitrogen emitted from industry on Murujuga, including an estimated 25 t/year of ammonium nitrate dust-sized particles from the ammonium nitrate facility (EPA 2011), will increase nitrogen available for adventitious microbial and fungal growth. MacLeod (2005) showed a log increase in microbial mass with increasing nitrate in rock surface water. There is evidence that organic acids from trees (Bednarik 2009) and acidic bird droppings (Duffy et al. 2017) dissolve the patina from rocks on Murujuga. Microbes, fungi and lichen produce organic acids which further increase the acidity of rock surfaces and dissolve rock patina (Dragovich 1986).

³⁹ 2005-09-12-16 Ian MacLeod-Effects of moisture, micronutrient supplies and microbiological activity on the surface pH of rocks in the Burrup Peninsula

As surface acidity increases, dissolution of the darker manganese, magnetite and associated iron compounds occurs. At the same time, there is an increase in the proportion of red ferrous oxide and lighter coloured clay minerals, making the rock surfaces lighter, redder and more white/yellow in colour over time. The 'patina' or 'rock varnish' is also likely to become thinner and more porous as the manganese and iron compounds are dissolved.

Recommendation

Acidity of rock surfaces has increased up to 1000-fold since the introduction of industry at some sites on Murujuga. Theoretically, an increase in acidity of this magnitude leach the manganese and iron compounds from the rock 'patina' or 'rock varnish' over time.

Research needs to be conducted to establish whether the patina on Murujuga rocks is dissolving. Dissolution of the patina may not become visibly evident until the majority has been removed. However, whenever the patina is dissolved or flaked away, the petroglyphs will be disfigured or destroyed.

Laboratory research is required to determine whether the combinations of chemicals emitted from industry and shipping, in conjunction with those from the natural environment, will dissolve the Murujuga rock patina and, if so, the concentrations required for dissolution. Estimates must be made of the rate of patina dissolution to assess when destruction of the petroglyphs through industrial emissions is likely to occur.

Research is needed to confirm the results of MacLeod (2005) showing that the increase in nitrogen compounds on rock surfaces stimulates adventitious microbial growth, the types of organisms and quantities of acids produced. In addition, comprehensive understanding of the chemical reactions involved must be obtained so that simulation models can be constructed to predict likely impacts of future emissions on the petroglyphs, and to elucidate the means of arresting negative impacts. The proposed research is needed urgently. The University of Western Australia through the Centre for Rock Art Research + Management has established a research project to undertake the needed measurements. However, in the meantime, the Precautionary Principle in the Western Australian Environmental Protection Act 1986 should be invoked with the prevention of new industry and strict regulations to ensure emissions are near zero for existing industries and shipping.

4. Current proposals for Industrial Development on the Burrup Peninsula and the mainland.

Coogee Methanol Plant

Coogee Chemicals Pty Ltd, Mitsubishi Corporation and Wesfarmers Ltd are undertaking a joint prefeasibility study to develop a US\$1 billion+ methanol and monoethylene glycol (MEG) petrochemical plant at Site E in the Burrup SIA. MEG is a precursor chemical in the manufacture of other downstream products including polyester resins, films and fibres and is also used for antifreeze, coolants and solvents. Accordingly, this project represents a new pathway to a long standing strategic aim to produce plastics precursor petrochemicals in the State.

The proposed development would require at least 75 ha of land and consume up to 125T J/d of natural gas, as well as use of the bulk liquids jetty, seawater pipelines and infrastructure services corridors.

The Government endorsed an Option to Lease Site E on 6 December 2017 and Landcorp's board approved the grant of the option on 26 March 2018. The Option grants the proponent a right to lease Site E to 30 June 2022.

Chevron has substantial gas available for the Western Australian market through its Gorgon, Wheatstone and North West Shelf domestic gas obligations. The Department is not aware of any constraint that would prevent Chevron supplying the gas required for the project. It is currently reviewing LNG exporters' annual domestic gas reports and confirming the timing of Gorgon tranche two (expected in 2021).

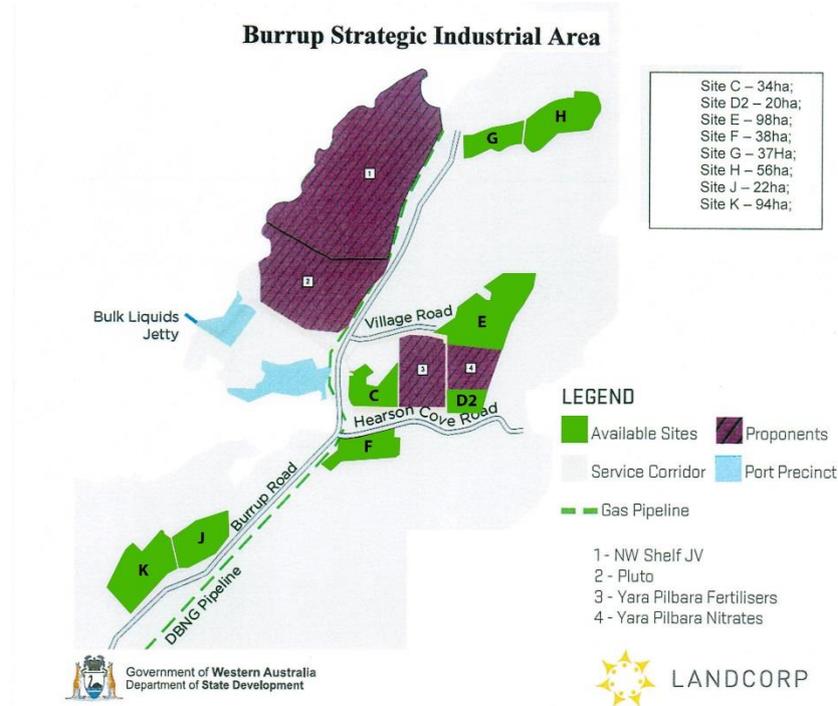
Perdaman Karratha Urea Project (see Map⁴⁰)

Perdaman Chemicals and Fertilisers Pty Ltd (Perdaman) has requested a land allocation in the Burrup SIA to progress feasibility studies for its proposed US\$3.3 billion+ Karratha Urea Project.

The Department has provided key land, port and other infrastructure information to Mr Vikas Rambal, Chairman and Managing Director of Perdaman, to inform site selection.

Mr Rambal indicated he would contact the Department to arrange agency meetings and a site visit pending the outcome of gas contract negotiations.

The sites for proposed future industrial development on the Burrup are shown on the map below:



Recommendation: to limit further acidic impact on the petroglyphs these plants must go to the mainland.

⁴⁰ 2018 Perdaman site.jpg