Yara Pilbara Nitrates

2018 Annual Compliance Report

EPBC 2008/4546

Technical Ammonium Nitrate Plant

Document No:	650-200-ACR-YPN-0006
Validity	This report was issued for information on 5th October 2018
Document Custodian	Environmental Superintendent
Document Approver	Plant Manager

Yara Pilbara

Postal Address
Locked Bag 5009
Karratha WA 6714
Australia

Visiting Address
Lot 564 and 3017 Village Road
Burrup WA 6714
Australia

Telephone
+61 8 9183 4100
Facsimile
+61 8 9185 6776

Registered Office:
Level 5, 182 St George Terrace
Perth WA 6000
Australia
Telephone: +61 8 9327 8100
Facsimile: +61 8 9327 8199

Declaration of Accuracy

Yara Pilbara Nitrates Pty Ltd (YPN) is pleased to submit this Annual Compliance Report as per condition 3 of the EPBC 2008/4546 Approval Decision (dated 14 September 2011) and Condition 3 of the directed variation (dated 12 September 2017) requiring reporting to 30 June to be submitted by 6 October each year.

In making this declaration, I am aware that sections 490 and 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents. The offence is punishable on conviction by imprisonment or a fine, or both. I declare that all the information and documentation supporting this compliance report is true and correct in every particular. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed .....

Full Name Chris Rijksen

Position Plant Manager

Organisation Yara Pilbara Nitrates Pty Ltd

ABN 33127391422

Date 5/10/2018

Yara Pilbara

Postal Address
Locked Bag 5009
Karratha WA 6714
Australia

Visiting Address
Lot 564 and 3017 Village Road
Burrup WA 6714
Australia

Telephone
+61 8 9183 4100
Facsimile
+61 8 9185 6776

Registered Office:
Level 5, 182 St George Terrace
Perth WA 6000
Australia
Telephone: +61 8 9327 8100
Facsimile: +61 8 9327 8199

TABLE OF CONTENTS

1 Introduction

1.1 Purpose

The purpose of this Annual Compliance Report (ACR) is to assess compliance with all conditions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval decision issued 14 September 2011 for the Yara Pilbara Nitrates Pty Ltd (YPN) Technical Ammonium Nitrate (TAN) production facility (TAN Plant) located on Lot 3017 within the Burrup Strategic Industrial Area on the Burrup Peninsula, Western Australia (EPBC 2008/4546).

EPBC 2008/4546 conditions have been varied by three (3) separate variations, issued in accordance with s 143 of the EPBC Act:

- Variation to conditions 8(d), 10 and 11, dated 18 December 2013;
- Variation to condition 10(c)iv, dated 10 February 2014; and
- Directed variation to condition 3, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 (delete), substitute with conditions 3, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 and add conditions 3A, 7 A, 9A, 9B, 10A, 11 A and 11 B, dated 12 September 2017.

Condition 3(a) of the revised approval issued on 12 September 2017 states:

> *By 6 October each year, the person taking the action must:*
>
> *i. Publish a report on their website addressing compliance with each of the conditions of this approval (for the reporting period 1 July of the previous year to 30 June of the reporting year), including implementation of any management plans and monitoring programs as specified in the conditions including an analysis of monitoring data required under condition 9A and 10A that has been collected during the reporting period; and*
>
> *ii. Provide documentary evidence providing proof of the date of publication to the Department.*

Following receipt of the varied conditions, the Department of Environment and Energy (DEE) informed YPN that an ACR was required to be submitted by 6 October 2017 for the reporting period 18 February 2017 to 30 June 2017. The 2017 Addendum ACR assessed an approximate four-month period in order to address the transition from the previous 12-month reporting period required under the original condition 3, (18 February to 17 February each year), to the new reporting period provided under revised condition 3.

In accordance with revised condition 3 this 2018 ACR addresses the 12-month period 1 July 2017 to 30 June 2018 and is to be published on YPN's website by 6 October 2018.

Preparation of the ACR has been guided by the Annual Compliance Report Guidelines (Commonwealth of Australia, 2014).

1.2 Scope

This 2018 ACR applies to the Project being developed by YPN to construct and operate a Technical Ammonium Nitrate (TAN) production facility (TAN Plant) located on Lot 3017 within the Burrup Strategic Industrial Area on the Burrup Peninsula, Western Australia. The TAN Plant is located approximately 13 kilometres (km) north-west of Karratha.

This 2018 ACR assesses compliance with EPBC 2008/4546 for activities carried out during the reporting period 1 July 2017 to 30 June 2018.

1.3 Project Details

The TAN Plant has a production capacity of 350,000 tonnes per annum (TPA) or 915 tonnes per day (TPD) of TAN. The project comprises three major process units, each producing a separate product in the manufacturing process:

1. Nitric Acid plant to convert ammonia and atmospheric air into Nitric Acid (NA). The NA plant has a capacity of 760 TPD as 100% weight. The main feedstock, ammonia, shall be delivered from the adjacent ammonia plant.
2. Ammonium Nitrate (AN) Solution plant to convert ammonia and NA into AN solution. This AN wet section has a capacity of 965 TPD in balance with nitric acid production capacity.
3. TAN plant to convert AN solution into TAN prill (final product). This is a dry section for production of TAN prill (0.7 and 0.8 kg/m3 density) with a capacity of 915 TPD. Surplus AN solution shall be sold as liquid.

The project also has storage, loading and transport facilities, including an incoming liquid ammonia pipeline, bulk and bagged TAN storage, bulk loading system, bagging unit and truck loading.

The project is adjacent to the Yara Pilbara Fertiliser plant operated by Yara Pilbara Fertilisers Pty Ltd (YPF), which is the source of the aforementioned liquid ammonia and which shares some common activities and personnel with YPN.

1.4 ACR Public Availability

This 2018 ACR is to be placed on the YPN website for the life of the Project. At the time of publication this 2018 ACR is available at:

https://www.yara.com.au/about-yara/about-yara-australia/pilbara/yara-pilbara-nitrates/

A URL link to the uploaded report will be sent to the DEE Compliance and Enforcement Branch through its post.approvals@environment.gov.au email address.

2 Current Status

Project construction commenced on 17 February 2013, with project commissioning completed and operations commencing on 15 September 2017, after the revised EPBC Act approval conditions were issued. The TAN Plant stopped operations on 21 September 2017, restarted on 20 May 2018, shut down again on 26 May 2018 and did not recommence within the reporting period.

An Operational Environmental Management Plan (OEMP) (including Hazardous Materials Management Plan and Aboriginal Heritage Management Plan), and an updated Emergency Response Management Plan for the TAN Plant were submitted to DoEE for review and approval on 14 September 2017. Approval was received on 15 September 2017.

The existing YPF Environmental Operating Licence (Licence No. L7997/9067/2002 issued under *Environmental Protection Act 1986* (EP Act) Part V) was amended during the audit period to include the TAN Plant operations. The amended Licence was issued on 29 June 2018. Of particular relevance to EPBC 2008/4546 is the inclusion of conditions regarding limits on emissions to air in the Licence.

Environmental monitoring and reporting continued during the reporting period, as YPN assumed responsibility for these functions from the Engineering Procurement Construction (EPC) contractor engaged for construction and commissioning.

As reported in the 2017 ACR Addendum, both the Burrup Rock Art Technical Working Group (BRATWG) and the DWER-managed rock art monitoring program were inactive during the previous audit period, as BRATWG completed its five year term of engagement on 30 June 2016. Notwithstanding, the resultant monitoring report required by EPBC 2008/4546 condition 10 was published on the DWER website in September 2017. In the 2017 audit period, YPN received the approval of the Commonwealth Minister for the Environment prior to engaging recognised Heritage experts to conduct rock art monitoring with Murujuga Aboriginal Corporation, at the same sites as previously monitored under condition 10, as required by new condition 10A.

As reported in the 2017 ACR Addendum, on 30 November 2016, the Senate Environment and Communications References Committee commenced an inquiry into the protection of Aboriginal rock art of the Burrup Peninsula, to report by 21 March 2017. The Senate granted various extensions of time to report until the final report was handed down on 21 March 2018.

The Senate report noted instances of administrative non-compliance with elements of the EPBC Act approval conditions. The report also noted YPN had not fully met approval conditions in relation to air monitoring (refer to condition 9 in the 2017 ACR Addendum), resulting in the directed variation to conditions, issued as a consolidated set of conditions on 12 September 2017.

3 Compliance

3.1 Statement of Compliance

The results of the assessment of compliance with EPBC 2008/4546 approval conditions are shown in Table 1.

A total of 15 conditions comprising of 50 assessable sub-conditions were assessed. The assessment found the following:

- 34 sub-conditions were found to be 'compliant';
- 1 sub-condition was found to be 'non-compliant' (although historical); and
- 15 sub-conditions were found to be 'not applicable'.

The non-compliance relates to condition 9(a), which is an historic issue related to baseline air quality monitoring commencing after the stipulated time. The monitoring was subsequently undertaken and completed prior to the audit period and; therefore, the condition can be taken to be not relevant to the reporting period and 'completed'.

As reported in the 2017 ACR Addendum YPN identified some gaps in evidence, specifically with reference to historic correspondence between YPN and various regulators that have been cited as evidence in previous ACRs. In these cases where YPN did not have the original or a copy of the evidence, but reference to the evidence has been previously made, the evidence was flagged as "not sighted". For this 2018 ACR, where relevant, reference is made to the 2017 ACR Addendum for these historical items and, if appropriate, noted as "complete" (i.e. "compliant [complete]").

In assessing compliance, the following definitions have been used:

Designations	Definition
Compliant	'Compliance' is achieved when all the requirements of a condition have been met, including the implementation of management plans or other measures required by those conditions.
Non-compliant	A designation of 'non-compliant' is given where the requirements of a condition or elements of a condition, including the implementation of management plans and other measures, have not been met.
Not applicable	A designation of 'not applicable' is given where the requirements of a condition or elements of a condition fall outside of the scope of the current reporting period. For example a condition which applies to an activity that has not yet commenced

3.2 EPBC2008/4546 Compliance Table

Table 1 EPBC2008/4546 Compliance Table

Condition Number	Condition	Is the Project compliant with this condition?	Evidence / Comments
1	Within 30 days after the commencement of the action, the person taking the action must advise the Department in writing of the actual date of commencement.	Compliant	Refer to 2017 ACR. YPN seeks Department agreement that this condition can be considered 'complete'.
2	The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the plan(s) and program(s) required by this approval, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	Compliant	Refer to all other items in this table. Refer to attachments provided. Further documentation is available upon request by DEE.
3(a)	By 6 October each year, the person taking the action must: i. Publish a report on their website addressing compliance with each of the conditions of this approval (for the reporting period 1 July of the previous year to 30 June of the reporting year), including implementation of any management plans and monitoring programs as specified in the conditions, including an analysis of monitoring data required under condition 9A and 10A that has been collected during the reporting period; and ii. Provide documentary evidence providing proof of the date of publication to the Department.	Compliant	The 2017 ACR Addendum was published on the YPN website by 6 October 2017, with the Department notified on that date (Attachment 3a). Separate supporting reports have been completed and published to the YPN website as follows: • Air Quality Analysis Report (as per Condition 9A) • Rock Art Monitoring Analysis Report (as per Condition 10A)
3(b)	Reports required under Condition 3a) must remain published for the life of the approval unless otherwise advised by the Minister in writing.	Compliant	The 2017 ACR Addendum was available on the YPN website during the preparation of this report at https://www.yara.com.au/about-yara/about-yara-australia/pilbara/yara-pilbara-nitrates/ (Attachment 3b)
3A	The person taking the action must advise the Department of a potential or actual non-compliance with these conditions in writing within 7 days of becoming aware of the potential or actual non-compliance.	Compliant	This assessment did not identify any potential or actual non-compliances in the audit period.
4	The person taking the action must ensure that wastewater from the facility meets the requirements set out in Statement 594 for discharges into the Multi User Brine Return Line (MUBRL).	Compliant	Please note Statement 594 applies to its proponent, Water Corporation, and addresses multiple users in the Burrup area (not only YPN). Water Corporation has advised that, in the reporting period, the discharge effluent from the MUBRL has met the relevant guidelines set out by the Burrup Peninsula Desalinated Water and Seawater Supplies Project: Operational Marine Environmental Management Plan (OMEMP) (refer to Attachment 4). The Water Corporation manages its obligations under Statement 594 through the approach outlined in, and implementation of, the OMEMP.
5	To ensure the protection of listed threatened species and listed migratory species, the person taking the action must only apply larvicide or adulticide within or outside the project area (as shown in Attachment 1) that is an Approved Class 11 insecticide, unless agreed to in writing by the Minister.	Compliant	No mosquito larvicide or adulticide has been applied within the TAN Plant site during the reporting period.
6	To ensure the protection of listed threatened species and listed migratory species, the person taking the action must:	N/A – refer below	Condition objective, sub-conditions refer below

6(a)	Employ such structures and apparatus as are necessary and agreed by the Western Australian Government to deter birds from entering the contaminated water pond, clean water pond, and sewage wastewater treatment station evaporation pond, as per Statement 870.	Compliant	The 2017 ACR Addendum confirmed the bird deterrence systems used on site are acceptable. Bird deterrent wires have been installed over contaminated water ponds, clean water ponds, and sewage wastewater treatment evaporation pond. Refer to Plates.
6(b)	Ensure these structures and apparatus are in place prior to commissioning and are maintained for the life of the approval.	Compliant	Refer to condition 6(a). The bird deterrent wires can deteriorate and break due to the harsh conditions on site (heat, salty air) – YPN ensures any broken wires are replaced as required and are currently reviewing materials options to improve longevity. Refer to Plates.
7	To ensure the protection of the listed threatened species; listed migratory species and the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, the person taking the action must submit to the Department the management plans mentioned below:	N/A – refer below	Condition objective, sub-conditions refer below
7(a)	Construction Environmental Management Plan (CEMP), which must be submitted to the Department at least two (2) months prior to construction and must include, but not be limited to, management measures for the following: • Air Quality and Dust; • Water Quality; • Erosion Control and Storm Water; • Waste; • Traffic; and • Blasting (if required).	Compliant	The 2017 ACR Addendum confirmed the approval status of the CEMP. YPN seeks Department agreement that this condition can be considered 'complete'.
7(b)	Operational Environmental Management Plan (OEMP), must be submitted to the Department at least two (2) months prior to operation and must include, but not be limited to, management measures for the following: • Erosion Control and Storm Water; • Water Quality; • Air Quality and Dust; • Waste; • Traffic; and • Blasting (if required).	Compliant	As reported in the 2017 ACR Addendum the revised Operational Environmental Management Plan (650-200-PLN-YPN-0001) (OEMP) and revised Emergency Response Management Plan were submitted to the Department for review in December 2016 (approximately 9 months prior to operations commencing – refer to condition 7[c]). An amended Operational Environmental Management Plan (OEMP) (including Hazardous Materials Management Plan and Aboriginal Heritage Management Plan prepared to address relevant parts of condition 7[d]) was submitted to the Department for review and approval on 14 September 2017, approval of the OEMP was received on 15 September 2017. YPN seeks Department agreement that this condition can be considered 'complete' as current and future plan revisions are addressed under conditions 12 and 13.
7(c)	Operations must not commence unless the OEMP is approved by the Minister	Compliant	The OEMP was approved on 15 September 2017 with operations commencing the same day.
7(d)	Additional management plans covering both construction and operations, must be submitted to the Department at least two (2) months prior to construction, including: • Aboriginal Heritage Management Plan; • Hazardous Materials Management Plan; and • Emergency Response Management Plan.	Compliant	The 2017 ACR Addendum confirmed the approval status of the original Aboriginal Heritage Management Plan (AHMP). The OEMP update included updates to the AHMP and Hazardous Materials Management Plan (HMMP). Emergency response is the subject of a separate plan (YPN code 250-500-PLN-000-0003). The original Emergency Response Management Plan (ERMP) was approved in 2012. A revised plan was submitted to the Department in December 2016, with the OEMP (refer to condition 7[b]). YPN seeks Department agreement that this condition can be considered 'complete' as current and future plan revisions are addressed under conditions 12 and 13.

7(e)	Once approved by the Minister, all plans required under condition 7 must be implemented.	Compliant	Refer to condition 7(b) and 7(d) regarding plan approval. All plans referred to in condition 7 were assessed for implementation status for this audit. Of 66 actions assessed in the OEMP (including AHMP and HMMP): • 64 were found to be 'conformant' • 2 were found to be 'non-conformant' The non-conformances related to: • An annual waste audit not conducted • Lack of records available regarding waste disposal As 64 of 66 actions were assessed as conformant, and the two non-conformances relate to a minor audit and records, the OEMP is assessed as satisfactorily implemented. Of 25 actions assessed in the ERMP: • 23 were found to be 'conformant' • one was found to be 'not applicable • one was found to be 'non-conformant' The non-conformance related to the schedule of planned simulated emergencies and regular exercises. This requirement is implemented, only not to the full extent listed in the plan. Although a regular program of simulations and other exercises is instituted, management advised that they have not been able to implement the total number of exercises (i.e. at the frequencies indicated in the ERMP) given demands on time. YPN is considering revisions to this element of the plan to institute a more practicable schedule without compromising competencies and preparedness. As all but one of the actions have been implemented, and the one non-conformance represents a partial non-conformance only, the ERMP is assessed as satisfactorily implemented.
7A	The management plans required under conditions 7 and 11A must not contain management actions that are inconsistent with these approval conditions or the National Heritage management principles.	Compliant	Refer to conditions 7 and 11A. Review of the plans by the Department and subsequent approval of plans by the Minister implies consistency with approval conditions and National Heritage (NH) management principles. Furthermore, this assessment has not readily identified any management plan actions that are inconsistent with the seven principles, summarised below for reference. 1. Identify, protect, conserve, present and transmit, to all generations, NH values. 2. Use best available knowledge, skills and standards; include ongoing technical and community input to decisions and actions that may have a significant impact on their NH values. 3. Respect all heritage values and seek to integrate government responsibilities. 4. Ensure that NH place use and presentation is consistent with the conservation of their NH values. 5. Make timely and appropriate provisions for community involvement, especially by people who: a) have a particular interest in, or associations with, the place; and b) may be affected by the management of the place. 6. Active participation of Indigenous people in identification, assessment and management is integral to the effective protection of Indigenous heritage values. 7. Provide for regular monitoring, review and reporting on the conservation of NH values.
8	To protect the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, particularly the rock art sites, the person taking the action must ensure that:	N/A – refer below	Condition objective, sub-conditions refer below.
8(a)	There is no unauthorised access by employees or contractors of the person taking the action to the Dampier Archipelago (including Burrup Peninsula) National Heritage Place outside of the	Compliant	YPN maintains a system to authorise access (for monitoring) including access forms and a register (Attachment 8a).

	project area (shown in Attachment 1) while those employees or contractors are undertaking work duties.		No signs of unauthorised access have been observed in the National Heritage area around the site. No incidents regarding unauthorised access have been identified.
8(b)	Chain mesh fencing of at least 2.5 metres in height is installed around the perimeter of the project site prior to construction.	Compliant	Chain mesh fencing of at least 2.5 metres in height is installed around the perimeter of the project site. The fence was installed prior to construction. Refer to Plates.
8(c)	Signs of at least $1m^2$ in size are attached to fencing at the entrance to the project site and at no less than 50 metre intervals along the fence. These signs must clearly indicate the requirements of Condition 8(a)	Compliant	The required signage is attached to fencing at the entrance to the project site. Due to the 2.5 m high security fencing completely surrounding the rest of the project site, fully restricting access to the National Heritage area, the existing signage at the entrance in combination with the high security fence is sufficient and together are measures which effectively 'go beyond compliance' with respect to the intention of this condition. Consequently, YPN asserts it is compliant with this requirement. YPN seeks agreement from the Department regarding this assertion and, if necessary to avoid future doubt, will request the condition be amended accordingly (i.e. to signage at entrance only, in combination with the high security fence on the perimeter of the remainder of the project site). Refer to Plates.
8(d)	The relevant supervisor of the person taking the action must record the names of all those required to access areas containing rock art sites inside the Dampier Archipelago (including Burrup Peninsula) National Heritage Place boundary and is able to provide these records if asked to do so by the Department.	Compliant	Refer to condition 8(a) - YPN maintains a NH register, which records the names of all those required to access areas containing rock art sites inside the NH area.
8(e)	Any impact the action has on the heritage values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place must be reported to the Department in writing within 72 hours. Impacts may include (but will not necessarily be limited to) any impacts caused by construction activity; vandalism perpetrated by personnel involved in plant construction or operations; spillage of potentially corrosive materials into the Dampier Archipelago (including Burrup Peninsula) National Heritage Place; impacts from blasting activity.	Not applicable	No impact on heritage values has been identified in the audit period.
9	To protect the National Heritage Place, particularly the rock art sites, the person taking the action must undertake an air quality monitoring program. The air quality monitoring program must:	N/A – refer below	Condition objective, sub-conditions refer below.
9(a)	Undertake air quality monitoring at three (3) sites as shown in Attachment 2. These sites being sites previously selected, designed, fenced off and used in the original Western Australian Department of Environment and Conservation (WA DEC)/CSIRO air quality monitoring program. • Site 5 - Burrup Road site; • Site 6 - Water tanks site; and • Site 7 - Deep Gorge site. The air quality monitoring must be undertaken for a period of not less than 24 months beginning from the commencement of construction. The results of this monitoring will be used to establish baseline data on levels of: • Ammonia (NH_3); • Nitrogen Oxides (NOx); • Sulphur Oxides (SOx); and • Total suspended particulates (TSP), including dust at those rock art sites.	Non-compliance (historic, complete)	As described in the 2017 ACR Addendum, YPN carried out this (baseline) air quality monitoring program at the indicated off-site locations. However, construction commenced in February 2013 and monitoring commenced in late Q3/early Q4 2013, which was assessed as a non-compliance. With the non-compliance being historic (related to timing, linked to commencement of construction), this timing element of the requirement could not be remedied. The program was otherwise implemented and completed as required by the condition. Continuation of the air quality monitoring program after the completion of the baseline program required by this condition 9(a) is addressed by condition 9A, below. As the baseline program has been completed and continuing monitoring is addressed by condition 9A, YPN seeks the agreement of the Department that this condition can now be considered 'complete'.
9(b)	Ensure that the monitoring of air quality at rock art sites is undertaken by a suitably qualified person (Air Quality).	Compliant	As described in the 2017 ACR Addendum, the review of the ambient air quality monitoring program and preparation of the baseline monitoring report was undertaken by Dr Peter Forster, Strategen Environmental Consultants Pty Ltd's air quality specialist. Peter has over 25 years' experience in air

<table>
<tr><td></td><td></td><td></td><td>quality assessments, including monitoring of gaseous, semi-volatile and particulate pollutants.

Refer to condition 9(a) above – this condition could be considered ‘complete’, on the agreement of the Department.</td></tr>
<tr><td>9(c)</td><td>Ensure air quality readings during the twenty four (24) months of baseline monitoring are taken at least four (4) times in every 12 months.</td><td>Compliant</td><td>As described in the 2017 ACR Addendum:
NH_3, NO_2 and SO_2 samples were collected for >24 months and at least once in each quarter for each year.
Dust deposition samples were collected for >24 months and at least once in each quarter for each year.
TSP samples were collected for >24 months and at least once in each quarter for each year, from the Water Tanks site only.
A baseline TSP data set was developed from TAN plant boundary monitoring of PM10 for application to all three sites. Those data were collected for >24 months and at least once in each quarter for each year.
Refer to condition 9(a) above – this condition could be considered ‘complete’, on the agreement of the Department.</td></tr>
<tr><td>9A</td><td>To protect the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, particularly the rock art sites, the person taking the action must ensure:</td><td>N/A – refer below</td><td>Condition objective, sub-conditions refer below.</td></tr>
<tr><td>9A(a)</td><td>Ongoing air quality monitoring is undertaken within 30 days after this condition comes into effect (the date the relevant variation to conditions notice is signed), and until expiry of the approval.</td><td>Compliant</td><td>Air quality monitoring has continued at sites 5, 6 and 7, with the first monitoring after condition 9A came into effect (on 12 September 2017) commencing on 14 September 2017 (reports are available on the YPN website: https://www.yara.com.au/about-yara/about-yara-australia/pilbara/yara-pilbara-nitrates/).</td></tr>
<tr><td>9A(b)</td><td>Air quality monitoring parameters are monitored at the rock art sites: Site 5 (Burrup Road), Site 6 (Water tanks site) and Site 7 (Deep Gorge site) as shown in Attachment 2.</td><td>Compliant</td><td>This condition is consistent with the previous, baseline, monitoring locations. Air quality monitoring has continued at sites 5, 6 and 7 as required (refer to the YPN website as provided in condition 9A[a]).</td></tr>
<tr><td>9A(c)</td><td>Monitoring of air quality at rock art sites is undertaken by a suitably qualified person (Air Quality).

The air quality monitoring parameters in the table below must be monitored at the frequencies indicated in the table below.
<table>
<tr><th>Element of air quality to be monitored</th><th>Specific air quality parameter to be sampled</th><th>Minimum frequency of monitoring</th></tr>
<tr><td rowspan="3">Ambient air concentration of gases</td><td>NH_3 (ammonia)</td><td rowspan="3">Continuous monitoring for at least 14 consecutive days, every month</td></tr>
<tr><td>NO_2 (nitrogen oxide)</td></tr>
<tr><td>SO_2 (sulfur oxide)</td></tr>
<tr><td>Airborne particulate concentration</td><td>Total suspended particulates up to 50 µm (TSP)</td><td>Every 6 days</td></tr>
<tr><td rowspan="2">Deposited dust</td><td>Total dust deposition per month (Insoluble Fraction)</td><td rowspan="2">Quarterly</td></tr>
<tr><td>Total dust deposition per month (Soluble Fraction)</td></tr>
</table></td><td>Compliant</td><td>Refer to condition 9(b), the continuing ambient air quality monitoring program continues to be undertaken by Dr Peter Forster (Strategen Environmental Consultants Pty Ltd), with the support of YPN environmental personnel.

Within the audit period, ambient air concentrations of NH_3, NO_2 and SO_2 have been monitored continuously from 1 July 2017 (i.e. prior to issue of amended approval with this new condition 9A) to 30 June 2018 (refer to reports on Yara website as provided in condition 9A[a] [for data to 15 May], and data have been received for sampling carried to 29 June 2018.

Within the audit period, TSP monitoring occurred every six days commencing 16 September 2017 (i.e. four days after issue of the amended approval) until 1 July 2018 (refer to reports on Yara website as provided in condition 9A[a] [for data to 8 May] and Attachment 9Ac [for data to 30 June]). Monitoring had also been carried out prior to issue of the amended approval and data for 12 month period beginning 1 July 2017 have been assessed.

Within the audit period, collection of dust deposition (insoluble and soluble fractions) data occurred on 29 September 2017, 31 October 2017, 2 January 2018, 31 January 2018, 28 February 2018, 29 March 2018, 27 April 2018, 31 May 2018 and 28 June 2018 (i.e. at least quarterly) (refer to Attachment 9Ac). As for the gases and TSP, deposition sampling was also carried out prior to issue of the amended approval and those data have been assessed.

Please note the correct names for NO_2 and SO_2 are nitrogen dioxide and sulfur dioxide, respectively; i.e. ‘oxide’ is a typographical error within the approval document.</td></tr>
</table>

9B	To protect the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, particularly the rock art sites:	N/A – refer below	Condition objective, sub-conditions refer below.
9B(a)	Emissions of air pollutants during operations must not exceed the limits described in a Licence under Part V of the *Environmental Protection Act 1986* issued by the Western Australian Government.	Compliant	The Part V Licence L7997/2002/11 amendment, to include the TAN Plant, was issued on 29 June 2018, one day prior to the completion of the audit period. The TAN Plant was in shutdown at that time. The Licence stipulates quarterly and continuous (CEMS) monitoring, for different analytes from different sources. As there was only one day in which the Licence was applicable in the audit period no meaningful data were collected - no stack testing was carried out on 30 June 2018 because it was not logistically feasible to conduct additional testing for a single day, when the date for Licence issue was not known in advance. Analysis of air emissions monitoring against Licence limits will be described in the next ACR. The Licence includes (point source) discharge air quality limits only (i.e. no ambient air quality limits), as follows: • Common stack: ○ PM – 15 mg/m^3 ○ NH_3 at – 10 mg/m^3 • Nitric Acid plant stack: ○ NO_x (as NO_2) – 103 mg/m^3 ○ NH_3 – 0.75 mg/m^3 ○ N_2O – 196 mg/m^3 • Nitric Acid plant stack during start-up (2 hour maximum period): ○ NO_x (as NO_2) – 1540 mg/m^3 ○ NH_3 – 11.5 mg/m^3
9B(b)	If a reporting requirement is triggered for air emissions in the conditions of the Licence issued by the Western Australian Government under Part V of the *Environmental Protection Act 1986*, the person taking the action must also report to the Department in writing within the same timeframe as reporting is required to be provided to the Western Australian Government.	Not applicable	Refer to condition 9B(a) – no reporting requirement for air emissions in the Licence was triggered during the audit period.
10	To protect the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, particularly the rock art sites, the person taking the action must participate in monitoring the rock art by:	N/A – refer below	Condition objective, sub-conditions refer below.
10(a)	Contributing a pro-rata amount annually (in line with that currently utilised by the Western Australian Department of Water and Environmental Regulation, but not exceeding $15,000/year) for a period of not less than two (2) years from the beginning of construction to the Burrup Rock Art Monitoring Program, which is an independent scientific program of monitoring, to detect any changes in patination, including any discolouration, of the surface of the rock art or the surrounding rock surface.	Not applicable	As discussed in the 2017 ACR Addendum, both the Burrup Rock Art Technical Working Group (BRATWG) and the DWER-managed rock art monitoring program were not active during the previous reporting period and as such, YPN were not able to financially contribute through BRATWG to the DWER-managed rock art monitoring program. Previously YPN had financially contributed, with the first payment being made in 2011. The WA Burrup Rock Art Monitoring Program expired in June 2016. Also, as discussed in the 2017 ACR Addendum, following monitoring in 2015 and 2016, a report was published by DWER on the BRATWG website in September 2017. As: • the timing element of the condition ('for a period of not less than two [2] years from the beginning of construction' i.e. the minimum date for completion of this condition was 13 February 2015), and • due to the inclusion of condition 10A, which addresses ongoing - current and future - rock art

			monitoring, YPN seeks the agreement of the Department that this condition can now be considered in effect no longer applicable and does not require further assessment.
10(b)	Revoked – on-going rock are monitoring is now in condition 10A.	Not applicable	Not applicable.
10(c)	In addition to the above condition 10(a) requirements, the person taking the action must provide for additional monitoring of rock art sites in a manner that is consistent with the Burrup Rock Art Monitoring Program. The monitoring of additional rock art sites must meet the following requirements:	Not applicable	Refer to sub-condition 10(c)(iv) and new condition 10A below. Sub-condition 10(c)(iv) timing is framed from the date of commencement of construction, with the monitoring to occur for at least two years until 13 June 2016. Condition 10A requires ongoing annual monitoring with the first event completed by 31 December 2017. As: • previous ACRs have reported on the status of this condition, • the timeframe for completion of sub-condition 10(c)(iv) and • the capacity of condition 10A to address ongoing -current and future - monitoring, YPN seeks the agreement of the Department that this condition be considered in effect no longer applicable and does not require further ongoing assessment.
10(c)(i)	Engage a heritage monitor or other suitably qualified person (Heritage) to survey rock art sites within a two (2) kilometre radius of the project site, to provide advice on any changes to the appearance, or cultural value, of rock art sites within the examined area.	Not applicable	Refer to condition 10(c) above – this condition could be considered no longer applicable, on the agreement of the Department.
10(c)(ii)	The monitoring must be undertaken in a manner that is consistent with and complementary to the monitoring of rock art sites undertaken through the Burrup Rock Art Monitoring Program. If agreed by Department of Water and Environmental Regulation the monitoring of additional rock art sites may be integrated with the Burrup Rock Art Monitoring Program, with the person taking the action providing full contribution to the Department of Water and Environmental Regulation for the additional site monitoring.	Not applicable	Refer to condition 10(c) above – this condition could be considered no longer applicable, on the agreement of the Department.
10(c)(iii)	Prior to undertaking condition 10(c) monitoring, provide the Department with written endorsement from a heritage monitor or other suitably qualified person (Heritage) on the suitability of the rock art monitoring proposed under condition 10(c).	Not applicable	Refer to condition 10(c) above – this condition could be considered no longer applicable, on the agreement of the Department.
10(c)(iv)	Undertake the condition 10(c) rock art monitoring at least once annually, where the first rock art monitoring event must be undertaken within 16 months of the commencement of construction, for a period of not less than two (2) years.	Not applicable	Refer to condition 10(c) above – this condition could be considered no longer applicable, on the agreement of the Department.
10(c)(v)	At least once annually, engage with the Murujuga Aboriginal Corporation in the planning and reporting associated with the annual survey of rock art sites required under condition 10(c).	Not applicable	Refer to condition 10(c) above – this condition could be considered no longer applicable, on the agreement of the Department.
10(d)	Revoked – publishing of baseline rock art monitoring is now in condition 14.	Not applicable	Not applicable.
10A	To protect the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, particularly the rock art sites, the person taking the action must ensure that on-going rock art monitoring is undertaken to identify any changes to the appearance, or cultural value, of rock art sites, as per the requirements below:	N/A – refer below	Condition objective, sub-conditions refer below.
10A(a)	On-going rock art monitoring must be undertaken at the same 6 sites as monitored under condition 10 (or other sites if agreed to in writing by the Minister).	Compliant	Rock art monitoring has continued at the same six sites as monitored under condition 10 (Attachment 10Aa).
10A(b)	The first on-going rock art monitoring event must be complete by no later than 31 December 2017. Subsequent rock art monitoring must be undertaken annually (undertaken between 15	Compliant	The first on-going rock art monitoring event was completed by 2 December 2017 (Attachment 10Ab).

	July and 15 September) for the life of the approval.		
10A(c)	On-going rock art monitoring must be undertaken by a suitably qualified person (Heritage).	Compliant	Rock art monitoring is being led by Warren Fish, who is a Masters Degree-qualified archaeologist and an ex-Registrar of Aboriginal Sites with the WA Government, with well over a decade of experience in Indigenous heritage. Mr Fish is supported by Dr Ian MacLeod, who is a highly respected international academic and scientist, specialising in heritage conservation. Dr MacLeod has been instrumental in the various rock art conservation and monitoring campaigns conducted on the Burrup (Attachment 10Aa). The Department confirmed on 21 December 2017 that it was satisfied Mr Fish and Dr MacLeod have suitable qualifications and experience to undertake the monitoring under this condition 10A (Attachment 10Ab).
10A(d)	On-going rock art monitoring must be undertaken either: i. by the person taking the action, using a methodology approved by the Minister in writing; or ii. through provision of an annual pro-rata amount for the Burrup Rock Art Monitoring Program or another program administered by the Western Australian Government Department of Water and Environmental Regulation.	Compliant	The methodology used was approved by the Minister on 21 December 2017 (Attachment 10Ab).
10A(e)	At least once annually, the person taking the action must engage with the Murujuga Aboriginal Corporation in the planning and reporting associated with the on-going annual rock art monitoring.	Compliant	YPN has engaged and included members of Murujuga Aboriginal Corporation (MAC) in its rock art monitoring activities. YPN has engaged with MAC on at least 28 separate occasions between August 2017 to August 2018. These include attendance and presentation at Circle of Elders meetings, and also at the MAC Annual Strategic Meeting, formal correspondence regarding licencing and regulatory requirements, meetings on issues related to the annual rock monitoring including MAC Ranger involvement in the monitoring itself, and regular discussions with the MAC CEO, MLSU Manager, MAC Administration staff and Rangers regarding monitoring and associated issues. The MAC agreed to assist in the rock art monitoring program for 2017. The experts engaged by YPN work with the Rangers to ensure knowledge and skills transfer take place. The Murujuga are supportive of this work and have indicate they look forward to working with YPN (Attachment 10Ab).
11	To protect the Dampier Archipelago (including Burrup Peninsula) National Heritage Place the person taking the action must ensure that there is no measurable impact from air pollutants to any rock art sites within 2km of the boundary of the action, at any time during the life of the approval. This includes measurable changes in patination, including but not limited to: discolouration of the surface of the rock art motif or the surrounding rock surface including patina; or changes that make the rock art site more difficult to interpret (for example a decrease in definition).	Compliant	YPN has not been notified of any evidence of any measurable impact from air pollutants to any rock art sites within 2 km of the project site.
11A	If the Minister is not satisfied that the outcome described in condition 11 is being met, the Minister may request (in writing) that the person taking the action submit a Rock Art Impact Mitigation Review (RAIMR) to the Department for approval by the Minister.	Not applicable	The Minister has not made any request to YPN with respect to this condition.

11A(a)	The RAIMR must: i. Be prepared by a suitably qualified person (Heritage) in consultation with a suitably qualified Person (Air Quality); ii. Be submitted within a timeframe specified by the Minister. iii. Include an analysis of the cause or causes of the detected change in the rock art surface; iv. Include a review of operations, including changes to operations to reduce the impact of air emissions on rock art; and v. Include mitigation and management measures to protect rock art sites within 2km of the boundary of the action from further impacts, to meet the requirements of condition 11.	Not applicable	Refer to condition 11A above.
11A(b)	If the Minister approves the RAIMR required under this condition, then the approved RAIMR must be implemented.	Not applicable	Refer to condition 11A above.
12	If the person taking the action wishes to carry out any activity otherwise than in accordance with the management plan(s) and or monitoring program(s) as specified in the conditions, the person taking the action must submit to the Department for the Minister's written approval a revised version of that management plan(s) and or monitoring program(s). The varied activity shall not commence until the Minister has approved the varied management plan(s) and or monitoring program(s) in writing. The Minister will not approve a varied management plan(s) and or monitoring program(s) unless the revised management plan(s) and or monitoring program(s) would result in an equivalent or improved environmental outcome over time. If the Minister approves the revised management plan(s), and or monitoring program(s) that management plan(s) and or monitoring program(s) must be implemented in place of the management plan(s) and or monitoring program(s) originally approved.	Compliant	As discussed in condition 7(b) a revised ERMP was submitted to the Department for review in December 2016, with the OEMP (refer to condition 7[b]). Minor updates to the ERMP were made in December 2016, a few days after the original submission, and in January 2017. This new condition 12 came into effect in September 2017, after the minor updates were made. To ensure YPN continues to remain compliant with this new condition, the amended ERMP was submitted to the Department for the Minister's approval on 20 September 2018. No other changes to other plan or programs were considered in the audit period. Refer to condition 7 regarding implementation status of plans.
13	If the Federal Minister believes that it is necessary or convenient for the better protection of National Heritage Place, listed threatened species and communities and listed migratory species to do so, the Minister may request that the person taking the action make specified revisions to the management plan(s), monitoring program(s) specified in the conditions and submit the revised management plan(s), monitoring program(s) for the Minister's written approval. The person taking the action must comply with any such request. The revised approved management plan(s), monitoring program(s), must be implemented. Unless the Minister has approved the revised management plan(s), monitoring program(s), then the person taking the action must continue to implement the management plan(s), monitoring program(s) originally approved, as specified in the conditions.	Not applicable	The Minister has made no request during the reporting period.
14	Unless otherwise agreed to in writing by the Minister, the person taking the action must publish on their website, for the life of the approval: a) Management plans required under conditions 7 and 11A, within 1 month of being approved. b) A revised version of any management plans required under conditions 7 and 11A, within 1 month of being approved under condition 12 or 13. c) All baseline air quality data collected under condition 9, by 31 October 2017. d) All ongoing air quality monitoring data required under condition 9A, within 3 months of collection of each datum. e) All baseline rock art data or reports relating to condition 10, within 30 days of any data or reports on being provided to the person taking the action. f) All rock art monitoring data or reports relating to on-going rock art monitoring required under condition 10A, within 30 days of the data or reports being provided to the person taking the action	Compliant	YPN publishes all management plan(s) and monitoring program(s) on the website, https://www.yara.com.au/about-yara/about-yara-australia/pilbara/yara-pilbara-nitrates/ as follows: Please note that it could be interpreted that to comply with both sub-conditions 14(a) and 14(b) the original management plans *and* any revised versions are to stay on the website for the life of the approval. To avoid confusion YPN has interpreted that the revised approved versions replace the originals, which can be removed from the website. a) Condition 7 plans include the CEMP, OEMP, AHMP, HMMP and ERP; condition 11A refers to the RAIMR. As discussed in condition 7 above, the OEMP has incorporated the AHMP and HMMP. All plans are available on the YPN website. b) NA.

			c) The Baseline Air Quality Monitoring Report is available on the YPN website. d) All ongoing quality monitoring data are available on the YPN website. Each report was posted within 30 days of the data becoming available to YPN. e) All baseline rock art monitoring reports are available on the YPN website. As discussed in the 2017 ACR Addendum, following monitoring in August of both 2015 and 2016 a report was published by DWER on the BRATWG website in September 2017. This report was also published on the YPN website. f) No usable 2017 rock art monitoring data has yet been received by YPN; DWER is acting as Project Manager to have 2017 rock art analysis conducted. Results will be published upon receipt.
15	If, at any time after 2 years from the date of this approval, the person taking the action has not substantially commenced the action, then the person taking the action must not substantially commence the action without the written agreement of the Minister.	Compliant	The TAN Plant substantially commenced in 2012, within 2 years of the date of approval. YPN seeks Department agreement that this condition can be considered 'complete'.

3.3 Details of Non-Compliance

No non-compliances were identified in the audit period.

4 Management Plans

During the reporting period the following management plans were implemented:

- Operational Environmental Management Plan (OEMP) including management measures for:
  - Erosion Control and Storm Water;
  - Water Quality;
  - Air Quality and Dust;
  - Waste; and
  - Traffic.
- Aboriginal Heritage Management Plan (incorporated into OEMP);
- Hazardous Materials Management Plan (incorporated into OEMP); and
- Emergency Response Management Plan:

On 15 September 2017 the OEMP was approved by the DoEE.

5 New Environmental Risks

No new environmental risks that were not contemplated in the Project referral and assessment process have been identified in the audit period.

6 Attachments

The following documents are attached to this 2018 ACR as evidence of compliance:

- Attachment 3a: Email from YPN to Department, dated 6 October 2017, regarding submission of 2017 ACR Addendum.
- Attachment 3b: Screenshot dated 7 September 2018 showing 2017 ACR Addendum remains on YPN website.
- Attachment 4: Water Corporation email to YPN dated 28 September 2018 regarding discharges to the MUBRL
- Attachment 8a: Natural Heritage Place Access Register (screenshot)
- Attachment 9Ac: Air quality monitoring for period 1 July 2017 to 30 June 2018
- Attachment 10Aa: Letter YPN to Department regarding Rock Art Monitoring, dated 3 November 2017
- Attachment 10Ab: Letter YPN to Department regarding Rock Art Monitoring, dated 2 July 2018
- Plates

Attachment 3a: Email from YPN to Department, dated 6 October 2017, regarding submission of 2017 ACR Addendum

From:	Susan Giles
Sent:	Friday, 6 October 2017 4:55 PM
To:	'post.approvals@environment.gov.au'
Cc:	Carly Mott; YP_Environment
Subject:	RE: Yara Pilbara Submission of EPBC2008/4546 2017 Annual Compliance Report - Addendum

Good Afternoon

Further to my email at 1:17PM today, please find following a screen shot of the Yara Pilbara Nitrates webpage with the link to the EPBC2008/4546 2017 Annual Compliance Report – Addendum highlighted and the date and time on the computer visible.

This link can be accessed from here.

Yara Pilbara Nitrates | Ya

www.yara.com.au/about-yara/about-yara-local/yara-pilbara/nitrates

Apps Bookmarks Google Flying Weather Nitrogen-Ion Convers

Contact | About Yara | News and Events | Safety Data

Knowledge grows

About Yara

Search Yara

Yara Australia | Sustainability | Yara Global | Careers

You are here: Home / About Yara / Yara Australia / Yara Pilbara / Yara Pilbara Nitrates

Yara Pilbara Nitrates

Yara is the operator of Yara Pilbara Nitrates Pty Ltd (YPNPL), a joint venture between Yara (55%) and Orica (45%).

YPNPL is in the process of constructing a technical ammonium nitrate (TAN) facility adjacent to Yara Pilbara's existing liquid ammonia plant on the Burrup Peninsula. When commissioned the TAN Plant will be owned by Yara Pilbara Nitrates Pty Ltd, operated by Yara International ASA and marketed by Orica Mining Services Pilbara (OMSP), a joint venture operated by Orica. The product manufactured at the TAN plant will be distributed into the local Pilbara market by OMSP.

Yara Pilbara
- Yara Pilbara Fertilisers
- Yara Pilbara Nitrates

Environment

Compliance Assessment Reports MS870

TAN Plant MS870 Compliance Assessment Report 2012 (PDF, 1.76 MB)

TAN Plant MS870 Compliance Assessment Report 2013 (PDF, 51.2 MB)

TAN Plant MS870 Compliance Assessment Report 2014 (PDF, 1.16 MB)

TAN Plant MS870 Compliance Assessment Report 2015 (PDF, 31.3 MB)

TAN Plant MS870 Compliance Assessment Report 2016 (PDF, 24.9 MB)

Annual Environmental Compliance Reports EPBC 2008/4546

TAN Plant EPBC Annual Compliance Report 2014 (PDF, 13.2 MB)

TAN Plant EPBC Annual Compliance Report 2015 (PDF, 4.87 MB)

TAN Plant EPBC Annual Compliance Report 2016 (PDF, 3.5 MB)

TAN Plant EPBC Annual Compliance Report 2017 (PDF, 7.94 MB)

TAN Plant EPBC Annual Compliance Report 2017 – Addendum (PDF, 5 MB)

Rock Art Monitoring Reports

Burrup Penninsula Aboriginal Petroglyphs Report 2004-2014 (PDF, 9.77 MB)

Susan Giles
Environmental Superintendent
HESQ
Production
Global Plants
Office: +618 9183 4167
Email: susan.giles@yara.com

Yara Pilbara Fertilisers Pty Ltd
Lot 564 Village Road
WA 6714 Burrup Peninsula, Australia
www.yara.com

From: Susan Giles
Sent: Friday, October 06, 2017 1:17 PM
To: post.approvals@environment.gov.au
Cc: Carly Mott; YP_Environment
Subject: Yara Pilbara Submission of EPBC2008/4546 2017 Annual Compliance Report - Addendum

Good Afternoon

Following receipt of the varied conditions on 13 September, DEE informed Yara Pilbara Nitrates Pty Ltd (YPN) that an Annual Compliance Report (ACR) was required to be submitted by 6 October 2017 for the reporting period 18 February 2017 to 30 June 2017. Attached is the EPBC2008/4546 2017 Annual Compliance Report – Addendum in compliance with this requirement.

Please note a copy of the complete report (including attachments) will be loaded to the www.yara.com.au website and the URL link will be forwarded once complete.

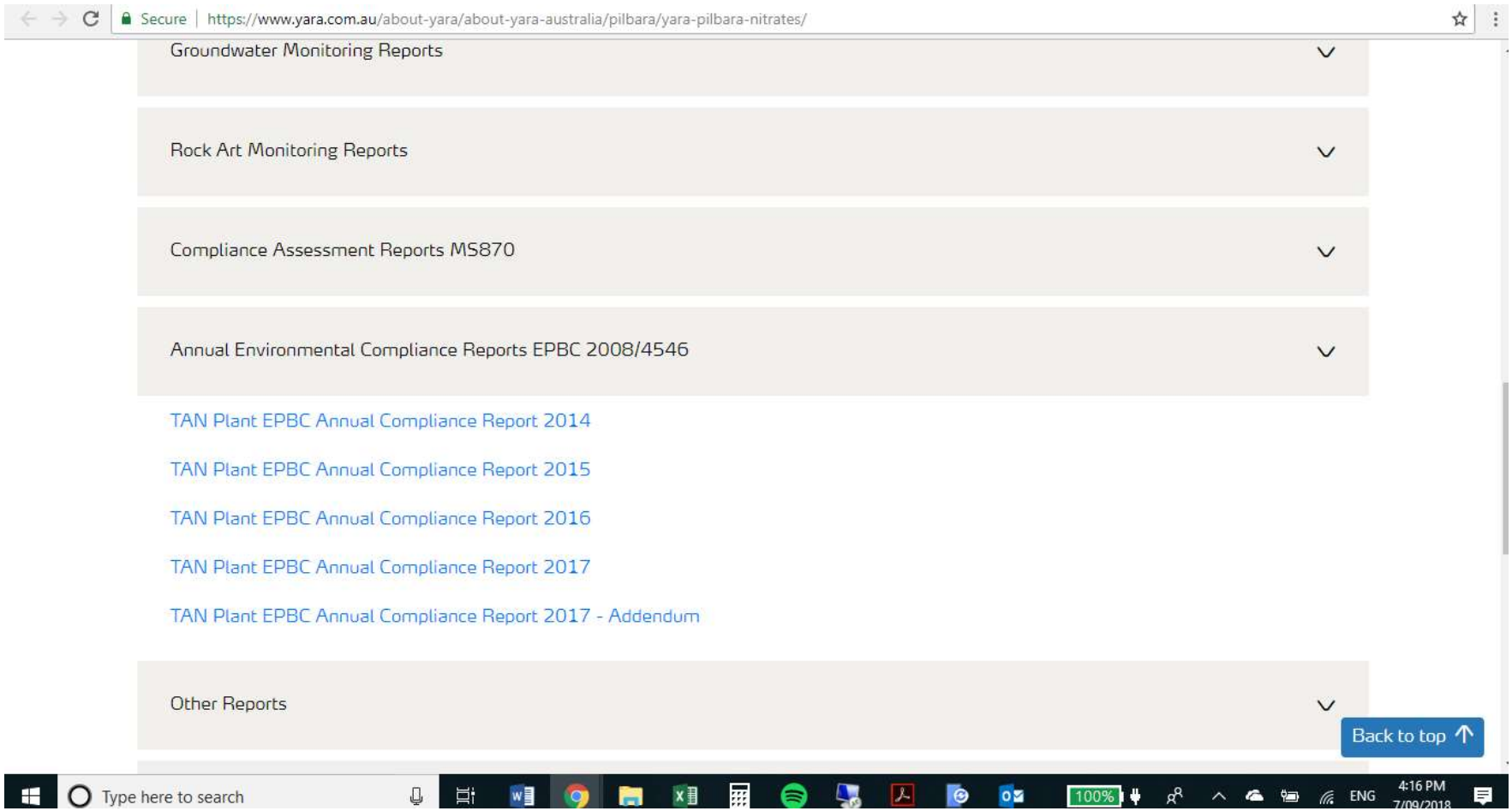
Yara Pilbara Nitrates requires acknowledgement that you have received this correspondence. Please acknowledge receipt by return email.

Thank you and kind regards

Susan Giles
Environmental Superintendent
HESQ
Production
Global Plants
Office: +618 9183 4167
Email: susan.giles@yara.com

Yara Pilbara Fertilisers Pty Ltd
Lot 564 Village Road
WA 6714 Burrup Peninsula, Australia www.yara.com

Attachment 3b: Screenshot dated 7 September 2018 showing 2017 ACR Addendum remains on YPN website


Secure | https://www.yara.com.au/about-yara/about-yara-australia/pilbara/yara-pilbara-nitrates/
Groundwater Monitoring Reports
Rock Art Monitoring Reports
Compliance Assessment Reports MS870
Annual Environmental Compliance Reports EPBC 2008/4546
TAN Plant EPBC Annual Compliance Report 2014
TAN Plant EPBC Annual Compliance Report 2015
TAN Plant EPBC Annual Compliance Report 2016
TAN Plant EPBC Annual Compliance Report 2017
TAN Plant EPBC Annual Compliance Report 2017 - Addendum
Other Reports
Back to top
Type here to search
100%
ENG
4:16 PM
7/09/2018

Attachment 4: Water Corporation email to YPN dated 28 September 2018 regarding discharges to the MUBRL

Yara Pilbara Fertilisers Pty Ltd
Lot 564 Village Road
WA 6714 Burrup Peninsula, Australia
www.yara.com

From: Cara Price [mailto:Cara.Price@watercorporation.com.au]
Sent: Friday, September 28, 2018 11:49 AM
To: Susanna Delbost
Subject: Yara Discahrge to the MUBRL

Hi Susanna,

I can confirm that for the 2017-18 reporting period the discharge effluent from the MUBRL has met the relevant guidelines set out by the OMEMP.

Cheers,
Cara

Cara Price
Tech Adv - Environment
North West Region

E: Cara.Price@watercorporation.com.au
T: 9186 8291

Keep in touch **W:** watercorporation.com.au

Attachment 8a: Natural Heritage Place Access Register (screenshot)

National Heritage Place Access Register

250-200-REG-YPN-0001
Last Updated: 21.08.2018

	Given Name	Position Title	a Number (if applicable)	Contracting Company (if not Yara)	Date Authorised	Valid Until (+5 years Col D)
	Joe	*Example Person*	*a931834*	*Clough Amec*	*02-Nov-17*	*02-Nov-22*
	Leanne	Security		ERS	08-Nov-17	08-Nov-22
	Ed	Security		ERS	08-Nov-17	08-Nov-22
	Brian	HESQ Manager	a922606	Yara	08-Nov-17	08-Nov-22
	Amy	Trainee Laboratory Technician	a928492	Yara	08-Nov-17	08-Nov-22
	Corinne	Laboratory Chemist	a924280	Yara	08-Nov-17	08-Nov-22
	Jim	H&S Advisor	a923799	Yara	08-Nov-17	08-Nov-22
	Doug	H&S Advisor	a903703	Yara	08-Nov-17	08-Nov-22
	Narelle	Business Administration Trainee	a933554	Yara	08-Nov-17	08-Nov-22
	Justin	H&S Superintendent	a933576	Yara	08-Nov-17	08-Nov-22
	Nicole	Graduate Environmental Officer	a930939	Yara	08-Nov-17	08-Nov-22
	Susan	Environmental Officer	a923267	Yara	08-Nov-17	08-Nov-22
	Susanna	Environmental Officer	a904476	Yara	08-Nov-17	08-Nov-22
	Neil	Secuirity & ER Superintendent	a925395	Yara	08-Nov-17	08-Nov-22
	Damien	Laboratory Technician		Yara	08-Nov-17	08-Nov-22
	Ronald	Quality & Laboratory Superintendent	a911741	Yara	08-Nov-17	08-Nov-22
	Scott	Security		ERS	13-Nov-17	13-Nov-22
	Bradley	Security		ERS	09-Nov-17	09-Nov-22
	Andrea	Security		ERS	10-Nov-17	10-Nov-22
	Jenny	Security		ERS	15-Nov-17	15-Nov-22
	Matthew	Security		ERS	15-Nov-17	15-Nov-22
	Rick	Security		ERS	20-Nov-17	20-Nov-22
	Nickola	Security		ERS	20-Nov-17	20-Nov-22
	Vanessa	Vacation Student	a934358	Yara	30-Nov-17	30-Nov-22
	Bill	Consultant		WS Fish Consulting	23-Nov-17	23-Nov-22
	Ian	Consultant		WS Fish Consulting	23-Nov-17	23-Nov-22
	Warren	Consultant		WS Fish Consulting	23-Nov-17	23-Nov-22
	Stephanie	Security		ERS	05-Dec-17	05-Dec-22
	Peter	Consultant		EcoTech	04-Jan-18	04-Jan-23
	Raymond	Consultant		EcoTech	02-Feb-18	02-Feb-23
	Kane	Contractor Supervisor		Karratha Contracting	26-Mar-18	26-Mar-23
	Thomas	Emergency Services Officer		PWR	23-Mar-18	23-Mar-23

Attachment 9Ac: Air quality monitoring for period 1 July 2017 to 30 June 2018

Compliance Monitoring Pty Ltd
ABN: 65 102 897 656
sales@compliancemonitoring.com.au
accounts@compliancemonitoring.com.au

VERIFIED AMBIENT AIR MONITORING REPORT

Date	8 August 2018
Prepared For	Yara Pilbara Nitrates Pty Ltd Main Entrance, Village Road BURRUP PENINSULA WA 6714
Client Representative	Ms Nicole Ivory
Monitoring Location/Name	Yara Pilbara - LVAS
Report Number	RPA1102-05
Report Period	19 June 2018 to 19 July 2018

Parameter	Limit of Reporting	Measurement Uncertainty	Method
Total Suspended Particulates, TSP	2 µg/m^3	±5 µg/m^3	CMWI58

Notes:
1. A coverage factor (k) of 2 has been used to calculate the expanded uncertainty providing a level of confidence of approximately 95%
2. There is currently insufficient data to determine measurement uncertainty.

Sheet Name	Data Set
DustData	TSP concentrations 19 Jun 2018 to 19 Jul 2018
Blanks	Weights for laboratory and field blanks
Filter Information	Information regarding deployment and collection of filters
DataComments	Information on data set manipulations and notable events
Equipment	Information about the LVAS deployed

	Name	Signature	Date
Report Prepared By	Alysha Abbott	A. Abbott	6 August 2018
Report Authorised By	Steven Edmett	Steven Edmett	8 August 2018

Note:
1. There is no specific AS for the measurement of total suspended particulates by LVAS. AS 3580.9.9 (PM_{10} by LVAS) has been used as a *de facto* standard.

Head Office:
28 Sorbonne Crescent
CANNING VALE WA 6155
Ph: +61 (0)8 9424 2900
Fax: +61 (0)8 6258 5120

Yara Pilbara - LVAS

Period Start Date/Time (GMT +0800)	Water Tanks TSP	Deep Gorge TSP	Burrup Rd TSP
Data Type	Concentration (0°C and 101.3 kPa)	Concentration (0°C and 101.3 kPa)	Concentration (0°C and 101.3 kPa)
Units	µg/m^3	µg/m^3	µg/m^3
19/06/2018	18	23	19
25/06/2018	16	19	12
1/07/2018	12	18	9
7/07/2018	11	22	16
13/07/2018	19	22	17
19/07/2018	22	19	27

Maximum	22	23	27
Minimum	11	18	9
Average	16	21	17
Standard Deviation	4	2	6

1. The LVAS unit runs for a nominal 24 hours. The date listed above is the day that sampling commenced.
2. Filter exchange was performed by Yara Pilbara personnel.
3. The LVASs at Water Tanks, Deep Gorge and Burrup Road have been set to run sixth day.
4. A pink cell indicates final weighing of the filters was more than 20 days after completion of sampling. This is outside AS 3580.9.9

Compliance Monitoring Pty Ltd

ABN: 65 102 897 656

sales@compliancemonitoring.com.au
accounts@compliancemonitoring.com.au

VERIFIED AMBIENT AIR MONITORING REPORT

Date	8 August 2018
Prepared For	Yara Pilbara Nitrates Pty Ltd Main Entrance, Village Road BURRUP PENINSULA WA 6714
Client Representative	Ms Nicole Ivory
Monitoring Location	Yara Pilbara - DDG
Report Number	RPA1102-06
Report Period	27 April 2018 to 31 May 2018
NATA Accreditation Number:	15217

Parameter	Limit of Reporting	Measurement Uncertainty	Method
Total Deposited Matter	1.2 g/m^2/month	± 0.05 g/m^2/month	CMWI30
Soluble Deposited Matter	0.7 g/m^2/month	± 0.05 g/m^2/month	CMWI30
Insoluble Deposited Matter	0.8 g/m^2/month	± 0.05 g/m^2/month	CMWI30

Note. A coverage factor (k) of 2 has been used to calculate the expanded uncertainty providing a level of confidence of approximately 95%

Sheet Name	Data Set
Deposited Matter	Deposited matter data for 27 Apr 2018 to 31 May 2018
Graph	Graph of insoluble deposited matter since Mar 2017

	Name	Signature	Date
Report Prepared By	Alysha Abbott	A. Abbott	6 August 2018
Report Reviewed By	Steven Edmett	Steven Edmett	8 August 2018

Notes:

1. The method reference for deposited matter is AS/NZS 3580.10.1
2. As the collection of the deposition bottles was performed by Yara Pilbara personnel, accreditation does not cover the performance of this service.
3. The samples are 'as received'.
4. Chemical analysis of the insoluble and soluble solid fractions were performed by ALS, Smithfield, NSW and ALS, Malga, WA respectively. Their reports are appended; report numbers ES1822391 and EP1808849.

Head Office:

52 Cooper Road
COCKBURN CENTRAL WA 6164

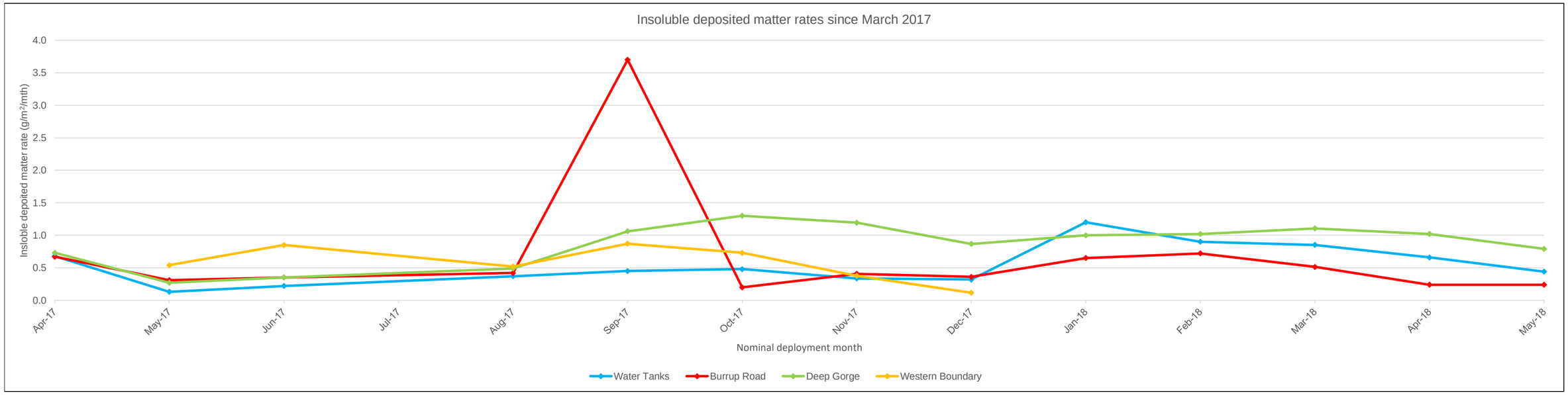
Yara Pilbara - DDG

Field Information											Lab Data						
Sample Name	GPS Sample Location Easting	GPS Sample Location Northing	GPS Elevation (m)	Site Classification	Sampling Start Date and Time (GMT +0800)	Deployed By	Sampling End Date and Time (GMT +0800)	Collected By	Days Sampled	Volume of water in deposition bottle (mL)	Total Solids (g)	Soluble Solids (g)	Insoluble Solids (g)	Total Solids ($g/m^2/mth$)	Soluble Solids ($g/m^2/mth$)	Insoluble Solids ($g/m^2/mth$)	Comments
Water Tanks	0477691	7720106	29	Peak	27/04/2018 09:11	NI	31/05/2018 11:25	NI	34	300	0.02	0.01	<0.01	<1.2	<0.7	<0.8	No algaecide in sample.
Burrup Road	0477617	7719570	4	Peak	27/04/2018 09:45	NI	31/05/2018 10:52	NI	34	190	<0.01	<0.01	<0.01	<1.2	<0.7	<0.8	No algaecide in sample.
Deep Gorge	0477957	7718032	20	Peak	27/04/2018 11:10	NI	31/05/2018 10:51	NI	34	190	0.02	<0.01	0.02	<1.2	<0.7	<0.8	No algaecide in sample.
Laboratory Blank	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<1.2	<0.7	<0.8	--
Field Blank	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	No field balnk provided
Measurement Uncertainty	-	-	-	-	-	-	-	-	-	-	± 0.01	± 0.01	± 0.01	± 0.05	± 0.05	± 0.05	--

Notes:

1. No algaecide was used in the sample bottles. This is a departure from AS 3580.10.1 which states that copper sulphate is to be used as algaecide. Otherwise, analysis of total, insoluble and soluble solids is as per Australian Standard AS/NZS 3580.10.1.

Yara Pilbara - DDG



Note:
1. No sample for Western Boundary submitted since December 2017.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1808849**	Page	: 1 of 4
Client	: **COMPLIANCE MONITORING PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: JASON QUARTERMAINE	Contact	: Lauren Ockwell
Address	: 52 Cooper Road Cockburn Central WESTERN AUSTRALIA 6164	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: +61 08 9175 2601	Telephone	: 08 9209 7606
Project	: JPA1006 DDG Samples	Date Samples Received	: 27-Jul-2018 17:00
Order number	: ----	Date Analysis Commenced	: 27-Jul-2018
C-O-C number	: YAR20180531_EXTALS	Issue Date	: 03-Aug-2018 13:21
Sampler	: ----		
Site	: ----		
Quote number	: EP/183/18		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Efua Wilson	Metals Chemist	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Bromide conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- EK055G: Ammonia result for EP1808849 #1 has been confirmed by re-preparation and re-analysis.
- EK059G: NOx result for EP1808849 #1 has been confirmed by re-preparation and re-analysis.
- EG020A-F: Metals results for EP1808849 #1 have been confirmed by re-preparation and re-analysis.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Lab Blank	Water Tanks	Boundary Rd	Deep Gorge	----
				Client sampling date / time	[31-May-2018]	31-May-2018 11:25	31-May-2018 10:52	31-May-2018 10:16	----
Compound	CAS Number	LOR	Unit		EP1808849-001	EP1808849-002	EP1808849-003	EP1808849-004	--------
					Result	Result	Result	Result	----
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		<0.010	**0.015**	**0.011**	<0.010	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		<1	**2**	**1**	<1	----
Total Alkalinity as CaCO3	----	1	mg/L		<1	**2**	**1**	<1	----
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		<0.05	**1.27**	**0.42**	**0.37**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		<1	**3**	**2**	**2**	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		<1	**8**	**8**	**7**	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	**2**	**1**	**1**	----
Magnesium	7439-95-4	1	mg/L		<1	<1	<1	<1	----
Sodium	7440-23-5	1	mg/L		<1	**6**	**5**	**4**	----
Potassium	7440-09-7	1	mg/L		<1	<1	<1	<1	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	**0.11**	**0.08**	**0.09**	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Barium	7440-39-3	0.001	mg/L		**0.003**	**0.007**	**0.007**	**0.006**	----
Cadmium	7440-43-9	0.0001	mg/L		**0.0001**	**0.0005**	**0.0007**	**0.0005**	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L		<0.001	**0.004**	**0.002**	**0.003**	----
Manganese	7439-96-5	0.001	mg/L		<0.001	**0.013**	**0.013**	**0.019**	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.001**	<0.001	**0.008**	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Thallium	7440-28-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Lab Blank	Water Tanks	Boundary Rd	Deep Gorge	----
				Client sampling date / time	[31-May-2018]	31-May-2018 11:25	31-May-2018 10:52	31-May-2018 10:16	----
Compound	CAS Number	LOR	Unit		EP1808849-001	EP1808849-002	EP1808849-003	EP1808849-004	--------
					Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.09**	**0.08**	**0.10**	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	<0.1	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.02**	**0.02**	**0.02**	**0.02**	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.02**	**0.22**	**0.37**	**0.36**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.02**	**0.22**	**0.37**	**0.36**	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	**0.10**	**0.01**	**0.01**	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		<0.01	**0.33**	**0.29**	**0.24**	----
Total Cations	----	0.01	meq/L		<0.01	**0.36**	**0.27**	**0.22**	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1822391**	Page	: 1 of 3
Client	: **COMPLIANCE MONITORING PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: JASON QUARTERMAINE	Contact	: Customer Services ES
Address	: 52 Cooper Road Cockburn Central WESTERN AUSTRALIA 6164	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 08 9175 2601	Telephone	: +61-2-8784 8555
Project	: JPA1006	Date Samples Received	: 31-Jul-2018 11:30
Order number	: EP-183-18	Date Analysis Commenced	: 02-Aug-2018
C-O-C number	: YAR20180531_EXT ALS	Issue Date	: 03-Aug-2018 12:41
Sampler	: ----		
Site	: ----		
Quote number	: EP/620/17		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA144: NATA accreditation covers the standard 8 metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)
- EA144: The metal concentration in the filter is reported in µg/filter on a total filter basis calculated up from the proportion of the filter analysed.
- EA144: The metal concentration in the filter is reported in µg/filter on a total filter basis calculated up from the proportion of the filter paper analysed.

Analytical Results

Sub-Matrix: FILTER (Matrix: AIR)				Client sample ID	37/072 Lab Blank	37/073 Water Tanks	37/074 Boundary Road	37/075 Deep Gorge	----
				Client sampling date / time	31-May-2018 00:00	31-May-2018 11:25	31-May-2018 10:52	31-May-2018 10:16	----
Compound	CAS Number	LOR	Unit		ES1822391-001	ES1822391-002	ES1822391-003	ES1822391-004	--------
					Result	Result	Result	Result	----
EA144: Particulate Base Metals in Filter Papers									
Aluminium	7429-90-5	100	µg/filter		<100	**160**	<100	**180**	**----**
Antimony	7440-36-0	10	µg/filter		<10	<10	<10	<10	**----**
Arsenic	7440-38-2	10	µg/filter		<10	<10	<10	<10	**----**
Barium	7440-39-3	100	µg/filter		<100	<100	<100	<100	**----**
Beryllium	7440-41-7	5	µg/filter		<5	<5	<5	<5	**----**
Cadmium	7440-43-9	5	µg/filter		<5	<5	<5	<5	**----**
Chromium	7440-47-3	5	µg/filter		<5	<5	<5	<5	**----**
Cobalt	7440-48-4	5	µg/filter		<5	<5	<5	<5	**----**
Copper	7440-50-8	5	µg/filter		<5	**6**	**7**	<5	**----**
Magnesium	7439-95-4	500	µg/filter		<500	<500	<500	<500	**----**
Manganese	7439-96-5	5	µg/filter		<5	<5	<5	<5	**----**
Molybdenum	7439-98-7	5	µg/filter		<5	<5	<5	<5	**----**
Nickel	7440-02-0	5	µg/filter		<5	<5	<5	<5	**----**
Thallium	7440-28-0	5	µg/filter		<5	<5	<5	<5	**----**
Tin	7440-31-5	5	µg/filter		<5	<5	<5	<5	**----**
Titanium	7440-32-6	5	µg/filter		<5	**5**	<5	**8**	**----**
Vanadium	7440-62-2	5	µg/filter		<5	<5	<5	<5	**----**
Iron	7439-89-6	10	µg/filter		<10	**484**	**392**	**496**	**----**
Lead	7439-92-1	10	µg/filter		<10	<10	<10	<10	**----**
Selenium	7782-49-2	10	µg/filter		<10	<10	<10	<10	**----**
Mercury	7439-97-6	0.5	µg/filter paper		<0.5	<0.5	<0.5	<0.5	**----**

Compliance Monitoring Pty Ltd

ABN: 65 102 897 656

sales@compliancemonitoring.com.au
accounts@compliancemonitoring.com.au

VERIFIED AMBIENT AIR MONITORING REPORT

Date	8 August 2018
Prepared For	Yara Pilbara Nitrates Pty Ltd Main Entrance, Village Road BURRUP PENINSULA WA 6714
Client Representative	Ms Nicole Ivory
Monitoring Location	Yara Pilbara - DDG
Report Number	RPA1102-07
Report Period	31 May 2018 to 28 June2018
NATA Accreditation Number:	15217

Parameter	Limit of Reporting	Measurement Uncertainty	Method
Total Deposited Matter	1.2 g/m^2/month	± 0.05 g/m^2/month	CMWI30
Soluble Deposited Matter	0.7 g/m^2/month	± 0.05 g/m^2/month	CMWI30
Insoluble Deposited Matter	0.8 g/m^2/month	± 0.05 g/m^2/month	CMWI30

Note. A coverage factor (k) of 2 has been used to calculate the expanded uncertainty providing a level of confidence of approximately 95%

Sheet Name	Data Set
Deposited Matter	Deposited matter data for 31 May 2018 to 28 Jun 2018
Graph	Graph of insoluble deposited matter since Mar 2017

	Name	Signature	Date
Report Prepared By	Alysha Abbott	A. Abbott	6 August 2018
Report Reviewed By	Steven Edmett	Steven Edmett	8 August 2018

Notes:

1. The method reference for deposited matter is AS/NZS 3580.10.1
2. As the collection of the deposition bottles was performed by Yara Pilbara personnel, accreditation does not cover the performance of this service.
3. The samples are 'as received'.
4. Chemical analysis of the insoluble and soluble solid fractions were performed by ALS, Smithfield, NSW and ALS, Malga, WA respectively. Their reports are appended; report numbers ES1822396 and EP1808847.

Head Office:

52 Cooper Road
COCKBURN CENTRAL WA 6164

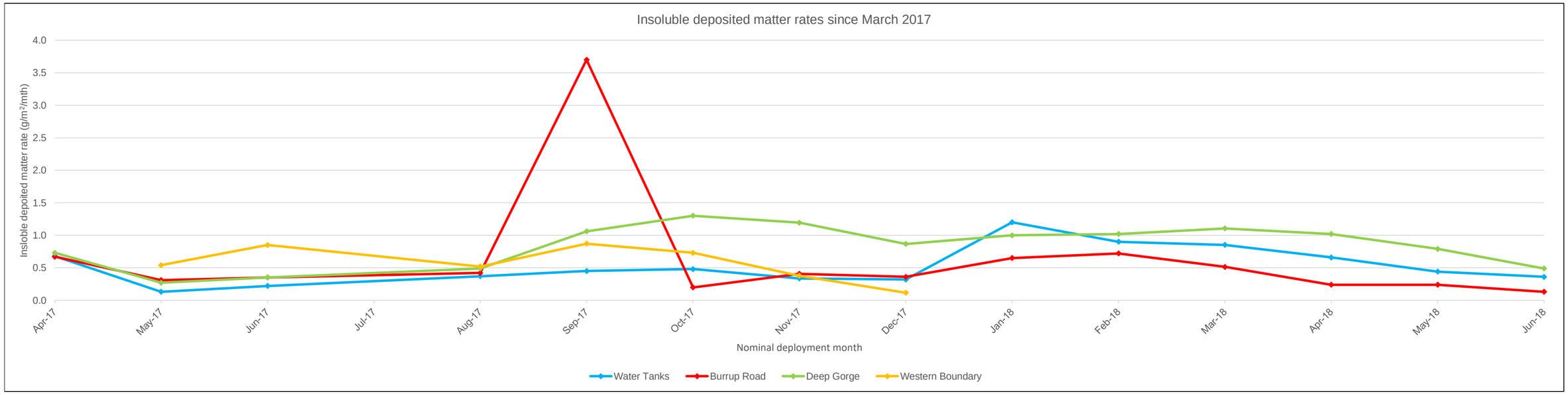
Yara Pilbara - DDG

Field Information											Lab Data						
Sample Name	GPS Sample Location Easting	GPS Sample Location Northing	GPS Elevation (m)	Site Classification	Sampling Start Date and Time (GMT +0800)	Deployed By	Sampling End Date and Time (GMT +0800)	Collected By	Days Sampled	Volume of water in deposition bottle (mL)	Total Solids (g)	Soluble Solids (g)	Insoluble Solids (g)	Total Solids ($g/m^2/mth$)	Soluble Solids ($g/m^2/mth$)	Insoluble Solids ($g/m^2/mth$)	Comments
Water Tanks	0477691	7720106	29	Peak	31/05/2018 11:25	NI	28/06/2018 13:25	NI	28	950	0.03	0.03	<0.01	2.0	1.6	<0.8	0.0270 g copper fluoride in sample.
Burrup Road	0477617	7719570	4	Peak	31/05/2018 10:52	NI	28/06/2018 13:08	NI	28	850	0.02	0.02	<0.01	1.4	1.3	<0.8	0.0270 g copper fluoride in sample.
Deep Gorge	0477957	7718032	20	Peak	31/05/2018 10:16	NI	28/06/2018 12:40	NI	28	1200	0.03	0.02	<0.01	<2.5	<2	<0.8	0.0270 g copper fluoride in sample. LOR for SS and ST raised due to volume of water in DDG bottle
Laboratory Blank	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<1.2	<0.7	<0.8	--
Field Blank	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<1.2	<0.7	<0.8	0.0270 g copper fluoride in sample.
Measurement Uncertainty	-	-	-	-	-	-	-	-	-	-	± 0.01	± 0.01	± 0.01	± 0.05	± 0.05	± 0.05	--

Notes:

1. Copper fluoride was used as the algaecide. This is a departure from AS 3580.10.1 which states that copper sulphate is to be used as algaecide. Otherwise, analysis of total, insoluble and soluble solids is as per Australian Standard AS/NZS 3580.10.1.

Yara Pilbara - DDG



Note:
1. No sample for Western Boundary submitted since December 2017.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1808847**	Page	: 1 of 4
Client	: **COMPLIANCE MONITORING PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: JASON QUARTERMAINE	Contact	: Lauren Ockwell
Address	: 52 Cooper Road Cockburn Central WESTERN AUSTRALIA 6164	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: +61 08 9175 2601	Telephone	: 08 9209 7606
Project	: JPA1006 DDG Samples	Date Samples Received	: 27-Jul-2018 17:00
Order number	:	Date Analysis Commenced	: 27-Jul-2018
C-O-C number	: YAR20180628_EXTALS	Issue Date	: 02-Aug-2018 17:28
Sampler	: ----		
Site	: ----		
Quote number	: EP/183/18		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Efua Wilson	Metals Chemist	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Bromide conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- EK059G (NOx): LOR for samples EP1808847-003, 004 and 005 raised due to possible sample matrix interference.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Lab Blank	Field Blank	Water Tanks	Burrup Rd	Deep Gorge
				Client sampling date / time	[28-Jun-2018]	[28-Jun-2018]	28-Jun-2018 13:25	28-Jun-2018 13:08	28-Jun-2018 12:40
Compound	CAS Number	LOR	Unit		EP1808847-001	EP1808847-002	EP1808847-003	EP1808847-004	EP1808847-005
					Result	Result	Result	Result	Result
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		<0.010	<0.010	**0.030**	**0.025**	<0.010
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		<1	**2**	**2**	**1**	**2**
Total Alkalinity as CaCO3	----	1	mg/L		<1	**2**	**2**	**1**	**2**
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		<0.05	**3.76**	**5.78**	**6.36**	**1.35**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		<1	<1	**2**	**3**	<1
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		<1	<1	**10**	**9**	**1**
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	**2**	**3**	**2**	**1**
Magnesium	7439-95-4	1	mg/L		<1	<1	**1**	**1**	<1
Sodium	7440-23-5	1	mg/L		<1	**3**	**10**	**10**	**2**
Potassium	7440-09-7	1	mg/L		<1	<1	**1**	<1	<1
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.01**	**0.22**	**1.66**	**0.51**	**0.15**
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	**0.002**	**0.003**	<0.001
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		**0.001**	**0.014**	**0.019**	**0.018**	**0.006**
Cadmium	7440-43-9	0.0001	mg/L		**0.0037**	**0.0034**	**0.0067**	**0.0033**	**0.0015**
Chromium	7440-47-3	0.001	mg/L		<0.001	**0.007**	**0.003**	**0.004**	**0.001**
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	**0.001**	**0.001**	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	**0.025**	**0.016**	**0.036**	**0.008**
Manganese	7439-96-5	0.001	mg/L		<0.001	**0.008**	**0.016**	**0.014**	**0.004**
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	**0.003**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.005**	**0.005**	**0.005**	**0.002**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Thallium	7440-28-0	0.001	mg/L		<0.001	**0.005**	**0.002**	**0.004**	<0.001
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	**0.01**	<0.01	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Lab Blank	Field Blank	Water Tanks	Burrup Rd	Deep Gorge
				Client sampling date / time	[28-Jun-2018]	[28-Jun-2018]	28-Jun-2018 13:25	28-Jun-2018 13:08	28-Jun-2018 12:40
Compound	CAS Number	LOR	Unit		EP1808847-001	EP1808847-002	EP1808847-003	EP1808847-004	EP1808847-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Iron	7439-89-6	0.05	mg/L		<0.05	**0.12**	**0.19**	**0.28**	<0.05
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**28.0**	**36.0**	**33.7**	**8.0**
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.02**	**0.07**	**0.72**	**0.37**	**0.08**
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.50	<0.50	<0.20
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.50	<0.50	<0.20
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		<0.01	**0.04**	**0.36**	**0.34**	**0.07**
Total Cations	----	0.01	meq/L		<0.01	**0.23**	**0.69**	**0.62**	**0.14**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1822396**	Page	: 1 of 3
Client	: **COMPLIANCE MONITORING PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: JASON QUARTERMAINE	Contact	: Customer Services ES
Address	: 52 Cooper Road Cockburn Central WESTERN AUSTRALIA 6164	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 08 9175 2601	Telephone	: +61-2-8784 8555
Project	: JPA1006	Date Samples Received	: 31-Jul-2018 11:30
Order number	: EP-183-18	Date Analysis Commenced	: 02-Aug-2018
C-O-C number	: YAR20180628_EXT ALS	Issue Date	: 03-Aug-2018 16:57
Sampler	: ----		
Site	: ----		
Quote number	: EP/620/17		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA144: NATA accreditation covers the standard 8 metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)
- EA144: The metal concentration in the filter is reported in µg/filter on a total filter basis calculated up from the proportion of the filter analysed.
- EA144: The metal concentration in the filter is reported in µg/filter on a total filter basis calculated up from the proportion of the filter paper analysed.

Analytical Results

Sub-Matrix: FILTER (Matrix: AIR)			Client sample ID	37/089 Lab Blank	37/090 Field Blank	37/091 Water Tanks	37/092 Burrup Road	37/093 Deep Gorge
			Client sampling date / time	28-Jun-2018 00:00	28-Jun-2018 00:00	28-Jun-2018 13:25	28-Jun-2018 13:08	28-Jun-2018 12:40
Compound	CAS Number	LOR	Unit	ES1822396-001	ES1822396-002	ES1822396-003	ES1822396-004	ES1822396-005
				Result	Result	Result	Result	Result
EA144: Particulate Base Metals in Filter Papers								
Aluminium	7429-90-5	100	µg/filter	<100	<100	**760**	<100	<100
Antimony	7440-36-0	10	µg/filter	<10	<10	<10	<10	<10
Arsenic	7440-38-2	10	µg/filter	<10	<10	<10	<10	<10
Barium	7440-39-3	100	µg/filter	<100	<100	<100	<100	<100
Beryllium	7440-41-7	5	µg/filter	<5	<5	<5	<5	<5
Cadmium	7440-43-9	5	µg/filter	<5	<5	<5	<5	<5
Chromium	7440-47-3	5	µg/filter	<5	<5	<5	<5	<5
Cobalt	7440-48-4	5	µg/filter	<5	<5	<5	<5	<5
Copper	7440-50-8	5	µg/filter	<5	**2230**	**1110**	**197**	**391**
Magnesium	7439-95-4	500	µg/filter	<500	<500	<500	<500	<500
Manganese	7439-96-5	5	µg/filter	<5	<5	<5	<5	<5
Molybdenum	7439-98-7	5	µg/filter	<5	<5	<5	<5	<5
Nickel	7440-02-0	5	µg/filter	<5	<5	<5	<5	<5
Thallium	7440-28-0	5	µg/filter	<5	<5	<5	<5	<5
Tin	7440-31-5	5	µg/filter	<5	<5	<5	<5	<5
Titanium	7440-32-6	5	µg/filter	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	µg/filter	<5	<5	<5	<5	<5
Iron	7439-89-6	10	µg/filter	<10	**12**	**240**	**165**	**496**
Lead	7439-92-1	10	µg/filter	<10	<10	<10	<10	<10
Selenium	7782-49-2	10	µg/filter	<10	<10	<10	<10	<10
Mercury	7439-97-6	0.5	µg/filter paper	<0.5	<0.5	<0.5	<0.5	<0.5

Attachment 10Aa: Letter YPN to Department regarding Rock Art Monitoring, dated 3 November 2017

Knowledge grows

3 November 2017

Our Reference: 650-208-LET-YPN-0001

Your Reference: EPBC 2008/4546

Monica Collins
Chief Compliance Officer
Office of Compliance
Department of the Environment and Energy
GPO Box 787
Canberra ACT 2601

Dear Ms Collins

Proposed Technical Ammonium Nitrate Production Facility (EPBC 2008/4546)

I write in relation to the Consolidated Approval Notice for the above referral, issued by your Department and dated 12 September 2017.

Condition 10A of the Consolidated Approval Notice, *On-going Rock Art Monitoring*, requires the first on-going rock art monitoring event to be completed by no later than 31 December 2017, and I wish to update you with respect to Yara Pilbara Nitrates actions to date to meet this condition, and seek approval of our proposed methodology and monitors.

As you are aware, previous rock art monitoring on the Burrup Peninsula was undertaken by CSIRO as part of the Western Australian Government's Burrup Rock Art Monitoring Program which expired in June 2016. Since that time, the WA Government has failed to replace the program and so we are in the position of needing to conduct our own rock art monitoring as per the Consolidated Approval Notice. Yara recognises the importance of obtaining data in 2017 so as to avoid a year-long gap in the monitoring data. Our efforts aim to make the data we gather as useful as possible in contributing to the understanding of the rock art and any potential impacts thereon.

A key aspect of our initial efforts has been to engage and include members of Murujuga Aboriginal Corporation (MAC) in our rock art monitoring activities. We note that as freehold title holders for the Murujuga National Park, as cultural custodians for the rock art and as Indigenous Rangers working on country, MAC are key stakeholders regarding Burrup rock art, yet they continue to state that they are being sidelined and treated paternalistically with respect to the Burrup rock art, as they attested at the Senate Inquiry earlier this year.

We have met the CEO, Chairperson, Circle of Elders and the Manager of the Murujuga Land and Sea Unit. They have agreed to assist in the rock art monitoring program for 2017, and our experts will work with the Rangers to ensure knowledge and skills transfer take place. Murujuga are supportive of this work and look forward to working with Yara.

Yara Pilbara Nitrates Pty Ltd

Postal Address
Locked Bag 5009
Karratha WA 6714
Australia

Visiting Address
Lot 564 and 3017 Village Road
Burrup WA 6714
Australia

Telephone
+61 8 9183 4100
Facsimile
+61 8 9185 6776
ABN
33127391422

Registered Office:
Level 5, 182 St George Terrace
Perth WA 6000
Australia
Telephone: +61 8 9327 8100
Facsimile: +61 8 9327 8199

Knowledge grows

The proposed methodology is attached, and we trust it will meet with the approval of the Minister. As you will see, we have taken the previous CSIRO methodology, and made some changes to reflect clear recommendations of the Data Analysis Australia report *Review of CSIRO Report on Burrup Peninsula Rock Art Monitoring* found on the web at

https://www.der.wa.gov.au/images/documents/our-work/consultation/Burrup-Rock-Art/DAA-independent-review-report---May-2017.pdf

We noted your Department's endorsement of the role of CSIRO in previous rock art monitoring in the Department's response to comments in Dr Ken Mulvaney's submission to the Senate Inquiry. We trust that the Department therefore has a familiarity and understanding of the methodology presented.

Condition 10A c) requires the rock art monitoring to "…be undertaken by a suitably qualified person (Heritage)", with the definition later provided:

> ***Suitably qualified person (Heritage)*** *is a person with at least a bachelors degree with Honours in archaeology or five (5) years experience in Indigenous heritage or archaeology recognised by a relevant body such as the Australian Association of Consulting Archaeologists.*

Our program will be led by Warren Fish, who is a Masters Degree qualified archaeologist and an ex-Registrar of Aboriginal Sites with the WA Government, with well over a decade of experience in Indigenous heritage. Warren will be supported by Dr Ian MacLeod, who is a highly respected international academic and scientist, specialising in heritage conservation. Dr MacLeod has been instrumental in the various rock art conservation and monitoring campaigns conducted on the Burrup. CVs are attached for both. As previously mentioned, the heritage custodians of the Burrup rock art, Murujuga Aboriginal Corporation, will be actively involved in the monitoring. These participants ensure we meet this Condition of the Consolidated Approval Notice.

We trust that this interim program meets with approval of the Minister, and would like to state our keenness to support updated methodology and monitoring in subsequent years. We are more than happy to provide further information, and look forward to working with the Department to ensure monitoring takes place in a timely manner. Should you need any further information before putting the proposed monitoring program to the Minister, please do not hesitate to contact us. In addition, if you feel that Departmental staff may benefit from a visit to the Burrup to better understand Yara's activities and the context in which we operate, we would be only too happy to host them.

Yours Sincerely,

Brian HOWARTH

HESQ Manager

Yara Pilbara Nitrates

Attachments

1. CV Fish
2. CV MacLeod
3. Proposed Technical Ammonium Nitrate Production Facility Rock Art Monitoring Methodology

cc. Craig Bonney, CEO MAC

CV

Warren Stuart FISH

PERSONAL DETAILS

Name: Warren Stuart FISH

Address:

Telephone:

Email:

Warren has over 20 years of leadership experience and is highly skilled at developing and implementing strategic objectives.

He has international experience in corporate governance, Health Safety and Environment leadership, enterprise risk management, government relations, corporate affairs, Indigenous affairs, and people logistics.

Warren has held senior leadership positions in the Western Australian State Government; worked in the United States, southern Africa and Australia; and held key management roles in successful major projects.

IN BRIEF

20 years working in:

- Executive management
- Corporate Affairs
- Heritage and native title
- Sustainability
- Health, safety and environment (HSE) and sustainable development
- Corporate compliance and approvals
- Enterprise risk management

Experience:

- Project Director: Stakeholder Relations and Approvals, encompassing all HSE components. $8 billion greenfields JV with multi-cultural partners and complicated commercial arrangements. Construction of a mine, railway and port and marketing of product and project into China and Korea.
- Executive Director: Health, Safety, Environment and Corporate Logistics at CITIC Pacific Mining, an $15 billion greenfield magnetite project in north-west Western Australia. Greenfields construction of a mine, processing plant, infrastructure corridor, power station and port. My role extended to Executive Director of the company.

- Key management and leadership roles:
    - Aurizon
    - CITIC Pacific Mining
    - North West Shelf Venture

    - Woodside Pluto LNG projects
    - Registrar of Aboriginal Sites, WA State Government

- Work locations in the United States, southern Africa and Australia

Qualifications:

- MA (2001): respected in the international academic community, with numerous papers published in peer-reviewed journals, and have reviewed wide-ranging papers for academic publications.

Board representation:

- Previous membership of 14 Boards, including CITIC Pacific Mining Management Pty Ltd.

EMPLOYMENT HISTORY

September 2016 - Present:

WS Fish Consulting
Principal

Consulting to industry on:

- Stakeholder Management and Corporate Affairs
- Government relations
- Heritage and native title
- Sustainability
- Health and Safety
- Environment

Skills include, although not limited to the following:

- Utilising strong government relationships (both State and Federal) to connect business leaders to political leaders in order to influence policy direction.
- Providing strategic advice to senior management and board on sustainability, stakeholder relations and community engagement.
- Delivery of regulatory approvals.

August 2014 – September 2016:

Aurizon
Project Director: Stakeholder Relations, HSE and Approvals

The West Pilbara Infrastructure Project (WPIP) is a Joint Venture with Baosteel, POSCO, and AMCI to construct and operate an iron ore mine, 280km railway and port in the west Pilbara, Australia. Initial capacity is 40mtpa scalable to 250mtpa. Reporting to the Executive Vice President Strategy and Business Development I held formal accountability for below but was also heavily involved in Corporate Affairs issues across the business. This included providing advice to the then CEO on State and Federal political matters.

Portfolio included accountability for:

- Stakeholder Management and Corporate Affairs
- Sustainability
- Health and Safety
- Environment
- Heritage and native title

Responsibilities included:

- Successful delivery of regulatory approvals
- Lead negotiations for a State Agreement with the WA Government, including driving its passage through Parliament.
- Lead negotiations on a State Development Agreement for the Port, allowing sufficient control for Aurizon to take advantage of significant opportunities.
- Lead negotiations on Native Title Agreements.
- Ensure that commercial relationships were appropriately established and maintained.
- Develop and maintain strong joint venture, supplier and stakeholder relationships.
- Lead the implementation of the Heads of Agreement in terms of the management of major stakeholder relationships.

Key achievements

- Negotiated changes to approved Government port layout and design. Led to $600m construction savings.
- Negotiated change to Government position on State Agreement term from 16 yrs +10+10 to 50 yrs +10+10. This increased project viability and led to significantly more favourable financing terms.
- Negotiated changes to Government policy relating to financial mechanisms usually required in State Agreements (use of trust structures as proponents)

May 2010 - June 2014:

CITIC Pacific Mining Management Pty Ltd
Executive Director: Health, Safety, Environment and Corporate Affairs

CITIC Pacific Mining (CPM) is an Australian company wholly owned by the CITIC Group, one of China's largest SOE's. CPM constructed China's largest resource project in Australia in the form of a magnetite mine in the Pilbara. The Project is a $15bn resource and infrastructure project consisting of a mine, concentrator, 450MW gas-fired power station, 30km infrastructure corridor, tailings facility, 60GL desalination plant and port. Peak construction workforce was 4500.

Portfolio included accountability for:

- Health and Safety
- Corporate Affairs
- Sustainability
- Corporate Logistics
- Environment
- Heritage & Native Title
- Pastoral Management (Mardie Station)

Reporting to the Executive Chairman, this position carried accountability for CITIC Pacific Mining's license to operate.

Responsibilities included, although not limited to the following;

- Staff compliment – approximately 120 (300 including contractors) people and $90m annual budget.
- Board level decision-making and planning advice on company strategic direction.
- Health and Safety portfolio for construction, commissioning and operations. Peak workforce of over 4500.
- Cultural change programs in Health and Safety leading to a significant reduction in injuries.

Key achievements

- Introduced the first publication of a comprehensive Sustainability Report in the CITIC Group's history. Sustained and sophisticated internal stakeholder management at senior executive and board level required to gain approval for this to be undertaken in a traditionally conservative Chinese SOE. The report was well-received and the template was used for other business units in Hong Kong and mainland China. This lead to wide-ranging internal discussion on the potential effects of climate change on various parts of the business.
- Stakeholder relations campaign with Federal politicians around the Carbon Pollution Reduction Scheme (CPRS) and Clean Energy Futures (CEF). Design of carbon

policy for CITIC Pacific Mining, particularly around 450MW power station and the construction of a solar farm to contribute to offset. We were able to win significant Federal funding to support the construction of the solar farm, leading to dramatic reduction of accommodation village costs.

- Significant issues were being encountered with the Safety portfolio, with poor performance and high injury rates. After a fatality occurred, I was asked by then-CEO to lead the undertaking of a cultural change project in the Safety portfolio. Detailed and sophisticated stakeholder work with Australian Board, Hong Kong Board and CITIC Board in Beijing. Program design and implementation across site with 4500 construction workers. Led to decrease in Recordable Injury Frequency Rate from 14 down to 3 within six months.
- Company Logistics were not being efficiently managed. Then then-CEO requested I undertake a change management project to rectify. I led renegotiations of contracts with QANTAS and other air and bus charter providers, as well as accommodation village service providers (3 different providers and 3 villages). Security contracts were redesigned. Outcome was a more disciplined approach to corporate logistics and significant cost savings. CEO then requested that the same study be undertaken on other portfolios, including site maintenance, which was also posted under my aegis.
- Mardie Station had been purchased by the company to shore up tenure and secure land access. The station had been running at a loss and the then then-CEO turned to me to rectify. I undertook a full review of operations which led to leaner operating models and the setup of a feedlot. This included capital spend on infrastructure, which was a difficult sell when instruction was to cut costs. The Board agreed with my logic and proposal, capital costs were incurred and Mardie Station has run at a healthy profit every year since.
- Site faced a significant fibrous materials issue and State Mining Engineer's advice to Mines and Petroleum Minister was to temporarily shut down the site. I led negotiations for Project to remain active while safety regime was being re-designed.
- Maintained strong relationships with Federal and State Government despite contentious issues, including significant cross-cultural and political miscommunication.

March 2008 – April 2010:

CITIC Pacific Mining Management Pty Ltd
Director, Corporate Affairs, Environment and Heritage

Reporting to the CEO, this position was created to direct the Environment and Heritage portfolio and increase focus on approvals, compliance, sustainable and responsible development, and the management of community and stakeholder expectations in these spheres including;

- High level negotiations and interaction with various Commonwealth and State Government Departments.
- Environment, Heritage and Land Access processes and approvals, within accelerated timeframes, and Tenement Management.
- Indigenous relationships, consultations, approvals, surveys and negotiations with Traditional Custodians.
- Negotiator to CPM Legal Counsel during negotiations with three different Native Title Claimant Groups and on-going administration of Native Title portfolio.
- Responsibility for Indigenous Business and Employment strategy

Key achievements

- Approvals were the major risk to the project and were holding up construction at a

cost of US$7m/day. I led the turnaround to a position where approvals were 6-8 months ahead of construction. This involved complex negotiations with Government and led to parallel approval processes being put in place. This had not been done before by Government.
- Significant fibrous materials (asbestos) issue on site with Dept of Mines and Petroleum Safety Branch advice to temporarily close site and halt construction. I successfully negotiated an outcome at Director General level that allowed construction to continue whilst new protocols were being designed and implemented.
- Re-negotiated approval conditions that were expensive and onerous to comply with. This led to significant cost savings.

Dec 2006 - March 2008:

Woodside Energy Limited
Corporate Affairs, Heritage Manager

This position was created in the face of increased scrutiny in land access negotiations and entailed managing all Woodside heritage matters, including:
- Staff compliment – 5 reports
- High level negotiations with various Commonwealth and State Government Departments on National Heritage Listing.
- Drafting of Conservation Agreements between Woodside and the Commonwealth, and the NWSV and the Commonwealth.
- Heritage work exceeding international best practice on the Pluto Project.
- Managing corporate social responsibility.

Key achievements
- Led work negotiating National Heritage Listing of the Burrup peninsula with Pluto and North West Shelf areas excised.
- Negotiated Traditional Owner participation in heritage projects despite high-profile opposition from conservation groups and activists.

Nov 2004 - Dec 2006:

Woodside Energy Limited
Manager Corporate Affairs, Karratha

Woodside Energy is Australia's largest oil and gas producer. Their primary facility is the Northwest Shelf Gas Plant, outside Karratha in Western Australia and is the largest resource project in Australia.

This position entailed managing a team to ensure delivery on the following issues:
- Staff compliment – 9 reports
- Corporate affairs advice
- Government and community relations
- Media and issues management
- Emergency response
- Government approvals
- Native Title and heritage
- Sustainability portfolio

Key achievements
- Member of the senior leadership team of 6 responsible for delivery of LNG cargoes as well as domestic gas to WA.
- Expansion of gas plant with no community issues raised.

May 2004 - Nov 2004:

Department of Industry and Resources, Perth
Heritage Manager

This position was created in order to provide advice to the Department, industry proponents and external stakeholders regarding heritage, Native Title and land access issues. Most of this work was undertaken on major projects and areas of my involvement included the Burrup Peninsula, Ord Stage II, ALCOA and Gorgon amongst others. This senior management position provided high-level advice to the Minister for State Development.

July 2002 - May 2004:

Department of Indigenous Affairs, Perth
Assistant Director, Heritage and Culture Branch
Registrar of Aboriginal Sites

The role as Assistant Director managed the Heritage and Culture Branch and the compliance arm of heritage legislation and attendant approvals system. A network of regional offices reported to this position. Strategic and operational policy was designed and implemented.

The Registrar is responsible for Aboriginal sites in Western Australia. High-level discussions and negotiations were undertaken with other State Agencies (usually at Director-level and upwards), industry representatives and Aboriginal organizations to facilitate responsible development. The Registrar provides the Minister for Indigenous Affairs with advice on development approvals.

February 2001 - July 2002:	Curtin University of Western Australia Consultant/Sessional Academic
March 1998 - Feb 2001:	KwaZulu-Natal Museum Service Media and Liaison Officer
1997 (3 months):	University of Colorado Denver Museum of Natural History Canyon Archaeological Centre Selected to participate USA government sponsored program of work.
April 1994 - March 1998:	Northern Province Heritage Service Archaeologist

QUALIFICATIONS

CURTIN UNIVERSITY OF TECHNOLOGY
Perth, Western Australia
Postgraduate courses completed at Curtin Business School:

- Marketing Theory 568
- Marketing Research 562
- Internet Marketing 567
- Applied Cases in Electronic Marketing 560
- Research Methodology 655

UNIVERSITY OF THE WITWATERSRAND
Johannesburg, South Africa
M.A.
2001 Masters Degree by research in archaeology
Thesis: “Early Venda History and the Mutokolwe Ruins near Tshiendeulu”

UNIVERSITY OF CAPE TOWN
Cape Town, South Africa
B.A. HONOURS
1991 - Graduated with Honours in maritime archaeology
Thesis: “Historic Shipwrecks; Issues in Management in a South African Context”

UNIVERSITY OF CAPE TOWN
Cape Town, South Africa
B.A.
1990 - Graduated with Bachelor of Arts, majoring in Archaeology

REFERENCES

References can be provided on request.

Curriculum Vitae for Ian Macleod

Place & Date of Birth:

Nationality:

Business Address: Heritage Conservation Solutions
2/258 Labouchere Road, Como, Western Australia 6152
Telephone: 61-419952706
e-mail: iandonaldmacleod@gmail.com

Research Address: Western Australian Maritime Museum
Peter Hughes Drive, Victoria Quay
Fremantle, Western Australia 6160
Telephone: 61-8 94318302 (messages)
e-mail: ian.macleod@museum.wa.gov.au

Education:

2007: Doctor of Science, University of Melbourne: Thesis title *Chemistry and Conservation of Shipwrecks and Rock Art*, March 2007.

1974: Doctor of Philosophy, University of Melbourne: The thesis *"Polarography in anhydrous hydrogen fluoride"* reported on the electrochemistry of the transition and p-block metal-fluorides dissolved in liquid anhydrous-hydrogen-fluoride. Supervisor was the late professor Tom O'Donnell.
1970: Bachelor of Science (Hons) - (H2A), **University of Melbourne**. The thesis "*Potentiometry in Anhydrous Hydrogen Fluoride"* reported a study of the electrochemical properties of tin fluorides dissolved in liquid anhydrous-hydrogen-fluoride.

1961 – 1966: Ballarat High School, Victoria

Awards and Fellowships

Fellow of the Society of Antiquaries of Scotland (FSA Scot, 1974)
Fellow of the Royal Australian Chemical Institute (FRACI 1986)
Chartered Chemist (C.Chem. 1986)
Fellow of the International Institute for the Conservation of Artistic and Historic Works (FIIC, 1987)
Fellow of the Australian Academy of Technological Sciences & Engineering (FTSE, 2000)
Fellow of the Royal Society of Chemistry (FRSC, 2013)

International Council of Museums Committee for Conservation Triennial Medal (2017)
Heritage Council of Western Australia Medal, Professional Category (2017)
Bathurst Macquarie Heritage Medal finalist (2017)
Life Professional Member of the Australian Institute for the Conservation of Cultural Materials (2015)
Life member of the Australasian Corrosion Association (2014)
Corrosion Medal, the Australasian Corrosion Association for service and public engagement (2004)
Centenary Medal for services to Metallurgy and Technological Sciences, Australian Government (2003)
Alton Batty Medal for applied chemistry, Royal Australian Chemical Institute (1999)

Employment History in Conservation Management

May 2016 - present: Principal *Heritage Conservation Solutions,* an independent corrosion and deterioration assessment consultancy group operating in the museum and community sectors. Specialities include problem solving in corrosion degradation and management of buildings and sites.

May 2011- May 2016
Executive Director, Fremantle Museums and Collections
The primary responsibility of this position was the integrated management and service delivery of museum programs in Fremantle, including engagement with many community groups in the region. The role coordinated the departments of Materials Conservation, Maritime Archaeology and Maritime History and front of house staff. During this period applied research included microbial corrosion, the conservation of historic shipwrecks and the application of *in-situ* treatment methodologies to site management strategies. The assessment of buildings for passive conservation management for large collections has been shown to be cost effective and sustainable. A new approach for the determination of intervention priorities for major collections has been developed.

June 2006 – May 2011 Executive Director, Collection Management and Conservation
The position involved the management, development and integration of the museum collections and conservation programs with the relocation of objects and staff within the metropolitan area. During this interval I effected the safe relocation of collections from five metropolitan storage sites to the central facility that I set up in suburban Welshpool. This rationalisation involved closing two museum sites and three storage locations. I project managed the valuation of the 12½ million objects in the WA Museum collections which were valued at $638 million. During this period my research focus was on corrosion phenomena on the Australian WWI submarine AE2 in the Sea of Marmara in Turkey and Japanese shipwrecks from WWII in Chuuk Lagoon in Micronesia.

July 2003 to June 2006
Director, Museum Relocation Project & Museum Services
I was responsible for the relocation of 85 staff, honorary associates, volunteers and 4½ million collection items from the WA Museum site in Perth site to the new Collections and Research Centre in Welshpool. The relocation was necessitated due to a unique combination of hazards from latent asbestos risk and major dangerous goods fire hazards associated with more than 130,000 litres of ethanol stored on site in the main museum building. The project consisted of the conversion of a 9,000 m^2 building into an integrated suite of laboratories and collection boxes which had a high-quality temperature and relative humidity controlled storage facility with dust removal to 1µm. This was a massive preventive conservation project covering the bulk of the WA Museum collections. As project manager I coordinated engineers, architects, space planners, curators, collection managers, staff, and the development of communication strategies for key players. The project involved regular briefings with the Minister and Director General of the Department for Culture and the Arts as well as the chair of the Board of Trustees. The project was completed on time and within the $11 million budget.

1978 – 2003
Various positions within the WA Museum Materials Conservation and general administration.

Research Background:

Applied Chemistry

During my PhD and post-doctoral fellowships I developed a range of techniques for solving complex problems which involved careful experimentation, fine motor coordination skills and ability to engage a wide variety of audiences with the nature of the applied research.

Cultural Materials Conservation

I have pursued an understanding of the mechanisms of decay of cultural materials with detailed analysis of the layers of degraded materials on objects recovered from terrestrial and marine environments. Part of this work has involved surface analysis of tool-marks; wear patterns and fabrication techniques, as well as provenance studies on the materials used in the manufacturing processes. I have achieved an international reputation for my *in-situ* corrosion studies on historic shipwrecks, with particular emphasis on iron shipwrecks. Through successful modelling of the electrochemical processes involved in corrosion of shipwreck materials I have developed models that predict the decay rate of the vessels. I pioneered the use of sacrificial anodes on iron artefacts as a method of *in-situ* conservation. Major achievements have incorporated sites such as the SS *Xantho* (1872) steam engine in Western Australia, the best bower anchor and a carronade from the HMS *Sirius* (1790) on Norfolk Island, a the composite wooden-iron wreck of the *Zanoni* (1867) in South Australia and cannon from the *Swan* (1653) in Scotland and both HMVS *Cerberus* (1926) and the *City of Launceston* (1865) in Victoria. A method of assessing the age of corroded cast iron cannon has been stablished using chloride diffusion data.

Successful identification of contemporary forgeries in silver coins recovered from the wreck of the Dutch *Batavia* (1629) and the American *Rapid* (1812) provided insights into corruption in the Spanish Netherlands in 1562 and in Mexico during 1796. Surface analysis of corroded silver coins on the Portuguese shipwreck of the *San Pedro de Alcantara* (1786) provided an energy map of the turbulent wreck site. Industrial practices of the 19th century have revealed the way in which ships' fastenings contributed to the ultimate loss of the vessels through decay mechanisms associated with premature structural failure due to inclusions. Analysis of the encrusting marine organisms has shown that bacteria convert phosphorus impurities in iron into a growth stimulant.

I developed the method for determining the dimensions of scantlings on historic iron shipwrecks from the combination of residual metal thickness and the long-term corrosion rate. I determined the impact of stresses during manufacture and shipwrecking processes on the corrosion rate of non-ferrous metals. The effect of chloride ion concentration on the corrosion rates of iron alloys has been characterised. Detailed analysis of corrosion data from 70-year old wrecks in Chuuk Lagoon in the Federated States of Micronesia has enabled prediction of when they will collapse. Collaborative work with marine biologists has established the first evidence of biodynamic interaction of marine organisms with wrecked ships and aircraft and how marine organisms affect the deterioration of wrecks.

Through applied micrometeorology it was demonstrated that the active decay of historic prisoner-painted surfaces was due to hard render on the exterior of the World Heritage listed former convict-built Fremantle Prison. This study prompted the Heritage Council of WA to order removal of the 100 year old render which has now stabilised the site. Chloride mapping at St Georges Anglican cathedral in Perth demonstrated that salt movement was the primary cause of degradation of brick and stonework. Wide scale application of papier-mâché poultices enabled the bulk of the salts to be removed and to retain the original materials, which was the first time the process had been carried out on an industrial scale in Australia.

My work on the Australian WWI submarine HMAS AE2 in the Sea of Marmara, Turkey has resulted in the application of ten tonnes of zinc sacrificial anodes to conserve this historic vessel on the seabed at a depth of 73 metres. Data collected from in-situ corrosion measurements has shown the pH profiles found adjacent to the submarine and at a distance of 25 metres are replicated in microenvironments inside the complex submarine. I have developed a method to determine when in-situ conservation of marine iron objects has reached effective completion without the need for excavation activities.

I have developed the method for migrating formalin-preserved natural science specimens from 70% ethanol to 65% aqueous glycerol which has been applied to the WA Museum's iconic Megamouth III, a

5.2 metre The treatment program was conducted inside a public gallery at the WA Maritime Museum and has resulted in a stabilised shark that has lost a lot of its shrinkage caused by 13 years of alcohol induced desiccation. The method is now being used by the Natural History Museum in London on a large great white shark.

Working with the Benedictine community at New Norcia, Australia's only monastic township, I developed a significance and conservation ranking which enables calculation of which objects are the most important to treat. This work has been successfully extended to the management of iron shipwrecks in Port Phillip Bay and Bass Strait. I also developed a method of removing tarnish from metallic threads in a 17th century cope by using neutral buffered solutions of dithionite and immersion of the textiles.

Conservation of Aboriginal Rock Art

Thirty-five years ago, my introduction to Aboriginal rock art in the Wheatbelt of Western Australia began. The task was to assess the impact of previous interventions involving installation of drip lines and graffiti removal to control degradation of sites. Through connections at Murdoch University I established the methodology of applying the principles of micrometeorology to model the decay rates of engraved and painted surfaces. This work lead to a series of successful grant applications to fund basic research into the physical microenvironment of the sites to see how the chemical and microbiological activity interact to control the rates of physical and biological degradation. Micro-environmental modelling correctly replicated the temperature profiles of rock art sites in the West Kimberley and Murchison regions of Western Australia. This work enables estimation of the annual climate of the sites without the need for repeated visitation.

The complexities of the decay patterns on the Kimberley Wandjina paintings were shown to be due to acid dissolution of the intensely white pigment huntite, $Mg_3Ca(CO_3)_4$ into pseudomorphic whewellite $CaC_2O_4.H_2O$, which preserved the form of the totemic images. Acidic solutions from rainfall events in the absence of oxalate ions dissolve the images. Microenvironment and mineralogy studies at *Walga Rock* has revealed a series of complex dissolution and re-precipitation reactions whereby water born ions derived from aged avian guano results in the preservation of calcitic and kaolinitic pigments on the images. Research in the Burrup peninsula established the direct relationship between acidity of the rocks and the number of bacteria, yeasts and moulds growing on their surface and the impact of nitrates on the overall microbiological activity. I introduced using pH measurements to assess the local environment and now have extended the work to include E_h data collected directly from the rock surfaces. I have established the connection between industrial emissions and apparent acceleration of the decay rate of petroglyphs.

I was the deputy ex-officio WA Museum member on the Aboriginal Cultural Materials Committee of the Department of Aboriginal Affairs for eight years. This committee met monthly and advised the Minister on the impact of proposed mining and development applications on Aboriginal sites with recommendations on which sites should be preserved and which can be destroyed.

Professional Activities

I have been a member of the Royal Australian Chemical Institute since 1970 and was the Media Liaison Officer for the WA Branch in 1984 and a Fellow since 1986. I have been a member of the Australasian Corrosion Association (ACA) for 40 years and was on the Editorial Board of their journal *Corrosion and Materials* for five years and am the present Editor. The ACA recognised my contribution to corrosion science through the invitation to present the *P.F. Thomson Memorial Lecture* at the ACA Bicentennial Conference in Perth in 1988, in Adelaide for 2002 and in Perth 2011 for the 18th International Corrosion Congress of which I was the chair. I was awarded their ***Corrosion Medal*** in 2004 for services to the Association and to public education. In 2005 I was a plenary lecturer at the

Golden Jubilee conference of the ACA and opened the Trade Fair. I have given numerous seminars for the association over the last 38 years. I was elected to Life Membership of the ACA in 2014. I was Federal Treasurer of the Australian Institute for the Conservation of Cultural Material (AICCM) from 1980- 89 and Western Australian Branch President in 1979, 1988-1992 and again in 2006 and was a member of the Professional Accreditation Committee for ten years. I am a Professional Conservator life member of the AICCM.

I was a member of the Conservation and Collections Management Working Party of the Heritage Collections Council of the Commonwealth of Australia for five years. In September 1999 I was elected to the Directory Board of the Conservation Committee of the International Council of Museums and completed my second term in 2005, having brought about fundamental changes in the by-laws that facilitated universal access to the election processes for the Directory Board of ICOM-CC. November 2000 saw my election as a Fellow of the Australian Academy of Technological Sciences and Engineering and I was invited by the IIC to be a member of the editorial board of new international journal *Reviews in Conservation*.

I give regular media interviews and lectures to service organisations and community groups and run public workshops in Preventive and Metals Conservation for Edith Cowan University's *Certificate in Museum Studies*. From 1998-2004 a series of keynote addresses were presented at the Murdoch University Science Summer School for year 10 & 11 high school students. I was appointed to the Editorial board of *Conservation and Management of Archaeological Sites*. In 2007 I was a guest lecturer for the Murdoch University STAR program and gave a RioTinto sponsored talk on *Conservation Chemistry Science* to year 10-11 high school students in Northam, Tom Price, Carnarvon and Bunbury and reached more than 1200 students in one week. In 2009 the Murdoch University Science Summer School appointed me as plenary lecturer for their science communication program for year 10 and 11 students. On average I delivered 45 public talks a year at community groups or at conferences and workshops during my five-year term as Executive Director of the Fremantle Museums. In 2017 I was awarded the medal for Professional Practice by the WA Heritage Council and the ICOM-Committee for Conservation Silver medal for services to materials conservation.

Research Grants

The Lotteries Commission grant was given to the Swan Bells Foundation of which I am the chair.
I was a principal investigator under Peter Veth for the ARC Historic Shipwrecks Preservation Project
The Synchrotron analysis of the de Vlamingh was a joint project with the National Gallery of Victoria (David Thurrowgood). The present study on the Hartog plate is a joint venture between the Rijksmuseum (Amsterdam), the Queen Victoria Museum in Launceston and the Western Australian Museum.

For all other grants, I was the applicant and awardee.

Year	Source	Value	Title
2017	Synchrotron	$35,000	*XFM Study of the Hartog Plate*
2015	Lotteries Commission (WA)	$300,000	ANZAC 100th Anniversary memorial bell
2013	Synchrotron	$35,000	*XFM Study of the de Vlamingh Plate*
2011	ARC Linkage	$180,000 cash $521,000 in kind	*Australian Historic Shipwreck Preservation Project: Clarence (1850)*
1994	British Council	$2,600	*In-situ corrosion studies on a Cromwellian warship in Scotland*
1994	AIATSIS	$10,856	*Microclimate modelling of rock art sites in the Kimberley Region of WA.*
1991	WA Heritage Council	$24,000	*Microclimate studies and site management strategies II*
1990	AIATSIS	$10,000	*Microclimate studies - effects of animal excreta on rock art.*
1990	National Estate Program	$72,000	*Microclimate studies and development of site management programmes for conservation of rock art in West Kimberley Region of Western Australia.*
1988	ARC	$18,000	*Conservation of wood-iron composite materials and pewter.*
1987	AIATSIS	$11,150	*Conservation of rock art at McKay Caves*
1987	AIATSIS	$6,750	*Conservation of rock art at Walga Rock*
1985	ARC	$35,500	*Conservation and degradation of pewter and wood-iron composite materials recovered from historic shipwrecks'*

Career Highlights

2017 Awarded Professional Contribution medal by the WA Heritage Council. Work on the conservation of the fire ravaged Yarloop Railway Workshop museum. Work with *Nutopia Films* on bacterial corrosion of iron shipwrecks in Chuuk Lagoon, Federated States of Micronesia. Recording pH and E_h of Burrup rock art. Microenvironment analysis at an early bronze age mound at the Japanese Centre for Anatolian Archaeology at Kaman, Turkey. Awarded ICOM-CC Triennial medal at the XVIII Conference, Copenhagen.

2016 Developed and co-presented a 5-day metals in textile conservation workshop for the Queen Sirikit Textile Museum in Bangkok and quantified the impact of high temperatures and humidity on biodeterioration of textiles. I co-presented an AICCM Textile Working Group workshop in Sydney on treatment of composite metal and textile objects. Coordinated fund-raising for $485,000 for a 6.5 tonne ANZAC Memorial bell for the Swan Bell Tower to commemorate the 100th anniversary of the ill-fated campaign. Solved accelerated corrosion of jetty piles at a yacht club as *Heritage Conservation Solutions*.

2015 Presented plenary lecture on in-situ conservation of the AE2 submarine in Istanbul and participated in the 100th anniversary ceremonies over the wreck site on board HMAS Anzac. Conducted field work and presented a course in application of micro-climate studies on the mineralogy and microbial activity on rock art sites in Mexico City. Elected to Honorary Professional Life Membership of the AICCM. Part time Ph. D. supervision of Susie Collis at the Grimwade conservation centre. Presented summary of in-situ conservation assessment and treatment of HMAS AE2 with sacrificial anodes at the concluding international workshop at the Maritime Museum in Istanbul in April. I also presented the Stanhope Oration at the annual national conference of the science teachers and school laboratory technicians association. Appointed community reference member for the University of WA Cultural Collections Board.

2014 Presented closing plenary lecture at the International Council of Museums' Committee for Conservation Triennial conference, Melbourne on *Innovative Australian conservators preserve heritage* and delivered three papers on aspects of applied conservation research. Elected to Life Membership of the Australasian Corrosion Association. Appointed as corrosion advisor to the USS Lexington (WWII) aircraft carrier search team. Presented a plenary lecture at a corrosion conference in Washington DC on historic aluminium artefacts. Featured in ABC TV *Catalyst* on AE2 submarine in the Sea of Marmara, Turkey.

2013 Awarded a Synchrotron grant with David Thurrowgood of the National Gallery of Victoria for access to the X-Ray Fluorescence Microscopy beam line for studying the de Vlamingh plate (1697). I presented the RACI-WA Division Bayliss Youth lecture titled *Chemists and Heritage Conservation* to Year 10-12 High School students in Western Australia and the Northern Territory. I was awarded a Fellowship of the Royal Society of Chemistry. I conducted a corrosion survey on the wreck of HMCS *Protector,* Heron Island, in the Great Barrier Reef. I took on co-supervision of Ph D candidate Maria Jacobsen, University of Haifa regarding the archaeology of the H. L. Hunley (1864) submarine site. Identified a 19th century high quality steel hand axe on ABC TV show *Somebody has been sleeping in my house*. I was appointed by Minister of Science and Innovation to a three member panel to review the operations of the Chemistry Centre of WA and our report has been presented to the Premier of WA.

2012 Appointed Editor of *Corrosion and Materials*, the journal of the Australasian Corrosion Association. I became a member of the management advisory committee for the Royal Australian Air Force Association Aviation Memorial Museum in Perth. Engagement with the *Clarence* (1850) site management and excavation - reburial team off St Leonard's, Port Phillip Bay under the auspices of the ARC Cooperative Research Centre on Historic Shipwrecks. Conducted a webinar on stainless steel corrosion in Beijing and a web based

tutorial for American high school students on redox and corrosion chemistry and a web enabled lecture on the conservation of the RMS Titanic at the Royal Institution in Adelaide. Delivered a one-week metals intensive training program to Masters' students that the University of Melbourne's Centre Cultural Materials Conservation program.

2011 Principal investigator in ARC Linkage Grant on "In-situ preservation of the *Clarence* (1850) shipwreck in Port Phillip Bay Victoria". Undertook the office of Past President of Australasian Corrosion Association and was Conference chair for the 18th International Corrosion Congress in Perth. Four months at the Getty Conservation Institute in Los Angeles studying the corrosion and conservation of shipwreck artefacts. Presented papers at the ICOM-CC conference in Lisbon on the glycerol treatment of sharks to replace ethanol and on the corrosion of wrecks in Lake Huron, Canada. I undertook a Significance assessment of the ecclesiastical textile collection at the Benedictine community at New Norcia, Western Australia which led to the modelling of treatment prioritisation matrices to assist in the effective management of their collection.

2010 Elected President of the Australasian Corrosion Association. Pre-prints committee member for ICOM-CC in Lisbon. Presented work on the Australian submarine AE2 (1915) at the Metal 2010 conference and conducted practical workshops at the Clemson University Conservation Centre in North Charleston. I also presented a paper on the corrosion of iron shipwrecks in Chuuk Lagoon to the NOAA international conference on WWII ocean risks from leaking oil, Newport News, Virginia in October. An *in-situ* corrosion survey of HMVS *Cerberus* showed its back is broken and that the *City of Launceston* is being conserved with anodes.

2009 Elected President of the WA Division of the Australasian Corrosion Association and national Vice President. Expert witness in Darlinghurst Supreme Court at the retrial of Phuong Ngo, for the murder of John Newman, MP. Program coordinator for AICCM National Conference in Fremantle, "Conservation of Public and Private Collections", Presented with award for Outstanding Contribution to Research in Materials Conservation by AICCM. Chair of symposium in Belgium on the conservation options for the historic former Antarctic research vessel the *Belgica*, lying wrecked in Norway.

2008 Appeared in the documentary *Gallipoli Submarine* with experimental work in Turkey and Australia. Provided commentary on the 4 Corners (ABC TV) program regarding the alleged murder weapon used in the assassination of John Newman MP in New South Wales. Appeared on French TV3 documentary *Phantoms de Chuuk* set in Federated States of Micronesia. External examiner for the University of Stockholm, on the chemistry of sulphur compounds in the Vasa (1628) shipwreck. I presented a plenary lecture on the application of long-term corrosion data to containment of nuclear wastes at the Gordon Corrosion Conference, New Hampshire. I taught a one-week metals conservation intensive at the Centre for Cultural Materials Conservation, University of Melbourne.

2007 Appointed Chair of the Swan Bells Foundation, member of the Fulbright Fundraising Committee for Western Australia which raised its $1 million target in less than a year. Trained divers in conducting corrosion measurements on WWI submarine J5 off Port Phillip Heads. Undertook field measurements in Turkey on the AE2 submarine. Present Rio Tinto sponsored talks to high school students in regional and remote centres. Appointed to the USS Monitor (1862) International Conservation Advisory Panel and made a member of the ICOM-CC preprints team for New Delhi. Data collected on Japanese shipwrecks and aeroplanes in Chuuk Lagoon established new decay mechanisms, leading to improved heritage management outcomes.

2006 Appointed to the Editorial board of journal *Conservation and Management of Archaeological Sites*. Appointed corrosion advisor to the Submarine Institute of Australia for the AE2 Marine Archaeological Assessment in Turkey. Determined that the *City of Launceston* could be opened for controlled diving access. Taught a one week course in Metals Conservation for the

University of Melbourne Masters in Conservation program. I presented lectures and workshops for Old Dominion University in Norfolk, Virginia as part of the Distinguished Visiting Speaker program. Supervised and managed the move of two collection stores to the central museum facility in Welshpool.

2005 In-situ corrosion studies on HMVS *Cerberus* demonstrated a 25% increase in corrosion rate and the *City of Launceston* returned to its stable rate after experiencing increased decay due to archaeological intervention. I presented a five-day conservation of outdoor sculptures and monuments in Hong Kong workshop with Colin Pearson. Presented the first intensive on Metals Conservation at the University of Melbourne. Motivational speaker for emerging corrosion scientists at the 50th Anniversary conference of the ACA in Brisbane. Reviewed the conservation treatment of the turret, engine and condenser recovered from the USS *Monitor* (1862) at The Mariners Museum, Newport News, USA.

2004 Awarded the ***Corrosion Medal*** of the Australasian Corrosion Association for services to the profession and for services to public education and community awareness. Project managed the relocation of the WA Museum staff and collections from the asbestos contaminated 1970's building in Perth to a collections and research facility 9.5 km away in Welshpool. Work involved extensive engagement and planning with architects, HVAC and fire engineers with security advisors and collection management staff. Fortnightly reporting to the Director General, Department of Culture and the Arts, the chair of the Board of the Trustees of the museum and the Minister assisted in bringing the project in on time and within the $11 million budget.

2003 Received a **Centenary Medal** from the Prime Minister for ***"For service to Australian Society in metallurgical science and engineering***". Appointed to the Board of the Swan Bells Foundation by the Minister for Culture and the Arts. Presentations at ICCROM in Rome, at the Technological Educational Institution and at the IIC Hellenic Group in Athens. Presented a one-week intensive in the interpretation of corrosion processes on archaeological metals at the Institute for Conservation de Netherlands in Amsterdam. Inspection of corrosion processes on the wreck of the former HMAS Perth in Albany. The quantification of the impact of nitrate and sulphate ions on the acidification of rock surfaces in the Burrup peninsula. A new corrosion mechanism for turbulent wreck sites was developed from data collected on corroded silver coins from an 18th century Portuguese shipwreck.

2002 Elected to the Directory Board of the International Council of Museums – Conservation Committee in the Rio de Janeiro for a second term. Appointed to the Ministerial Burrup Rock Art Management Committee. Determined the impact of *in-situ* conservation techniques on the *James Matthews* wreck. Plenary lecturer at the International Congress on the Conservation and Restoration for Archaeological Objects in Nara, Japan. Initiated the first corrosion study of WWII Japanese wrecks in Chuuk Lagoon, Federated States of Micronesia.

2001 Expert corrosion witness during a murder trial in the Supreme Court of NSW regarding the immersion period of a Beretta pistol. Provided expert witness on iron corrosion in the Perth Magistrates court. Presented a four-week course on in-situ shipwreck conservation and micro-environmental analysis at Evtek Institute of Art & Design, Finland. Prepared the guided missile destroyer HMAS Perth for corrosion monitoring over the next 100 years.

2000: Elected Fellow of the Australian Academy of Technological and Engineering Sciences (FTSE) and became a member of the Editorial Board of *Reviews in Conservation*. Delivered a speech at the opening of the 600 year-old *Bremen Cog* in Bremerhaven, Germany. Managed the handover of a conserved WWII PBY-5A Catalina at Hawkins, Texas. Published a review of rock art conservation in the inaugural issue of *Reviews in Conservation.*

1999: Elected to the Directory Board of ICOM-CC and Assistant Coordinator, Metals Working Group. Appointed a board member of the Australian American Catalina Memorial Foundation and coordinated the conservation of a WWII PBY5A Catalina in Hawkins, East Texas, USA. Conducted *in-situ* corrosion studies on silver coins from the 18th century wreck the *San Pedro*

del Alcantara in the Atlantic Ocean in Portugal. Presented at the planning seminar for the recovery of the confederate submarine *HL Hunley* (1864), Charleston, South Carolina, USA.

1998 Presented at the *Metal '98* conference in France and conducted *in-situ* studies on cannon and anchors on the wreck of the *Swan*, Duart Point, Scotland. Reviewed corrosion management strategies through *in-situ* measurements on the *City of Launceston* and HMVS *Cerberus* in Port Phillip Bay. Assessed the condition of a WWII Catalina undergoing restoration in Texas.

1997 Awarded Public Sector Management Office Scholarship for *Skills for an Effective Manager*, School of Management, Curtin University and obtained a Distinction. Conducted contracted *in-situ* corrosion studies on iron and composite wood-iron wrecks in Gulf St Vincent and Spencer Gulf in South Australia and on the *City of Launceston* in Victoria. Expert witness at an International Arbitration Court in Kuala Lumpur for the Malaysian Government regarding the conservation of materials from the wreck of the *Diana* (1817).

1996 Delivered applied research papers at the International Institute for Conservation conference in Copenhagen, the ICOM-CC meeting in Edinburgh and at the ICOM-CC Waterlogged Archaeological Organic Materials Conference in York. I delivered a lead paper at the 13th International Corrosion Congress in Melbourne on the corrosion of the wreck of HMVS *Cerberus* (1926). Performed corrosion measurements on the *Clan Ranald* (1909) wreck and the *Willyama* (1907) in Investigator Strait, South Australia.

1995 Performed an in-situ corrosion survey of a series of historic iron shipwrecks in Investigator Strait, South Australia discovering systematic differences in the rate of corrosion, which were dependent on alloy composition. Provided conservation advice on the corrosion of bronzes in the National Museum of Cambodia in Phnom Penh with a UNESCO-ICCROM team of heritage consultants.

1994 Awarded an AIATSIS grant for *Microclimate modelling of rock art sites in the Kimberley Region of WA* and a British Council travel grant to perform in-situ corrosion studies on the wreck of the *Swan,* a Cromwellian frigate that sank off the Isle of Mull in 1653. Completed the treatment of a carronade from HMS *Sirius* (1790) on Norfolk Island. Performed a corrosion survey of the wreck of HMVS *Cerberus* in Port Phillip Bay and established the method of determining the original thicknesses of metal structures.

1993 Awarded a Senior Fulbright Fellowship for study at the Smithsonian Institution and participation in conferences in the United States of America and assessed the wreck of the *USS Arizona* in Pearl Harbour, Hawaii. In Lake Huron I conducted *in-situ* corrosion studies in the Fathom Five National Park at Tobermory. This established the corrosion mechanisms of historic iron-fastened wooden wrecks in cold, fresh water. Elected coordinator of the ICOM-CC Metals Working Group and presented papers at the Waterlogged Archaeological Organic Materials conference in Portland, Maine. Consultant on the conservation of materials just recovered from the wreck of the RMS *Titanic*.

1992 Established the methodology for *in-situ* corrosion studies of wrecked barges and paddle steamers in zero-visibility conditions of the River Murray in South Australia. The results of rock art research in the Kimberley region of WA were presented at the Second International Rock Art Conference in Cairns, Queensland. Established model for prediction of desalination rates for corroded iron cannon and how the shipwreck can be dated from the chloride extraction kinetics.

1991 Awarded a Western Australian Heritage Council grant for *Microclimate studies and site management strategies II* for wet season rock art conservation research in the West Kimberley Region. Data from shipwrecks in Port Philip Bay established the applicability of corrosion measurements to the management of iron shipwrecks in cool seawater**.** I presented a paper on corrosion and conservation of ships' fastenings at the Getty Museum conference on Ancient and Historic Metals in Los Angeles, USA.

1990 Awarded an AIATSIS grant for *Microclimate studies - effects of animal excreta on rock art.* Presentations to conservators in London, York and at the ICOM-CC conferences in Bremerhaven and Dresden. I was elected coordinator of the ICOM-CC Metals Working Group

and chaired the UNESCO–UNDP of ASEAN Heads of Conservation meeting in Bangkok. Awarded Honorary Life Membership of the Australian Institute for the Conservation of Cultural Materials.

1989 Conducted a series of museum assessments and conservation workshops during a four-week UNESCO-UNDP Consultancy while based at the National Museum of the Philippines in metro-Manilla. Interviewed for the ABC Radio Science Show regarding iron corrosion, phosphorus impurities and their effects on concretion formation. I participated in the ABC TV and Science Bookshop interviews on conservation of underwater archaeological sites.

1988 Presentation plenary at the 3rd Australasian Archaeometry Conference, Adelaide on the Archaeometallurgy of 19th century shipwreck fastenings. Delivered the P.F. Thomson Memorial Lecture on *'Marine corrosion on historic shipwrecks and its application to modern materials*' and the paper *"Conservation of corroded concreted iron"* at the Australasian Corrosion Association Bicentennial Conference in Perth, Western Australia.

1987 Elected fellow of the International Institute for the Conservation of Historic and Artistic Works (FIIC). Organised the first combined meeting of the ICOM-CC metals and waterlogged organic archaeological materials working groups in Fremantle. Presented papers on rock art, metals conservation and desalination of ceramics at the ICOM-CC Triennial Conservation Conference, Sydney and at the ICOMOS Built in Wood Conference, in Brisbane. I was awarded an ARGS continuation grant for research into pewter and composite object conservation. Awarded Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) grant for conservation work on rock art at MacKay Caves and for conservation studies of the rock art at Walga Rock. Awarded a National Estate Program grant for a four-year program on *Microclimate studies and development of site management programs* for conservation of rock art in West Kimberley Region of Western Australia.

1986 Elected fellow of the Royal Australian Chemical Institute (FRACI). I presented on the ABC Science program *Quantum* on the use of oxygen isotope ratios in barnacles to determination of the seawater temperatures and to track the voyage of a ship in 1811. Chemical analysis of wines provided an insight into the American China trade before the 1812 war with Canada.

1985 Awarded a three-year Australian Research Grants Scheme (ARGS) grant to study the *Conservation and degradation of pewter and wood-iron composite materials recovered from historic shipwrecks.*

1984 Bayliss Youth Lecturer, Royal Australian Chemical Institute (WA Branch) which involved presenting the address "*Conservation Chemistry"* around Western Australia to year 10 & 11 high school chemistry students. Attended the ACA Conference at Rotorua, New Zealand and presented on the effects of concretion on the corrosion of non-ferrous metals. Conducted a feasibility study on relocation of the vessel *Edwin Fox* to Western Australia.

1980 Joint award with Neil North for the Best Research Paper at Conference 19 - Australasian Corrosion Association, Perth 1979 for the paper entitled *"350 years of marine corrosion in Western Australia*.

Materials Conservation Papers

MacLeod, I.D. & North, N.A. (1979) "Conservation of corroded silver", *Studies in Conservation.* 24:165-170.

MacLeod, I.D. & North, N.A. (1980), "350 years of marine corrosion in Western Australia", *Corrosion Australasia.* 5:11-15.

MacLeod, I.D. & Ritchie, I.M. (1981) "The detection of debasement in (forged) silver coins by means of corrosion potential measurements", *Archaeometry.* 23: 65-70.

MacLeod, I.D., (1981) "Shipwrecks and applied electrochemistry", *J. Electroanalytical and Interfacial Electrochemistry,* 118: 291-303.

MacLeod, I.D. (1981) "Bronze disease - an electrochemical explanation", *ICCM Bulletin* VII (1): 16-26.

MacLeod, I.D. & North, N.A. (1982) "Conservation of a composite cannon –*Batavia* (1629)", *International J. Nautical Archaeology* 11(3): 213-219.

MacLeod, I.D. & Killingley, J.S. (1982) "The use of barnacles to establish past temperatures on historic shipwrecks", *International J. Nautical Archaeology* 11(3): 249-252.

MacLeod, I.D. (1982) "The formation of marine concretions on copper and its alloys" International *J. Nautical Archaeology* 11(4): 267-275.

MacLeod, I.D. (1982) "Environmental effects on shipwreck material from analysis of marine concretions", Archaeometry*: an Australasian Perspective (ANU Press)* Eds. W. Ambrose & P. Duerden. 361-367.

MacLeod, I.D. (1982) "A study of some forged silver coins recovered from 17th C and 19th C shipwrecks" *Chemistry in Australia* 49: 317-320.

Henderson, G.J., Lyon, D. & MacLeod, I.D. (1983) "HMS "Pandora" Lost and Found", Archaeology 36: 28-35.

MacLeod, I.D. (1983) "Stabilization of corroded aluminium", *Studies in Conservation.* 28: 1-7.

MacLeod, I.D. (1983) - "Report on the crystals found on metal fragments and on bamboo from the Pattaya wreck site" in "The excavation of the Pattaya wreck site and survey of three other sites in Thailand 1982". J. Green and R. Harper, *Australian Institute Maritime Archaeology Special Pub*. No 1, pp 80-82.

MacLeod, I.D. (1983) "A microphotographic review of corrosion phenomena from a shipwreck". *AICCM Bulletin.* 9(2): 92-96.

Mills Reid, N.K., MacLeod, I.D. & Sander N. (1984) "Conservation of waterlogged organic materials: comments on the analysis of polyethyleneglycol and the treatment of leather and rope" *Preprints of 1984 ICOM Committee for Conservation Meeting* (Copenhagen) 84.7.l6-20.

MacLeod, I.D. (1984) "A genuine sixteenth century forged coin". *Australian Institute Maritime Archaeology Bulletin.* 8(2): 1-9.

MacLeod, I.D. (1984) "Conservation, applied science and why treatments must be monitored", *AICCM Bulletin.* 10(2): 19-41.

MacLeod, I.D. (1985) "The effects of concretion on the corrosion of non-ferrous metals". *Corrosion Australasia* 10(4): 10-13.

MacLeod, I.D. (1985) "Shipwreck conservation chemistry" in *Chemistry Resource Book*, p 113-131, R.A.C.I., Ed. C.L. Fogliani.

MacLeod, I.D. (1985) "Copper corrosion in the "real world"" in *Chemistry Resource Book*, p 1-4, R.A.C.I., Ed. C.L. Fogliani.

Taylor, R.J. & MacLeod, I.D. (1985) “Corrosion of bronzes on shipwrecks: a comparison of corrosion rates deduced from shipwreck material and from electrochemical methods”, *Corrosion* 41: 100-104

MacLeod, I.D., North, N.A. & Beegle, C.J. (1986) “The excavation, analysis and conservation of shipwreck sites” In, *Preventative measures during excavation and site protection*. ICCROM, Rome p. 113-132

MacLeod, I.D. (1986) “Conservation of the steam ship "Xantho"” *ICCM Bulletin,* 12(3&4): 66-94.

MacLeod, I.D. & Pitrun, M. (1986) “The effects of microstructure on long-term corrosion”. *Australasian Corrosion Association, Proceedings Conference 26,* Adelaide 1986 Vol II - Symposium 11, Lead paper

MacLeod, I.D. (1987) “Secondhand metal - conservation and industrial archaeology of shipwreck artefacts”. In *Archaeometry - Further Australasian Studies. (ANU Press).* Eds. W.R. Ambrose and J.M.J. Mummery, p 280-291.
Mills Reid, N.K. & MacLeod, I.D. (1987) “The use of aqueous glycerol solutions in the conservation of waterlogged archaeological organic materials” In *Archaeometry - Further Australasian Studies. (ANU Press).* Eds. W.R. Ambrose and J.M.J. Mummery, p 292-302.

MacLeod, I.D. (1987) “Conservation of corroded iron artefacts -new methods for on-site preservation and cryogenic deconcreting”, *International J. Nautical Archaeology* 16(1): 49-56.

MacLeod, I.D. (1987) “Stabilization of corroded copper alloys: a study of corrosion and desalination mechanisms” *ICOM Committee for Conservation*, Sydney, September 1987, p 1079-1085.

MacLeod, I.D. (1987) “Conservation of corroded copper alloys: a comparison of new and traditional methods for removing chloride ions” *Studies in Conservation.* 32:25-40.

MacLeod, I.D. & Davies, J.A. (1987) “Desalination of glass, stone and ceramics recovered from shipwreck sites”. *ICOM Committee for Conservation*, Sydney, September 1987, p 1003-1007.

MacLeod, I.D. (1987) “Conservation of waterlogged wood”. *Preprints ICOMOS Built in Wood Conference,* Brisbane, April 198, p 111-125.

Haydock, P. & MacLeod, I.D. (1987) “The use of micro-meteorological studies as an aid to the conservation of aboriginal rock art”. *ICOM Committee for Conservation*, Sydney, September 1987, p 1149-1153.

MacLeod, I.D. & North, N.A. (1987) "Corrosion of metals", Chapter 4, in *Conservation of marine archaeological objects*. Ed. Pearson, C., Butterworths (London). pp 68-98.

MacLeod, I.D., (1987), Book review, The Corrosion and Conservation of Metallic Antiquities and Works of Art, by Todor Stambolov, *Studies in Conservation,* 32 pp 138-139.

MacLeod, I.D. (1988) “Conservation of corroded metals with special reference to iron and steamships” in M. McCarthy (ed.) *Iron ships and steam shipwrecks*, Western Australian Museum, Perth p 93-102.

MacLeod, I.D. (1988) - "On-site conservation during the SS *Xantho* excavation - with special reference to the *Xantho* engine", M. McCarthy (ed.) *Iron ships and steam shipwrecks* p 91-92.

MacLeod, I.D. & Pitrun, M. (1988) - "Metallography of copper and its alloys recovered from nineteenth century shipwrecks", in. *Archaeometry: Australasian Studies 1988,* Ed. J.R. Prescott, University of Adelaide, Adelaide. pp 121-130.

MacLeod, I.D. (1988) "Conservation of corroded concreted iron". *Proceedings of Conference 28, Australasian Corrosion Association*, Perth, Vol.1. 2-6:1-9.

Stanbury, M. & MacLeod, I.D. (1988) "Colonies, convicts and filtering stones: roads to solutions", *Bulletin Australian Institute Maritime Archaeology.* 12(2):1-10.

MacLeod, I.D. (1989) “Marine corrosion on historic shipwrecks and its application to modern materials” *Corrosion Australasia.* 14(3):8-14.

MacLeod, I.D. (1989) - "Conservation of Wet Wood and Metal", Proceedings of the ICOM Conservation Working Groups on Wet Organic Archaeological Materials and Metals. Fremantle 1987. Compiled and edited by I.D. MacLeod, International Wood Study edited by D.W. Grattan. pp 304. Western Australian Museum.

MacLeod, I.D., Fraser, F.M. & Richards, V.L. (1989) "The PEG water solvent system: effects of composition on extraction of chloride and iron from wood and concretion", Ibid. p 245-257.

MacLeod, I.D. (1989), "Hygroscopicity of archaeological timber: effects of impregnant and degree of degradation", Ibid. p 211-214.

MacLeod, I.D. and Gilroy D.R. (1989) "Colour measurement of treated and air-dried wood", Ibid. p 203-210.

MacLeod, I.D. (1989) "Electrochemistry and conservation of iron in sea water ", *Chemistry in Australia,* 56(7). pp 227-229.

MacLeod, I.D. (1989) "The application of corrosion science to the management of maritime archaeological sites", *Bulletin Australian Institute Maritime Archaeology*. 13(2) p 7-16.

MacLeod, I.D. (1990) "The conservation laboratory of the National Museum, Philippines", *Technical Report Series. No. FMR/CC/CH/90/201 (UNDP) UNESCO, Paris.* pp 1-50.

MacLeod, I.D. and Pennec, S. (1990) "The effects of composition and microstructure on the corrosivity of copper alloys in chloride media" *ICOM Committee for Conservation, 1990 Preprints 9th Triennial Meeting, Dresden. Vol II.* pp 732-739.

MacLeod, I.D. (1990) "Conservation management of iron shipwrecks: SS *Xantho* (1872)", *Preprints 5th National Conference on Engineering Heritage*, Perth, December 1990, pp 75-80

MacLeod, I.D. (1990) "Conservation of waterlogged timbers from the *Batavia* (1629)", *Bulletin Australian Institute Maritime Archaeology.* 14(2), p 1-8

MacLeod, I.D. (1991) "Microclimate modelling in old museum buildings". *Historic Environment-Conservation in Context: Artefact and Place,* 8(1&2), p 37-41

MacLeod, I.D. & Kenna, C. (1991) "Degradation of archaeological timbers by pyrite: oxidation of iron and sulphur species" *Proceedings of the 4th ICOM Group on Wet Organic Archaeological Materials Conference, Bremerhaven 1990.* p. 133-142.

MacLeod, I.D., Brooke, P. & Richards, V.L. (1991) "Iron corrosion products and their interactions with waterlogged wood and PEG" *Proceedings of the 4th ICOM Group on Wet Organic Archaeological Materials Conference, Bremerhaven, 1990.* Ed. Per Hoffmann. pp 119-132.

MacLeod, I.D. (1991) "Identification of corrosion products on non-ferrous metal artefacts recovered from shipwrecks". *Studies in Conservation.* 36(4), pp 222-234

MacLeod, I.D., (1992) "Conservation management of Iron Steamships- The SS *Xantho* (1872). *Multi-Disciplinary Engineering Transactions* GE no 1, 45-51.

MacLeod, I.D., (1992), "Current approaches to the Underwater Cultural Heritage- Strengths and Weaknesses. Materials Conservation Management" *Historic Environment* 9(3), pp 11-16.

Carpenter, J & MacLeod, I.D.,(1993), "Conservation of corroded iron cannon and the influence of degradation on treatment times" *ICOM-Committee for Conservation, Preprints 10th Triennial Conference, Washington*, Volume II pp 759-766.

MacLeod, I.D., (1993), Chapter 6. "Conservation Assessment" in *Historic Shipping on the River Murray. A guide to the terrestrial and submerged archaeological sites in South Australia,* Sarah Kenderdine, State Heritage Branch, Department of Environment and Land Management, Adelaide, South Australia, pp. 273-282

MacLeod, I.D. (1994) "Report on the corrosion of iron shipwrecks in South Australia: with particular reference to the River Murray" Chapter 10 in *Muddy Waters: Proceedings of the first conference on the submerged and terrestrial*

archaeology of historic shipping on the River Murray, Echuca, September 1992, State Heritage Branch, SA Department of Environment and Natural Resources, Adelaide. pp 1-14.

MacLeod, I.D., (1993). "Metal corrosion on shipwrecks: Australian case studies", *Trends in Corrosion Research*, 1, pp 221-245.

MacLeod, I.D. & Richards, V.L., (1994) "Monitoring moisture in *Batavia* timbers", *Proceedings of 5th ICOM Group on Wet Organic Archaeological Materials Conference*, Portland/Maine 1993.,p 79-95, Ed. Per Hoffmann, Special Discussions edited by Tara Grant and Thomas Daley.

MacLeod, I.D., Mardikian, P.,& Richards, V.L.(1994) "Observations on the extraction of iron and chloride ions from composite materials" *Proceedings of 5th ICOM Group on Wet Organic Archaeological Materials Conference*, Portland/Maine 1993.,p 199-211, Ed. Per Hoffmann, Special Discussions edited by Tara Grant and Thomas Daley.

MacLeod, I.D. (1994) "Conservation of corroded metals - a study of ships' fastenings from the wreck of HMS *Sirius*." *Ancient and Historic Metals Conservation and Scientific Research*, Ed D.A. Scott, J. Podany, B.B. Considine, Getty Conservation Institute, Los Angeles, p 265-278.

Ford, B., MacLeod, I.D., and Haydock, P., (1994) "Rock art pigments from the Kimberley region of Western Australia: identification of the minerals and conversion mechanisms", *Studies in Conservation* 39, p 57-69.

Lanagan, M.D., MacLeod, I.D., Singh, P. & Hefter, G.T.,(1995) "Corrosion of iron in aqueous glycol mixtures" *Corrosion and Prevention 95 - Proceedings of the 1995 Australasian Corrosion Association Conference*, Perth November 1995, Paper 50 pp 1-10.

MacLeod, I.D., (1995) "In-situ corrosion studies on the Duart Point wreck 1994" *International Journal of Nautical Archaeology* 24(1) 53-59.

MacLeod, I.D., Haydock, P., Tulloch, D. & Ford, B. (1995) "Effects of microbiological activity on the conservation of aboriginal rock art" *AICCM Bulletin* 21(1), 3-10

MacLeod, I.D. and Wozniak, R., (1996) "Corrosion and Conservation of Lead in Sea Water" *ICOM-Committee for Conservation Preprints 11th Triennial Meeting, Edinburgh, Sept 1996*. James & James, London. pp 884-890.

Corvaia, C., MacLeod, I.D., and Harley, C.(1996) "Conservation of glass recovered from shipwreck sites" *ICOM-Committee for Conservation, Preprints 11th Triennial Meeting, Edinburgh Sept 1996*, James & James, London, 819-825.

Herrenschmidt, F., Moinot, M., Pennec, S.L., MacLeod, I.D. and Chahine, C. (1996)"Une lieue sous la mer, le Titanic: traitement des papiers" *ICOM-Committee for Conservation, Preprints 11th Triennial Meeting, Edinburgh, Sept. 1996*. James & James, London, p 517-522.

MacLeod, I.D. (1996) "In-situ conservation of cannon and anchors on shipwreck sites" in *Conservation of Archaeological Sites and its Consequences*, IIC, London. Ed Ashok Roy and Perry Smith, 111-115.

MacLeod, I.D., Haydock, P & Charton, E., (1996) "Avian guano and its effects on the preservation of rock paintings" *Preservation of Rock Art 1995 AURA Occasional Papers 9*, Ed. Andrew Thorn & Jacques Brunet p 60-64.

MacLeod, I.D., (1996) "An in-situ study of the corroded hull of HMVS *Cerberus* (1926)", *Proceedings of the 13th International Corrosion Congress* Paper 125 pp 1-10.

MacLeod, I.D. & Wozniak, R., (1997) "Corrosion and conservation of tin and pewter", *Metal 95 - Proceedings of the ICOM -CC Metals Working Group Conference*, Semur-en-Auxois, France 1995, James & James, London, 118-123.

MacLeod, I.D., (1997) "The use of *in-situ* metal corrosion studies as an archaeological management tool" in Delgado, J. Ed *British Museum Encyclopaedia of Underwater and Maritime Archaeology* p. 111-113.

MacLeod, I.D., Haydock P. and Ford, B. (1997) "Conservation Management of West Kimberley Rock Art: Microclimate studies and Decay Mechanisms" *Kimberley Society Occasional Paper No 1. Aboriginal Rock Art of the Kimberley* Ed K.F. Kenneally, M.R. Lewis., M. Donaldson and C. Clement, Kimberley Society Inc, Perth, Western Australia. pp 65-69.

MacLeod, I.D. & Richards, V.L. (1997) "The impact of metal corrosion products on the degradation of waterlogged wood recovered from historic shipwreck sites" *Proceedings of the 6th ICOM Group on Wet Organic Archaeological Materials Conference* York 1996, Eds Per Hoffmann, Tara Grant, James A. Spriggs, Thomas Daley, ICOM-CC Wet Organic Archaeological Materials, Bremerhaven pp 331-353.

MacLeod, I.D. & Richards, V.L. (1997) "Wood degradation on historic shipwreck sites: the use of FTIR spectroscopy to the study of the loss of hemicellulose" *Proceedings of the 6th ICOM Group on Wet Organic Archaeological Materials Conference* York 1996, Eds Per Hoffmann, Tara Grant, James A. Spriggs, Thomas Daley, ICOM-CC Wet Organic Archaeological Materials, Bremerhaven. pp 203-228.

MacLeod, I.D. and Beng, E.W., (1998) "Analysis and interpretation of glass artefacts from the 17th-19th century Dutch and colonial Australian shipwrecks" *Glass, Ceramics and Related Materials* Proceedings of the Interim Meeting of the ICOM-CC Working Group Conference, Vantaa, Finland, September 1998. Ed Alice B Paterakis, pp 58-69

MacLeod, I.D., (1998) "In-situ corrosion studies on iron and composite wrecks in South Australian waters: implications for site managers and cultural tourism" *Bulletin Australian Institute Maritime Archaeology* 22: 81-90

MacLeod, I.D., (1998) "In-situ corrosion studies on iron shipwrecks and cannon: the impact of water depth and archaeological activities on corrosion rates" *Metal 98 Proceedings of the ICOM -CC Metals Working Group Conference*, *Draguignan-Faginère* France 1998, Ed Mourey, W. & Robbiola, L, James & James, London. pp 116-124.

MacLeod, I.D. & Romanet, A-S, (1999) "The effects of pH and stress on seawater corrosion and conservation of copper and its alloys in seawater. *Preprints of the ICOM-CC 12th Triennial Meeting, Lyon* September 1999, James & James, London, pp 828-833.

MacLeod, I.D. (1999) "Conservation of the SS *Xantho* engine: lessons learnt", *AICCM Bulletin*, 24, 10-19.

Theile, J. M., Yutronic, N. and MacLeod, I.D., (1999) "Análisis Y Restauración de Máscaras Ceremoniales Del Altiplano", *Revista de Teorá del Arte* 1 pp 108-119.

MacLeod, I.D. and Beng, J., (2000) "The contribution of alloy composition to the fate of foundered vessels", *Tradition and Innovation: Advances in Conservation, IIC Melbourne Conference, 10-14thOctober, 2000.* pp. 124-127.

MacLeod, I.D., (2000) "Rock art conservation and management: the past, present and future options", *Reviews in Conservation,* 1, pp 32-45.

MacLeod, I.D. and Bassett, S., (2001), "Light fading of the painted deck on *Australia II* in an exhibition environment", *AICCM Bulletin*, 26, 1- 9.

MacLeod, I.D. and Kelly, D., (2001), "The effect of chloride ions on the corrosion of aluminium alloys used in the construction of *Australia II*", *AICCM Bulletin*, 26, 10 - 19.

MacLeod, I.D., (2002), Chapter 41 "In-situ corrosion measurements and managing shipwreck sites", in *International Handbook of Underwater Archaeology*, Ed C.V. Ruppe and J.F. Barstad, Plenum Press, New York, pp 697-714.

MacLeod, I.D., (2002) "Effects of structure on the corrosion performance of gold and silver alloys on shipwrecks", Proceedings of the International Congress on the Conservation and Restoration for Archaeological Objects, Nara National Research Institute for Cultural Properties, Japan, pp 178-185.

MacLeod, I.D., and Haydock, P., (2002) "Microclimate modelling for prediction of environmental conditions within rock art shelters", Preprints for ICOM-CC Triennial Meeting, Rio de Janeiro, Brazil September 2002, Vol II, 571-577.

MacLeod, I.D., (2002) "In-situ corrosion monitoring of the iron shipwreck *City of Launceston* (1865)", Preprints for ICOM-CC Triennial Meeting, Rio de Janeiro, Brazil September 2002, Vol II, 871-877.

MacLeod, I.D. and Flecker, M., (2004) "Corrosion of tin and its alloys recovered from a 10th century wreck in the Java Sea", *Metal 2001, Proceedings of the International Conference on Metals Conservation, Santiago, Chile, April 2001, Eds. I. D. MacLeod, J. M. Theile & C. Degrigny*, Western Australian Museum, 191-201

MacLeod, I.D. and Pennec, S., (2004) "Characterisation of corrosion products on artifacts recovered from the RMS *Titanic* (1912)", *Metal 2001, Proceedings of the International Conference on Metals Conservation, Santiago, Chile, April 2001, Eds. I. D. MacLeod, J. M. Theile & C. Degrigny*, Western Australian Museum, 270-278.

MacLeod, I.D., Theile J. M. & Degrigny, (2004) C *Metal 2001, Proceedings of the International Conference on Metals Conservation, Santiago, Chile, April 2001, Eds. I. D. MacLeod, J. M. Theile & C. Degrigny*, Western Australian Museum, pp 1- 330.

MacLeod I.D., Morrison P., Richards V. and West, N (2004) "Corrosion monitoring and the environmental impact of decommissioned naval vessels as artificial reefs", in *Metal 2004 Proceedings of the International Conference on Metals Conservation, Canberra, October 2004, Eds. J. Ashton & D. Hallam,* National Museum of Australia, 53-74

MacLeod, I.D. and Schindelholz, E., (2004) "Surface analysis of corroded silver coins from the wreck of the *San Pedro De Alcantara* (1786)", in *Metal 2004 Proceedings of the International Conference on Metals Conservation, Canberra, October 2004, Eds. J. Ashton & D. Hallam,* National Museum of Australia, 114-125.

Heldtberg, M., MacLeod, I.D. and Richards V. L., (2004) "Corrosion and cathodic protection of iron in seawater: a case study of the *James Matthews* (1841)", in *Metal 2004 Proceedings of the International Conference on Metals Conservation, Canberra, October 2004, Eds. J. Ashton & D. Hallam,* National Museum of Australia, 75-87

MacLeod, I.D. (2005) "The decay and conservation of museum objects of tin", *Studies in Conservation*, 50, 1-2.

MacLeod, I.D. (2005) "A new corrosion mechanism for iron shipwrecks in seawater: a study of the Fujikawa Maru (1944) in Chuuk Lagoon, Federated States of Micronesia", Preprints for ICOM-CC Triennial Meeting, Den Haag, The Netherlands, September 2005, Vol II 310-316

MacLeod, I.D. (2005) "The effects of moisture, micronutrient supplies and microbiological activity on the surface pH of rocks in the Burrup peninsula", Preprints for ICOM-CC Triennial Meeting, Den Haag, The Netherlands, September 2005, Vol II 386-393

Bergstrand, T, Gjelstrup Björdal, C, Nilsson, T, Bohm, C, Christensson E, Gregory, D. Nyström, I, Peacock, E. E, Richards, V. & MacLeod, I. (2005), Reburial as a method of preserving archaeological remains, A presentation of the Marstrand project. In *Proceedings of the 9th ICOM Group on Wet Organic Archaeological Materials Conference, Copenhagen, 7-11 June 2004,* P. Hoffmann, K. Strætkvern, J.A. Spriggs & D. Gregory (eds.), The International Council of Museums, Committee for Conservation Working Group on Wet Organic Archaeological Materials, Bremerhaven. pp. 9-39.

MacLeod, I.D., (2006) "In-situ corrosion studies on wrecked aircraft of the Imperial Japanese Navy in Chuuk Lagoon, Federated States of Micronesia", *International Journal of Nautical Archaeology*, 35.1: 128-136

MacLeod, I.D., (2006) "Corrosion and conservation management of iron shipwrecks in Chuuk Lagoon", *Conservation and Management of Archaeological Sites,* 7, 203-223.

Richards, V.L. & MacLeod, I.D. (2006) Reburial and analyses of archaeological remains: Investigations into the effects of reburial on metals', in Reburial and Analyses of Archaeological Remains – Studies on the Effect of Reburial on Archaeological Materials Performed in Marstrand, Sweden 2003-2005. Eds I. Nystrom-Godfrey & T. Bergstrand. Bohuslans Museum, Sweden, pp. 1-90.

MacLeod, I.D., (2006) "Assessment of potential impacts to the long-term corrosion rates of shipwrecks in Port Phillip Bay" in appendix 62, Volume 10, Technical Appendices of the Supplementary Environmental Effects Statement, Channel Deepening Project, Port of Melbourne Corporation: 283-315.

MacLeod, I.D., Beger, M., Richards, V., Jeffery, B., and Hengeveld, M., (2007) "Dynamic interactions of marine ecosystems with wrecks in Chuuk Lagoon, Federated States of Micronesia" in Metal 07, Preprints of the ICOM-CC Metals Working Group meeting, Amsterdam, Ed Degrigny, C., Ankersmit, B., Yolanda, I., and van Langh R., vol 3, 51-54.

Hallam, D. MacLeod I.D., and Higgins, M., (2007) "Finding evidence of a lost explorer: LUDWIG LEICHHARDT 1848 not just a nameplate and a provenance study?", *Metal 07 - interim meeting of the ICOM-CC Metal WG, Amsterdam 17-21 September 2007*, Ed. Degrigny C., van Langh, R., Yolanda I., and Ankersmit, B., Rijksmuseum Amsterdam (2007), Book 1 pp 73-77

MacLeod, I.D., (2007) "Creation of a collection facility and relocation of the Western Australian Museum's collections", *Contemporary Collections: Preprints of the AICCM National Conference, Brisbane 2007,* Pagliarino, A. and Osmond, G., editors, AICCM, Canberra, Australia, 272 pp. 5-11.

Jeffery, W., Beger M, MacLeod I, Richards V., Hengeveld M. and Carpenter, J., (2007), Guidelines in recording and monitoring the natural and cultural attributes of submerged historic sites in the Federated States of Micronesia, Report for the National Historic Preservation Office, Federated States of Micronesia, Pohnpei.

Richards V.L. and I. D. MacLeod 2007 Reburial and analyses of archaeological remains: Investigations into the effects of reburial on metals in *Reburial and Analyses of Archaeological Remains – Studies on the Effect of Reburial on Archaeological Materials Performed in Marstrand, Sweden 2003-2005. The RAAR Project, I.* Eds Nyström-Godfrey & T. Bergstrand, Bohusläns Museum and Studio VästSvensk Konservering, Sweden, pp. 91-179.

Peacock, E E; Bergstrand, T; Nyström Godfrey, I; Björdal, C; Bohm, C; Christensson, E; Gregory, D; MacLeod, I; Nilsson, T; Richards, V & Turner-Walker, G. (2008). The Marstrand reburial project - Overview, phase I and future work. In *PARIS3 Preserving Archaeological Remains in Situ*. Geoarchaeological and Bioarchaeological Studies 10, Amsterdam, pp. 253-263.

MacLeod I.D, Hallam, D. and Kaus, D. (2008) "It's all in the nameplate; brass and bronze in colonial Australia", *Preprints for ICOM-CC Triennial Meeting, New Delhi, India*, September 2008, 272-278

MacLeod I.D., (2008), "The legal consequences of inadequate conservation for contract maritime archaeology*", Preprints for ICOM-CC Triennial Meeting, New Delhi, India*, September 2008, 217-223

MacLeod I.D., Cook D. and Schindelholz E., (2008)," Corrosion and conservation of the American civil war ironclad USS *Monitor* (1862)", *Preprints for ICOM-CC Triennial Meeting, New Delhi*, India, September 2008 279-285

MacLeod, I.D., (2008) "Shipwreck graves and their conservation management", *AICCM Bulletin*, 31, 5-14.

MacLeod, I.D., (2008) "Washing formaldehyde from fixed spirit specimens: a mechanism for the preservation of *megamouth III" AICCM Bulletin*, 31, 36-43.

MacLeod, I.D. and Haydock, P., (2008) "Effects of water vapour and rock substrates on the microclimates of painted rock art surfaces and their impact on the preservation of the images", *AICCM Bulletin*, 31, 66-86.

MacLeod, I.D., (2009) "Where to now: conservation of iron shipwrecks. Experiences from the SS *Xantho* project and their application to the *H L Hunley* and USS *Monitor* projects" in *Iron, Steel and Steamship Archaeology,* Proceedings of the 2nd Australian Seminar held in Perth, Melbourne and Sydney 2006, McCarthy, M., Ed, Australasian Institute of Maritime Archaeology, Special Publication no 13, pp 119-127.

Nyström Godfrey, I., T. Berstrand, C. Gjelstrup Björdal, T. Nilsson, C. Bohm, E. Christenssen, D. Gregory, E.E. Peacock, V. Richards, & I.D. MacLeod, (2009) Reburial and analysis of archaeological remains – The RAAR project. Project status and cultural heritage management implications based on the first preliminary results in *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam, 10-15 September 2007*, eds K. Straetkvern & D.J. Huisman, Rijksdienst voor Archeologie, Cultuurlandschap en Monumenten (RACM), Amersfoort: 169-196.

MacLeod, I.D., (2010) "Assessment of the impact of scallop dredging, site clearance and cathodic protection on the *City of Launceston* (1865) in Port Phillip Bay", in Final Report on SS *City of Launceston* (1863-1865) excavation and conservation 1997-2009, *Australasian Institute for Maritime Archaeology, Special Publication no 15,* Ed Ross Anderson, p 94-103.

Richards, V., MacLeod, I. D., Morrison, P., (2010), Corrosion monitoring and the environmental impact of decommissioned naval vessels as artificial reefs in *In-Situ Conservation of Cultural Heritage: Public, Professionals, and Preservation*, eds. V. Richards & J. McKinnon, PAST Foundation Publications, pp. 50-67.

Carpenter, J., MacLeod, I., Richards, V., (2010), Conserving the WWII wrecks of Truk Lagoon in *In-situ Conservation of Cultural Heritage: Public, Professionals, and Preservation*, eds. V. Richards & J. McKinnon, PAST Foundation Publications, pp. 32-39.

MacLeod, I.D., (2010) 'Corrosion and Conservation Management of the HMAS *AE2* (1915) Submarine in the Sea of Marmara, Turkey', in *METAL 2010, Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group, Charleston, South Carolina 11-15 October 2010*, ed. P. Mardikian, C. Chemello, C. Watters and P. Hull, Clemson University (2011) 56-62. Publisher www.lulu.com

MacLeod, I.D. and Viduka, A., (2010) Assessment of the impact of diving tourism and cyclones on the SS Yongala (1911) shipwreck in the Great Barrier Reef from in-situ corrosion data, *AICCM Bulletin*, 32, 134-143.

MacLeod, I.D. and Richards, V.L., (2010) In situ conservation surveys of iron shipwrecks in Chuuk Lagoon and the impact of human intervention, *AICCM Bulletin*, 32, pp. 106-122

Richards, V.L., & MacLeod, I.D, (2010) "Reburial and analyses of archaeological remains: Investigations into the effects of reburial of metals", Marstrand Sweden Dec 2010, Chapter 4, pp. 1-103.
Richards, V.L., MacLeod, I.D., 2011, Reburial and analyses of archaeological remains: Investigations into the effects of reburial on metals in *Reburial and Analyses of Archaeological Remains – Phase II Results from the 4th retrieval in 2009 from Marstrand, Sweden. The RAAR Project, Appendix 4*, eds I. Nystrom-Godfrey, T. Bergstrand & H. Petersson, Bohusläns Museum and Studio VästSvensk Konservering, Udevalla, Sweden, pp. 1-103.

MacLeod, I.D., & Binnie N. E., (2011), "A long-term study of conservation management and corrosion of shipwrecks in the Fathom Five Underwater National Park, Lake Huron, Canada" *Preprints for ICOM-CC Triennial Meeting,* Lisbon, Portugal, September 2011, Ed J Bridgland, ICOM-CC Lisbon, paper 0903, pp. 1-8

MacLeod, I.D., & van Dam A.J., (2011), "A migration mechanism for transfer of sharks from ethanol to aqueous glycerol solutions" *Preprints for ICOM-CC Triennial Meeting,* Lisbon, Portugal, September 2011, Ed J Bridgland, ICOM-CC Lisbon paper 1201, pp. 1-8

Godfrey, I. M., Richards, V. L., MacLeod, I.D., (2011), The Batavia – Past, Current and Future Conservation, in *Proceedings of the Shipwrecks 2011 – Chemistry and Preservation of Waterlogged Wooden Shipwrecks Conference*, 18-21 October 2011, Stockholm, Sweden, ed. L. I. Elding, Royal Institute of Technology (KTH), Sweden, pp. 22-29

Steyne, H., & MacLeod, I.D., (2011) "In-situ conservation management of historic iron shipwrecks in Port Phillip Bay: a study of J7 (1924), HMVS Cerberus (1926) and the City of Launceston (1865)", *Bulletin of the Australasian Institute for Maritime Archaeology,* 35: 67-80

MacLeod, I.D., & Steyne, H., (2011), "Managing a Monitor – the case of HMVS Cerberus in Port Phillip Bay: Integration of corrosion measurements with site management strategies", *Conservation and Management of Archaeological Sites*, 13(4), 334-61.

MacLeod, I.D., Richards, V.L., & Beger, M (2011), "The effects of human and biological interactions on the corrosion of WWII iron shipwrecks in Chuuk Lagoon", 18th International Corrosion Congress, Perth, November 2011, Paper 124, 1-12

MacLeod, I.D., (2011) "Consuming corrosion –A journey into the realm of materials conservation", P F Thompson Memorial Lecture, 18th International Corrosion Congress, Perth, November 2011, 1-12.

MacLeod, I.D., (2011) "Spiritual dimensions in Materials Conservation", Museums Australia Conference, "*At the Frontier, Exploring the Possibilities*" Perth, November 2011, pages 1-8,
http://www.museumsaustralia.org.au/site/conf_perth2011.php

Veth, P., A. Viduka, M. Staniforth, I.D. MacLeod, V.L. Richards, & A Barham, A., (2011), The Australian historic shipwreck protection project in *Proceedings of the Asia-Pacific Regional Conference on Underwater Cultural Heritage, 8-12 November 2011, Manila, Philippines*, eds M. Staniforth, J. Craig, S.C. Jago-on, B. Orillaneda & L. Lacsina, Jericopim Publishing House, Manila: 753-762.

Human, B.A†, Morrison, S.M., & MacLeod I.D., (2012), "Is the Megamouth Shark susceptible to mega-distortion? Investigating the effects of twenty-two years of fixation and preservation on a large specimen of *Megachasma pelagios* (Chondrichthyes: Megachasmidae" *Records of the Western Australian Museum* 27, 7-20.

Preβlinger, H., Pichler, B. & MacLeod, I.D., (2012), "Werkstoffkundliche Untersuchungsergebnisse einer im 17. Jahrhundert aus Gusseisen gefertigten englischen Schiffskanone", *Berg-und Hüttenmännische Monatshefte* 157(5) 209-213.

MacLeod, I.D., & Taylor, P., (2012), The effects of depth and time on the corrosion of cast iron in Port Phillip, *Corrosion and Protection 12, Australasian Corrosion Association Conference, Melbourne November 2011,* Paper 126, 1-8

Nyström Godfrey, T. Bergstrand, C. Bohm, E. Christensson, D. Gregory, I. MacLeod , E.E. Peacock & V. Richards. (2012). Reburial and analyses of archaeological remains (RAAR). Phase II - Project status and new findings. In *Proceedings of the 11th ICOM-CC Working group on wet organic archaeological materials conference. Greenville, USA 24-28 May 2010.* K. Strætkvern & E. Williams (eds.), The International Council of Museums, Committee for Conservation Working Group on Wet Organic Archaeological Materials, pp. 23-47.

Nyström Godfrey, I, Bergstrand, T., Petersson H., Bohm, C., Christensson E., Gjelstrup Björdal, C., Gregory, D., MacLeod, I., Peacock, E., Richards, V., (2012), The RAAR Project – Heritage Management Aspects on Reburial after Ten Years of Work, *Conservation and Management of Archaeological Sites,* 14(1-4) 360-371.

Richards, V., Gregory, D., MacLeod, I. & Matthiesen, H., (2012), Reburial and analyses of archaeological remains in the marine environment – Investigations into the effects on metals. *Conservation and Management of Archaeological Sites, Vol. 14 no. 1-4 2012*, Special Edition, Proceedings from the 4th Preservation of Archaeological Remains In Situ (PARIS4) Conference, 23-26 May 2011, Copenhagen, pp. 35-47.

MacLeod, I.D., (2012), Shipwreck Conservation In: McCarthy, M. (ed.), *Shipwrecks of Australia's West Coast*, Western Australian Museum, Perth, 44-47.

MacLeod, I.D., (2013) "The mechanism and kinetics of in-situ conservation of iron cannon on shipwreck sites", *International Journal of Nautical Archaeology*, 42(2), 382-391.

MacLeod, I.D., (2013), "Corrosion reversed: deposition of elemental copper and silver in marine concretions", *Corrosion and Materials,* 38(6), 48-53.

MacLeod, I.D., (2013), Chapter 21, Monitoring, modelling and prediction of corrosion rates of historical iron shipwrecks, in *Corrosion and conservation of cultural heritage metallic artefacts,* in European Federation of Corrosion Publication No 65, Eds Dillman, D. Watkinson, E. Angelini & A. Adriaens, Woodhead Publishing Limited, 466-477.

MacLeod, I.D., (2013) Metals conservation via reductive dissolution and consolidation of corrosion products, Pre-prints of the *METAL 2013, Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group, Edinburgh, Scotland September 2013*, 335.

Veth, P., Philippou, C., Richards, V., Staniforth, M., Rodrigues, J., Khan, A., Creagh, D., Viduka, A., MacLeod I., and Harvey, P., (2013) The Australian Historic Shipwreck Project 2012: First report on the background, reburial and in-situ preservation at the *Clarence* (1841-1850), *Bulletin of the Australasian Institute for Maritime Archaeology,* 37, 1-19.

Abu Baker, A., MacLeod, I.D., Sloggett, R., and Taylor, R., (2013), A comparative study of salicylaldoxime, cysteine and benzotriazole as inhibitors for the active chloride-based corrosion of copper and bronze artifacts, *European Scientific Journal*, 9(33) 228-251.

MacLeod, I.D., Jateff, E and Hunter, J W III, (2014), Corrosion on a wrecked colonial warship: HMCS Protector 1882-1944, *Corrosion and Materials*, 39(3), 52-56.

MacLeod, I.D., (2014), In-Situ Preservation of Shipwreck Artefacts, in C. Smith (Ed.) *Encyclopedia of Global Archaeology*, pp. 3725-3741. New York: Springer.

MacLeod, I.D., (2014), Metals: Preservation and Conservation. In: C. Smith (Ed.) Encyclopedia of Global Archaeology, pp. 4841-4850. New York: Springer.

MacLeod, I.D. & R.J. Car, (2014), Determining treatment priorities for ecclesiastical textiles using significance and conservation assessments, *Journal of Cultural Heritage* 15, 628-636.

Richards, V., MacLeod, I. and Veth P., (2014) The Australian Historic Shipwreck Preservation Project – In-situ preservation and long-term monitoring of the *Clarence* (1850) and *James Matthews* (1841) shipwreck sites. In *Proceedings of the 2nd Asia-Pacific Regional Conference on Underwater Cultural Heritage, 12-16 May 2014, Honolulu,*

Hawaii, eds. H. Van Tilburg, S. Tripati, V. Walker Vadillo, B. Fahy and J. Kimura, 2014 Asia-Pacific Regional Conference on Underwater Cultural Heritage Planning Committee, Hawaii, USA, pp. 469-482.

Usher, K. M., Kaksonen, A, and MacLeod, I. D. (2014), Marine rust tubercles harbour iron corroding archaea and sulphate reducing bacteria, *Corrosion Science* 83, 189-197.

MacLeod I.D., R.J. Car, (2014), Oxidation of dithionite treatment solutions and the effects of pH on fading textile dyes *AICCM Bulletin*, 35, 69-78.

MacLeod, I.D., & Car, R.J., (2014), Conservation of a mid-18th-century Italian embroidered ecclesiastical cope and treatment of corroded metal threads using neutral dithionite solutions, In *ICOM-CC 17th Triennial Conference Preprints, Melbourne,15–19 September 2014,* ed. J. Bridgland, art. 1306, 7 pp. Paris: International Council of Museums, (ISBN 978-92-9012-410-8)

MacLeod, I.D., V.L. Richards, (2014), In-situ corrosion studies of wrecked WWII aircraft in Saipan, Commonwealth of the Northern Mariana Islands. In *ICOM-CC 17th Triennial Conference Preprints, Melbourne, 15–19 September 2014*, ed. J. Bridgland, art. 0902, 8 pp. Paris: International Council of Museums, (ISBN 978-92-9012-410-8)

MacLeod, I.D, D. Thurrowgood, G. Pohl, D. Howard, D. Patterson. (2014) Centuries of decay revealed by synchrotron analysis of the de Vlamingh 1697 pewter plate. In *ICOM-CC 17th Triennial Conference Preprints, Melbourne, 15–19 September 2014*, ed. J. Bridgland, art. 0903, 6 pp. Paris: International Council of Museums, (ISBN 978-92-9012-410-8)

MacLeod, I.D., & Harvey, P., (2014), The application of significance and conservation assessments to the development of a priority matrix for intervention on historic shipwreck sites, *Conservation and Management of Archaeological Sites,* 16(3) 245-267.

MacLeod, I.D., (2015), Change management in materials conservation in *Change! Combining analytic approaches with street wisdom,* Ed Gabriele Bammer, *ANU Press* pp. 217-228

MacLeod, I.D., (2015), Conservation of a museum megamouth shark specimen by changing its preservative from aqueous ethanol to aqueous glycerol, *Collection Forum*, Society for Preservation of Natural History Collections, 29(1-2), 73-89.

Stanbury, M., Kasi, K. and MacLeod, I.D., (2015), Copper and copper alloy artefacts: contemporary experimentation and modern analyses. In: M. Stanbury (ed.), *The Mermaid Atoll shipwreck—a mysterious early 19th-century loss*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 21 Australasian Institute for Maritime Archaeology Special Publication No. 17 (Chapter 11) pp. 131-174

Stanbury, M. and MacLeod, I. D., (2015), Corrosion of cast and wrought iron on the Mermaid Atoll site. In: M. Stanbury (ed.), *The Mermaid Atoll shipwreck—a mysterious early 19th-century loss,* Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 21 Australasian Institute for Maritime Archaeology Special Publication No. 17 (Chapter 14) pp. 205-210.

MacLeod, I.D., (2015), Underwater insights from wrecks of war, *Chemistry in Australia*, April, pp 18-21.

MacLeod, I.D., (2015), Micrometeorological assessment of passive climate controls for museums, *AICCM Bulletin*, 37, 33-43.

MacLeod, I.D., and Curran, B., (2015), Conservation of waterlogged convict-built wooden roadblocks with PEG 3350 and Luviskol K90, *AICCM Bulletin,* 37, 56-66.

MacLeod, I.D., (2015), Corrosion products and site formation processes, Chapter 5 in *Site Formation Processes on historic shipwrecks*, Ed., Matt Keith, Florida University Press, 90-213.

MacLeod, I.D., (2015), The application of chemistry to conserve cultural heritage, *Teaching Science,* 52-62.

MacLeod, I.D., (2016), In-situ corrosion measurements of WWII shipwrecks in Chuuk Lagoon, quantification of decay mechanisms and rates of deterioration, in *Frontiers in Marine Science 30 March 2016*
http://dx.doi.org/10.3389/fmars.2016.00038

MacLeod, I.D., (2016), The composition and properties of "refined" iron: a metallurgical analysis of Gun 8, in *A Cromwellian warship wrecked off Duart castle, Mull, Scotland in 1653,* C.J.M. Martin, Society of Antiquaries of Scotland, pp 147-150.

MacLeod, I.D., (2016), Corrosion of guns as indicators of site-formation processes, in Chapter 4, Wreck-site formation processes, in *A Cromwellian warship wrecked off Duart castle, Mull, Scotland in 1653,* C.J.M. Martin, Society of Antiquaries of Scotland, pp 71-73.

Veth, P., Richards, V., Philippou, C., Rodrigues, J., Staniforth, M., Khan, A., Viduka, A., Zubrzycka, A., Harvey, P., Parkinson, J., MacLeod, I., Shefi D., Barham, A. and Creagh, D., 2016, *Australian Historic Shipwreck Preservation Project, the in-situ preservation & reburial of the colonial trader Clarence (*1850), *Excavation & Monitoring Program Report 2012-2015*, pp i-viii, 1-210, www.ahspp.org.au

Richards, V., MacLeod, I., & Veth, P., (2016), The Australian Historic Shipwreck Preservation Project: In situ Preservation and Long-Term Monitoring of the Clarence (1850) and James Matthews (1841) Shipwreck Sites, *Conservation and Management of Archaeological Sites*, 18:1-3, pp. 240-253.

MacLeod, I. D., (2016), Conservation of corroded aluminium alloys: in-situ conservation to exhibitions, Proceedings of *Metal 2014: Conservation of aluminium artefacts,* Joint AIC and ICOM CC Metals Working Group meeting, Washington, DC, April 6-9, 2014, in press.

MacLeod, I.D. and Car R., (2016), Conservation of a mid-19th century pretiosa mitre from the Benedictine community, New Norcia, Western Australia, *AICCM Bulletin,* 37(2), pp 96-106.

MacLeod, I.D., (2016), Corrosion of copper alloys on historic shipwrecks and materials performance, *Proceedings of Corrosion and Protection Conference, November 13-16, 2016,* Australasian Corrosion Association, Paper 105, pp. 1-10.

MacLeod, I.D. and McCarthy, M, (2016), Corrosion on HMAS Sydney II and HSK Kormoran in *From Great Depths; the wrecks of HMAS Sydney II and HSK Kormoran,* Ed M. McCarthy, WA Museum and UWA Press, pp 304-309.

MacLeod, I.D., (2016), "Refining conservation treatments for iron shipwrecks: lessons learned from experiences with the USS *Monitor* (1862) and the SS *Xantho* (1872)", *Bulletin Australasian Institute of Maritime Archaeology*, 40, 39-50.

Black, J., MacLeod I.D., and Smith, B., (2017), Theoretical effects of industrial emissions on colour change at rock art sites on Burrup Peninsula, *J Archaeological Science*: *Reports* 12, 457-462.

MacLeod, I.D., (2017), Preventive Conservation of Archaeological Metals in *Preventive Conservation: Collection Storage*, Ed R Waller and L. Elkin, Joint publication by the AIC and SPNHC, Smithsonian Institution, Washington DC, in press.

MacLeod, I.D., Selman, A., and Selman C., (2017), "Assessing the impact of typhoons on historic iron shipwrecks in Chuuk Lagoon through changes in the corrosion microenvironment", *Conservation and Management of Archaeological Sites*, in presss

MacLeod I.D., Brennan, J., and Car R J., (2018), "Development of textile education options for treatment of gilded and oxidized silver found in textiles", *AICCM Bulletin* – submitted.

MacLeod I.D., (2018), "Quantifying the effects of site conditions on the long-term corrosion of bronzes on historic shipwreck sites", submitted to the *Journal of Australasian Institute for Maritime Archaeology,*

MacLeod I.D., (2017), "Surface chloride activity measurements on brick and stone: a guide to underlying decay and treatment options", *AICCM Bulletin*, in preparation.

Popular Publications

MacLeod, I.D., (2012), Two Fremantle Maritime Museums, *Signals* 99 June to August 2012, 44-49.
MacLeod, I.D., (2012), *The mutineer's mortar*, Collectors Corner, *Chemistry in Australia* June 2012, 32
Not just a gilded bowl, AICCM National Newsletter 114, March 2010, page 20
Shipwrecks in Port Phillip Bay, AICCM National Newsletter 114, March 2010, page 28
MacLeod, I.D., (2011) *Regilding the golden goddess* Collectors Corner, *Chemistry in Australia*, April, p 35
MacLeod, I.D., (2011, 2012), President's Column in *Corrosion and Materials* 35 (5, 6) & 36 (1, 2, 3, 4 & 5)

MacLeod, I.D., (2013) Book review on *George Charles Smith: from Nelson sailor to Mission Pioneer*, The Great Circle 35(1) 115-116.
MacLeod, I.D., (2014), Afterlife of a Scottish Steamship, *Chemistry in Australia, April* p 34-35
Anstey, S and MacLeod I.D., (2014), 100 Postcards from the Frontline, *Chemistry in Australia,* May p 37
MacLeod, I.D. and Power, G, (2014), Vale: Professor Ian McKay Ritchie, *Corrosion and Materials* 39(6), p 13
MacLeod, I.D. and Power, G, (2015), Obituary Ian Mackay Ritchie, Corrosion Expert, *Chemistry in Australia*, April p 29
Power, G., Ritchie A, Drock, K., & MacLeod I.D., (2016), Ian McKay Ritchie 1936-2014, *Historical Records of Australian Science*, 28, 1-8
MacLeod, I.D., (2016), Book Review, The life and times of Dirk Hartog, *History West* page 7

Unpublished Reports

MacLeod, I.D. (1985) - Conservation of shipwreck material on Norfolk Island, in *Expedition Report on the wreck of HMS Sirius (1790)* by Henderson, G. and Stanbury, M. Australian Bicentennial Authority Project Report, pp 43-65.

MacLeod, I.D. (1989) - "Conservation of relics from HMS Sirius", 16 pages in Norfolk Island Government Project, *1988 Expedition report on the wreck of HMS Sirius (1790)*, Compiled by Graeme Henderson.

MacLeod, I.D. (1991)- "Conservation of Cultural Property -Report to UNESCO on a meeting of consultants, ASEAN National Museum conservation delegates, UNDP and ICOM delegates" Bangkok, 28th January to 1st February.

MacLeod, I.D., Haydock, P. and Ford, B (1991) - "Conservation research into the preservation of rock paintings in the West Kimberley region of Western Australia", Report to the Western Australian Heritage Committee, pp 1-89.

MacLeod, I.D., Haydock, P & Charton, E., (1992) "The effects of avian guano on the preservation at *Walga Rock*". Report to the Australian Institute of Aboriginal and Torres Strait Islanders Studies, Canberra, pp 1-45.

MacLeod, I.D., (1993) "Implications of the marine aggregate proposal on the degradation of historic shipwrecks south of Sydney, New South Wales", Report for Corkery and Co., Environmental Consultants, Orange, New South Wales, pp 1-22.

MacLeod, I.D., Haydock, P and Ford, B (1994) *Conservation research into the preservation of rock paintings in the West* Kimberley Region of Western Australia: Wet Season Report. Report to the Heritage Council of WA, March 1994, pp-143.

de Giuchen, G., Delivré J. and MacLeod I.D., (1995) "Musée National du Cambodge Phnom Penh", Mission de L'Unesco, 7 au 14 mai 1995, ICCROM, Rome 1995 pp 1 - 50.

MacLeod, I.D. and Haydock, P., (1996) *Research into the Conservation or rock paintings in the West Kimberley: Microclimate data analysis* Report to AIATSIS, May 1996, pp 1-132

MacLeod, I.D., (1997), "Treatment of artefacts from the wreck of the *Diana* (1817): Conservation Issues", Affidavit for the International Tribunal, Government of Malaysia, Kuala Lumpur, Malaysia, pp 1-70

Ford, B., Officer, K. and MacLeod, I.D., (1999) *A study of lichen invasion of Nursery Swamp II, Aboriginal Rock Art Site, Namadji National Park, Australian Capital Territory, Final Report May 1999*, Australian Capital Territory National Parks Association, Canberra 1999, pp. 1-28.

MacLeod, I.D., (2003) "*Metal corrosion in Chuuk Lagoon: A survey of iron shipwrecks and aluminium aircraft,* Report to the US National Parks Authority, Pacific Division, San Francisco, USA, pp 1-92.

MacLeod, I.D., (2003) "The microenvironment of rocks on the Burrup: analysis of the relationships between nutrient supplies, surface pH and microflora – preliminary report, Report to the Minister of Culture and the Arts, pp 1-55.

MacLeod, I.D., (2006), "Conservation of the USS *Monitor* (1862). A report on the conservation facilities at The Mariners' Museum & artefacts from the USS *Monitor* (1862), Western Australian Museum, Unpublished report CMC WAM no 1, pp 1-35.

Jeffery, B., Beger, M., MacLeod I.D., Richards, V.L., Hengeveld, M., and Carpenter J., (2007), Guidelines in Recording and Monitoring the Natural and Cultural Attributes of Submerged Historic Sites in the Federated States of Micronesia, Report to the US National Parks and Wildlife Services, pp 1-65.

MacLeod, I. D., (2009) "Corrosion of a Beretta Pistol in the Georges River", Report to the Attorney General, New South Wales Supreme Court, pp 1- 15.

MacLeod, I. D., & Garcia R., (2009) "Conservation Report on HMVS *Cerberus*: Options for Gun Turrets and Hull" Report No. 2009.001 pp 1-17 Report to the Friends of the Cerberus

MacLeod, I.D., (2009) "Corrosion assessment of a 1989 Mitsubishi Bus" Report No. 2009.002 pp 1-11, Report to the Department of Transport

MacLeod I.D., and Car, R.J., (2012), Significance Assessment of the Textile Collection, New Norcia, Report to the National Library of Australia, 1- 62.

MacLeod I.D., and Car, R.J., (2013), New Norcia ecclesiastical textiles collection: Significance and conservation assessment with development of a treatment priority matrix, Report to the National Library of Australia, 1-78.

MacLeod, I.D. and Richards, V.L., (2013), Conservation survey: Randell Dry Dock, March 2013, Report to the Mannum Dock Museum Board, South Australia, pp 1-40

MacLeod, I.D., (2015), Report on the microenvironment of the interior and exterior of showcases, National Anzac Centre, Albany, Western Australia, October 2014- August 2015, pp 1-18.

Inorganic Chemistry Publications

MacLeod, I.D., Bond, A.M. & O'Donnell, T.A. (1973) "Polarographic procedures in anhydrous hydrogen fluoride: oxidation and reduction of tin (II)" *J. Electroanalytical. Chemistry*: 45:89-98.

MacLeod, I.D., Millington, D., Prescott, A. & Sharp, D.W.A. (1975) "A thermally dependent redox equilibrium in solution" Inorganic *Nuclear Chemistry Letters,* 11: 447-450.

MacLeod, I.D., Manojlovic-Muir, L., Millington, D., Muir, K.W., Sharp, D.W.A. & Walker, R. (1975) "The preparation, n.m.r. spectra and structure of unsymmetrical ditertiary phosphine complexes of platinum (II)" *J. Organometallic Chemistry.* 97: C7.

MacLeod, I.D., Muir, D.M., Parker, A.J. & Singh, P. (1977) "Solvation of Ions. Some Applications. II. Electrolysis of Copper (I) sulphate in water-nitrile mixtures", *Australian J. Chemistry* 30:1423-37.

MacLeod, I.D. & O'Donnell, T.A. (1977) "Polarography of some p-block elements in anhydrous hydrogen fluoride" Inorganic *Chemistry* 16:1433-1437.

Burns, R.C., MacLeod, I.D., O'Donnell, T.A., Peel, T.E., Phillips, K.A. & Waugh, A.B. (1977) – "Xenon difluoride as a selective inorganic fluorinating agent" *J. Inorganic Nuclear Chemistry,* 39:1737-1739.

Filmer, A.O., MacLeod, I.D. & Parker, A.J. (1979) "Oxidation of copper sulphides in aqueous Ammonia II - Electrochemical Aspects" *Australian J. Chemistry* 32:975-87.

Singh, P., MacLeod, I.D. & Parker, A.J. (1982) "Solvation of ions. Part XXX. Thermodynamics of transfer of copper ions from water to solvent mixtures" *J. Solution Chemistry* 11:495-508.

Singh, P., MacLeod, I.D. & Parker, A.J. (1983) "Solvation of ions. Part XXXI. Partial molal volumes of sodium, silver (I) and copper (I) ions in acetonitrile-water mixtures" *Australian J. Chemistry* 36, pp 1675-85.

MacLeod, I.D. & Muir, D.M. (1983) "Reduction of chalcopyrite with copper (I)", *J. Applied Electrochemistry* 13 pp 411-416.

Singh, P., MacLeod, I.D. & Parker, A.J. (1984) "Solvation of ions. Part XXIX. Ionic conductances in acetonitrile-water and pyridine-water mixtures" *J. Solution Chemistry* 13(2): 103-119.

Proposed Technical Ammonium Nitrate Production Facility (EPBC 2008/4546)

Consolidated Approval Notice Condition 10A, On-going Rock Art Monitoring

METHODOLOGY

For 10 years (2004 to 2013), petroglyphs at seven specially selected sites (chosen under the guidance of indigenous elders) in the Burrup Peninsula were measured using colour and reflectance spectroscopy measurements. Three spots on each engraving and three spots on each background rock were measured *in situ* using a portable photospectrometer for colour measurement and a reflectance spectrometer for visible and near infrared analysis. In 2014, the rock art monitoring project expanded at the request of Yara Pilbara Nitrates Pty Ltd (YPNPL). The company was building a Technical Ammonium Nitrate (TAN) Production Facility Project (TAN) on the Burrup Peninsula, and to adhere to the requirements of the Environment Protection and Biodiversity Conservation Act 1999, YPNPL needed to engage a heritage monitor to survey the rock art sites within a two kilometre radius of the project site. CSIRO had been a heritage monitor for the then West Australian Government "Department of Environment Regulation (DER)", now the Department of Water & Environment Regulation (DWER) for the monitoring of the Burrup petroglyphs for the last decade and was considered appropriate to be the heritage monitor for YPNPL.

The rock art study dedicated for the TAN Project required the heritage monitoring of petroglyphs sites within 2km of the plant site. Selected sites were determined in consultation with members of Murujuga Aboriginal Corporation to respect the cultural laws of the traditional owners for the entitlement of access. The selected petroglyphs were firstly evaluated for their appropriateness for scientific study, including petroglyph size and quality, direction of exposure, elevation, dominant and wind direction. From the six selected monitoring sites, three were already part of the decade-old and ongoing Burrup Rock Art Technical Working Group (BRATWG) monitoring program and an additional three sites were also selected. After initial monitoring in February 2014, the three new sites have become part of the BRATWG monitoring program. As well as the three new sites, an extra spot (both engraving and background) was added on each monitored petroglyph panel, bringing the total to eight sampling spots (four areas classified as ‘engraving’ and four areas classified as ‘background’) to increase the accuracy of future statistical analysis of measurements.

Proposed methodology for 2017 rock art monitoring to ensure compliance with Condition 10 of EPBC 2008/4546:

The six sites previously sampled are as follows:

Site name	Coordinates (GDA 94, Zone 50)	
Burrup Rd	475,959	7,719,771
Water Tanks	477,698	7,720,137
Deep Gorge	477,956	7,717,987
Yara West	476,558	7,719,223
Yara North East	479,112	7,720,155
Yara East	478,849	7,719,565

At each of these sites, and in the same locations as previous sampling, measurements will be taken as follows:

1. **Colour and colour contrast**

   Spectrophotometry. Colour measurements will be collected by the use of a portable, hand-held spectrophotometer that measures the degree of lightness (L*), degree of red/green (a*) and degree of yellow/blue (b*) to provide a tri-stimulus value (3D L*a*b*) for each sample point on the specimens. Differences in 3D values across time can be numerically evaluated to identify potential changes in colour.

2. **Mineralogy**

   Reflectance spectrography. A portable spectrometer operating over a 400 to 2500nm wavelength range will be used. An internal light source will be used to irradiate the surface of the rocks, with the reflected light detected by an array of photodiodes. A spectrum of reflectance vs wavelength is generated for each monitoring point on the surface of the rocks, which is then compared to previously collected data from the same points on the same rocks. Changes in the spectra are an indicator of changes in the mineralogy of the rock surface.

Data Analysis Australia review, conclusions and responses

In 2017 DWER commissioned Data Analysis Australia (DAA) to undertake a review of CSIRO work to date (Henstridge *et al* 2017). In terms of the recommendations that were made by Data Analysis Australia in 2016, the following summarises compliance with responses in ***bold italic***:

1. *The historical data collected by the CSIRO should be systematically archived and held by DER, with consistent naming conventions, both to provide a baseline record and to facilitate comparisons with future data. The archival data format should enable ready access to the data via standard statistical software such as R.*

We would describe this as **largely** met:

· The management of the data appears to have improved considerably, although it is not perfect in that the metadata – details of how the data was collected and hence what the data might therefore mean – is not systematically available.
This will be rectified in the current study. Detailed records will be kept on data collection according to scientific norms.

· We remain concerned that there are undocumented features of the data collection process that should be taken into account in any analysis. For example, the substantial year-to-year variation in the ASD data is only partially explained by the differences in recording practices described in the Reports, and the descriptions that do exist are not always consistent.
This will be taken into account.

2. *The CSIRO should be asked to revisit the cross-calibration issues with the BYK and KM spectrophotometers, both to ensure that the historical data is properly understood and to confirm whether or not the historical BYK data is capable of comparison with current and future measurement instruments.*

We would describe this as being **not addressed** in the Draft Report:

· The cross validation methodology for the BYK data has not been revised and is still deficient. The Draft Report appears ambivalent about the utility of the BYK data.

· Whilst the Executive Summary does state “the BYK spectrophotometer data appears unreliable for drawing conclusions on colour change in the rock art”, the data is still given undeserved prominence in the report and the ASD colour data is not discussed as a credible replacement.

· However we suggest that the first part of this recommendation from 2016 concerning the cross calibration should not be given high priority as one solution may be to largely drop reference to the BYK data.

This will be taken into account. Consideration will be given to taking two readings for every point using firstly the previous BYK instrument and then the KM instrument to allow comparison of contemporaneous readings. This will also allow comparison across historical data sets.

3. An analysis similar to that of Black and Diffey should be conducted using verified ASD estimates of L*, a*, b*, *ideally using the original ASD spectra rather than the averaged spectra.*

We would describe this being only **partially** met:

· The analysis in the Draft Report does use linear mixed models as suggested by Black and Diffey. However this is poorly reported and not convincing. Whilst the conclusion given in the Draft Report is that there is no evidence of relevant changes to the rock art in the areas close to the industrial development, it remains arguable that a more careful analysis would demonstrate changes.

This will be addressed in the analysis of data collected in the field.

4. Future work by the CSIRO should be based upon an agreed analysis plan certified by a competent statistician. Since each year the CSIRO reports have covered the full data set since 2004, it would be appropriate for the next published report to incorporate this improved analysis and in doing so, make it clear that it should replace the analyses in their previous reports.

We would describe this as **not** being met:

· No formal analysis plan appears to exist. The analysis methods in Chapters 4 and 5 of the Draft Report are essentially unchanged.

Noted, once data has been collected consideration will be given to commissioning a competent statistician to certify the analysis.

5. Consideration should be given to expanding the number of measured sites and in doing so, improving the balance of the design to include more effective controls, if feasible.

We would describe this as **not** being met:

· No change has been made to expanding the data collection or to include improved controls, although we recognise that the time of the data collection in 2016 meant it could not be affected by our 2016 Recommendations.

· The Draft Report does not discuss possible changes to the design of the data collection.
This will be addressed through consultation with Murujuga Aboriginal Corporation. Consideration will be given to expanding the data set by data collection at additional rock art sites.

7. To maintain scientific rigour, future data collection should follow a fully documented and detailed protocol, and ensure that departures are documented.

We would describe this as **not** being met:
· Documentation of the data collection protocol does not appear to have improved.
Documentation of the data collection protocol will be improved and will meet international scientific norms and benchmarks.

REFERENCES

Henstridge, J. Haskard, K.Mehryar, M. 2017 Review of CSIRO Report on Burrup Peninsula Rock Art Monitoring. Data Analysis Australia for the Department of Environment Regulation.

Attachment 10Ab: Letter YPN to Department regarding Rock Art Monitoring, 2 July 2018

YARA

Knowledge grows

2 July 2018

Our Reference: 650-200-LET-DOE-0002

Your Reference: EPBC 2008/4546

Monica Collins
Chief Compliance Officer
Office of Compliance
Department of the Environment and Energy
GPO Box 787
Canberra ACT 2601

Dear Ms Collins

Proposed Technical Ammonium Nitrate Production Facility (EPBC 2008/4546)

I write in relation to the Consolidated Approval Notice for the above referral, issued by your Department and dated 12 September 2017, and to recent discussions with yourself and colleagues.

As discussed, Condition 10A of the Consolidated Approval Notice, *On-going Rock Art Monitoring*, requires that, from 2018, rock art monitoring must be undertaken annually between 15 July and 15 September of each year, for the life of the approval. Condition 10A also requires that the monitoring be undertaken by a suitably qualified person (Heritage), and using a methodology approved by the Minister in writing, or through a program administered by the Western Australian Government Department of Water and Environmental Regulation (DWER).

As DWER has confirmed that they will not be conducting a monitoring program in 2018, Yara Pilbara Nitrates' proposes the following actions to meet the requirements of Condition 10A in 2018:

- Yara seeks approval to replicate the monitoring program that was approved in 2017 (see attached DOEE letter dated 21 December 2017)
- All aspects of the monitoring methodology will remain the same, with Warren Fish and Dr Ian MacLeod again managing the monitoring, with the heritage custodians of the Burrup rock art, Murujuga Aboriginal Corporation, actively involved (see attached Yara Pilbara Nitrates letter dated 3 November 2017, ref 650-208-LET-YPN-0001)
- With respect to the requirement of Condition 10A to engage at least once annually with the Murujuga Aboriginal Corporation in the planning and reporting associated with the on-going annual rock art monitoring, Yara Pilbara Nitrates has held multiple face-to-face meetings with Murujuga Aboriginal Corporation, as well as correspondence and telephone discussions to ensure their support for this proposal

Yara Pilbara Nitrates Pty Ltd

Postal Address
Locked Bag 5009
Karratha WA 6714
Australia

Visiting Address
Lot 564 and 3017 Village Road
Burrup WA 6714
Australia

Telephone
+61 8 9183 4100
Facsimile
+61 8 9185 6776
ABN
33127391422

Registered Office:
Level 5, 182 St George Terrace
Perth WA 6000
Australia
Telephone: +61 8 9327 8100
Facsimile: +61 8 9327 8199

Knowledge grows

Should this proposal meet with approval, the next step would be to identify with Murujuga Aboriginal Corporation an optimal time within the required dates for the monitoring, and begin logistical planning immediately to ensure compliance.

For your information, our intent is to conduct additional monitoring in partnership with Murujuga Aboriginal Corporation, according to methodology developed by Fish and Macleod and shared with Murujuga Aboriginal Corporation. This methodology has been submitted for consideration to the Director General of DWER by Murujuga Aboriginal Corporation's CEO during a recent meeting on country. Data gathered via this monitoring may well inform future approaches to protection of the Burrup rock art.

Yours Sincerely

Luke BLACKBOURN

Manager Government and External Relations

Yara Pilbara Nitrates

Attachments

1. DOEE letter, 21 Dec 2017
2. YPN letter, 3 Nov 2017

cc. Peter Jeffries, Acting CEO Murujuga Aboriginal Corporation

Australian Government
Department of the Environment and Energy

Ref: 2008/4546

Mr Brian Howarth
HESQ Manager
Yara Pilbara Nitrates Pty Ltd
Locked Bag 5009
Karratha WA 6714

EPBC 2008/4546 – Proposed Technical Ammonium Nitrate Production Facility – Approval of Methodology

Dear Mr Howarth

Thank you for your letter dated 3 November 2017 to the Department, requesting approval of Yara Pilbara Nitrates interim rock art monitoring methodology under condition 10A(d) of EPBC Act approval 2008/4546.

I note that the Western Australian Government recently published the draft Burrup Rock Art Strategy which will provide a long-term framework to protect Aboriginal rock art on the Burrup Peninsula. In this context I understand that Yara Pilbara Nitrates Pty Ltd is seeking the approval of its methodology as an interim method to be used for 2017 monitoring, pending the development of a new method by the Western Australian Government and the independent Burrup Rock Art Monitoring Management Committee.

I also understand that Yara Pilbara Nitrates Pty Ltd has sought to address the recommendations of the Data Analysis Australia report to the extent feasible and that those recommendations will also be considered by the independent Burrup Rock Art Monitoring Management Committee in the development of the Burrup Rock Art Strategy.

On this basis, as delegate of the Minister I approve the proposed rock art monitoring methodology for 2017. I am also satisfied that Mr Warren Fish and Dr Ian Macleod, have suitable qualifications and experience to undertake the rock art monitoring under condition 10A.

Should you require any further information please contact Officer Dwaine McMaugh, A/g Director, Environmental Audit Section, on 02 6274 1641 or by email: EPBCmonitoring@environment.gov.au.

Yours sincerely

Monica Collins
Chief Compliance Officer
Office of Compliance

21 December 2017

Knowledge grows

3 November 2017

Our Reference: 650-208-LET-YPN-0001

Your Reference: EPBC 2008/4546

Monica Collins
Chief Compliance Officer
Office of Compliance
Department of the Environment and Energy
GPO Box 787
Canberra ACT 2601

Dear Ms Collins

Proposed Technical Ammonium Nitrate Production Facility (EPBC 2008/4546)

I write in relation to the Consolidated Approval Notice for the above referral, issued by your Department and dated 12 September 2017.

Condition 10A of the Consolidated Approval Notice, *On-going Rock Art Monitoring*, requires the first on-going rock art monitoring event to be completed by no later than 31 December 2017, and I wish to update you with respect to Yara Pilbara Nitrates actions to date to meet this condition, and seek approval of our proposed methodology and monitors.

As you are aware, previous rock art monitoring on the Burrup Peninsula was undertaken by CSIRO as part of the Western Australian Government's Burrup Rock Art Monitoring Program which expired in June 2016. Since that time, the WA Government has failed to replace the program and so we are in the position of needing to conduct our own rock art monitoring as per the Consolidated Approval Notice. Yara recognises the importance of obtaining data in 2017 so as to avoid a year-long gap in the monitoring data. Our efforts aim to make the data we gather as useful as possible in contributing to the understanding of the rock art and any potential impacts thereon.

A key aspect of our initial efforts has been to engage and include members of Murujuga Aboriginal Corporation (MAC) in our rock art monitoring activities. We note that as freehold title holders for the Murujuga National Park, as cultural custodians for the rock art and as Indigenous Rangers working on country, MAC are key stakeholders regarding Burrup rock art, yet they continue to state that they are being sidelined and treated paternalistically with respect to the Burrup rock art, as they attested at the Senate Inquiry earlier this year.

We have met the CEO, Chairperson, Circle of Elders and the Manager of the Murujuga Land and Sea Unit. They have agreed to assist in the rock art monitoring program for 2017, and our experts will work with the Rangers to ensure knowledge and skills transfer take place. Murujuga are supportive of this work and look forward to working with Yara.

Yara Pilbara Nitrates Pty Ltd

Postal Address
Locked Bag 5009
Karratha WA 6714
Australia

Visiting Address
Lot 564 and 3017 Village Road
Burrup WA 6714
Australia

Telephone
+61 8 9183 4100
Facsimile
+61 8 9185 6776
ABN
33127391422

Registered Office:
Level 5, 182 St George Terrace
Perth WA 6000
Australia
Telephone: +61 8 9327 8100
Facsimile: +61 8 9327 8199

Knowledge grows

The proposed methodology is attached, and we trust it will meet with the approval of the Minister. As you will see, we have taken the previous CSIRO methodology, and made some changes to reflect clear recommendations of the Data Analysis Australia report *Review of CSIRO Report on Burrup Peninsula Rock Art Monitoring* found on the web at

https://www.der.wa.gov.au/images/documents/our-work/consultation/Burrup-Rock-Art/DAA-independent-review-report---May-2017.pdf

We noted your Department's endorsement of the role of CSIRO in previous rock art monitoring in the Department's response to comments in Dr Ken Mulvaney's submission to the Senate Inquiry. We trust that the Department therefore has a familiarity and understanding of the methodology presented.

Condition 10A c) requires the rock art monitoring to "…be undertaken by a suitably qualified person (Heritage)", with the definition later provided:

> ***Suitably qualified person (Heritage)*** *is a person with at least a bachelors degree with Honours in archaeology or five (5) years experience in Indigenous heritage or archaeology recognised by a relevant body such as the Australian Association of Consulting Archaeologists.*

Our program will be led by Warren Fish, who is a Masters Degree qualified archaeologist and an ex-Registrar of Aboriginal Sites with the WA Government, with well over a decade of experience in Indigenous heritage. Warren will be supported by Dr Ian MacLeod, who is a highly respected international academic and scientist, specialising in heritage conservation. Dr MacLeod has been instrumental in the various rock art conservation and monitoring campaigns conducted on the Burrup. CVs are attached for both. As previously mentioned, the heritage custodians of the Burrup rock art, Murujuga Aboriginal Corporation, will be actively involved in the monitoring. These participants ensure we meet this Condition of the Consolidated Approval Notice.

We trust that this interim program meets with approval of the Minister, and would like to state our keenness to support updated methodology and monitoring in subsequent years. We are more than happy to provide further information, and look forward to working with the Department to ensure monitoring takes place in a timely manner. Should you need any further information before putting the proposed monitoring program to the Minister, please do not hesitate to contact us. In addition, if you feel that Departmental staff may benefit from a visit to the Burrup to better understand Yara's activities and the context in which we operate, we would be only too happy to host them.

Yours Sincerely,

Brian HOWARTH

HESQ Manager

Yara Pilbara Nitrates

Attachments

1. CV Fish
2. CV MacLeod
3. Proposed Technical Ammonium Nitrate Production Facility Rock Art Monitoring Methodology

cc. Craig Bonney, CEO MAC

CV

Warren Stuart FISH

PERSONAL DETAILS

Name: Warren Stuart FISH

Address:

Telephone:

Email:

Warren has over 20 years of leadership experience and is highly skilled at developing and implementing strategic objectives.

He has international experience in corporate governance, Health Safety and Environment leadership, enterprise risk management, government relations, corporate affairs, Indigenous affairs, and people logistics.

Warren has held senior leadership positions in the Western Australian State Government; worked in the United States, southern Africa and Australia; and held key management roles in successful major projects.

IN BRIEF

20 years working in:

- Executive management
- Corporate Affairs
- Heritage and native title
- Sustainability
- Health, safety and environment (HSE) and sustainable development
- Corporate compliance and approvals
- Enterprise risk management

Experience:

- Project Director: Stakeholder Relations and Approvals, encompassing all HSE components. $8 billion greenfields JV with multi-cultural partners and complicated commercial arrangements. Construction of a mine, railway and port and marketing of product and project into China and Korea.
- Executive Director: Health, Safety, Environment and Corporate Logistics at CITIC Pacific Mining, an $15 billion greenfield magnetite project in north-west Western Australia. Greenfields construction of a mine, processing plant, infrastructure corridor, power station and port. My role extended to Executive Director of the company.

- Key management and leadership roles:
    - Aurizon
    - CITIC Pacific Mining
    - North West Shelf Venture

    - Woodside Pluto LNG projects
    - Registrar of Aboriginal Sites, WA State Government

- Work locations in the United States, southern Africa and Australia

Qualifications:

- MA (2001): respected in the international academic community, with numerous papers published in peer-reviewed journals, and have reviewed wide-ranging papers for academic publications.

Board representation:

- Previous membership of 14 Boards, including CITIC Pacific Mining Management Pty Ltd.

EMPLOYMENT HISTORY

September 2016 - Present:

WS Fish Consulting
Principal

Consulting to industry on:

- Stakeholder Management and Corporate Affairs
- Government relations
- Heritage and native title
- Sustainability
- Health and Safety
- Environment

Skills include, although not limited to the following:

- Utilising strong government relationships (both State and Federal) to connect business leaders to political leaders in order to influence policy direction.
- Providing strategic advice to senior management and board on sustainability, stakeholder relations and community engagement.
- Delivery of regulatory approvals.

August 2014 – September 2016:

Aurizon
Project Director: Stakeholder Relations, HSE and Approvals

The West Pilbara Infrastructure Project (WPIP) is a Joint Venture with Baosteel, POSCO, and AMCI to construct and operate an iron ore mine, 280km railway and port in the west Pilbara, Australia. Initial capacity is 40mtpa scalable to 250mtpa. Reporting to the Executive Vice President Strategy and Business Development I held formal accountability for below but was also heavily involved in Corporate Affairs issues across the business. This included providing advice to the then CEO on State and Federal political matters.

Portfolio included accountability for:

- Stakeholder Management and Corporate Affairs
- Sustainability
- Health and Safety
- Environment
- Heritage and native title

Responsibilities included:

- Successful delivery of regulatory approvals
- Lead negotiations for a State Agreement with the WA Government, including driving its passage through Parliament.
- Lead negotiations on a State Development Agreement for the Port, allowing sufficient control for Aurizon to take advantage of significant opportunities.
- Lead negotiations on Native Title Agreements.
- Ensure that commercial relationships were appropriately established and maintained.
- Develop and maintain strong joint venture, supplier and stakeholder relationships.
- Lead the implementation of the Heads of Agreement in terms of the management of major stakeholder relationships.

Key achievements

- Negotiated changes to approved Government port layout and design. Led to $600m construction savings.
- Negotiated change to Government position on State Agreement term from 16 yrs +10+10 to 50 yrs +10+10. This increased project viability and led to significantly more favourable financing terms.
- Negotiated changes to Government policy relating to financial mechanisms usually required in State Agreements (use of trust structures as proponents)

May 2010 - June 2014:

CITIC Pacific Mining Management Pty Ltd
Executive Director: Health, Safety, Environment and Corporate Affairs

CITIC Pacific Mining (CPM) is an Australian company wholly owned by the CITIC Group, one of China's largest SOE's. CPM constructed China's largest resource project in Australia in the form of a magnetite mine in the Pilbara. The Project is a $15bn resource and infrastructure project consisting of a mine, concentrator, 450MW gas-fired power station, 30km infrastructure corridor, tailings facility, 60GL desalination plant and port. Peak construction workforce was 4500.

Portfolio included accountability for:

- Health and Safety
- Corporate Affairs
- Sustainability
- Corporate Logistics
- Environment
- Heritage & Native Title
- Pastoral Management (Mardie Station)

Reporting to the Executive Chairman, this position carried accountability for CITIC Pacific Mining's license to operate.

Responsibilities included, although not limited to the following;

- Staff compliment – approximately 120 (300 including contractors) people and $90m annual budget.
- Board level decision-making and planning advice on company strategic direction.
- Health and Safety portfolio for construction, commissioning and operations. Peak workforce of over 4500.
- Cultural change programs in Health and Safety leading to a significant reduction in injuries.

Key achievements

- Introduced the first publication of a comprehensive Sustainability Report in the CITIC Group's history. Sustained and sophisticated internal stakeholder management at senior executive and board level required to gain approval for this to be undertaken in a traditionally conservative Chinese SOE. The report was well-received and the template was used for other business units in Hong Kong and mainland China. This lead to wide-ranging internal discussion on the potential effects of climate change on various parts of the business.
- Stakeholder relations campaign with Federal politicians around the Carbon Pollution Reduction Scheme (CPRS) and Clean Energy Futures (CEF). Design of carbon

policy for CITIC Pacific Mining, particularly around 450MW power station and the construction of a solar farm to contribute to offset. We were able to win significant Federal funding to support the construction of the solar farm, leading to dramatic reduction of accommodation village costs.

- Significant issues were being encountered with the Safety portfolio, with poor performance and high injury rates. After a fatality occurred, I was asked by then-CEO to lead the undertaking of a cultural change project in the Safety portfolio. Detailed and sophisticated stakeholder work with Australian Board, Hong Kong Board and CITIC Board in Beijing. Program design and implementation across site with 4500 construction workers. Led to decrease in Recordable Injury Frequency Rate from 14 down to 3 within six months.
- Company Logistics were not being efficiently managed. Then then-CEO requested I undertake a change management project to rectify. I led renegotiations of contracts with QANTAS and other air and bus charter providers, as well as accommodation village service providers (3 different providers and 3 villages). Security contracts were redesigned. Outcome was a more disciplined approach to corporate logistics and significant cost savings. CEO then requested that the same study be undertaken on other portfolios, including site maintenance, which was also posted under my aegis.
- Mardie Station had been purchased by the company to shore up tenure and secure land access. The station had been running at a loss and the then then-CEO turned to me to rectify. I undertook a full review of operations which led to leaner operating models and the setup of a feedlot. This included capital spend on infrastructure, which was a difficult sell when instruction was to cut costs. The Board agreed with my logic and proposal, capital costs were incurred and Mardie Station has run at a healthy profit every year since.
- Site faced a significant fibrous materials issue and State Mining Engineer's advice to Mines and Petroleum Minister was to temporarily shut down the site. I led negotiations for Project to remain active while safety regime was being re-designed.
- Maintained strong relationships with Federal and State Government despite contentious issues, including significant cross-cultural and political miscommunication.

March 2008 – April 2010:

CITIC Pacific Mining Management Pty Ltd
Director, Corporate Affairs, Environment and Heritage

Reporting to the CEO, this position was created to direct the Environment and Heritage portfolio and increase focus on approvals, compliance, sustainable and responsible development, and the management of community and stakeholder expectations in these spheres including;

- High level negotiations and interaction with various Commonwealth and State Government Departments.
- Environment, Heritage and Land Access processes and approvals, within accelerated timeframes, and Tenement Management.
- Indigenous relationships, consultations, approvals, surveys and negotiations with Traditional Custodians.
- Negotiator to CPM Legal Counsel during negotiations with three different Native Title Claimant Groups and on-going administration of Native Title portfolio.
- Responsibility for Indigenous Business and Employment strategy

Key achievements

- Approvals were the major risk to the project and were holding up construction at a

cost of US$7m/day. I led the turnaround to a position where approvals were 6-8 months ahead of construction. This involved complex negotiations with Government and led to parallel approval processes being put in place. This had not been done before by Government.
- Significant fibrous materials (asbestos) issue on site with Dept of Mines and Petroleum Safety Branch advice to temporarily close site and halt construction. I successfully negotiated an outcome at Director General level that allowed construction to continue whilst new protocols were being designed and implemented.
- Re-negotiated approval conditions that were expensive and onerous to comply with. This led to significant cost savings.

Dec 2006 - March 2008:

Woodside Energy Limited
Corporate Affairs, Heritage Manager

This position was created in the face of increased scrutiny in land access negotiations and entailed managing all Woodside heritage matters, including:
- Staff compliment – 5 reports
- High level negotiations with various Commonwealth and State Government Departments on National Heritage Listing.
- Drafting of Conservation Agreements between Woodside and the Commonwealth, and the NWSV and the Commonwealth.
- Heritage work exceeding international best practice on the Pluto Project.
- Managing corporate social responsibility.

Key achievements
- Led work negotiating National Heritage Listing of the Burrup peninsula with Pluto and North West Shelf areas excised.
- Negotiated Traditional Owner participation in heritage projects despite high-profile opposition from conservation groups and activists.

Nov 2004 - Dec 2006:

Woodside Energy Limited
Manager Corporate Affairs, Karratha

Woodside Energy is Australia's largest oil and gas producer. Their primary facility is the Northwest Shelf Gas Plant, outside Karratha in Western Australia and is the largest resource project in Australia.

This position entailed managing a team to ensure delivery on the following issues:
- Staff compliment – 9 reports
- Corporate affairs advice
- Government and community relations
- Media and issues management
- Emergency response
- Government approvals
- Native Title and heritage
- Sustainability portfolio

Key achievements
- Member of the senior leadership team of 6 responsible for delivery of LNG cargoes as well as domestic gas to WA.
- Expansion of gas plant with no community issues raised.

May 2004 - Nov 2004:

Department of Industry and Resources, Perth
Heritage Manager

This position was created in order to provide advice to the Department, industry proponents and external stakeholders regarding heritage, Native Title and land access issues. Most of this work was undertaken on major projects and areas of my involvement included the Burrup Peninsula, Ord Stage II, ALCOA and Gorgon amongst others. This senior management position provided high-level advice to the Minister for State Development.

July 2002 - May 2004:

Department of Indigenous Affairs, Perth
Assistant Director, Heritage and Culture Branch
Registrar of Aboriginal Sites

The role as Assistant Director managed the Heritage and Culture Branch and the compliance arm of heritage legislation and attendant approvals system. A network of regional offices reported to this position. Strategic and operational policy was designed and implemented.

The Registrar is responsible for Aboriginal sites in Western Australia. High-level discussions and negotiations were undertaken with other State Agencies (usually at Director-level and upwards), industry representatives and Aboriginal organizations to facilitate responsible development. The Registrar provides the Minister for Indigenous Affairs with advice on development approvals.

February 2001 - July 2002:	Curtin University of Western Australia Consultant/Sessional Academic
March 1998 - Feb 2001:	KwaZulu-Natal Museum Service Media and Liaison Officer
1997 (3 months):	University of Colorado Denver Museum of Natural History Canyon Archaeological Centre Selected to participate USA government sponsored program of work.
April 1994 - March 1998:	Northern Province Heritage Service Archaeologist

QUALIFICATIONS

CURTIN UNIVERSITY OF TECHNOLOGY
Perth, Western Australia
Postgraduate courses completed at Curtin Business School:

- Marketing Theory 568
- Marketing Research 562
- Internet Marketing 567
- Applied Cases in Electronic Marketing 560
- Research Methodology 655

UNIVERSITY OF THE WITWATERSRAND
Johannesburg, South Africa
M.A.
2001 Masters Degree by research in archaeology
Thesis: “Early Venda History and the Mutokolwe Ruins near Tshiendeulu”

UNIVERSITY OF CAPE TOWN
Cape Town, South Africa
B.A. HONOURS
1991 - Graduated with Honours in maritime archaeology
Thesis: “Historic Shipwrecks; Issues in Management in a South African Context”

UNIVERSITY OF CAPE TOWN
Cape Town, South Africa
B.A.
1990 - Graduated with Bachelor of Arts, majoring in Archaeology

REFERENCES

References can be provided on request.

Curriculum Vitae for Ian Macleod

Place & Date of Birth:

Nationality:

Business Address: Heritage Conservation Solutions
2/258 Labouchere Road, Como, Western Australia 6152
Telephone: 61-419952706
e-mail: iandonaldmacleod@gmail.com

Research Address: Western Australian Maritime Museum
Peter Hughes Drive, Victoria Quay
Fremantle, Western Australia 6160
Telephone: 61-8 94318302 (messages)
e-mail: ian.macleod@museum.wa.gov.au

Education:

2007: Doctor of Science, University of Melbourne: Thesis title *Chemistry and Conservation of Shipwrecks and Rock Art*, March 2007.

1974: Doctor of Philosophy, University of Melbourne: The thesis *"Polarography in anhydrous hydrogen fluoride"* reported on the electrochemistry of the transition and p-block metal-fluorides dissolved in liquid anhydrous-hydrogen-fluoride. Supervisor was the late professor Tom O'Donnell.
1970: Bachelor of Science (Hons) - (H2A), **University of Melbourne**. The thesis "*Potentiometry in Anhydrous Hydrogen Fluoride"* reported a study of the electrochemical properties of tin fluorides dissolved in liquid anhydrous-hydrogen-fluoride.

1961 – 1966: Ballarat High School, Victoria

Awards and Fellowships

Fellow of the Society of Antiquaries of Scotland (FSA Scot, 1974)
Fellow of the Royal Australian Chemical Institute (FRACI 1986)
Chartered Chemist (C.Chem. 1986)
Fellow of the International Institute for the Conservation of Artistic and Historic Works (FIIC, 1987)
Fellow of the Australian Academy of Technological Sciences & Engineering (FTSE, 2000)
Fellow of the Royal Society of Chemistry (FRSC, 2013)

International Council of Museums Committee for Conservation Triennial Medal (2017)
Heritage Council of Western Australia Medal, Professional Category (2017)
Bathurst Macquarie Heritage Medal finalist (2017)
Life Professional Member of the Australian Institute for the Conservation of Cultural Materials (2015)
Life member of the Australasian Corrosion Association (2014)
Corrosion Medal, the Australasian Corrosion Association for service and public engagement (2004)
Centenary Medal for services to Metallurgy and Technological Sciences, Australian Government (2003)
Alton Batty Medal for applied chemistry, Royal Australian Chemical Institute (1999)

Employment History in Conservation Management

May 2016 - present: Principal *Heritage Conservation Solutions,* an independent corrosion and deterioration assessment consultancy group operating in the museum and community sectors. Specialities include problem solving in corrosion degradation and management of buildings and sites.

May 2011- May 2016
Executive Director, Fremantle Museums and Collections
The primary responsibility of this position was the integrated management and service delivery of museum programs in Fremantle, including engagement with many community groups in the region. The role coordinated the departments of Materials Conservation, Maritime Archaeology and Maritime History and front of house staff. During this period applied research included microbial corrosion, the conservation of historic shipwrecks and the application of *in-situ* treatment methodologies to site management strategies. The assessment of buildings for passive conservation management for large collections has been shown to be cost effective and sustainable. A new approach for the determination of intervention priorities for major collections has been developed.

June 2006 – May 2011 Executive Director, Collection Management and Conservation
The position involved the management, development and integration of the museum collections and conservation programs with the relocation of objects and staff within the metropolitan area. During this interval I effected the safe relocation of collections from five metropolitan storage sites to the central facility that I set up in suburban Welshpool. This rationalisation involved closing two museum sites and three storage locations. I project managed the valuation of the 12½ million objects in the WA Museum collections which were valued at $638 million. During this period my research focus was on corrosion phenomena on the Australian WWI submarine AE2 in the Sea of Marmara in Turkey and Japanese shipwrecks from WWII in Chuuk Lagoon in Micronesia.

July 2003 to June 2006
Director, Museum Relocation Project & Museum Services
I was responsible for the relocation of 85 staff, honorary associates, volunteers and 4½ million collection items from the WA Museum site in Perth site to the new Collections and Research Centre in Welshpool. The relocation was necessitated due to a unique combination of hazards from latent asbestos risk and major dangerous goods fire hazards associated with more than 130,000 litres of ethanol stored on site in the main museum building. The project consisted of the conversion of a 9,000 m^2 building into an integrated suite of laboratories and collection boxes which had a high-quality temperature and relative humidity controlled storage facility with dust removal to 1µm. This was a massive preventive conservation project covering the bulk of the WA Museum collections. As project manager I coordinated engineers, architects, space planners, curators, collection managers, staff, and the development of communication strategies for key players. The project involved regular briefings with the Minister and Director General of the Department for Culture and the Arts as well as the chair of the Board of Trustees. The project was completed on time and within the $11 million budget.

1978 – 2003
Various positions within the WA Museum Materials Conservation and general administration.

Research Background:

Applied Chemistry

During my PhD and post-doctoral fellowships I developed a range of techniques for solving complex problems which involved careful experimentation, fine motor coordination skills and ability to engage a wide variety of audiences with the nature of the applied research.

Cultural Materials Conservation

I have pursued an understanding of the mechanisms of decay of cultural materials with detailed analysis of the layers of degraded materials on objects recovered from terrestrial and marine environments. Part of this work has involved surface analysis of tool-marks; wear patterns and fabrication techniques, as well as provenance studies on the materials used in the manufacturing processes. I have achieved an international reputation for my *in-situ* corrosion studies on historic shipwrecks, with particular emphasis on iron shipwrecks. Through successful modelling of the electrochemical processes involved in corrosion of shipwreck materials I have developed models that predict the decay rate of the vessels. I pioneered the use of sacrificial anodes on iron artefacts as a method of *in-situ* conservation. Major achievements have incorporated sites such as the SS *Xantho* (1872) steam engine in Western Australia, the best bower anchor and a carronade from the HMS *Sirius* (1790) on Norfolk Island, a the composite wooden-iron wreck of the *Zanoni* (1867) in South Australia and cannon from the *Swan* (1653) in Scotland and both HMVS *Cerberus* (1926) and the *City of Launceston* (1865) in Victoria. A method of assessing the age of corroded cast iron cannon has been stablished using chloride diffusion data.

Successful identification of contemporary forgeries in silver coins recovered from the wreck of the Dutch *Batavia* (1629) and the American *Rapid* (1812) provided insights into corruption in the Spanish Netherlands in 1562 and in Mexico during 1796. Surface analysis of corroded silver coins on the Portuguese shipwreck of the *San Pedro de Alcantara* (1786) provided an energy map of the turbulent wreck site. Industrial practices of the 19th century have revealed the way in which ships' fastenings contributed to the ultimate loss of the vessels through decay mechanisms associated with premature structural failure due to inclusions. Analysis of the encrusting marine organisms has shown that bacteria convert phosphorus impurities in iron into a growth stimulant.

I developed the method for determining the dimensions of scantlings on historic iron shipwrecks from the combination of residual metal thickness and the long-term corrosion rate. I determined the impact of stresses during manufacture and shipwrecking processes on the corrosion rate of non-ferrous metals. The effect of chloride ion concentration on the corrosion rates of iron alloys has been characterised. Detailed analysis of corrosion data from 70-year old wrecks in Chuuk Lagoon in the Federated States of Micronesia has enabled prediction of when they will collapse. Collaborative work with marine biologists has established the first evidence of biodynamic interaction of marine organisms with wrecked ships and aircraft and how marine organisms affect the deterioration of wrecks.

Through applied micrometeorology it was demonstrated that the active decay of historic prisoner-painted surfaces was due to hard render on the exterior of the World Heritage listed former convict-built Fremantle Prison. This study prompted the Heritage Council of WA to order removal of the 100 year old render which has now stabilised the site. Chloride mapping at St Georges Anglican cathedral in Perth demonstrated that salt movement was the primary cause of degradation of brick and stonework. Wide scale application of papier-mâché poultices enabled the bulk of the salts to be removed and to retain the original materials, which was the first time the process had been carried out on an industrial scale in Australia.

My work on the Australian WWI submarine HMAS AE2 in the Sea of Marmara, Turkey has resulted in the application of ten tonnes of zinc sacrificial anodes to conserve this historic vessel on the seabed at a depth of 73 metres. Data collected from in-situ corrosion measurements has shown the pH profiles found adjacent to the submarine and at a distance of 25 metres are replicated in microenvironments inside the complex submarine. I have developed a method to determine when in-situ conservation of marine iron objects has reached effective completion without the need for excavation activities.

I have developed the method for migrating formalin-preserved natural science specimens from 70% ethanol to 65% aqueous glycerol which has been applied to the WA Museum's iconic Megamouth III, a

5.2 metre The treatment program was conducted inside a public gallery at the WA Maritime Museum and has resulted in a stabilised shark that has lost a lot of its shrinkage caused by 13 years of alcohol induced desiccation. The method is now being used by the Natural History Museum in London on a large great white shark.

Working with the Benedictine community at New Norcia, Australia's only monastic township, I developed a significance and conservation ranking which enables calculation of which objects are the most important to treat. This work has been successfully extended to the management of iron shipwrecks in Port Phillip Bay and Bass Strait. I also developed a method of removing tarnish from metallic threads in a 17th century cope by using neutral buffered solutions of dithionite and immersion of the textiles.

Conservation of Aboriginal Rock Art

Thirty-five years ago, my introduction to Aboriginal rock art in the Wheatbelt of Western Australia began. The task was to assess the impact of previous interventions involving installation of drip lines and graffiti removal to control degradation of sites. Through connections at Murdoch University I established the methodology of applying the principles of micrometeorology to model the decay rates of engraved and painted surfaces. This work lead to a series of successful grant applications to fund basic research into the physical microenvironment of the sites to see how the chemical and microbiological activity interact to control the rates of physical and biological degradation. Micro-environmental modelling correctly replicated the temperature profiles of rock art sites in the West Kimberley and Murchison regions of Western Australia. This work enables estimation of the annual climate of the sites without the need for repeated visitation.

The complexities of the decay patterns on the Kimberley Wandjina paintings were shown to be due to acid dissolution of the intensely white pigment huntite, $Mg_3Ca(CO_3)_4$ into pseudomorphic whewellite $CaC_2O_4.H_2O$, which preserved the form of the totemic images. Acidic solutions from rainfall events in the absence of oxalate ions dissolve the images. Microenvironment and mineralogy studies at *Walga Rock* has revealed a series of complex dissolution and re-precipitation reactions whereby water born ions derived from aged avian guano results in the preservation of calcitic and kaolinitic pigments on the images. Research in the Burrup peninsula established the direct relationship between acidity of the rocks and the number of bacteria, yeasts and moulds growing on their surface and the impact of nitrates on the overall microbiological activity. I introduced using pH measurements to assess the local environment and now have extended the work to include E_h data collected directly from the rock surfaces. I have established the connection between industrial emissions and apparent acceleration of the decay rate of petroglyphs.

I was the deputy ex-officio WA Museum member on the Aboriginal Cultural Materials Committee of the Department of Aboriginal Affairs for eight years. This committee met monthly and advised the Minister on the impact of proposed mining and development applications on Aboriginal sites with recommendations on which sites should be preserved and which can be destroyed.

Professional Activities

I have been a member of the Royal Australian Chemical Institute since 1970 and was the Media Liaison Officer for the WA Branch in 1984 and a Fellow since 1986. I have been a member of the Australasian Corrosion Association (ACA) for 40 years and was on the Editorial Board of their journal *Corrosion and Materials* for five years and am the present Editor. The ACA recognised my contribution to corrosion science through the invitation to present the *P.F. Thomson Memorial Lecture* at the ACA Bicentennial Conference in Perth in 1988, in Adelaide for 2002 and in Perth 2011 for the 18th International Corrosion Congress of which I was the chair. I was awarded their ***Corrosion Medal*** in 2004 for services to the Association and to public education. In 2005 I was a plenary lecturer at the

Golden Jubilee conference of the ACA and opened the Trade Fair. I have given numerous seminars for the association over the last 38 years. I was elected to Life Membership of the ACA in 2014. I was Federal Treasurer of the Australian Institute for the Conservation of Cultural Material (AICCM) from 1980- 89 and Western Australian Branch President in 1979, 1988-1992 and again in 2006 and was a member of the Professional Accreditation Committee for ten years. I am a Professional Conservator life member of the AICCM.

I was a member of the Conservation and Collections Management Working Party of the Heritage Collections Council of the Commonwealth of Australia for five years. In September 1999 I was elected to the Directory Board of the Conservation Committee of the International Council of Museums and completed my second term in 2005, having brought about fundamental changes in the by-laws that facilitated universal access to the election processes for the Directory Board of ICOM-CC. November 2000 saw my election as a Fellow of the Australian Academy of Technological Sciences and Engineering and I was invited by the IIC to be a member of the editorial board of new international journal *Reviews in Conservation*.

I give regular media interviews and lectures to service organisations and community groups and run public workshops in Preventive and Metals Conservation for Edith Cowan University's *Certificate in Museum Studies*. From 1998-2004 a series of keynote addresses were presented at the Murdoch University Science Summer School for year 10 & 11 high school students. I was appointed to the Editorial board of *Conservation and Management of Archaeological Sites*. In 2007 I was a guest lecturer for the Murdoch University STAR program and gave a RioTinto sponsored talk on *Conservation Chemistry Science* to year 10-11 high school students in Northam, Tom Price, Carnarvon and Bunbury and reached more than 1200 students in one week. In 2009 the Murdoch University Science Summer School appointed me as plenary lecturer for their science communication program for year 10 and 11 students. On average I delivered 45 public talks a year at community groups or at conferences and workshops during my five-year term as Executive Director of the Fremantle Museums. In 2017 I was awarded the medal for Professional Practice by the WA Heritage Council and the ICOM-Committee for Conservation Silver medal for services to materials conservation.

Research Grants

The Lotteries Commission grant was given to the Swan Bells Foundation of which I am the chair.
I was a principal investigator under Peter Veth for the ARC Historic Shipwrecks Preservation Project
The Synchrotron analysis of the de Vlamingh was a joint project with the National Gallery of Victoria (David Thurrowgood). The present study on the Hartog plate is a joint venture between the Rijksmuseum (Amsterdam), the Queen Victoria Museum in Launceston and the Western Australian Museum.

For all other grants, I was the applicant and awardee.

Year	Source	Value	Title
2017	Synchrotron	$35,000	*XFM Study of the Hartog Plate*
2015	Lotteries Commission (WA)	$300,000	ANZAC 100th Anniversary memorial bell
2013	Synchrotron	$35,000	*XFM Study of the de Vlamingh Plate*
2011	ARC Linkage	$180,000 cash $521,000 in kind	*Australian Historic Shipwreck Preservation Project: Clarence (1850)*
1994	British Council	$2,600	*In-situ corrosion studies on a Cromwellian warship in Scotland*
1994	AIATSIS	$10,856	*Microclimate modelling of rock art sites in the Kimberley Region of WA.*
1991	WA Heritage Council	$24,000	*Microclimate studies and site management strategies II*
1990	AIATSIS	$10,000	*Microclimate studies - effects of animal excreta on rock art.*
1990	National Estate Program	$72,000	*Microclimate studies and development of site management programmes for conservation of rock art in West Kimberley Region of Western Australia.*
1988	ARC	$18,000	*Conservation of wood-iron composite materials and pewter.*
1987	AIATSIS	$11,150	*Conservation of rock art at McKay Caves*
1987	AIATSIS	$6,750	*Conservation of rock art at Walga Rock*
1985	ARC	$35,500	*Conservation and degradation of pewter and wood-iron composite materials recovered from historic shipwrecks'*

Career Highlights

2017 Awarded Professional Contribution medal by the WA Heritage Council. Work on the conservation of the fire ravaged Yarloop Railway Workshop museum. Work with *Nutopia Films* on bacterial corrosion of iron shipwrecks in Chuuk Lagoon, Federated States of Micronesia. Recording pH and E_h of Burrup rock art. Microenvironment analysis at an early bronze age mound at the Japanese Centre for Anatolian Archaeology at Kaman, Turkey. Awarded ICOM-CC Triennial medal at the XVIII Conference, Copenhagen.

2016 Developed and co-presented a 5-day metals in textile conservation workshop for the Queen Sirikit Textile Museum in Bangkok and quantified the impact of high temperatures and humidity on biodeterioration of textiles. I co-presented an AICCM Textile Working Group workshop in Sydney on treatment of composite metal and textile objects. Coordinated fund-raising for $485,000 for a 6.5 tonne ANZAC Memorial bell for the Swan Bell Tower to commemorate the 100th anniversary of the ill-fated campaign. Solved accelerated corrosion of jetty piles at a yacht club as *Heritage Conservation Solutions*.

2015 Presented plenary lecture on in-situ conservation of the AE2 submarine in Istanbul and participated in the 100th anniversary ceremonies over the wreck site on board HMAS Anzac. Conducted field work and presented a course in application of micro-climate studies on the mineralogy and microbial activity on rock art sites in Mexico City. Elected to Honorary Professional Life Membership of the AICCM. Part time Ph. D. supervision of Susie Collis at the Grimwade conservation centre. Presented summary of in-situ conservation assessment and treatment of HMAS AE2 with sacrificial anodes at the concluding international workshop at the Maritime Museum in Istanbul in April. I also presented the Stanhope Oration at the annual national conference of the science teachers and school laboratory technicians association. Appointed community reference member for the University of WA Cultural Collections Board.

2014 Presented closing plenary lecture at the International Council of Museums' Committee for Conservation Triennial conference, Melbourne on *Innovative Australian conservators preserve heritage* and delivered three papers on aspects of applied conservation research. Elected to Life Membership of the Australasian Corrosion Association. Appointed as corrosion advisor to the USS Lexington (WWII) aircraft carrier search team. Presented a plenary lecture at a corrosion conference in Washington DC on historic aluminium artefacts. Featured in ABC TV *Catalyst* on AE2 submarine in the Sea of Marmara, Turkey.

2013 Awarded a Synchrotron grant with David Thurrowgood of the National Gallery of Victoria for access to the X-Ray Fluorescence Microscopy beam line for studying the de Vlamingh plate (1697). I presented the RACI-WA Division Bayliss Youth lecture titled *Chemists and Heritage Conservation* to Year 10-12 High School students in Western Australia and the Northern Territory. I was awarded a Fellowship of the Royal Society of Chemistry. I conducted a corrosion survey on the wreck of HMCS *Protector,* Heron Island, in the Great Barrier Reef. I took on co-supervision of Ph D candidate Maria Jacobsen, University of Haifa regarding the archaeology of the H. L. Hunley (1864) submarine site. Identified a 19th century high quality steel hand axe on ABC TV show *Somebody has been sleeping in my house*. I was appointed by Minister of Science and Innovation to a three member panel to review the operations of the Chemistry Centre of WA and our report has been presented to the Premier of WA.

2012 Appointed Editor of *Corrosion and Materials*, the journal of the Australasian Corrosion Association. I became a member of the management advisory committee for the Royal Australian Air Force Association Aviation Memorial Museum in Perth. Engagement with the *Clarence* (1850) site management and excavation - reburial team off St Leonard's, Port Phillip Bay under the auspices of the ARC Cooperative Research Centre on Historic Shipwrecks. Conducted a webinar on stainless steel corrosion in Beijing and a web based

tutorial for American high school students on redox and corrosion chemistry and a web enabled lecture on the conservation of the RMS Titanic at the Royal Institution in Adelaide. Delivered a one-week metals intensive training program to Masters' students that the University of Melbourne's Centre Cultural Materials Conservation program.

2011 Principal investigator in ARC Linkage Grant on "In-situ preservation of the *Clarence* (1850) shipwreck in Port Phillip Bay Victoria". Undertook the office of Past President of Australasian Corrosion Association and was Conference chair for the 18th International Corrosion Congress in Perth. Four months at the Getty Conservation Institute in Los Angeles studying the corrosion and conservation of shipwreck artefacts. Presented papers at the ICOM-CC conference in Lisbon on the glycerol treatment of sharks to replace ethanol and on the corrosion of wrecks in Lake Huron, Canada. I undertook a Significance assessment of the ecclesiastical textile collection at the Benedictine community at New Norcia, Western Australia which led to the modelling of treatment prioritisation matrices to assist in the effective management of their collection.

2010 Elected President of the Australasian Corrosion Association. Pre-prints committee member for ICOM-CC in Lisbon. Presented work on the Australian submarine AE2 (1915) at the Metal 2010 conference and conducted practical workshops at the Clemson University Conservation Centre in North Charleston. I also presented a paper on the corrosion of iron shipwrecks in Chuuk Lagoon to the NOAA international conference on WWII ocean risks from leaking oil, Newport News, Virginia in October. An *in-situ* corrosion survey of HMVS *Cerberus* showed its back is broken and that the *City of Launceston* is being conserved with anodes.

2009 Elected President of the WA Division of the Australasian Corrosion Association and national Vice President. Expert witness in Darlinghurst Supreme Court at the retrial of Phuong Ngo, for the murder of John Newman, MP. Program coordinator for AICCM National Conference in Fremantle, "Conservation of Public and Private Collections", Presented with award for Outstanding Contribution to Research in Materials Conservation by AICCM. Chair of symposium in Belgium on the conservation options for the historic former Antarctic research vessel the *Belgica*, lying wrecked in Norway.

2008 Appeared in the documentary *Gallipoli Submarine* with experimental work in Turkey and Australia. Provided commentary on the 4 Corners (ABC TV) program regarding the alleged murder weapon used in the assassination of John Newman MP in New South Wales. Appeared on French TV3 documentary *Phantoms de Chuuk* set in Federated States of Micronesia. External examiner for the University of Stockholm, on the chemistry of sulphur compounds in the Vasa (1628) shipwreck. I presented a plenary lecture on the application of long-term corrosion data to containment of nuclear wastes at the Gordon Corrosion Conference, New Hampshire. I taught a one-week metals conservation intensive at the Centre for Cultural Materials Conservation, University of Melbourne.

2007 Appointed Chair of the Swan Bells Foundation, member of the Fulbright Fundraising Committee for Western Australia which raised its $1 million target in less than a year. Trained divers in conducting corrosion measurements on WWI submarine J5 off Port Phillip Heads. Undertook field measurements in Turkey on the AE2 submarine. Present Rio Tinto sponsored talks to high school students in regional and remote centres. Appointed to the USS Monitor (1862) International Conservation Advisory Panel and made a member of the ICOM-CC preprints team for New Delhi. Data collected on Japanese shipwrecks and aeroplanes in Chuuk Lagoon established new decay mechanisms, leading to improved heritage management outcomes.

2006 Appointed to the Editorial board of journal *Conservation and Management of Archaeological Sites*. Appointed corrosion advisor to the Submarine Institute of Australia for the AE2 Marine Archaeological Assessment in Turkey. Determined that the *City of Launceston* could be opened for controlled diving access. Taught a one week course in Metals Conservation for the

University of Melbourne Masters in Conservation program. I presented lectures and workshops for Old Dominion University in Norfolk, Virginia as part of the Distinguished Visiting Speaker program. Supervised and managed the move of two collection stores to the central museum facility in Welshpool.

2005 In-situ corrosion studies on HMVS *Cerberus* demonstrated a 25% increase in corrosion rate and the *City of Launceston* returned to its stable rate after experiencing increased decay due to archaeological intervention. I presented a five-day conservation of outdoor sculptures and monuments in Hong Kong workshop with Colin Pearson. Presented the first intensive on Metals Conservation at the University of Melbourne. Motivational speaker for emerging corrosion scientists at the 50th Anniversary conference of the ACA in Brisbane. Reviewed the conservation treatment of the turret, engine and condenser recovered from the USS *Monitor* (1862) at The Mariners Museum, Newport News, USA.

2004 Awarded the ***Corrosion Medal*** of the Australasian Corrosion Association for services to the profession and for services to public education and community awareness. Project managed the relocation of the WA Museum staff and collections from the asbestos contaminated 1970's building in Perth to a collections and research facility 9.5 km away in Welshpool. Work involved extensive engagement and planning with architects, HVAC and fire engineers with security advisors and collection management staff. Fortnightly reporting to the Director General, Department of Culture and the Arts, the chair of the Board of the Trustees of the museum and the Minister assisted in bringing the project in on time and within the $11 million budget.

2003 Received a **Centenary Medal** from the Prime Minister for ***"For service to Australian Society in metallurgical science and engineering***". Appointed to the Board of the Swan Bells Foundation by the Minister for Culture and the Arts. Presentations at ICCROM in Rome, at the Technological Educational Institution and at the IIC Hellenic Group in Athens. Presented a one-week intensive in the interpretation of corrosion processes on archaeological metals at the Institute for Conservation de Netherlands in Amsterdam. Inspection of corrosion processes on the wreck of the former HMAS Perth in Albany. The quantification of the impact of nitrate and sulphate ions on the acidification of rock surfaces in the Burrup peninsula. A new corrosion mechanism for turbulent wreck sites was developed from data collected on corroded silver coins from an 18th century Portuguese shipwreck.

2002 Elected to the Directory Board of the International Council of Museums – Conservation Committee in the Rio de Janeiro for a second term. Appointed to the Ministerial Burrup Rock Art Management Committee. Determined the impact of *in-situ* conservation techniques on the *James Matthews* wreck. Plenary lecturer at the International Congress on the Conservation and Restoration for Archaeological Objects in Nara, Japan. Initiated the first corrosion study of WWII Japanese wrecks in Chuuk Lagoon, Federated States of Micronesia.

2001 Expert corrosion witness during a murder trial in the Supreme Court of NSW regarding the immersion period of a Beretta pistol. Provided expert witness on iron corrosion in the Perth Magistrates court. Presented a four-week course on in-situ shipwreck conservation and micro-environmental analysis at Evtek Institute of Art & Design, Finland. Prepared the guided missile destroyer HMAS Perth for corrosion monitoring over the next 100 years.

2000: Elected Fellow of the Australian Academy of Technological and Engineering Sciences (FTSE) and became a member of the Editorial Board of *Reviews in Conservation*. Delivered a speech at the opening of the 600 year-old *Bremen Cog* in Bremerhaven, Germany. Managed the handover of a conserved WWII PBY-5A Catalina at Hawkins, Texas. Published a review of rock art conservation in the inaugural issue of *Reviews in Conservation.*

1999: Elected to the Directory Board of ICOM-CC and Assistant Coordinator, Metals Working Group. Appointed a board member of the Australian American Catalina Memorial Foundation and coordinated the conservation of a WWII PBY5A Catalina in Hawkins, East Texas, USA. Conducted *in-situ* corrosion studies on silver coins from the 18th century wreck the *San Pedro*

del Alcantara in the Atlantic Ocean in Portugal. Presented at the planning seminar for the recovery of the confederate submarine *HL Hunley* (1864), Charleston, South Carolina, USA.

1998 Presented at the *Metal '98* conference in France and conducted *in-situ* studies on cannon and anchors on the wreck of the *Swan*, Duart Point, Scotland. Reviewed corrosion management strategies through *in-situ* measurements on the *City of Launceston* and HMVS *Cerberus* in Port Phillip Bay. Assessed the condition of a WWII Catalina undergoing restoration in Texas.

1997 Awarded Public Sector Management Office Scholarship for *Skills for an Effective Manager*, School of Management, Curtin University and obtained a Distinction. Conducted contracted *in-situ* corrosion studies on iron and composite wood-iron wrecks in Gulf St Vincent and Spencer Gulf in South Australia and on the *City of Launceston* in Victoria. Expert witness at an International Arbitration Court in Kuala Lumpur for the Malaysian Government regarding the conservation of materials from the wreck of the *Diana* (1817).

1996 Delivered applied research papers at the International Institute for Conservation conference in Copenhagen, the ICOM-CC meeting in Edinburgh and at the ICOM-CC Waterlogged Archaeological Organic Materials Conference in York. I delivered a lead paper at the 13th International Corrosion Congress in Melbourne on the corrosion of the wreck of HMVS *Cerberus* (1926). Performed corrosion measurements on the *Clan Ranald* (1909) wreck and the *Willyama* (1907) in Investigator Strait, South Australia.

1995 Performed an in-situ corrosion survey of a series of historic iron shipwrecks in Investigator Strait, South Australia discovering systematic differences in the rate of corrosion, which were dependent on alloy composition. Provided conservation advice on the corrosion of bronzes in the National Museum of Cambodia in Phnom Penh with a UNESCO-ICCROM team of heritage consultants.

1994 Awarded an AIATSIS grant for *Microclimate modelling of rock art sites in the Kimberley Region of WA* and a British Council travel grant to perform in-situ corrosion studies on the wreck of the *Swan,* a Cromwellian frigate that sank off the Isle of Mull in 1653. Completed the treatment of a carronade from HMS *Sirius* (1790) on Norfolk Island. Performed a corrosion survey of the wreck of HMVS *Cerberus* in Port Phillip Bay and established the method of determining the original thicknesses of metal structures.

1993 Awarded a Senior Fulbright Fellowship for study at the Smithsonian Institution and participation in conferences in the United States of America and assessed the wreck of the *USS Arizona* in Pearl Harbour, Hawaii. In Lake Huron I conducted *in-situ* corrosion studies in the Fathom Five National Park at Tobermory. This established the corrosion mechanisms of historic iron-fastened wooden wrecks in cold, fresh water. Elected coordinator of the ICOM-CC Metals Working Group and presented papers at the Waterlogged Archaeological Organic Materials conference in Portland, Maine. Consultant on the conservation of materials just recovered from the wreck of the RMS *Titanic*.

1992 Established the methodology for *in-situ* corrosion studies of wrecked barges and paddle steamers in zero-visibility conditions of the River Murray in South Australia. The results of rock art research in the Kimberley region of WA were presented at the Second International Rock Art Conference in Cairns, Queensland. Established model for prediction of desalination rates for corroded iron cannon and how the shipwreck can be dated from the chloride extraction kinetics.

1991 Awarded a Western Australian Heritage Council grant for *Microclimate studies and site management strategies II* for wet season rock art conservation research in the West Kimberley Region. Data from shipwrecks in Port Philip Bay established the applicability of corrosion measurements to the management of iron shipwrecks in cool seawater**.** I presented a paper on corrosion and conservation of ships' fastenings at the Getty Museum conference on Ancient and Historic Metals in Los Angeles, USA.

1990 Awarded an AIATSIS grant for *Microclimate studies - effects of animal excreta on rock art.* Presentations to conservators in London, York and at the ICOM-CC conferences in Bremerhaven and Dresden. I was elected coordinator of the ICOM-CC Metals Working Group

and chaired the UNESCO–UNDP of ASEAN Heads of Conservation meeting in Bangkok. Awarded Honorary Life Membership of the Australian Institute for the Conservation of Cultural Materials.

1989 Conducted a series of museum assessments and conservation workshops during a four-week UNESCO-UNDP Consultancy while based at the National Museum of the Philippines in metro-Manilla. Interviewed for the ABC Radio Science Show regarding iron corrosion, phosphorus impurities and their effects on concretion formation. I participated in the ABC TV and Science Bookshop interviews on conservation of underwater archaeological sites.

1988 Presentation plenary at the 3rd Australasian Archaeometry Conference, Adelaide on the Archaeometallurgy of 19th century shipwreck fastenings. Delivered the P.F. Thomson Memorial Lecture on *'Marine corrosion on historic shipwrecks and its application to modern materials*' and the paper *"Conservation of corroded concreted iron"* at the Australasian Corrosion Association Bicentennial Conference in Perth, Western Australia.

1987 Elected fellow of the International Institute for the Conservation of Historic and Artistic Works (FIIC). Organised the first combined meeting of the ICOM-CC metals and waterlogged organic archaeological materials working groups in Fremantle. Presented papers on rock art, metals conservation and desalination of ceramics at the ICOM-CC Triennial Conservation Conference, Sydney and at the ICOMOS Built in Wood Conference, in Brisbane. I was awarded an ARGS continuation grant for research into pewter and composite object conservation. Awarded Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) grant for conservation work on rock art at MacKay Caves and for conservation studies of the rock art at Walga Rock. Awarded a National Estate Program grant for a four-year program on *Microclimate studies and development of site management programs* for conservation of rock art in West Kimberley Region of Western Australia.

1986 Elected fellow of the Royal Australian Chemical Institute (FRACI). I presented on the ABC Science program *Quantum* on the use of oxygen isotope ratios in barnacles to determination of the seawater temperatures and to track the voyage of a ship in 1811. Chemical analysis of wines provided an insight into the American China trade before the 1812 war with Canada.

1985 Awarded a three-year Australian Research Grants Scheme (ARGS) grant to study the *Conservation and degradation of pewter and wood-iron composite materials recovered from historic shipwrecks.*

1984 Bayliss Youth Lecturer, Royal Australian Chemical Institute (WA Branch) which involved presenting the address "*Conservation Chemistry"* around Western Australia to year 10 & 11 high school chemistry students. Attended the ACA Conference at Rotorua, New Zealand and presented on the effects of concretion on the corrosion of non-ferrous metals. Conducted a feasibility study on relocation of the vessel *Edwin Fox* to Western Australia.

1980 Joint award with Neil North for the Best Research Paper at Conference 19 - Australasian Corrosion Association, Perth 1979 for the paper entitled *"350 years of marine corrosion in Western Australia*.

Materials Conservation Papers

MacLeod, I.D. & North, N.A. (1979) "Conservation of corroded silver", *Studies in Conservation.* 24:165-170.

MacLeod, I.D. & North, N.A. (1980), "350 years of marine corrosion in Western Australia", *Corrosion Australasia.* 5:11-15.

MacLeod, I.D. & Ritchie, I.M. (1981) "The detection of debasement in (forged) silver coins by means of corrosion potential measurements", *Archaeometry.* 23: 65-70.

MacLeod, I.D., (1981) "Shipwrecks and applied electrochemistry", *J. Electroanalytical and Interfacial Electrochemistry,* 118: 291-303.

MacLeod, I.D. (1981) "Bronze disease - an electrochemical explanation", *ICCM Bulletin* VII (1): 16-26.

MacLeod, I.D. & North, N.A. (1982) "Conservation of a composite cannon –*Batavia* (1629)", *International J. Nautical Archaeology* 11(3): 213-219.

MacLeod, I.D. & Killingley, J.S. (1982) "The use of barnacles to establish past temperatures on historic shipwrecks", *International J. Nautical Archaeology* 11(3): 249-252.

MacLeod, I.D. (1982) "The formation of marine concretions on copper and its alloys" International *J. Nautical Archaeology* 11(4): 267-275.

MacLeod, I.D. (1982) "Environmental effects on shipwreck material from analysis of marine concretions", Archaeometry*: an Australasian Perspective (ANU Press)* Eds. W. Ambrose & P. Duerden. 361-367.

MacLeod, I.D. (1982) "A study of some forged silver coins recovered from 17th C and 19th C shipwrecks" *Chemistry in Australia* 49: 317-320.

Henderson, G.J., Lyon, D. & MacLeod, I.D. (1983) "HMS "Pandora" Lost and Found", Archaeology 36: 28-35.

MacLeod, I.D. (1983) "Stabilization of corroded aluminium", *Studies in Conservation.* 28: 1-7.

MacLeod, I.D. (1983) - "Report on the crystals found on metal fragments and on bamboo from the Pattaya wreck site" in "The excavation of the Pattaya wreck site and survey of three other sites in Thailand 1982". J. Green and R. Harper, *Australian Institute Maritime Archaeology Special Pub*. No 1, pp 80-82.

MacLeod, I.D. (1983) "A microphotographic review of corrosion phenomena from a shipwreck". *AICCM Bulletin.* 9(2): 92-96.

Mills Reid, N.K., MacLeod, I.D. & Sander N. (1984) "Conservation of waterlogged organic materials: comments on the analysis of polyethyleneglycol and the treatment of leather and rope" *Preprints of 1984 ICOM Committee for Conservation Meeting* (Copenhagen) 84.7.l6-20.

MacLeod, I.D. (1984) "A genuine sixteenth century forged coin". *Australian Institute Maritime Archaeology Bulletin.* 8(2): 1-9.

MacLeod, I.D. (1984) "Conservation, applied science and why treatments must be monitored", *AICCM Bulletin.* 10(2): 19-41.

MacLeod, I.D. (1985) "The effects of concretion on the corrosion of non-ferrous metals". *Corrosion Australasia* 10(4): 10-13.

MacLeod, I.D. (1985) "Shipwreck conservation chemistry" in *Chemistry Resource Book*, p 113-131, R.A.C.I., Ed. C.L. Fogliani.

MacLeod, I.D. (1985) "Copper corrosion in the "real world"" in *Chemistry Resource Book*, p 1-4, R.A.C.I., Ed. C.L. Fogliani.

Taylor, R.J. & MacLeod, I.D. (1985) “Corrosion of bronzes on shipwrecks: a comparison of corrosion rates deduced from shipwreck material and from electrochemical methods”, *Corrosion* 41: 100-104

MacLeod, I.D., North, N.A. & Beegle, C.J. (1986) “The excavation, analysis and conservation of shipwreck sites” In, *Preventative measures during excavation and site protection*. ICCROM, Rome p. 113-132

MacLeod, I.D. (1986) “Conservation of the steam ship "Xantho"” *ICCM Bulletin,* 12(3&4): 66-94.

MacLeod, I.D. & Pitrun, M. (1986) “The effects of microstructure on long-term corrosion”. *Australasian Corrosion Association, Proceedings Conference 26,* Adelaide 1986 Vol II - Symposium 11, Lead paper

MacLeod, I.D. (1987) “Secondhand metal - conservation and industrial archaeology of shipwreck artefacts”. In *Archaeometry - Further Australasian Studies. (ANU Press).* Eds. W.R. Ambrose and J.M.J. Mummery, p 280-291.
Mills Reid, N.K. & MacLeod, I.D. (1987) “The use of aqueous glycerol solutions in the conservation of waterlogged archaeological organic materials” In *Archaeometry - Further Australasian Studies. (ANU Press).* Eds. W.R. Ambrose and J.M.J. Mummery, p 292-302.

MacLeod, I.D. (1987) “Conservation of corroded iron artefacts -new methods for on-site preservation and cryogenic deconcreting”, *International J. Nautical Archaeology* 16(1): 49-56.

MacLeod, I.D. (1987) “Stabilization of corroded copper alloys: a study of corrosion and desalination mechanisms” *ICOM Committee for Conservation*, Sydney, September 1987, p 1079-1085.

MacLeod, I.D. (1987) “Conservation of corroded copper alloys: a comparison of new and traditional methods for removing chloride ions” *Studies in Conservation.* 32:25-40.

MacLeod, I.D. & Davies, J.A. (1987) “Desalination of glass, stone and ceramics recovered from shipwreck sites”. *ICOM Committee for Conservation*, Sydney, September 1987, p 1003-1007.

MacLeod, I.D. (1987) “Conservation of waterlogged wood”. *Preprints ICOMOS Built in Wood Conference,* Brisbane, April 198, p 111-125.

Haydock, P. & MacLeod, I.D. (1987) “The use of micro-meteorological studies as an aid to the conservation of aboriginal rock art”. *ICOM Committee for Conservation*, Sydney, September 1987, p 1149-1153.

MacLeod, I.D. & North, N.A. (1987) "Corrosion of metals", Chapter 4, in *Conservation of marine archaeological objects*. Ed. Pearson, C., Butterworths (London). pp 68-98.

MacLeod, I.D., (1987), Book review, The Corrosion and Conservation of Metallic Antiquities and Works of Art, by Todor Stambolov, *Studies in Conservation,* 32 pp 138-139.

MacLeod, I.D. (1988) “Conservation of corroded metals with special reference to iron and steamships” in M. McCarthy (ed.) *Iron ships and steam shipwrecks*, Western Australian Museum, Perth p 93-102.

MacLeod, I.D. (1988) - "On-site conservation during the SS *Xantho* excavation - with special reference to the *Xantho* engine", M. McCarthy (ed.) *Iron ships and steam shipwrecks* p 91-92.

MacLeod, I.D. & Pitrun, M. (1988) - "Metallography of copper and its alloys recovered from nineteenth century shipwrecks", in. *Archaeometry: Australasian Studies 1988,* Ed. J.R. Prescott, University of Adelaide, Adelaide. pp 121-130.

MacLeod, I.D. (1988) "Conservation of corroded concreted iron". *Proceedings of Conference 28, Australasian Corrosion Association*, Perth, Vol.1. 2-6:1-9.

Stanbury, M. & MacLeod, I.D. (1988) "Colonies, convicts and filtering stones: roads to solutions", *Bulletin Australian Institute Maritime Archaeology.* 12(2):1-10.

MacLeod, I.D. (1989) “Marine corrosion on historic shipwrecks and its application to modern materials” *Corrosion Australasia.* 14(3):8-14.

MacLeod, I.D. (1989) - "Conservation of Wet Wood and Metal", Proceedings of the ICOM Conservation Working Groups on Wet Organic Archaeological Materials and Metals. Fremantle 1987. Compiled and edited by I.D. MacLeod, International Wood Study edited by D.W. Grattan. pp 304. Western Australian Museum.

MacLeod, I.D., Fraser, F.M. & Richards, V.L. (1989) "The PEG water solvent system: effects of composition on extraction of chloride and iron from wood and concretion", Ibid. p 245-257.

MacLeod, I.D. (1989), "Hygroscopicity of archaeological timber: effects of impregnant and degree of degradation", Ibid. p 211-214.

MacLeod, I.D. and Gilroy D.R. (1989) "Colour measurement of treated and air-dried wood", Ibid. p 203-210.

MacLeod, I.D. (1989) "Electrochemistry and conservation of iron in sea water ", *Chemistry in Australia,* 56(7). pp 227-229.

MacLeod, I.D. (1989) "The application of corrosion science to the management of maritime archaeological sites", *Bulletin Australian Institute Maritime Archaeology*. 13(2) p 7-16.

MacLeod, I.D. (1990) "The conservation laboratory of the National Museum, Philippines", *Technical Report Series. No. FMR/CC/CH/90/201 (UNDP) UNESCO, Paris.* pp 1-50.

MacLeod, I.D. and Pennec, S. (1990) "The effects of composition and microstructure on the corrosivity of copper alloys in chloride media" *ICOM Committee for Conservation, 1990 Preprints 9th Triennial Meeting, Dresden. Vol II.* pp 732-739.

MacLeod, I.D. (1990) "Conservation management of iron shipwrecks: SS *Xantho* (1872)", *Preprints 5th National Conference on Engineering Heritage*, Perth, December 1990, pp 75-80

MacLeod, I.D. (1990) "Conservation of waterlogged timbers from the *Batavia* (1629)", *Bulletin Australian Institute Maritime Archaeology.* 14(2), p 1-8

MacLeod, I.D. (1991) "Microclimate modelling in old museum buildings". *Historic Environment-Conservation in Context: Artefact and Place,* 8(1&2), p 37-41

MacLeod, I.D. & Kenna, C. (1991) "Degradation of archaeological timbers by pyrite: oxidation of iron and sulphur species" *Proceedings of the 4th ICOM Group on Wet Organic Archaeological Materials Conference, Bremerhaven 1990.* p. 133-142.

MacLeod, I.D., Brooke, P. & Richards, V.L. (1991) "Iron corrosion products and their interactions with waterlogged wood and PEG" *Proceedings of the 4th ICOM Group on Wet Organic Archaeological Materials Conference, Bremerhaven, 1990.* Ed. Per Hoffmann. pp 119-132.

MacLeod, I.D. (1991) "Identification of corrosion products on non-ferrous metal artefacts recovered from shipwrecks". *Studies in Conservation.* 36(4), pp 222-234

MacLeod, I.D., (1992) "Conservation management of Iron Steamships- The SS *Xantho* (1872). *Multi-Disciplinary Engineering Transactions* GE no 1, 45-51.

MacLeod, I.D., (1992), "Current approaches to the Underwater Cultural Heritage- Strengths and Weaknesses. Materials Conservation Management" *Historic Environment* 9(3), pp 11-16.

Carpenter, J & MacLeod, I.D.,(1993), "Conservation of corroded iron cannon and the influence of degradation on treatment times" *ICOM-Committee for Conservation, Preprints 10th Triennial Conference, Washington*, Volume II pp 759-766.

MacLeod, I.D., (1993), Chapter 6. "Conservation Assessment" in *Historic Shipping on the River Murray. A guide to the terrestrial and submerged archaeological sites in South Australia,* Sarah Kenderdine, State Heritage Branch, Department of Environment and Land Management, Adelaide, South Australia, pp. 273-282

MacLeod, I.D. (1994) "Report on the corrosion of iron shipwrecks in South Australia: with particular reference to the River Murray" Chapter 10 in *Muddy Waters: Proceedings of the first conference on the submerged and terrestrial*

archaeology of historic shipping on the River Murray, Echuca, September 1992, State Heritage Branch, SA Department of Environment and Natural Resources, Adelaide. pp 1-14.

MacLeod, I.D., (1993). "Metal corrosion on shipwrecks: Australian case studies", *Trends in Corrosion Research*, 1, pp 221-245.

MacLeod, I.D. & Richards, V.L., (1994) "Monitoring moisture in *Batavia* timbers", *Proceedings of 5th ICOM Group on Wet Organic Archaeological Materials Conference*, Portland/Maine 1993.,p 79-95, Ed. Per Hoffmann, Special Discussions edited by Tara Grant and Thomas Daley.

MacLeod, I.D., Mardikian, P.,& Richards, V.L.(1994) "Observations on the extraction of iron and chloride ions from composite materials" *Proceedings of 5th ICOM Group on Wet Organic Archaeological Materials Conference*, Portland/Maine 1993.,p 199-211, Ed. Per Hoffmann, Special Discussions edited by Tara Grant and Thomas Daley.

MacLeod, I.D. (1994) "Conservation of corroded metals - a study of ships' fastenings from the wreck of HMS *Sirius*." *Ancient and Historic Metals Conservation and Scientific Research*, Ed D.A. Scott, J. Podany, B.B. Considine, Getty Conservation Institute, Los Angeles, p 265-278.

Ford, B., MacLeod, I.D., and Haydock, P., (1994) "Rock art pigments from the Kimberley region of Western Australia: identification of the minerals and conversion mechanisms", *Studies in Conservation* 39, p 57-69.

Lanagan, M.D., MacLeod, I.D., Singh, P. & Hefter, G.T.,(1995) "Corrosion of iron in aqueous glycol mixtures" *Corrosion and Prevention 95 - Proceedings of the 1995 Australasian Corrosion Association Conference*, Perth November 1995, Paper 50 pp 1-10.

MacLeod, I.D., (1995) "In-situ corrosion studies on the Duart Point wreck 1994" *International Journal of Nautical Archaeology* 24(1) 53-59.

MacLeod, I.D., Haydock, P., Tulloch, D. & Ford, B. (1995) "Effects of microbiological activity on the conservation of aboriginal rock art" *AICCM Bulletin* 21(1), 3-10

MacLeod, I.D. and Wozniak, R., (1996) "Corrosion and Conservation of Lead in Sea Water" *ICOM-Committee for Conservation Preprints 11th Triennial Meeting, Edinburgh, Sept 1996*. James & James, London. pp 884-890.

Corvaia, C., MacLeod, I.D., and Harley, C.(1996) "Conservation of glass recovered from shipwreck sites" *ICOM-Committee for Conservation, Preprints 11th Triennial Meeting, Edinburgh Sept 1996*, James & James, London, 819-825.

Herrenschmidt, F., Moinot, M., Pennec, S.L., MacLeod, I.D. and Chahine, C. (1996)"Une lieue sous la mer, le Titanic: traitement des papiers" *ICOM-Committee for Conservation, Preprints 11th Triennial Meeting, Edinburgh, Sept. 1996*. James & James, London, p 517-522.

MacLeod, I.D. (1996) "In-situ conservation of cannon and anchors on shipwreck sites" in *Conservation of Archaeological Sites and its Consequences*, IIC, London. Ed Ashok Roy and Perry Smith, 111-115.

MacLeod, I.D., Haydock, P & Charton, E., (1996) "Avian guano and its effects on the preservation of rock paintings" *Preservation of Rock Art 1995 AURA Occasional Papers 9*, Ed. Andrew Thorn & Jacques Brunet p 60-64.

MacLeod, I.D., (1996) "An in-situ study of the corroded hull of HMVS *Cerberus* (1926)", *Proceedings of the 13th International Corrosion Congress* Paper 125 pp 1-10.

MacLeod, I.D. & Wozniak, R., (1997) "Corrosion and conservation of tin and pewter", *Metal 95 - Proceedings of the ICOM -CC Metals Working Group Conference*, Semur-en-Auxois, France 1995, James & James, London, 118-123.

MacLeod, I.D., (1997) "The use of *in-situ* metal corrosion studies as an archaeological management tool" in Delgado, J. Ed *British Museum Encyclopaedia of Underwater and Maritime Archaeology* p. 111-113.

MacLeod, I.D., Haydock P. and Ford, B. (1997) "Conservation Management of West Kimberley Rock Art: Microclimate studies and Decay Mechanisms" *Kimberley Society Occasional Paper No 1. Aboriginal Rock Art of the Kimberley* Ed K.F. Kenneally, M.R. Lewis., M. Donaldson and C. Clement, Kimberley Society Inc, Perth, Western Australia. pp 65-69.

MacLeod, I.D. & Richards, V.L. (1997) "The impact of metal corrosion products on the degradation of waterlogged wood recovered from historic shipwreck sites" *Proceedings of the 6th ICOM Group on Wet Organic Archaeological Materials Conference* York 1996, Eds Per Hoffmann, Tara Grant, James A. Spriggs, Thomas Daley, ICOM-CC Wet Organic Archaeological Materials, Bremerhaven pp 331-353.

MacLeod, I.D. & Richards, V.L. (1997) "Wood degradation on historic shipwreck sites: the use of FTIR spectroscopy to the study of the loss of hemicellulose" *Proceedings of the 6th ICOM Group on Wet Organic Archaeological Materials Conference* York 1996, Eds Per Hoffmann, Tara Grant, James A. Spriggs, Thomas Daley, ICOM-CC Wet Organic Archaeological Materials, Bremerhaven. pp 203-228.

MacLeod, I.D. and Beng, E.W., (1998) "Analysis and interpretation of glass artefacts from the 17th-19th century Dutch and colonial Australian shipwrecks" *Glass, Ceramics and Related Materials* Proceedings of the Interim Meeting of the ICOM-CC Working Group Conference, Vantaa, Finland, September 1998. Ed Alice B Paterakis, pp 58-69

MacLeod, I.D., (1998) "In-situ corrosion studies on iron and composite wrecks in South Australian waters: implications for site managers and cultural tourism" *Bulletin Australian Institute Maritime Archaeology* 22: 81-90

MacLeod, I.D., (1998) "In-situ corrosion studies on iron shipwrecks and cannon: the impact of water depth and archaeological activities on corrosion rates" *Metal 98 Proceedings of the ICOM -CC Metals Working Group Conference*, *Draguignan-Faginère* France 1998, Ed Mourey, W. & Robbiola, L, James & James, London. pp 116-124.

MacLeod, I.D. & Romanet, A-S, (1999) "The effects of pH and stress on seawater corrosion and conservation of copper and its alloys in seawater. *Preprints of the ICOM-CC 12th Triennial Meeting, Lyon* September 1999, James & James, London, pp 828-833.

MacLeod, I.D. (1999) "Conservation of the SS *Xantho* engine: lessons learnt", *AICCM Bulletin*, 24, 10-19.

Theile, J. M., Yutronic, N. and MacLeod, I.D., (1999) "Análisis Y Restauración de Máscaras Ceremoniales Del Altiplano", *Revista de Teorá del Arte* 1 pp 108-119.

MacLeod, I.D. and Beng, J., (2000) "The contribution of alloy composition to the fate of foundered vessels", *Tradition and Innovation: Advances in Conservation, IIC Melbourne Conference, 10-14thOctober, 2000.* pp. 124-127.

MacLeod, I.D., (2000) "Rock art conservation and management: the past, present and future options", *Reviews in Conservation,* 1, pp 32-45.

MacLeod, I.D. and Bassett, S., (2001), "Light fading of the painted deck on *Australia II* in an exhibition environment", *AICCM Bulletin*, 26, 1- 9.

MacLeod, I.D. and Kelly, D., (2001), "The effect of chloride ions on the corrosion of aluminium alloys used in the construction of *Australia II*", *AICCM Bulletin*, 26, 10 - 19.

MacLeod, I.D., (2002), Chapter 41 "In-situ corrosion measurements and managing shipwreck sites", in *International Handbook of Underwater Archaeology*, Ed C.V. Ruppe and J.F. Barstad, Plenum Press, New York, pp 697-714.

MacLeod, I.D., (2002) "Effects of structure on the corrosion performance of gold and silver alloys on shipwrecks", Proceedings of the International Congress on the Conservation and Restoration for Archaeological Objects, Nara National Research Institute for Cultural Properties, Japan, pp 178-185.

MacLeod, I.D., and Haydock, P., (2002) "Microclimate modelling for prediction of environmental conditions within rock art shelters", Preprints for ICOM-CC Triennial Meeting, Rio de Janeiro, Brazil September 2002, Vol II, 571-577.

MacLeod, I.D., (2002) "In-situ corrosion monitoring of the iron shipwreck *City of Launceston* (1865)", Preprints for ICOM-CC Triennial Meeting, Rio de Janeiro, Brazil September 2002, Vol II, 871-877.

MacLeod, I.D. and Flecker, M., (2004) "Corrosion of tin and its alloys recovered from a 10th century wreck in the Java Sea", *Metal 2001, Proceedings of the International Conference on Metals Conservation, Santiago, Chile, April 2001, Eds. I. D. MacLeod, J. M. Theile & C. Degrigny*, Western Australian Museum, 191-201

MacLeod, I.D. and Pennec, S., (2004) "Characterisation of corrosion products on artifacts recovered from the RMS *Titanic* (1912)", *Metal 2001, Proceedings of the International Conference on Metals Conservation, Santiago, Chile, April 2001, Eds. I. D. MacLeod, J. M. Theile & C. Degrigny*, Western Australian Museum, 270-278.

MacLeod, I.D., Theile J. M. & Degrigny, (2004) C *Metal 2001, Proceedings of the International Conference on Metals Conservation, Santiago, Chile, April 2001, Eds. I. D. MacLeod, J. M. Theile & C. Degrigny*, Western Australian Museum, pp 1- 330.

MacLeod I.D., Morrison P., Richards V. and West, N (2004) "Corrosion monitoring and the environmental impact of decommissioned naval vessels as artificial reefs", in *Metal 2004 Proceedings of the International Conference on Metals Conservation, Canberra, October 2004, Eds. J. Ashton & D. Hallam,* National Museum of Australia, 53-74

MacLeod, I.D. and Schindelholz, E., (2004) "Surface analysis of corroded silver coins from the wreck of the *San Pedro De Alcantara* (1786)", in *Metal 2004 Proceedings of the International Conference on Metals Conservation, Canberra, October 2004, Eds. J. Ashton & D. Hallam,* National Museum of Australia, 114-125.

Heldtberg, M., MacLeod, I.D. and Richards V. L., (2004) "Corrosion and cathodic protection of iron in seawater: a case study of the *James Matthews* (1841)", in *Metal 2004 Proceedings of the International Conference on Metals Conservation, Canberra, October 2004, Eds. J. Ashton & D. Hallam,* National Museum of Australia, 75-87

MacLeod, I.D. (2005) "The decay and conservation of museum objects of tin", *Studies in Conservation*, 50, 1-2.

MacLeod, I.D. (2005) "A new corrosion mechanism for iron shipwrecks in seawater: a study of the Fujikawa Maru (1944) in Chuuk Lagoon, Federated States of Micronesia", Preprints for ICOM-CC Triennial Meeting, Den Haag, The Netherlands, September 2005, Vol II 310-316

MacLeod, I.D. (2005) "The effects of moisture, micronutrient supplies and microbiological activity on the surface pH of rocks in the Burrup peninsula", Preprints for ICOM-CC Triennial Meeting, Den Haag, The Netherlands, September 2005, Vol II 386-393

Bergstrand, T, Gjelstrup Björdal, C, Nilsson, T, Bohm, C, Christensson E, Gregory, D. Nyström, I, Peacock, E. E, Richards, V. & MacLeod, I. (2005), Reburial as a method of preserving archaeological remains, A presentation of the Marstrand project. In *Proceedings of the 9th ICOM Group on Wet Organic Archaeological Materials Conference, Copenhagen, 7-11 June 2004,* P. Hoffmann, K. Strætkvern, J.A. Spriggs & D. Gregory (eds.), The International Council of Museums, Committee for Conservation Working Group on Wet Organic Archaeological Materials, Bremerhaven. pp. 9-39.

MacLeod, I.D., (2006) "In-situ corrosion studies on wrecked aircraft of the Imperial Japanese Navy in Chuuk Lagoon, Federated States of Micronesia", *International Journal of Nautical Archaeology*, 35.1: 128-136

MacLeod, I.D., (2006) "Corrosion and conservation management of iron shipwrecks in Chuuk Lagoon", *Conservation and Management of Archaeological Sites,* 7, 203-223.

Richards, V.L. & MacLeod, I.D. (2006) Reburial and analyses of archaeological remains: Investigations into the effects of reburial on metals', in Reburial and Analyses of Archaeological Remains – Studies on the Effect of Reburial on Archaeological Materials Performed in Marstrand, Sweden 2003-2005. Eds I. Nystrom-Godfrey & T. Bergstrand. Bohuslans Museum, Sweden, pp. 1-90.

MacLeod, I.D., (2006) "Assessment of potential impacts to the long-term corrosion rates of shipwrecks in Port Phillip Bay" in appendix 62, Volume 10, Technical Appendices of the Supplementary Environmental Effects Statement, Channel Deepening Project, Port of Melbourne Corporation: 283-315.

MacLeod, I.D., Beger, M., Richards, V., Jeffery, B., and Hengeveld, M., (2007) "Dynamic interactions of marine ecosystems with wrecks in Chuuk Lagoon, Federated States of Micronesia" in Metal 07, Preprints of the ICOM-CC Metals Working Group meeting, Amsterdam, Ed Degrigny, C., Ankersmit, B., Yolanda, I., and van Langh R., vol 3, 51-54.

Hallam, D. MacLeod I.D., and Higgins, M., (2007) "Finding evidence of a lost explorer: LUDWIG LEICHHARDT 1848 not just a nameplate and a provenance study?", *Metal 07 - interim meeting of the ICOM-CC Metal WG, Amsterdam 17-21 September 2007*, Ed. Degrigny C., van Langh, R., Yolanda I., and Ankersmit, B., Rijksmuseum Amsterdam (2007), Book 1 pp 73-77

MacLeod, I.D., (2007) "Creation of a collection facility and relocation of the Western Australian Museum's collections", *Contemporary Collections: Preprints of the AICCM National Conference, Brisbane 2007,* Pagliarino, A. and Osmond, G., editors, AICCM, Canberra, Australia, 272 pp. 5-11.

Jeffery, W., Beger M, MacLeod I, Richards V., Hengeveld M. and Carpenter, J., (2007), Guidelines in recording and monitoring the natural and cultural attributes of submerged historic sites in the Federated States of Micronesia, Report for the National Historic Preservation Office, Federated States of Micronesia, Pohnpei.

Richards V.L. and I. D. MacLeod 2007 Reburial and analyses of archaeological remains: Investigations into the effects of reburial on metals in *Reburial and Analyses of Archaeological Remains – Studies on the Effect of Reburial on Archaeological Materials Performed in Marstrand, Sweden 2003-2005. The RAAR Project, I.* Eds Nyström-Godfrey & T. Bergstrand, Bohusläns Museum and Studio VästSvensk Konservering, Sweden, pp. 91-179.

Peacock, E E; Bergstrand, T; Nyström Godfrey, I; Björdal, C; Bohm, C; Christensson, E; Gregory, D; MacLeod, I; Nilsson, T; Richards, V & Turner-Walker, G. (2008). The Marstrand reburial project - Overview, phase I and future work. In *PARIS3 Preserving Archaeological Remains in Situ*. Geoarchaeological and Bioarchaeological Studies 10, Amsterdam, pp. 253-263.

MacLeod I.D, Hallam, D. and Kaus, D. (2008) "It's all in the nameplate; brass and bronze in colonial Australia", *Preprints for ICOM-CC Triennial Meeting, New Delhi, India*, September 2008, 272-278

MacLeod I.D., (2008), "The legal consequences of inadequate conservation for contract maritime archaeology*", Preprints for ICOM-CC Triennial Meeting, New Delhi, India*, September 2008, 217-223

MacLeod I.D., Cook D. and Schindelholz E., (2008)," Corrosion and conservation of the American civil war ironclad USS *Monitor* (1862)", *Preprints for ICOM-CC Triennial Meeting, New Delhi*, India, September 2008 279-285

MacLeod, I.D., (2008) "Shipwreck graves and their conservation management", *AICCM Bulletin*, 31, 5-14.

MacLeod, I.D., (2008) "Washing formaldehyde from fixed spirit specimens: a mechanism for the preservation of *megamouth III" AICCM Bulletin*, 31, 36-43.

MacLeod, I.D. and Haydock, P., (2008) "Effects of water vapour and rock substrates on the microclimates of painted rock art surfaces and their impact on the preservation of the images", *AICCM Bulletin*, 31, 66-86.

MacLeod, I.D., (2009) "Where to now: conservation of iron shipwrecks. Experiences from the SS *Xantho* project and their application to the *H L Hunley* and USS *Monitor* projects" in *Iron, Steel and Steamship Archaeology,* Proceedings of the 2nd Australian Seminar held in Perth, Melbourne and Sydney 2006, McCarthy, M., Ed, Australasian Institute of Maritime Archaeology, Special Publication no 13, pp 119-127.

Nyström Godfrey, I., T. Berstrand, C. Gjelstrup Björdal, T. Nilsson, C. Bohm, E. Christenssen, D. Gregory, E.E. Peacock, V. Richards, & I.D. MacLeod, (2009) Reburial and analysis of archaeological remains – The RAAR project. Project status and cultural heritage management implications based on the first preliminary results in *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam, 10-15 September 2007*, eds K. Straetkvern & D.J. Huisman, Rijksdienst voor Archeologie, Cultuurlandschap en Monumenten (RACM), Amersfoort: 169-196.

MacLeod, I.D., (2010) "Assessment of the impact of scallop dredging, site clearance and cathodic protection on the *City of Launceston* (1865) in Port Phillip Bay", in Final Report on SS *City of Launceston* (1863-1865) excavation and conservation 1997-2009, *Australasian Institute for Maritime Archaeology, Special Publication no 15,* Ed Ross Anderson, p 94-103.

Richards, V., MacLeod, I. D., Morrison, P., (2010), Corrosion monitoring and the environmental impact of decommissioned naval vessels as artificial reefs in *In-Situ Conservation of Cultural Heritage: Public, Professionals, and Preservation*, eds. V. Richards & J. McKinnon, PAST Foundation Publications, pp. 50-67.

Carpenter, J., MacLeod, I., Richards, V., (2010), Conserving the WWII wrecks of Truk Lagoon in *In-situ Conservation of Cultural Heritage: Public, Professionals, and Preservation*, eds. V. Richards & J. McKinnon, PAST Foundation Publications, pp. 32-39.

MacLeod, I.D., (2010) 'Corrosion and Conservation Management of the HMAS *AE2* (1915) Submarine in the Sea of Marmara, Turkey', in *METAL 2010, Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group, Charleston, South Carolina 11-15 October 2010*, ed. P. Mardikian, C. Chemello, C. Watters and P. Hull, Clemson University (2011) 56-62. Publisher www.lulu.com

MacLeod, I.D. and Viduka, A., (2010) Assessment of the impact of diving tourism and cyclones on the SS Yongala (1911) shipwreck in the Great Barrier Reef from in-situ corrosion data, *AICCM Bulletin*, 32, 134-143.

MacLeod, I.D. and Richards, V.L., (2010) In situ conservation surveys of iron shipwrecks in Chuuk Lagoon and the impact of human intervention, *AICCM Bulletin*, 32, pp. 106-122

Richards, V.L., & MacLeod, I.D, (2010) "Reburial and analyses of archaeological remains: Investigations into the effects of reburial of metals", Marstrand Sweden Dec 2010, Chapter 4, pp. 1-103.
Richards, V.L., MacLeod, I.D., 2011, Reburial and analyses of archaeological remains: Investigations into the effects of reburial on metals in *Reburial and Analyses of Archaeological Remains – Phase II Results from the 4th retrieval in 2009 from Marstrand, Sweden. The RAAR Project, Appendix 4*, eds I. Nystrom-Godfrey, T. Bergstrand & H. Petersson, Bohusläns Museum and Studio VästSvensk Konservering, Udevalla, Sweden, pp. 1-103.

MacLeod, I.D., & Binnie N. E., (2011), "A long-term study of conservation management and corrosion of shipwrecks in the Fathom Five Underwater National Park, Lake Huron, Canada" *Preprints for ICOM-CC Triennial Meeting,* Lisbon, Portugal, September 2011, Ed J Bridgland, ICOM-CC Lisbon, paper 0903, pp. 1-8

MacLeod, I.D., & van Dam A.J., (2011), "A migration mechanism for transfer of sharks from ethanol to aqueous glycerol solutions" *Preprints for ICOM-CC Triennial Meeting,* Lisbon, Portugal, September 2011, Ed J Bridgland, ICOM-CC Lisbon paper 1201, pp. 1-8

Godfrey, I. M., Richards, V. L., MacLeod, I.D., (2011), The Batavia – Past, Current and Future Conservation, in *Proceedings of the Shipwrecks 2011 – Chemistry and Preservation of Waterlogged Wooden Shipwrecks Conference*, 18-21 October 2011, Stockholm, Sweden, ed. L. I. Elding, Royal Institute of Technology (KTH), Sweden, pp. 22-29

Steyne, H., & MacLeod, I.D., (2011) "In-situ conservation management of historic iron shipwrecks in Port Phillip Bay: a study of J7 (1924), HMVS Cerberus (1926) and the City of Launceston (1865)", *Bulletin of the Australasian Institute for Maritime Archaeology,* 35: 67-80

MacLeod, I.D., & Steyne, H., (2011), "Managing a Monitor – the case of HMVS Cerberus in Port Phillip Bay: Integration of corrosion measurements with site management strategies", *Conservation and Management of Archaeological Sites*, 13(4), 334-61.

MacLeod, I.D., Richards, V.L., & Beger, M (2011), "The effects of human and biological interactions on the corrosion of WWII iron shipwrecks in Chuuk Lagoon", 18th International Corrosion Congress, Perth, November 2011, Paper 124, 1-12

MacLeod, I.D., (2011) "Consuming corrosion –A journey into the realm of materials conservation", P F Thompson Memorial Lecture, 18th International Corrosion Congress, Perth, November 2011, 1-12.

MacLeod, I.D., (2011) "Spiritual dimensions in Materials Conservation", Museums Australia Conference, "*At the Frontier, Exploring the Possibilities*" Perth, November 2011, pages 1-8,
http://www.museumsaustralia.org.au/site/conf_perth2011.php

Veth, P., A. Viduka, M. Staniforth, I.D. MacLeod, V.L. Richards, & A Barham, A., (2011), The Australian historic shipwreck protection project in *Proceedings of the Asia-Pacific Regional Conference on Underwater Cultural Heritage, 8-12 November 2011, Manila, Philippines*, eds M. Staniforth, J. Craig, S.C. Jago-on, B. Orillaneda & L. Lacsina, Jericopim Publishing House, Manila: 753-762.

Human, B.A†, Morrison, S.M., & MacLeod I.D., (2012), "Is the Megamouth Shark susceptible to mega-distortion? Investigating the effects of twenty-two years of fixation and preservation on a large specimen of *Megachasma pelagios* (Chondrichthyes: Megachasmidae" *Records of the Western Australian Museum* 27, 7-20.

Preβlinger, H., Pichler, B. & MacLeod, I.D., (2012), "Werkstoffkundliche Untersuchungsergebnisse einer im 17. Jahrhundert aus Gusseisen gefertigten englischen Schiffskanone", *Berg-und Hüttenmännische Monatshefte* 157(5) 209-213.

MacLeod, I.D., & Taylor, P., (2012), The effects of depth and time on the corrosion of cast iron in Port Phillip, *Corrosion and Protection 12, Australasian Corrosion Association Conference, Melbourne November 2011,* Paper 126, 1-8

Nyström Godfrey, T. Bergstrand, C. Bohm, E. Christensson, D. Gregory, I. MacLeod , E.E. Peacock & V. Richards. (2012). Reburial and analyses of archaeological remains (RAAR). Phase II - Project status and new findings. In *Proceedings of the 11th ICOM-CC Working group on wet organic archaeological materials conference. Greenville, USA 24-28 May 2010.* K. Strætkvern & E. Williams (eds.), The International Council of Museums, Committee for Conservation Working Group on Wet Organic Archaeological Materials, pp. 23-47.

Nyström Godfrey, I, Bergstrand, T., Petersson H., Bohm, C., Christensson E., Gjelstrup Björdal, C., Gregory, D., MacLeod, I., Peacock, E., Richards, V., (2012), The RAAR Project – Heritage Management Aspects on Reburial after Ten Years of Work, *Conservation and Management of Archaeological Sites,* 14(1-4) 360-371.

Richards, V., Gregory, D., MacLeod, I. & Matthiesen, H., (2012), Reburial and analyses of archaeological remains in the marine environment – Investigations into the effects on metals. *Conservation and Management of Archaeological Sites, Vol. 14 no. 1-4 2012*, Special Edition, Proceedings from the 4th Preservation of Archaeological Remains In Situ (PARIS4) Conference, 23-26 May 2011, Copenhagen, pp. 35-47.

MacLeod, I.D., (2012), Shipwreck Conservation In: McCarthy, M. (ed.), *Shipwrecks of Australia's West Coast*, Western Australian Museum, Perth, 44-47.

MacLeod, I.D., (2013) "The mechanism and kinetics of in-situ conservation of iron cannon on shipwreck sites", *International Journal of Nautical Archaeology*, 42(2), 382-391.

MacLeod, I.D., (2013), "Corrosion reversed: deposition of elemental copper and silver in marine concretions", *Corrosion and Materials,* 38(6), 48-53.

MacLeod, I.D., (2013), Chapter 21, Monitoring, modelling and prediction of corrosion rates of historical iron shipwrecks, in *Corrosion and conservation of cultural heritage metallic artefacts,* in European Federation of Corrosion Publication No 65, Eds Dillman, D. Watkinson, E. Angelini & A. Adriaens, Woodhead Publishing Limited, 466-477.

MacLeod, I.D., (2013) Metals conservation via reductive dissolution and consolidation of corrosion products, Pre-prints of the *METAL 2013, Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group, Edinburgh, Scotland September 2013*, 335.

Veth, P., Philippou, C., Richards, V., Staniforth, M., Rodrigues, J., Khan, A., Creagh, D., Viduka, A., MacLeod I., and Harvey, P., (2013) The Australian Historic Shipwreck Project 2012: First report on the background, reburial and in-situ preservation at the *Clarence* (1841-1850), *Bulletin of the Australasian Institute for Maritime Archaeology,* 37, 1-19.

Abu Baker, A., MacLeod, I.D., Sloggett, R., and Taylor, R., (2013), A comparative study of salicylaldoxime, cysteine and benzotriazole as inhibitors for the active chloride-based corrosion of copper and bronze artifacts, *European Scientific Journal*, 9(33) 228-251.

MacLeod, I.D., Jateff, E and Hunter, J W III, (2014), Corrosion on a wrecked colonial warship: HMCS Protector 1882-1944, *Corrosion and Materials*, 39(3), 52-56.

MacLeod, I.D., (2014), In-Situ Preservation of Shipwreck Artefacts, in C. Smith (Ed.) *Encyclopedia of Global Archaeology*, pp. 3725-3741. New York: Springer.

MacLeod, I.D., (2014), Metals: Preservation and Conservation. In: C. Smith (Ed.) Encyclopedia of Global Archaeology, pp. 4841-4850. New York: Springer.

MacLeod, I.D. & R.J. Car, (2014), Determining treatment priorities for ecclesiastical textiles using significance and conservation assessments, *Journal of Cultural Heritage* 15, 628-636.

Richards, V., MacLeod, I. and Veth P., (2014) The Australian Historic Shipwreck Preservation Project – In-situ preservation and long-term monitoring of the *Clarence* (1850) and *James Matthews* (1841) shipwreck sites. In *Proceedings of the 2nd Asia-Pacific Regional Conference on Underwater Cultural Heritage, 12-16 May 2014, Honolulu,*

Hawaii, eds. H. Van Tilburg, S. Tripati, V. Walker Vadillo, B. Fahy and J. Kimura, 2014 Asia-Pacific Regional Conference on Underwater Cultural Heritage Planning Committee, Hawaii, USA, pp. 469-482.

Usher, K. M., Kaksonen, A, and MacLeod, I. D. (2014), Marine rust tubercles harbour iron corroding archaea and sulphate reducing bacteria, *Corrosion Science* 83, 189-197.

MacLeod I.D., R.J. Car, (2014), Oxidation of dithionite treatment solutions and the effects of pH on fading textile dyes *AICCM Bulletin*, 35, 69-78.

MacLeod, I.D., & Car, R.J., (2014), Conservation of a mid-18th-century Italian embroidered ecclesiastical cope and treatment of corroded metal threads using neutral dithionite solutions, In *ICOM-CC 17th Triennial Conference Preprints, Melbourne,15–19 September 2014,* ed. J. Bridgland, art. 1306, 7 pp. Paris: International Council of Museums, (ISBN 978-92-9012-410-8)

MacLeod, I.D., V.L. Richards, (2014), In-situ corrosion studies of wrecked WWII aircraft in Saipan, Commonwealth of the Northern Mariana Islands. In *ICOM-CC 17th Triennial Conference Preprints, Melbourne, 15–19 September 2014*, ed. J. Bridgland, art. 0902, 8 pp. Paris: International Council of Museums, (ISBN 978-92-9012-410-8)

MacLeod, I.D, D. Thurrowgood, G. Pohl, D. Howard, D. Patterson. (2014) Centuries of decay revealed by synchrotron analysis of the de Vlamingh 1697 pewter plate. In *ICOM-CC 17th Triennial Conference Preprints, Melbourne, 15–19 September 2014*, ed. J. Bridgland, art. 0903, 6 pp. Paris: International Council of Museums, (ISBN 978-92-9012-410-8)

MacLeod, I.D., & Harvey, P., (2014), The application of significance and conservation assessments to the development of a priority matrix for intervention on historic shipwreck sites, *Conservation and Management of Archaeological Sites,* 16(3) 245-267.

MacLeod, I.D., (2015), Change management in materials conservation in *Change! Combining analytic approaches with street wisdom,* Ed Gabriele Bammer, *ANU Press* pp. 217-228

MacLeod, I.D., (2015), Conservation of a museum megamouth shark specimen by changing its preservative from aqueous ethanol to aqueous glycerol, *Collection Forum*, Society for Preservation of Natural History Collections, 29(1-2), 73-89.

Stanbury, M., Kasi, K. and MacLeod, I.D., (2015), Copper and copper alloy artefacts: contemporary experimentation and modern analyses. In: M. Stanbury (ed.), *The Mermaid Atoll shipwreck—a mysterious early 19th-century loss*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 21 Australasian Institute for Maritime Archaeology Special Publication No. 17 (Chapter 11) pp. 131-174

Stanbury, M. and MacLeod, I. D., (2015), Corrosion of cast and wrought iron on the Mermaid Atoll site. In: M. Stanbury (ed.), *The Mermaid Atoll shipwreck—a mysterious early 19th-century loss,* Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 21 Australasian Institute for Maritime Archaeology Special Publication No. 17 (Chapter 14) pp. 205-210.

MacLeod, I.D., (2015), Underwater insights from wrecks of war, *Chemistry in Australia*, April, pp 18-21.

MacLeod, I.D., (2015), Micrometeorological assessment of passive climate controls for museums, *AICCM Bulletin*, 37, 33-43.

MacLeod, I.D., and Curran, B., (2015), Conservation of waterlogged convict-built wooden roadblocks with PEG 3350 and Luviskol K90, *AICCM Bulletin,* 37, 56-66.

MacLeod, I.D., (2015), Corrosion products and site formation processes, Chapter 5 in *Site Formation Processes on historic shipwrecks*, Ed., Matt Keith, Florida University Press, 90-213.

MacLeod, I.D., (2015), The application of chemistry to conserve cultural heritage, *Teaching Science,* 52-62.

MacLeod, I.D., (2016), In-situ corrosion measurements of WWII shipwrecks in Chuuk Lagoon, quantification of decay mechanisms and rates of deterioration, in *Frontiers in Marine Science 30 March 2016*
http://dx.doi.org/10.3389/fmars.2016.00038

MacLeod, I.D., (2016), The composition and properties of "refined" iron: a metallurgical analysis of Gun 8, in *A Cromwellian warship wrecked off Duart castle, Mull, Scotland in 1653,* C.J.M. Martin, Society of Antiquaries of Scotland, pp 147-150.

MacLeod, I.D., (2016), Corrosion of guns as indicators of site-formation processes, in Chapter 4, Wreck-site formation processes, in *A Cromwellian warship wrecked off Duart castle, Mull, Scotland in 1653,* C.J.M. Martin, Society of Antiquaries of Scotland, pp 71-73.

Veth, P., Richards, V., Philippou, C., Rodrigues, J., Staniforth, M., Khan, A., Viduka, A., Zubrzycka, A., Harvey, P., Parkinson, J., MacLeod, I., Shefi D., Barham, A. and Creagh, D., 2016, *Australian Historic Shipwreck Preservation Project, the in-situ preservation & reburial of the colonial trader Clarence (*1850), *Excavation & Monitoring Program Report 2012-2015*, pp i-viii, 1-210, www.ahspp.org.au

Richards, V., MacLeod, I., & Veth, P., (2016), The Australian Historic Shipwreck Preservation Project: In situ Preservation and Long-Term Monitoring of the Clarence (1850) and James Matthews (1841) Shipwreck Sites, *Conservation and Management of Archaeological Sites*, 18:1-3, pp. 240-253.

MacLeod, I. D., (2016), Conservation of corroded aluminium alloys: in-situ conservation to exhibitions, Proceedings of *Metal 2014: Conservation of aluminium artefacts,* Joint AIC and ICOM CC Metals Working Group meeting, Washington, DC, April 6-9, 2014, in press.

MacLeod, I.D. and Car R., (2016), Conservation of a mid-19th century pretiosa mitre from the Benedictine community, New Norcia, Western Australia, *AICCM Bulletin,* 37(2), pp 96-106.

MacLeod, I.D., (2016), Corrosion of copper alloys on historic shipwrecks and materials performance, *Proceedings of Corrosion and Protection Conference, November 13-16, 2016,* Australasian Corrosion Association, Paper 105, pp. 1-10.

MacLeod, I.D. and McCarthy, M, (2016), Corrosion on HMAS Sydney II and HSK Kormoran in *From Great Depths; the wrecks of HMAS Sydney II and HSK Kormoran,* Ed M. McCarthy, WA Museum and UWA Press, pp 304-309.

MacLeod, I.D., (2016), "Refining conservation treatments for iron shipwrecks: lessons learned from experiences with the USS *Monitor* (1862) and the SS *Xantho* (1872)", *Bulletin Australasian Institute of Maritime Archaeology*, 40, 39-50.

Black, J., MacLeod I.D., and Smith, B., (2017), Theoretical effects of industrial emissions on colour change at rock art sites on Burrup Peninsula, *J Archaeological Science*: *Reports* 12, 457-462.

MacLeod, I.D., (2017), Preventive Conservation of Archaeological Metals in *Preventive Conservation: Collection Storage*, Ed R Waller and L. Elkin, Joint publication by the AIC and SPNHC, Smithsonian Institution, Washington DC, in press.

MacLeod, I.D., Selman, A., and Selman C., (2017), "Assessing the impact of typhoons on historic iron shipwrecks in Chuuk Lagoon through changes in the corrosion microenvironment", *Conservation and Management of Archaeological Sites*, in presss

MacLeod I.D., Brennan, J., and Car R J., (2018), "Development of textile education options for treatment of gilded and oxidized silver found in textiles", *AICCM Bulletin* – submitted.

MacLeod I.D., (2018), "Quantifying the effects of site conditions on the long-term corrosion of bronzes on historic shipwreck sites", submitted to the *Journal of Australasian Institute for Maritime Archaeology,*

MacLeod I.D., (2017), "Surface chloride activity measurements on brick and stone: a guide to underlying decay and treatment options", *AICCM Bulletin*, in preparation.

Popular Publications

MacLeod, I.D., (2012), Two Fremantle Maritime Museums, *Signals* 99 June to August 2012, 44-49.
MacLeod, I.D., (2012), *The mutineer's mortar*, Collectors Corner, *Chemistry in Australia* June 2012, 32
Not just a gilded bowl, AICCM National Newsletter 114, March 2010, page 20
Shipwrecks in Port Phillip Bay, AICCM National Newsletter 114, March 2010, page 28
MacLeod, I.D., (2011) *Regilding the golden goddess* Collectors Corner, *Chemistry in Australia*, April, p 35
MacLeod, I.D., (2011, 2012), President's Column in *Corrosion and Materials* 35 (5, 6) & 36 (1, 2, 3, 4 & 5)

MacLeod, I.D., (2013) Book review on *George Charles Smith: from Nelson sailor to Mission Pioneer*, The Great Circle 35(1) 115-116.
MacLeod, I.D., (2014), Afterlife of a Scottish Steamship, *Chemistry in Australia, April* p 34-35
Anstey, S and MacLeod I.D., (2014), 100 Postcards from the Frontline, *Chemistry in Australia,* May p 37
MacLeod, I.D. and Power, G, (2014), Vale: Professor Ian McKay Ritchie, *Corrosion and Materials* 39(6), p 13
MacLeod, I.D. and Power, G, (2015), Obituary Ian Mackay Ritchie, Corrosion Expert, *Chemistry in Australia*, April p 29
Power, G., Ritchie A, Drock, K., & MacLeod I.D., (2016), Ian McKay Ritchie 1936-2014, *Historical Records of Australian Science*, 28, 1-8
MacLeod, I.D., (2016), Book Review, The life and times of Dirk Hartog, *History West* page 7

Unpublished Reports

MacLeod, I.D. (1985) - Conservation of shipwreck material on Norfolk Island, in *Expedition Report on the wreck of HMS Sirius (1790)* by Henderson, G. and Stanbury, M. Australian Bicentennial Authority Project Report, pp 43-65.

MacLeod, I.D. (1989) - "Conservation of relics from HMS Sirius", 16 pages in Norfolk Island Government Project, *1988 Expedition report on the wreck of HMS Sirius (1790)*, Compiled by Graeme Henderson.

MacLeod, I.D. (1991)- "Conservation of Cultural Property -Report to UNESCO on a meeting of consultants, ASEAN National Museum conservation delegates, UNDP and ICOM delegates" Bangkok, 28th January to 1st February.

MacLeod, I.D., Haydock, P. and Ford, B (1991) - "Conservation research into the preservation of rock paintings in the West Kimberley region of Western Australia", Report to the Western Australian Heritage Committee, pp 1-89.

MacLeod, I.D., Haydock, P & Charton, E., (1992) "The effects of avian guano on the preservation at *Walga Rock*". Report to the Australian Institute of Aboriginal and Torres Strait Islanders Studies, Canberra, pp 1-45.

MacLeod, I.D., (1993) "Implications of the marine aggregate proposal on the degradation of historic shipwrecks south of Sydney, New South Wales", Report for Corkery and Co., Environmental Consultants, Orange, New South Wales, pp 1-22.

MacLeod, I.D., Haydock, P and Ford, B (1994) *Conservation research into the preservation of rock paintings in the West* Kimberley Region of Western Australia: Wet Season Report. Report to the Heritage Council of WA, March 1994, pp-143.

de Giuchen, G., Delivré J. and MacLeod I.D., (1995) "Musée National du Cambodge Phnom Penh", Mission de L'Unesco, 7 au 14 mai 1995, ICCROM, Rome 1995 pp 1 - 50.

MacLeod, I.D. and Haydock, P., (1996) *Research into the Conservation or rock paintings in the West Kimberley: Microclimate data analysis* Report to AIATSIS, May 1996, pp 1-132

MacLeod, I.D., (1997), "Treatment of artefacts from the wreck of the *Diana* (1817): Conservation Issues", Affidavit for the International Tribunal, Government of Malaysia, Kuala Lumpur, Malaysia, pp 1-70

Ford, B., Officer, K. and MacLeod, I.D., (1999) *A study of lichen invasion of Nursery Swamp II, Aboriginal Rock Art Site, Namadji National Park, Australian Capital Territory, Final Report May 1999*, Australian Capital Territory National Parks Association, Canberra 1999, pp. 1-28.

MacLeod, I.D., (2003) "*Metal corrosion in Chuuk Lagoon: A survey of iron shipwrecks and aluminium aircraft,* Report to the US National Parks Authority, Pacific Division, San Francisco, USA, pp 1-92.

MacLeod, I.D., (2003) "The microenvironment of rocks on the Burrup: analysis of the relationships between nutrient supplies, surface pH and microflora – preliminary report, Report to the Minister of Culture and the Arts, pp 1-55.

MacLeod, I.D., (2006), "Conservation of the USS *Monitor* (1862). A report on the conservation facilities at The Mariners' Museum & artefacts from the USS *Monitor* (1862), Western Australian Museum, Unpublished report CMC WAM no 1, pp 1-35.

Jeffery, B., Beger, M., MacLeod I.D., Richards, V.L., Hengeveld, M., and Carpenter J., (2007), Guidelines in Recording and Monitoring the Natural and Cultural Attributes of Submerged Historic Sites in the Federated States of Micronesia, Report to the US National Parks and Wildlife Services, pp 1-65.

MacLeod, I. D., (2009) "Corrosion of a Beretta Pistol in the Georges River", Report to the Attorney General, New South Wales Supreme Court, pp 1- 15.

MacLeod, I. D., & Garcia R., (2009) "Conservation Report on HMVS *Cerberus*: Options for Gun Turrets and Hull" Report No. 2009.001 pp 1-17 Report to the Friends of the Cerberus

MacLeod, I.D., (2009) "Corrosion assessment of a 1989 Mitsubishi Bus" Report No. 2009.002 pp 1-11, Report to the Department of Transport

MacLeod I.D., and Car, R.J., (2012), Significance Assessment of the Textile Collection, New Norcia, Report to the National Library of Australia, 1- 62.

MacLeod I.D., and Car, R.J., (2013), New Norcia ecclesiastical textiles collection: Significance and conservation assessment with development of a treatment priority matrix, Report to the National Library of Australia, 1-78.

MacLeod, I.D. and Richards, V.L., (2013), Conservation survey: Randell Dry Dock, March 2013, Report to the Mannum Dock Museum Board, South Australia, pp 1-40

MacLeod, I.D., (2015), Report on the microenvironment of the interior and exterior of showcases, National Anzac Centre, Albany, Western Australia, October 2014- August 2015, pp 1-18.

Inorganic Chemistry Publications

MacLeod, I.D., Bond, A.M. & O'Donnell, T.A. (1973) "Polarographic procedures in anhydrous hydrogen fluoride: oxidation and reduction of tin (II)" *J. Electroanalytical. Chemistry*: 45:89-98.

MacLeod, I.D., Millington, D., Prescott, A. & Sharp, D.W.A. (1975) "A thermally dependent redox equilibrium in solution" Inorganic *Nuclear Chemistry Letters,* 11: 447-450.

MacLeod, I.D., Manojlovic-Muir, L., Millington, D., Muir, K.W., Sharp, D.W.A. & Walker, R. (1975) "The preparation, n.m.r. spectra and structure of unsymmetrical ditertiary phosphine complexes of platinum (II)" *J. Organometallic Chemistry.* 97: C7.

MacLeod, I.D., Muir, D.M., Parker, A.J. & Singh, P. (1977) "Solvation of Ions. Some Applications. II. Electrolysis of Copper (I) sulphate in water-nitrile mixtures", *Australian J. Chemistry* 30:1423-37.

MacLeod, I.D. & O'Donnell, T.A. (1977) "Polarography of some p-block elements in anhydrous hydrogen fluoride" Inorganic *Chemistry* 16:1433-1437.

Burns, R.C., MacLeod, I.D., O'Donnell, T.A., Peel, T.E., Phillips, K.A. & Waugh, A.B. (1977) – "Xenon difluoride as a selective inorganic fluorinating agent" *J. Inorganic Nuclear Chemistry,* 39:1737-1739.

Filmer, A.O., MacLeod, I.D. & Parker, A.J. (1979) "Oxidation of copper sulphides in aqueous Ammonia II - Electrochemical Aspects" *Australian J. Chemistry* 32:975-87.

Singh, P., MacLeod, I.D. & Parker, A.J. (1982) "Solvation of ions. Part XXX. Thermodynamics of transfer of copper ions from water to solvent mixtures" *J. Solution Chemistry* 11:495-508.

Singh, P., MacLeod, I.D. & Parker, A.J. (1983) "Solvation of ions. Part XXXI. Partial molal volumes of sodium, silver (I) and copper (I) ions in acetonitrile-water mixtures" *Australian J. Chemistry* 36, pp 1675-85.

MacLeod, I.D. & Muir, D.M. (1983) "Reduction of chalcopyrite with copper (I)", *J. Applied Electrochemistry* 13 pp 411-416.

Singh, P., MacLeod, I.D. & Parker, A.J. (1984) "Solvation of ions. Part XXIX. Ionic conductances in acetonitrile-water and pyridine-water mixtures" *J. Solution Chemistry* 13(2): 103-119.

Proposed Technical Ammonium Nitrate Production Facility (EPBC 2008/4546)

Consolidated Approval Notice Condition 10A, On-going Rock Art Monitoring

METHODOLOGY

For 10 years (2004 to 2013), petroglyphs at seven specially selected sites (chosen under the guidance of indigenous elders) in the Burrup Peninsula were measured using colour and reflectance spectroscopy measurements. Three spots on each engraving and three spots on each background rock were measured *in situ* using a portable photospectrometer for colour measurement and a reflectance spectrometer for visible and near infrared analysis. In 2014, the rock art monitoring project expanded at the request of Yara Pilbara Nitrates Pty Ltd (YPNPL). The company was building a Technical Ammonium Nitrate (TAN) Production Facility Project (TAN) on the Burrup Peninsula, and to adhere to the requirements of the Environment Protection and Biodiversity Conservation Act 1999, YPNPL needed to engage a heritage monitor to survey the rock art sites within a two kilometre radius of the project site. CSIRO had been a heritage monitor for the then West Australian Government "Department of Environment Regulation (DER)", now the Department of Water & Environment Regulation (DWER) for the monitoring of the Burrup petroglyphs for the last decade and was considered appropriate to be the heritage monitor for YPNPL.

The rock art study dedicated for the TAN Project required the heritage monitoring of petroglyphs sites within 2km of the plant site. Selected sites were determined in consultation with members of Murujuga Aboriginal Corporation to respect the cultural laws of the traditional owners for the entitlement of access. The selected petroglyphs were firstly evaluated for their appropriateness for scientific study, including petroglyph size and quality, direction of exposure, elevation, dominant and wind direction. From the six selected monitoring sites, three were already part of the decade-old and ongoing Burrup Rock Art Technical Working Group (BRATWG) monitoring program and an additional three sites were also selected. After initial monitoring in February 2014, the three new sites have become part of the BRATWG monitoring program. As well as the three new sites, an extra spot (both engraving and background) was added on each monitored petroglyph panel, bringing the total to eight sampling spots (four areas classified as ‘engraving’ and four areas classified as ‘background’) to increase the accuracy of future statistical analysis of measurements.

Proposed methodology for 2017 rock art monitoring to ensure compliance with Condition 10 of EPBC 2008/4546:

The six sites previously sampled are as follows:

Site name	Coordinates (GDA 94, Zone 50)	
Burrup Rd	475,959	7,719,771
Water Tanks	477,698	7,720,137
Deep Gorge	477,956	7,717,987
Yara West	476,558	7,719,223
Yara North East	479,112	7,720,155
Yara East	478,849	7,719,565

At each of these sites, and in the same locations as previous sampling, measurements will be taken as follows:

1. **Colour and colour contrast**

   Spectrophotometry. Colour measurements will be collected by the use of a portable, hand-held spectrophotometer that measures the degree of lightness (L*), degree of red/green (a*) and degree of yellow/blue (b*) to provide a tri-stimulus value (3D L*a*b*) for each sample point on the specimens. Differences in 3D values across time can be numerically evaluated to identify potential changes in colour.

2. **Mineralogy**

   Reflectance spectrography. A portable spectrometer operating over a 400 to 2500nm wavelength range will be used. An internal light source will be used to irradiate the surface of the rocks, with the reflected light detected by an array of photodiodes. A spectrum of reflectance vs wavelength is generated for each monitoring point on the surface of the rocks, which is then compared to previously collected data from the same points on the same rocks. Changes in the spectra are an indicator of changes in the mineralogy of the rock surface.

Data Analysis Australia review, conclusions and responses

In 2017 DWER commissioned Data Analysis Australia (DAA) to undertake a review of CSIRO work to date (Henstridge *et al* 2017). In terms of the recommendations that were made by Data Analysis Australia in 2016, the following summarises compliance with responses in ***bold italic***:

1. *The historical data collected by the CSIRO should be systematically archived and held by DER, with consistent naming conventions, both to provide a baseline record and to facilitate comparisons with future data. The archival data format should enable ready access to the data via standard statistical software such as R.*

We would describe this as **largely** met:

· The management of the data appears to have improved considerably, although it is not perfect in that the metadata – details of how the data was collected and hence what the data might therefore mean – is not systematically available.
This will be rectified in the current study. Detailed records will be kept on data collection according to scientific norms.

· We remain concerned that there are undocumented features of the data collection process that should be taken into account in any analysis. For example, the substantial year-to-year variation in the ASD data is only partially explained by the differences in recording practices described in the Reports, and the descriptions that do exist are not always consistent.
This will be taken into account.

2. *The CSIRO should be asked to revisit the cross-calibration issues with the BYK and KM spectrophotometers, both to ensure that the historical data is properly understood and to confirm whether or not the historical BYK data is capable of comparison with current and future measurement instruments.*

We would describe this as being **not addressed** in the Draft Report:

· The cross validation methodology for the BYK data has not been revised and is still deficient. The Draft Report appears ambivalent about the utility of the BYK data.

· Whilst the Executive Summary does state “the BYK spectrophotometer data appears unreliable for drawing conclusions on colour change in the rock art”, the data is still given undeserved prominence in the report and the ASD colour data is not discussed as a credible replacement.

· However we suggest that the first part of this recommendation from 2016 concerning the cross calibration should not be given high priority as one solution may be to largely drop reference to the BYK data.

This will be taken into account. Consideration will be given to taking two readings for every point using firstly the previous BYK instrument and then the KM instrument to allow comparison of contemporaneous readings. This will also allow comparison across historical data sets.

3. An analysis similar to that of Black and Diffey should be conducted using verified ASD estimates of L*, a*, b*, *ideally using the original ASD spectra rather than the averaged spectra.*

We would describe this being only **partially** met:

· The analysis in the Draft Report does use linear mixed models as suggested by Black and Diffey. However this is poorly reported and not convincing. Whilst the conclusion given in the Draft Report is that there is no evidence of relevant changes to the rock art in the areas close to the industrial development, it remains arguable that a more careful analysis would demonstrate changes.

This will be addressed in the analysis of data collected in the field.

4. Future work by the CSIRO should be based upon an agreed analysis plan certified by a competent statistician. Since each year the CSIRO reports have covered the full data set since 2004, it would be appropriate for the next published report to incorporate this improved analysis and in doing so, make it clear that it should replace the analyses in their previous reports.

We would describe this as **not** being met:

· No formal analysis plan appears to exist. The analysis methods in Chapters 4 and 5 of the Draft Report are essentially unchanged.

Noted, once data has been collected consideration will be given to commissioning a competent statistician to certify the analysis.

5. Consideration should be given to expanding the number of measured sites and in doing so, improving the balance of the design to include more effective controls, if feasible.

We would describe this as **not** being met:

· No change has been made to expanding the data collection or to include improved controls, although we recognise that the time of the data collection in 2016 meant it could not be affected by our 2016 Recommendations.

· The Draft Report does not discuss possible changes to the design of the data collection.
This will be addressed through consultation with Murujuga Aboriginal Corporation. Consideration will be given to expanding the data set by data collection at additional rock art sites.

7. To maintain scientific rigour, future data collection should follow a fully documented and detailed protocol, and ensure that departures are documented.

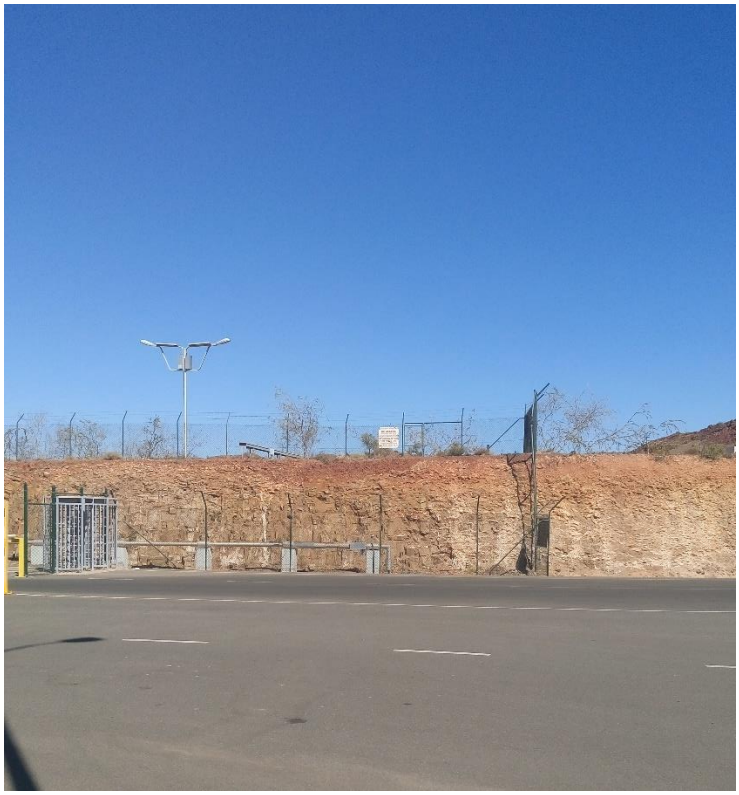
We would describe this as **not** being met:
· Documentation of the data collection protocol does not appear to have improved.
Documentation of the data collection protocol will be improved and will meet international scientific norms and benchmarks.

REFERENCES

Henstridge, J. Haskard, K.Mehryar, M. 2017 Review of CSIRO Report on Burrup Peninsula Rock Art Monitoring. Data Analysis Australia for the Department of Environment Regulation.

Plates

Condition 6: Bird deterrence wires installed over a contaminated water pond



Condition 8: 2.5 m chain link perimeter fence and signage near entrance