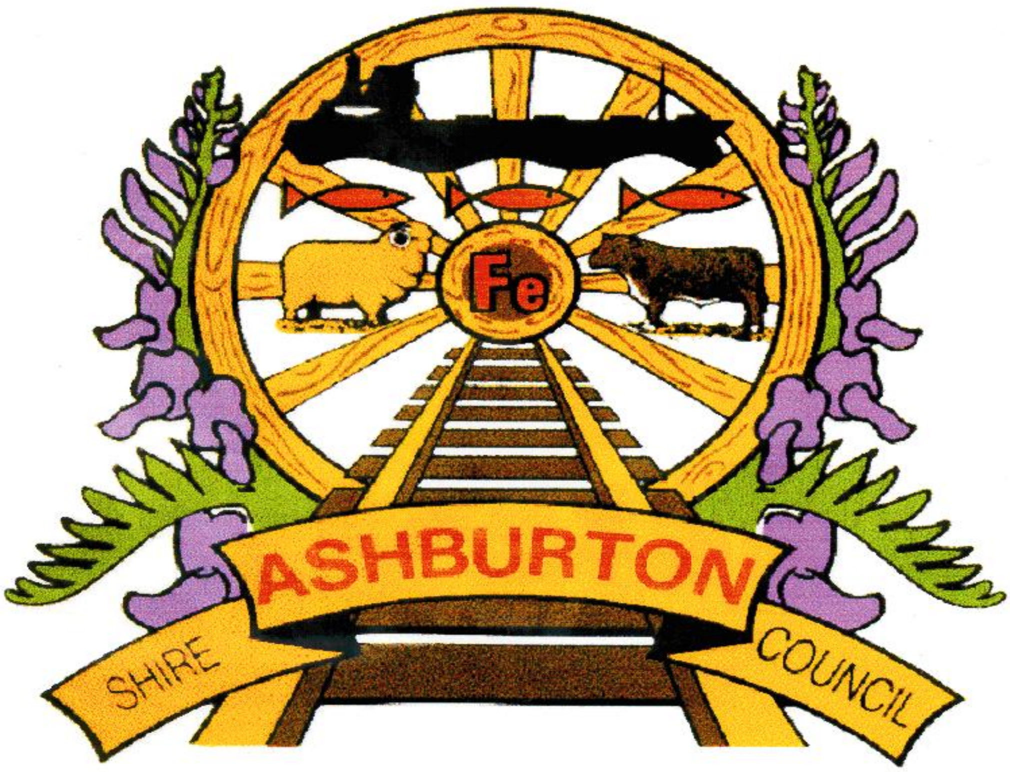

SHIRE OF ASHBURTON

SPECIAL MEETING OF COUNCIL

AGENDA
&
ATTACHMENTS

Council Chambers, Community Recreation Centre, Tom Price

21 March 2013

SHIRE OF ASHBURTON

SPECIAL COUNCIL MEETING

Dear Councillor

Notice is hereby given that an Special Meeting of the Council of the Shire of Ashburton will be held on 21 March 2013 at Council Chambers, Community Recreation Centre, Tom Price commencing at 10:00 am.

The business to be transacted is shown in the Agenda.

Frank Ludovico
A/CHIEF EXECUTIVE OFFICER

DISCLAIMER

The recommendations contained in the Agenda are subject to confirmation by Council. The Shire of Ashburton warns that anyone who has any application lodged with Council must obtain and should only rely on written confirmation of the outcomes of the application following the Council meeting, and any conditions attaching to the decision made by the Council in respect of the application. No responsibility whatsoever is implied or accepted by the Shire of Ashburton for any act, omission or statement or intimation occurring during a Council meeting.

1. DECLARATION OF OPENING

2. ANNOUNCEMENT OF VISITORS

3. ATTENDANCE

3.1 PRESENT

Conference Room, City of Kalgoorlie Boulder 577 Hannan Street, Kalgoorlie

Mr R Yuryevich	Commissioner

Council Chambers, Recreation Centre, Central Road, Tom Price

Mr F Ludovico	A/Chief Executive Officer
Ms F Keneally	Executive Manager, Operations
Ms J Smith	Executive Officer CEO

Onslow Multi-Purpose Centre, Cnr of McGrath & Hooley Avenue, Onslow

Ms A O'Halloran	Executive Manager, Strategic & Economic Development
Ms D Wilkes	Executive Manager, Community Development
Mr Ean McDowell	Construction Manager, Onslow Aerodrome Redevelopment

3.2 APOLOGIES

Mrs L Hannagan	A/Executive Manager, Corporate Services
Mr K Pearson	A/Executive Manager, Technical Services

3.3 APPROVED LEAVE OF ABSENCE

4. ANNOUNCEMENTS BY THE PRESIDING PERSON WITHOUT DISCUSSION

5. DECLARATION BY MEMBERS

That Commissioner Yuryevich has given due consideration to all matters contained in the Agenda presently before the meeting.

5..1 DECLARATION OF INTEREST

Councillors to Note

A member who has a Financial Interest in any matter to be discussed at a Council or Committee Meeting, that will be attended by the member, must disclose the nature of the interest:

(a) In a written notice given to the Chief Executive Officer before the Meeting

or;

(b) At the Meeting, immediately before the matter is discussed.

A member, who makes a disclosure in respect to an interest, must not:

(c) Preside at the part of the Meeting, relating to the matter or;

(d) Participate in, or be present during any discussion or decision-making procedure relative to the matter, unless to the extent that the disclosing member is allowed to do so under Section 5.68 or Section 5.69 of the Local Government Act 1995.

NOTES ON FINANCIAL INTEREST (FOR YOUR GUIDANCE)

The following notes are a basic guide for Councillors when they are considering whether they have a Financial Interest in a matter.

I intend to include these notes in each agenda for the time being so that Councillors may refresh their memory.

1. A Financial Interest requiring disclosure occurs when a Council decision might advantageously or detrimentally affect the Councillor or a person closely associated with the Councillor and is capable of being measure in money terms. There are exceptions in the Local Government Act 1995 but they should not be relied on without advice, unless the situation is very clear.
2. If a Councillor is a member of an Association (which is a Body Corporate) with not less than 10 members i.e. sporting, social, religious etc), and the Councillor is not a holder of office of profit or a guarantor, and has not leased land to or from the club, i.e., if the Councillor is an ordinary member of the Association, the Councillor has a common and not a financial interest in any matter to that Association.
3. If an interest is shared in common with a significant number of electors or ratepayers, then the obligation to disclose that interest does not arise. Each case needs to be considered.
4. If in doubt declare.
5. As stated in (b) above, if written notice disclosing the interest has not been given to the Chief Executive Officer before the meeting, then it **MUST** be given when the matter arises in the Agenda, and immediately before the matter is discussed.
6. Ordinarily the disclosing Councillor must leave the meeting room before discussion commences. The **only** exceptions are:

6.1 Where the Councillor discloses the **extent** of the interest, and Council carries a motion under s.5.68(1)(b)(ii) or the Local Government Act; or

6.2 Where the Minister allows the Councillor to participate under s.5.69(3) of the Local Government Act, with or without conditions.

6. BUSINESS

6.1 ONSLOW AERODROME RUNWAY CONSTRUCTION - DESIGN AND METHODOLOGY FOR PAVEMENT AND BITUMINOUS WORKS

FILE REFERENCE:	OR.CM.10.19
AUTHOR'S NAME AND POSITION:	Fiona Keneally Executive Manager, Operations
NAME OF APPLICANT/ RESPONDENT:	Not Applicable
DATE REPORT WRITTEN:	19 March 2013
DISCLOSURE OF FINANCIAL INTEREST:	The author has no financial interest in the proposal.
PREVIOUS MEETING REFERENCE:	Agenda Item 17.4, Ordinary Meeting of Council 15 February 2012 (Minute No: 11136) Agenda Item 14.1, Ordinary Meeting of Council 13 March 2013 (Minute No: 11466)

Summary

The Shire if currently undertaking the Onslow Aerodrome Redevelopment including the construction of a new 1900m airstrip to CASA Code 3C requirements.

The construction of the runway and associated access roads and carparks require extensive pavement, bituminous and asphalt works to complete the project.

Provision of the required quantities of construction water has been problematic since the commencement of the project given the shortage in available freshwater in the vicinity of Onslow. The construction of the runway embankment has been undertaken with the use of salt water and is nearing completion within the specified area of the runway pavement.

ARRB Group Ltd has been engaged to assist Council to seek possible salt mitigation measures and to gain a full understanding of the long term effects that the use of salt water, local climate and surrounding environment may have on the aerodrome construction site and whether the use of salt water as construction water is a suitable pavement construction alternative.

Prior to progressing further construction works, Council endorsement is required on the following:

1. Acceptance of ARRB Report and ARRB Design and Risk Mitigation Measures
2. Proposed pavement construction methodology
3. Modified Tender Evaluation Criteria for proposed Request for Tender Provision of Bituminous and Asphalt Supply and Services for Onslow Aerodrome and Associated Works.

Background

The Onslow aerodrome, located on Shire land at 16 Onslow Road, is a fit for purpose CASA certified facility that has more than adequately met the existing needs of the community to date.

With the formalisation of the Ashburton North Strategic Industrial Area (ANSIA), and the commencement of both the Macedon and Wheatstone projects, air transport will increase significantly. To serve the projected needs of industry, significant upgrades to all airport facilities are required.

The Onslow Aerodrome Redevelopment includes construction of a new runway, taxiway and apron, a terminal building, new access road and parking facilities. Chevron has agreed to contribute $30 million to the redevelopment project which is to be delivered over a twelve month period.

The provision of construction water has been an on-going concern since the commencement of the project given the shortage in available freshwater in the vicinity of Onslow. To ensure progress to meet required timelines, the construction of the runway embankment has been undertaken with the use of salt-water (in general sea water).

To best understand the effects of the use of salt water on the runway construction, ARRB Group Ltd (formerly the Australian Road Research Board) has been engaged to assist Council to gain a full understanding of the long term effects that the salt water, local climate and surrounding environment may have on the aerodrome construction site and whether the use of salt water as construction water is a suitable alternative.

ARRB Group was formed in 1960 and incorporated in 1965. ARRB Group is owned collectively by Australia's state, federal and local government road authorities. These agencies recognised the benefit of sharing a national strategic research program (NSRP), to provide not only short-term access to improved technical outcomes and efficiencies, but also as a basis for developing and sustaining long-term expertise in the maintenance, operation and development of the public asset and the services it provides.

ARRB Group has a national and international reputation for excellence in transport and infrastructure solutions through research, technical services, leading-edge products and technology transfer.

Approximately one million litres of water will be required per day for use in pavement material pre conditioning, pavement construction and compaction. No potable water is available in the Onslow Township, and the ongoing reliability of bores within 60km of site (along the Onslow Mount Stuart Road) is unknown. Installation of potential bore infrastructure on a pastoral property within 40km of site is awaiting approvals and the anticipated earliest availability of supply is 20th April 2013.

The runway pavement design consists of a 200mm depth subbase layer (consisting of a minus 75mm natural gravel) and a 200mm basecourse layer (consisting of a 20mm crushed rock ,generally to MRWA specifications).

As part of their brief, ARRB Group was requested to

- investigate the use of salt water (sea water) as an alternative solution
- consider and provide risk mitigation measures given the climate and surrounding environment to prevent ongoing asset management impacts

ARRB Group Risk Mitigation Measures are included in “Contract Report – the use of sea water in Onslow aerodrome pavement construction”.

ATTACHMENT 6.1

Comment

Analysis and Clarification of Costs

Water cost for pavement construction

Project Budgeted water costs (Ex GST)	$430,000
Estimated costs utilising sea water (Ex GST)	$430,000
Estimated costs utilising bores (Ex GST)	$950,000

There is a negligible difference in estimated water supply costs between utilising the Onslow – Mount Stuart (Main Roads Western Australia) and Minderoo Pastoral Company bores. However there are scheduling implications which will indirectly impact costs as follows :

- Onslow – Mount Stuart Road bores
    - Water pumping and delivery infrastructure - procurement, delivery, installation and commissioning – 2 weeks – Estimated pavement construction start date 5th April 2013.

- Minderoo Pastoral Company
    - Approvals pending (earliest approval date 12th April 2013)
    - Installation and commissioning of bore infrastructure (estimated earliest completion date 16th April 2013.
    - Water pumping and delivery infrastructure - installation and commissioning – 4 days weeks. Procurement and delivery to occur prior to 12th April 2013. Earliest pavement construction start date 20th April 2013. The cost of the delay to the project will need be calculated.
    - Potential unsealed road cost depended on location of stand pipe

There are also risks with utilising bores associated with the ongoing reliance of supply and quality through the duration of the works. Given historical information, it is unlikely that MRWA bores will yield the required daily quantities, and prior pumping and storage could raise the salinity of the water.

Quality of water from the Minderoo Pastoral Company bore is unknown and further resources may be required for maintenance of the unsealed road whilst water is being carted.

The use of sea water would provide for an immediate pavement construction start which will remain scheduled for the 22nd March 2013.

Primary Risk Mitigation – construction with sea water

The bituminous and asphalt component of the approved budget estimate was based on the initial specification supplied to the Shire by Chevron and their design consultant AMS.

Estimated costs, and current approved budget (inclusive of mobilisation and demobilisation), are based on 2011 contract rates and are as follows –

Primerseal C170 / 10mm Aggregate	$ 471,243
Wearing Course @ minimum depth 56mm AC14DG	$4,571,806
Total (Ex GST)	**$5,043,049**

A revised design was received following commencement of earthworks, however changes to the bituminous specification have only recently become evident to all parties. Design and indicative costs are –

Prime 50/50 Bitumen / medium curing cutter	$ 190,000
2 Coat Seal C320 10/5mm	$1,150,000
Asphalt C320 @ 60mm depth	$4,420,000
Mobilisation / Demobilisation	$ 150,000
Total (Ex GST)	**$5,910,000**

This matter has been brought to the attention of the Onslow Social Infrastructure Working Group and we have been awaiting the ARRB report before progressing the above issue to negotiate all construction variation.

ARRB Group recommendation for risk mitigation measures for the use of sea water throughout pavement construction, and for mitigating secondary environmental risk, includes the following bituminous and asphalt design (indicative costs are shown) –

Emulsion Prime	$ 310,000
Waterproofing polymer modified binder 14mm S10E	$ 880,000
Asphalt 56mm AAA MT 001 (Airport Mix)	$4,220,000
Mobilisation / Demobilisation	$ 150,000
Stand By Costs contingency[1]	$ 50,000
Total (Ex GST)	**$5,610,000**

[1] The ARRB option may incur standby costs (due to the recommended methodology) if dry back periods vary with weather conditions. A provisional amount of $50,000 should be considered additional to the total.

Secondary risk – sea water inundation

An option to mitigate additional capillary rise is the application of a thick geotextile fabric (PF2 or equivalent) prior to the placing of pavement material. Enquiries regarding the availability of PF2 indicate that it would not be available for 4-6 weeks and the application to PF1 with a polymer modified emulsion is not considered financially viable. Further discussion with ARRB has resulted in the recommendation of Bidim A34 (or equivalent) which is more readily available throughout the industry. Indicative costs to undertake this option are as follows –

Supply geotextile fabric (allow for overlap)	$170,000
Freight	$ 20,000
Installation	$ 40,000
Cost implication to placing subbase (up to 20%)	$105,000
Total (Ex GST)	**$335,000**

The process of spreading subbase material is less efficient than that of normal construction to avoid damage to the geotextile fabric.

Conclusion

Water for pavement construction

The decision to progress pavement construction with sea water does contain some risks, however ARRB Group conclude that these risks can be "contained to an acceptable level" if primary risk mitigation methodologies are applied during the construction process.

Disadvantages to the project in progressing with bore water supply include -

- Delays of 2 – 4 weeks (or more) in commencing pavement construction associated with the procurement, delivery and installation of bore infrastructure and potentially associated approvals.
- Estimated costs to proceed with bore water exceed the approved budget by approximately $520,000 ($950,000 less $430,000).

Risks associated with water supply from bores include the reliability of ongoing yields and water salinity levels.

Advantages in progressing with sea water are that the project can progress on its current schedule at no additional construction cost.

In considering the water supply options, it is important to be aware that the subbase material proposed for construction is from the same source as the select fill on the earthworks formation. Salt water has been used to precondition this material prior to ripping and crushing, and stockpiles watered as a dust control measure for the construction site and the operations of the existing runway.

Refer ARRB Contract Report – The use of sea water in Onslow aerodrome pavement construction, "Section 5.3 – *Having already compacted the select fill with sea water, the literature suggests that even if potable water was used for the subbase and basecourse, mitigation measures would still be required. This means that the use of saline bore water for remaining basecourse compaction would have no real advantage over continuing with sea water*."

ARRB have also advised via email "*any delays to the project are probably the highest risk of all – giving potential for salt to rise to the surface caused by the surface drying out (leaving the salt behind to crystallise) to be replaced by salt water arriving by capillary action.*"

It is therefore considered that the additional expense and the associated delays of sourcing water from bores is not required, providing that the primary risk mitigation design below is adopted and careful attention if given to risk mitigation measures in recommended chronological order.

Primary Risk Mitigation

It seems apparent that the original bituminous design is inadequate for the application to the aerodrome runway, given the runway location and the earthworks construction process. It is assumed that the revised project design resulted from later geotechnical investigations into the proposed runway alignment, however was never highlighted as a change in scope after the Aerodrome Project budget was established and agreed with stakeholders.

Regardless of whether pavement construction progresses with sea water or bore water, the ARRB Group Ltd bituminous seal and asphalt design would seem the most appropriate and cost effective, as it also addresses further risks associated with future capillary rise resulting from sea water inundation (tidal and storm surge).

The adjacent existing runway was constructed in 2006 using freshwater in both the rework of the existing basecourse and the addition of a 200mm pavement layer utilising imported natural gravel and treated with a stabilising product (Kalfoss). There have been ongoing maintenance issues with the sealed surface since construction, which have been mitigated with regular pneumatic rolling and resealing. These seal issues have been consistent with effects of salt damage.

The estimated costs to proceed with the ARRB Group design exceed the approved budget by approximately $520,000 (Ex GST) and would also require a provisional sum of up to $50,000 to allow for any material dry back delays that could result from weather conditions.

If the ARRB Group design is adopted, then given the careful methodology required and focus on particular materials for a purpose design it is seen as necessary to apply modified weightings to standard qualitative selection criteria for the provision of services and materials, to meet a purpose design specification and required construction methodology and timelines.

The tender will require submission of schedule of rates for the provision of bituminous and asphalt supply and services. It will also require the submission of a proposed asphalt design mix that complies with the specification. The General Conditions of Contract shall be AS2124 - 1992. A best value for money approach shall be applied to the tender. This means that although price is considered, the tender containing the lowest price will not necessarily be accepted, nor will the tender ranked highest on qualitative criteria. The following criteria and weighting is proposed for application to the tender:

a) Relevant Experience Demonstration of experience in completing / supplying similar requirements, particularly in relation to experience with supplying to State and/or Local Government	10%
b) Demonstration of ability to meet required timeframes Indication of how timeframes will be met. Outline of availability of plant and personnel and future known commitments	20%
c) Demonstration of ability to meet required specification Provision of compliant asphalt design mix; provisions of NATA Testing Certificates demonstrating compliance with specification from proposed mix sources	30%
d) Occupational Health Safety Management Provision of an overview of the status of Respondent's safety management system	10%
e) Tendered Price	30%

Shire of Ashburton FIN04 – Buy Local – Regional Price Preference Policy (Management Policy) shall also apply to the Tender evaluation.

Public invitation will need to occur as soon as practicable following receipt of Council's endorsement and approval of recommended specification in order that it may be awarded in a timely manner to ensure that works on the Aerodrome construction critical path continue.

Secondary risk – sea water inundation

The estimated cost to undertake the secondary risk mitigation of covering the earthworks formation with geotextile fabric exceeds the approved budget by approximately $335,000 (Ex GST).

Indicative prices and availability of appropriate geotextile fabric have been sought for the purposes of this report. Extensive on-line research has been conducted comparing technical data from suppliers and formal requests for these companies to supply equivalent product data sheets have been submitted We are aware a WALGA Preferred Supplier (this reduces the tender timeframes) can provide an equivalent product but quantities and delivery times are not confirmed.

It has previously been mentioned that salt water has already being utilised for moisture conditioning subbase material as the subbase material has been selected through the process of winning select fill for the earthworks embankment. The stockpiled material has also been watered with sea water for dust suppression to ensure the continued operation of the existing aerodrome service whilst undertaking the improvement project. This has minimised the impact on flight service for the Wheatstone Project.

If it is a practical mitigation proposal to cover the subbase with geofabric, and still achieve the desired mitigation outcome, then potential construction delays due to availability of the product would be minimised.

Consultation
Kym Neaylon - National Technical Leader – Surfacings (Pavements and Surfacings) ARRB Group Ltd
Riaan Burger - Principal Engineer, Sustainable Infrastructure Management, ARRB Group Ltd
Darren Lunburg - Project Team Leader - Community and Essential Infrastructure (Wheatstone)
Frank Ludovico - A/Chief Executive Officer
Amanda O'Halloran - Executive Manager Strategic and Economic Development
Ean McDowell - Construction Manager Onslow Aerodrome Redevelopment
Allan Monson - Capital Works Manager

Statutory Environment
Local Government Act 1995, S3.57 Tenders for providing goods or services
Local Government (Functions and General) Regulations 1996 – Part 4; Division 2; r. 14 (2a)

Financial Implications
Implementation of the design recommendations will exceed the Council approved budget, however adoption of the design is intended to improve the life cyclic costs of the aerodrome runway asset.

The original the bituminous and asphalt component of the approved budget (in 2011 dollars) was $5,043,049 and if Council agrees with the recommendations the anticipated cost for these works are $5,610,000 a difference of $566,951.

Including the secondary risk mitigation measures of $335,000, this will bring to the total additional cost to $901,951.

This amount provides for the construction of pavement with sea water. If other options are used then the estimated additional cost will be a minimum of $520,000.

The Administration believes this should be funded from the Wheatstone Community Development Fund as it is the major legacy project for Onslow.

Strategic Implications
Shire of Ashburton 10 Year Community Strategic Plan 2012-2022
Goal 04 – 'Distinctive and Well Serviced Places'
Objective 01 – Quality Public Infrastructure
Objective 02 – Accessible and Safe Towns
Objective 03 – Well Planned Towns

Policy Implications
FIN04 – Buy Local – Regional Price Preference Policy and
FIN12 – Purchasing & Tender Policy
FIN14 – Shire of Ashburton Tender Assessment Criteria Policy

Voting Requirement
Absolute Majority Required

Recommendation
That Council:

1. Receive ARRB Group Ltd Contract Report – The use of sea water in Onslow aerodrome pavement construction.

2. Endorse ARRB Group Ltd Contract Report – Section 6.1.1 – Risk mitigation measures 5, 6, 7, 8, and 9 with attributed costs of $520,000 plus provisional sum of $50,000 (Ex GST).

3. Endorse the construction of the aerodrome runway pavement using sea water, providing all primary risk mitigation measures as recommended in ARRB Group Ltd Contract Report Section 6.1.1 are adopted throughout construction.

4. Endorse ARRB Group Ltd Contract Report – Section 6.2 – Risk mitigation measures 1,2 and 4, providing ARRB Group Ltd confirm that, in the event of supply delays, it remains a practical mitigation measure to cover the subbase with geotextile fabric and achieve the desired mitigation outcome with attributed costs of $335,000 (Ex GST).

5. Negotiate with the Onslow Social Infrastructure Working Group to obtain the additional funds of to undertake the revised runway works.

6. invite public tenders for the Provision of Bituminous and Asphalt Supply and Services for Onslow Aerodrome and Associated Works, to be issued in accordance with the following evaluation criteria:

a)	Relevant Experience	10%
b)	Demonstration of ability to meet required timeframes	20%
c)	Demonstration of ability to meet required specifications	30%
d)	Occupational Health Safety Management	10%
e)	Tendered Price	30%

Author: Fiona Keneally	**Signature:**
Manager: Frank Ludovico	**Signature:**

7. NEXT MEETING

The next Ordinary Meeting of Council will be held on 10 April 2013, at the Council Chambers, Central Road, Tom Price commencing at 1.00 pm.

8. CLOSURE OF MEETING

ARRB Group Ltd

www.arrb.com.au

ACN 004 620 651
ABN 68 004 620 651

- Research and Consulting
- Systems

CONTRACT REPORT

The use of sea water in Onslow aerodrome pavement construction

Project No: 006623

by Kym Neaylon, Riaan Burger

for Shire of Ashburton

Commercial in confidence

Trusted advisor to road authorities for technical input and solutions

March 2013

The use of sea water in Onslow aerodrome pavement construction

for Shire of Ashburton

	Reviewed
Project Leader	Riaan Burger
Quality Manager	Tyrone Toole

006623-1
March 2013

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THE USE OF SEA WATER IN ONSLOW AERODROME PAVEMENT CONSTRUCTION

Version Control					
ARRB Project No	006623	Client Project No			
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Author	Kym Neaylon, Riaan Burger	PL	Riaan Burger	QM	Tyrone Toole
Milestone		Title			

Version	Date	Technical/Quality Checks	By
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1.11	6/03//13	Input by second author	AFB
1.12	5/03/13	Checked by Technical Manager	PM
1.13	5/03/13	Library references and superseded references checked	AJM
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1.16	8/03/13	Approved by Quality manager	TYT
2.00	13/03/13	Release to client	KLN
Comments			

SUMMARY

$30 million has been allocated for construction of a new runway and terminal at Onslow aerodrome. This construction is being managed by the Shire of Ashburton, which will become the asset owner.

Approximately one million litres of water will be required per day for use in pavement construction and compaction. No potable water is available in the Onslow township, and the reliability of supply of bore water within a 60 km radius is unknown. Other potential sources of freshwater from remote sources that were earlier considered have not now eventuated. Seawater is currently being used for the earthworks construction and compaction, and is under consideration for use in subbase and basecourse construction.

Senior management of both the Shire and Chevron need to make an informed decision on the risks of using a sea water option for the construction of the runway basecourse.

ARRB was engaged to identify these risks, and to identify engineering control measures to mitigate these risks.

As a result of this work, it is believed the risks of using sea water in the construction of the Onslow Aerodrome can be contained to an acceptable level by using the risk mitigation measures as described in Section 6 and applied during the subbase and basecourse construction.

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

1.1 Background

In late 2011, Chevron Australia began construction of the $29 billion Wheatstone liquid natural gas (LNG) project, located 12 kilometres west of Onslow on the Pilbara coast of Western Australia. This is planned to be one of Australia's largest resource projects. The initial stage will consist of two LNG trains with a combined capacity of 8.9 million tonnes per annum (MTPA), plus a 200 terajoule per day domestic gas plant. The project has approval to expand to 25 MTPA of LNG, with first LNG expected in 2016 (Chevron Australia 2012)

Chevron has committed more than $250 million to social infrastructure projects in Onslow. Of this, $30 million has been allocated for construction of a new runway and terminal at Onslow aerodrome. This construction is being managed by the Shire of Ashburton ('the Shire'), which will become the asset owner.

Approximately one million litres of water will be required per day for use in pavement construction and compaction. No potable water is available in the Onslow township, and the reliability of supply of bore water within a 60 km radius is unknown. Other potential sources of freshwater from remote sources that were earlier considered have not now eventuated. Seawater is currently being used for the earthworks construction/compaction, and is under consideration for use in subbase and basecourse construction.

An accompanied site inspection was undertaken by the authors on 26 February 2013, at which time the earthwork construction was almost complete, with pavement construction programmed to start in early April. It is understood the runway is programmed to open by the end of May.

Senior management of both the Shire and Chevron need to make an informed decision on the risks of using a sea water option for the construction of the runway subbase and basecourse.

1.2 Aim

This report aims to

- review previous published experience with the use of saline water in pavement construction
- gain an understanding of the mechanisms that lead to failure in pavements constructed with saline water
- devise engineering mitigation measures to reduce the risk of such failures
- assess the remaining risks and advise on the feasibility of using sea water for the total aerodrome pavement construction.

2 LITERATURE REVIEW

2.1 The salt content of seawater

The mention of sea water occurs frequently throughout this report, so it is appropriate to start with an introduction on the salt content of seawater, and the different ways of expressing it.

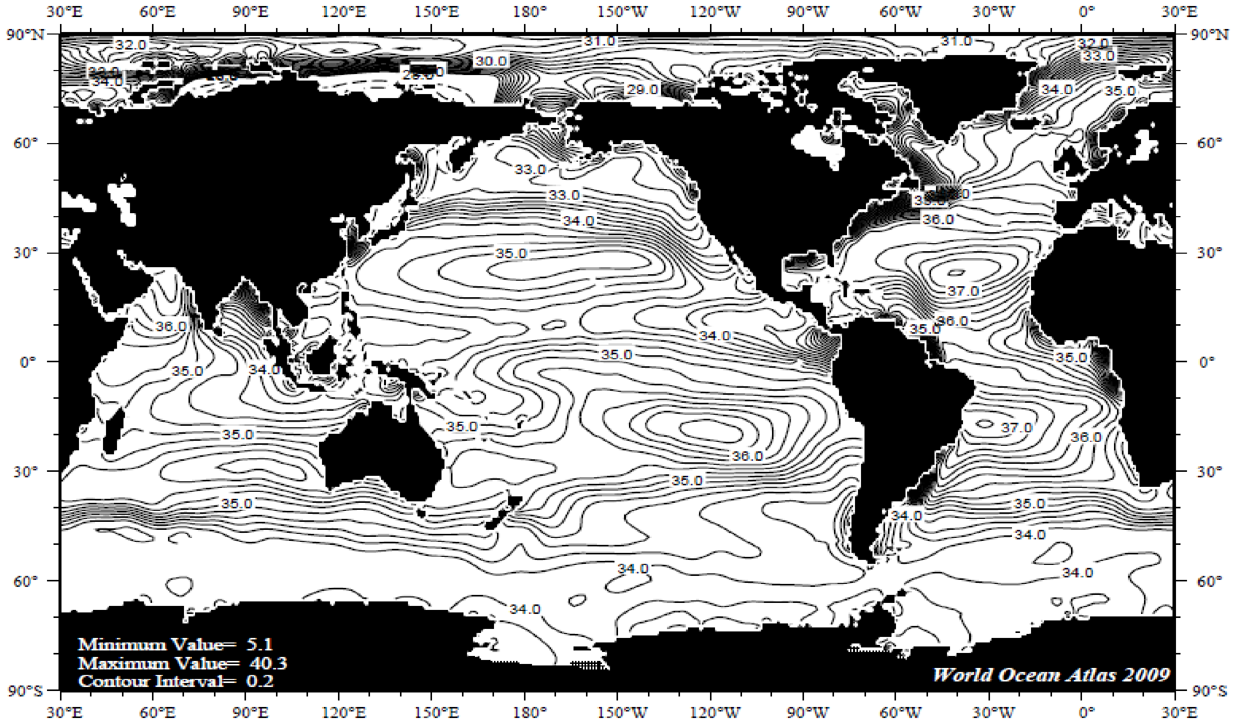
Ocean salinity is generally defined as the salt concentration (e.g. sodium and chloride) found in sea water. The internationally agreed unit for measuring salinity in seawater is the *practical salinity scale 1978*, (UNESCO 1981) which has resulted in the *practical salinity unit*.

The PSS (Practical Salinity Scale) is based on the properties of sea water conductivity at a standard temperature and pressure. In practice, it is roughly equivalent to dissolved salts in parts per thousand or (o/00) or g/kg.

Thus 35 units on the practical salinity scale is roughly equivalent to

- 35 parts per thousand (o/00) or
- 35,000 parts per million (ppm) or
- 3.5 parts per hundred (%) of dissolved salts.

The salinity of seawater at the ocean surface is not a constant, but varies as shown in Figure 2.1



Source: Antonov et. al. (2010).

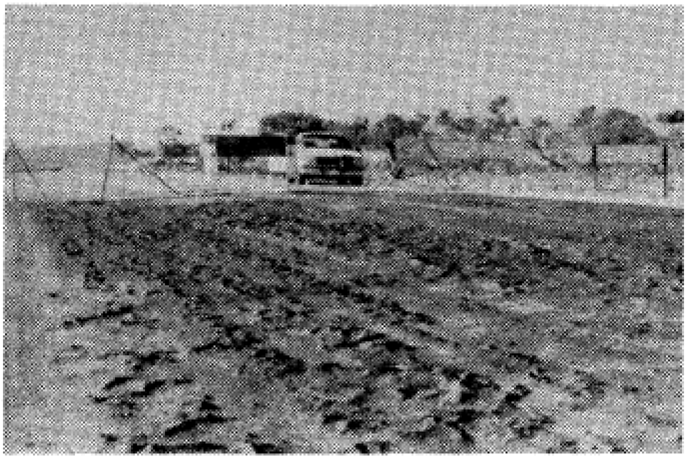
Figure 2.1: Annual salinity [PSS] at the ocean surface

From Figure 2.1, the salinity of surface seawater in the Onslow area would be around 3.5%

2.2 South Australia

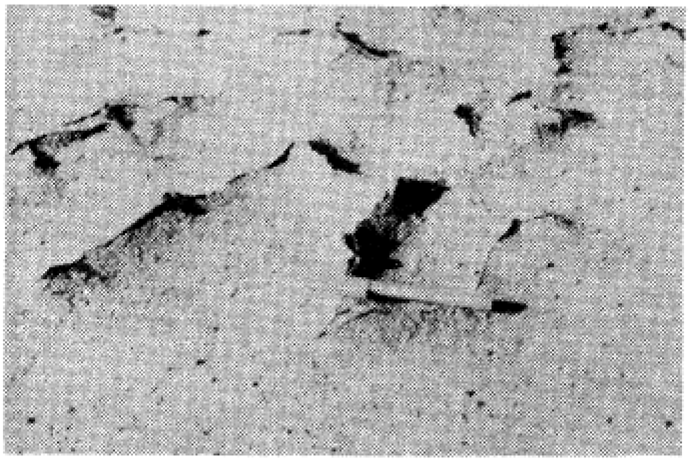
2.2.1 1980s

Sea water and some saline bore water have previously been used for road pavement construction in South Australia. Januszke and Booth (1984) report that the Streaky Bay to Ceduna road was constructed using mainly sea water and some saline bore water. The top of the base course powdered, but the problem was overcome by using a special primerseal (SP 1000). On this basis it was considered reasonable to use the same approach on the Stuart Highway (Port Augusta to Glendambo). However, the bore water used had extremely high soluble salt contents, usually between 6% and 14%, but sometimes up to 24%. The resulting primer-sealed surface exhibited 'blistering, cracking, lifting at the edges and, in extreme cases, disintegration'. Examples of this are shown in Figure 2.2, Figure 2.3, and Figure 2.4.



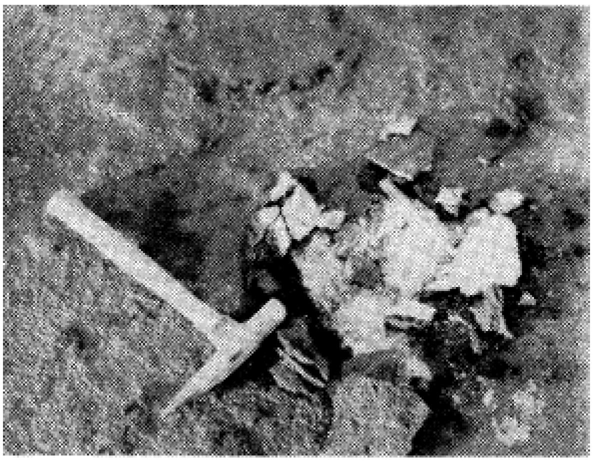
Source: Januszke and Booth (1984).

Figure 2.2: Severe blistering of tar prime section



Source: Januszke and Booth (1984).

Figure 2.3: Close-up of blisters



Source: Januszke and Booth (1984).

Figure 2.4: Salt crystals under prime

In order to understand the failure mechanism involved, Januszke and Booth undertook a literature review and concluded:

- Damage to the pavement surface was caused by upward migration of dissolved salts in water to the pavement surface.
- The upward migration of water appeared to be caused by capillarity and diurnal temperature fluctuations.
- Migration of salts had been recorded elsewhere from depths of up to one metre.
- Evaporation of the water and crystallisation of the salts under the seal weaken and eventually destroy the bond between the basecourse and seal.
- Vapour pressure of the evaporating water plus the crystal growth caused the blistering of the primerseal.
- The bursting of the blisters permitted more rapid escape of moisture and accelerated the migration of salts to the surface, with resulting degradation and powdering of the top of the basecourse.

With this in mind they undertook several field trials aimed at selecting construction techniques and preventing or retarding moisture migration using an impermeable seal. In these trials,

- Care was also taken to reduce the fines at the surface of the basecourse. The practice of slurrying the surface to give a smooth finish was avoided as it gave a surface high in fines and in salt.
- The primerseal was applied as soon as possible to prevent or retard the upward migration of water.
- If not immediately opened to traffic, the primerseals or seals were rolled daily with multi-tyred rollers to prevent blisters from forming and to roll down any that did.

They commented that only minor improvements could be achieved by modifying construction techniques within their economic constraints, and decided that the greatest hope of success lay with an improved seal design to achieve maximum impermeability. They also found that emulsion primes rather than cut-back primes added further weight and strength to resist salt attack.

Nine years after laying these trials, the authors reviewed their performance (Januszke and Booth 1992). They said they had also considered the possibility of using a sacrificial pavement layer about 30 mm deep above the finish level, which would collect concentrated salts and could then be removed. This treatment was not pursued because of the nature of the rubbles used, and the impracticality of being left with a rough surface.

They concluded that a polymer modified binder of around 1.5% - 3% would have further resisted salt attack, although these products were not available at the time of initial construction, and were considered too expensive even nine years later.

Their review supported all of the conclusions made in their earlier paper, which they summarised as

- Provision of an impervious seal is the most important factor.
- Follow this seal by immediate trafficking or rolling.
- A coarse textured basecourse low in fines is necessary.
- An emulsion prime and light holding seal, followed by a double seal, provided a strong waterproof surface which solved the problem.
- The holding seal should be trafficked (rolled) if there is a time delay before the final seal.
- Polymer modified binders would provide a stronger waterproofing seal.

2.2.2 2000s

In the early 2000s, the lead author (Neaylon, unpublished) monitored the early life of South Australian sprayed seals on the Port Lincoln Western Access, where the earthworks were constructed/compacted using sea water, and the Streaky Bay – Ceduna road near Streaky Bay, where the shoulder widening works were constructed with sea water. Sea water was used not by choice, but because of the severe drought in the area causing potable water restrictions.

It is understood that no special mitigation measures were taken for these seals. There was no visible evidence on the Port Lincoln western access that sea water had been used, however this was not the case for the shoulder widening.

The shoulder widening was constructed by bringing in a top-up material, reworking all material with a Bomag pavement recycler, compacting using sea water over the full depth, and then sealing with a 10 mm emulsion primerseal followed by a 5 mm emulsion seal in November 2002.

Salt appeared to prematurely age the binder very quickly, and when the new work was inspected by the author two months after construction, the binder condition was rated as ‘poor’. However, the seal was still functioning well at this stage (Figure 2.5 where RN is the Department of Transport Road Number, and MM is the maintenance marker, giving site location in km with zero commencing at the northern end of the highway).

Source: Neaylon

Figure 2.5: RN 2200 Flinders Highway, from MM 101.65, looking west towards Streaky Bay, 16 Jan 2003

However, the fresh binder continued to undergo rapid aging and soon started flaking from the surface, as shown in Figure 2.6.

Source: Neaylon

Figure 2.6: Salt damage on shoulder widening constructed with full depth sea water, 5 months old

At five months this damage was not serious enough to warrant rework, but monitoring ceased when the author relocated his employment interstate.

2.3 The United Kingdom and Botswana, 1990s

In the 1990s, collaborative research work by the UK Transport Research Agency (TRL), the Birmingham University, and the Ministry of Works, Botswana, resulted in the publication of a report entitled *Avoiding salt damage to bituminous surfacings: results from a road trial in Botswana* (Woodbridge et. al. 1994).

This report commences by asserting that damage is caused by the upward movement and then crystallisation of salt in the top of the pavement which then lifts bituminous material off and destroys adhesion to the pavement base. The process is essentially a physical one, no chemical effect between salt and bitumen is involved.

A field trial consisting of 13 different sections was devised and constructed, to investigate the salt content of the basecourse materials and the water used, the type of prime, the time delay between completion of the base and the application of the prime, and the time delay between completion of the prime and the application of the sprayed seal. Two impermeable membranes, one being a thick bitumen layer and the other being a polyethylene sheet, were also incorporated at the bottom of the basecourse at two sections.

Methods for determining salt content were time consuming and required skill, so the researchers used electrical conductivity (EC) and devised a relationship between that and total soluble salt (TSS).

Climate was an important factor in the research. The authors reported that

> Rapid evaporation, promoted by high temperatures and wind speeds, together with low precipitation are key elements in the salt damage process. Also, atmospheric humidity is fundamental to crystal growth because crystallisation will occur only when ambient relative humidity is lower than the equilibrium relative humidity of the saturated salt solution (Cooke et. al., 1993). For these reasons, the salt damage phenomenon is not encountered in cooler or wetter climates. The equilibrium relative humidity of sodium chloride, the main salt type, is 76%.

As evaporation is an essential process in the salt crystallisation cycle, permeabilities of various treatments were estimated. An un-primed base was approximately ten times more permeable than a primed base, and a cutback prime was slightly more permeable than an emulsion prime. Both single and double sprayed seals were virtually impermeable with the test method used.

The double sprayed seals on the saline subgrade trial section remained undamaged for as long as they were trafficked, but became progressively damaged when traffic was withdrawn. It was presumed that traffic must oppose the upward force of the salt crystallisation, and maintain the adhesion between bitumen and basecourse.

The impermeable polyethylene sheeting was regarded as a success in the field trial. However, it was cautioned that the coefficient of friction would be low at this interface and could result in shear failure if traffic stresses exceeded a ‘safe’ value. The polyethylene sheet acts as a debonding layer between the basecourse and lower layers, negating the friction (i.e. horizontal shear resistance) between the layers and thereby reducing the overall load bearing capacity of the pavement. Effective load transfer between pavement layers relies on the friction, or the bond, between subsequent layers in order for it to occur – this is analogous to a laminated timber beam.

2.4 Botswana, 2001

Following on from the previously discussed collaborative research by the TRL UK, Birmingham University and the Botswana Ministry of Works, the Republic of Botswana issued a *Guideline on the prevention and repair of salt damage to roads and runways* (Obika 2001). This guideline is probably still the most up-to-date guideline available on this topic.

It opens by saying that soluble salt damage to bituminous surfacings occurs in countries where the annual evaporation exceeds the annual rainfall, and there is a net upward migration of soil moisture. If soluble salts are present in this water, they will crystallise at or near the surface. In these countries there may also be a large variation between day and night temperatures and humidity. This can result is some salts dissolving and then recrystallising more than once in a day, causing large disruptive pressures.

The guideline discusses several case studies from Botswana, including runways and roads. Impermeable plastic sheeting placed at the top of the subgrade to prevent upward salt migration into the basecourse, seems to have worked well.

Extracts from this report are shown below, under various topics.

a) Surface impermeability

> Relative impermeability can be achieved by using a minimum of 30 mm dense asphalt concrete. The essential function of a thick surfacing is to stop evaporation and hence migration and crystallisation of salt at the surface. If salt is kept in solution or in a totally dry state, damage will not occur. Damage will occur once the salts are allowed to re-crystallise.
>
> Pavement damage from soluble salts appears to be confined to thin bituminous surfaces, generally less than 50 mm thick. Thick surfacings minimise evaporation and hence reduce migration and crystallisation of salts at the surface.
>
> Bitumen rubber or polymer modified binders used for sealing have been shown to retain impermeability for longer periods than conventional binders. Where there is a high risk of salt damage rubber bitumen should be considered

The reason for the apparent inconsistency in minimum thickness is not clear. The two paragraphs are from different sections of the guide. It appears that the authors intended the guide to set the minimum thickness at 50 mm to ensure a sufficiently impermeable surface.

b) Priming:

> Emulsion primes are less susceptible to salt damage than cutback primes. Emulsion primes tend to sit on the surface rather than penetrate into the pavement layer. This provides lower permeability and hence reduces the damage potential. Road sections with emulsion prime will generally not suffer damage despite high soluble salt contents, provided the prime is left no longer than 48 hours before application of a double seal.

c) Immediate covering:

Immediate sealing can prevent the accumulation of the salt at the surface after compaction with a relatively impermeable surfacing. This reduces evaporation and ensures that salt does not migrate rapidly and crystallise at the surface. This approach was used commonly on rural roads projects where salts were identified to be problematic.

Substantial salt accumulation may occur at the exposed surface in periods longer than 24 hours.

d) Basecourse finish

Fine grained pavement materials are more likely to encourage higher capillary rise of saline moisture. The resulting salt crystal pressures are also higher. To mitigate salt damage it is better to avoid a fine graded basecourse finish where practical. Slushing, for example, should be avoided where other considerations permit.

There is evidence, from laboratory studies and field observations, to suggest a high risk of surfacing damage when salts in a pavement layer are subjected to repeated wetting and drying (solution and re-crystallisation). Construction practices which involve repeated wetting of the pavement during construction should be avoided.

e) Climate

Temperature, relative humidity, wind-speed and rainfall all influence salt damage. They affect evaporation significantly and hence the potential for upward salt migration. Temperature and relative humidity also determine whether salt crystallisation thresholds are crossed. Precipitation influences the net water balance at a given location and also whether there is a seasonal or perennial moisture deficiency which would provide the conditions for a net upward saline moisture migration.

f) Risk evaluation

Salt damage risk evaluation is recommended whenever a bituminous surfacing is proposed for a pavement in Botswana. Clearly, the damage process is dependent on a complex interaction of many variables, but the proposed design method is based on two significant parameters, salt content and climate, which can be measured relatively easily. Further design parameters can be added as other variables can be linked to the damage process in qualitative terms.

2.5 Main Roads Western Australia,

2.5.1 2003

Main Roads Western Australia has a road note on *Surface 'blistering' and soil 'fluffing'* (MRWA 2003). The omission of the word salt in the title seems to be deliberate, as the document explains that:

> Soluble salts are not necessarily the sole agents causing the problem; rather they contribute in combination with other factors. Under some circumstances saline soils and seawater has been used without giving problems. However there is evidence that failure has resulted from the use of saline materials and it is therefore advisable to restrict their use to a minimum.

Mitigation measures suggested include:

- a light spray of distillate to lay dust, then sealing the surface immediately, and omitting the primerseal
- high void content within the base layer to prevent vapour pressure build-up
- limit use of compaction water to a minimum
- dry the formation as much as possible before applying a bituminous coating
- in extreme cases, priming the subgrade to produce a water-proofing layer that will prevent capillary rise.

None of the literature sighted thus far has suggested causes other than soluble salts, nor have any authors recommended a spray of diesel on the surface as a preventative measure. This may have been a specific local treatment arising from the past.

2.5.2 2007

The MRWA document. *Water to be used in Pavement Construction,* (Main Roads Western Australia 2007), specifies that water intended for use in pavement construction shall be potable, or shall contain not more than 3000 mg/L of total soluble salts (TSS).

For water that does not meet this specification a risk analysis is advised, with a high risk minimum treatment being:

> Apply prime and two coat seal (14/10 mm two coat seal) within 2 days of completing pavement. Traffic immediately or implement extended rolling.

2.6 Sua Pan airport runway, 2004

The failures at this airport were mentioned in the Botswana case examples of Obika (2001), however further detail is documented in a paper *Blistering and cracking of airport runway surfacing due to salt crystallisation* (Netterberg and Bennet 2004).

The formation was constructed using brine water with a total dissolved solids (TDS, another term for TSS) content of 4% to 15%. Due to a shortage of fresh water, the brine was also used for the subbase. Fresh water was however used for the basecourse. Construction progress suffered several delays in 1989. By July 1990 significant failures occurred, as shown in Figure 2.7 and Figure 2.8.

Source: Netterberg and Bennet (2004).

Figure 2.7: Volcano blisters and salt in loosened primed base

Source: Netterberg and Bennet (2004).

Figure 2.8: Salt blistering

Following an investigation, the authors considered that

> It is not the presence of dissolved or even high levels of solid salt that causes damage, but rather when dissolved salt crystallizes or salt is dissolved, migrates and crystallizes elsewhere. In essence, such damage is caused by upward migration of salts dissolved by or in the compaction water towards a permeable surfacing (or edge) and their crystallization on evaporation of sufficient of the water. The growing crystals weaken and/or destroy the bond between the base and the seal, disrupt the upper base and crack and/or blister the surfacing. Water vapour pressure during hot weather as well as crystal growth may play a role (Netterberg and Loudon, 1980). Cracking of the surfacing accelerates the damage by permitting more rapid evaporation and/or ingress of rain water which mobilizes further salt. The prime is incapable of binding the loosened upper base and some of the binder in the seal may also be absorbed. With time, traffic and insufficient maintenance the surfacing disintegrates, scabs off, and potholes form.

The authors commented that the longer the delay between layers in dry weather, the greater the likelihood of salt damage, due to extended capillary action, and also that the final surface (in this case a cape seal) was not impermeable enough.

They lamented that

> Although seawater has been successfully used up to the top of the sub-base for many years in the Cape and Namibia, the use of fresh water alone in the base without additional precautions was not successful in this case. Although precautions were specified, they were not achieved.

2.7 Australian Salinity Conference, 2004

The first National Salinity Engineering Conference was held in Perth from 9–12 November 2004. Kodikara et al. (2004) presented a paper *A Synthesis of Mechanisms and Factors Affecting Salt Damage to Road Infrastructure*, from which the following is quoted:

> The main mechanism of salt damage appears to be due to salt crystallization which can generate large pressures sufficient to lift or crack pavement materials. The composition of salt water is important because each salt type has its own crystallization phases and pressures, and the salt interaction can alter the individual salts properties.
>
> Preventive measures are based on both reducing the salt ingress and the salt concentration due to surface evaporation. The first is achieved by limiting the salt content in materials and/or water and limiting water ingress by various means. The second is achieved by providing thicker and less permeable seals and/or using stabilised pavement materials.

> References included in this paper should lead the reader to a range of guidelines for preventative measures. These include: limiting the salt content in the construction materials and water, using higher bitumen thickness (over 30 mm thickness) with less permeability (or limiting the permeability/thickness ratio), using aggregates with less fines to minimise potential for salt crystallization, raising pavement to cut down capillary rise, using capillary or ‘salt’ break to minimise water and salt ingress and salt crystallization, providing proper drainage blankets sometimes involving geotextiles, the use of hydrophobic polymeric products to enhance the properties of the pavement materials, and the use of plants to maintain the watertable adequately below the pavement base. However, owing to many interacting factors, the effectiveness of these measures should be examined on scientific and economic merit and on site specific basis.

2.8 Austroads/AAPA, 2008

Austroads is the association of Australian and New Zealand road transport and traffic jurisdictions, and AAPA is the Australian Asphalt Pavement Association, and industry body. They issue joint pavement work tips on a number of road surfacing related topics, including one titled *Sprayed sealing of drought and salt affected pavements* (Austroads/AAPA, 2008).

This document is fundamentally a simplification and reformatting of the work contained in Januszke, R. M. and. Booth E. H. S (1984 and 1992), and offers no new findings.

2.9 Austroads 2008

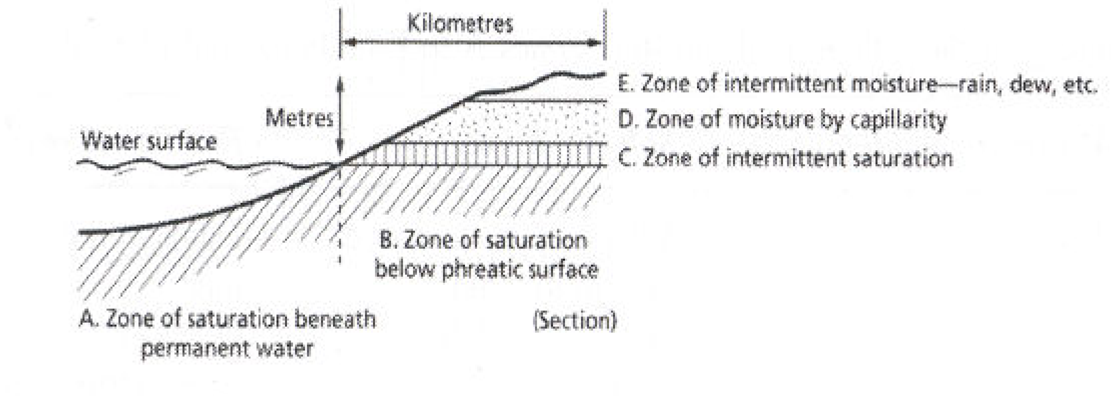
Austroads sponsored a Technical Research Project ‘*Managing the Impacts of Rising Watertables and Salinity on Pavement Performance*’. which commenced in 2005/2006. A technical report was published in 2008 (Austroads 2008). Some relevant extracts from this report are

> The term, ‘total dissolved solids’ (TDS) describes all solids that are dissolved in water, mostly mineral salts. TDS and electrical conductivity (EC) are dependent and closely correlated measures: the higher the salt content of water, the higher the electrical conductivity value. Rather than performing expensive chemical analyses, salinity measurements in the field are normally taken using an electrical conductivity meter (water salinities) or an electromagnetic survey instrument (soil-water salinities in the ground).

and

> Most road damage will be associated with thin granular pavements, particularly sprayed seal surfacings. The cycle of salinity damage will be initiated as soon as the pavement seal is cracked, allowing entry of water and losses by evaporation. The provision of a thin (30-50 mm) asphalt surfacing in lieu of a sprayed seal is an option for minimising evaporation and salt precipitation in the road base.

The *capillary fringe* referred to by other authors is also shown diagrammatically as zone D in Figure 2.9



Source: Austroads(2008) (after Bell 2004, after Fookes and French 1977).

Figure 2.9: Soil moisture zones in relation to road construction

2.10 University of Newcastle, 2013

Austroads has a current PhD fellowship awarded to Mr de Carteret, whose thesis topic with the University of Newcastle is *Environmental salinity and bitumen sealed unbound granular pavements*. To date he has published a literature review (de Carteret, Buzzi, Fityus, 2010), and details of the establishment of a field trial (de Carteret, Buzzi, Fityus, 2012).

In a personal discussion with Mr de Carteret on 20/2/13, he foresaw two issues with this aerodrome project.

- initial – caused by a very high salt content of the earthworks and pavement construction
- long term – caused by salt water intrusion at a later date. This mechanism has come under renewed scrutiny in Australia since the recent Queensland floods

With regard to managing the initial problem, he discussed:

- limiting the time between completion of the pavement construction, and application of the surfacing
- limiting the time between the prime/primerseal and the final surfacing
- reducing the permeability of the final surfacing
- using C320 bitumen or crumb rubber/polymer modified binders rather than C170 bitumen
- building in a moisture cut-off barrier
- building in a sacrificial thickness of base layer, and leave unsealed, if construction programming warranted it.

2.11 Summary

Previous published experience with the use of saline water in pavement construction has been reviewed. It has been presented in a chronological order, in order to show that in general the advice provided initially has been accepted and continually built upon by further generations - therefore it can be considered proven.

Thus, a common and international accepted understanding of the mechanisms that lead to failure in pavements constructed with saline water has been obtained, with various engineering mitigation measures identified to reduce the risk of such failures.

It appears also that if these mitigation measures are specified but not implemented, it is probable the surfacing will fail.

3 SITE INSPECTION

3.1 Introduction

For readers unfamiliar with civil construction, an introduction to *Australian Height Datum* (AHD) and *Reduced Level* (RL) will be of assistance. This discussion is relevant because of the close relationship of sea levels and sea water to this project, and the terms AHD and RL are used frequently in the remainder of the report.

Australian **Mean sea level** for 1966-1968 was assigned a value by analysing 30 tide gauges around the coast of the Australian continent (Geoscience Australia 2012). Of interest to this aerodrome project, these reference tide gauges included the ports of Broome, Port Hedland, and Carnarvon.

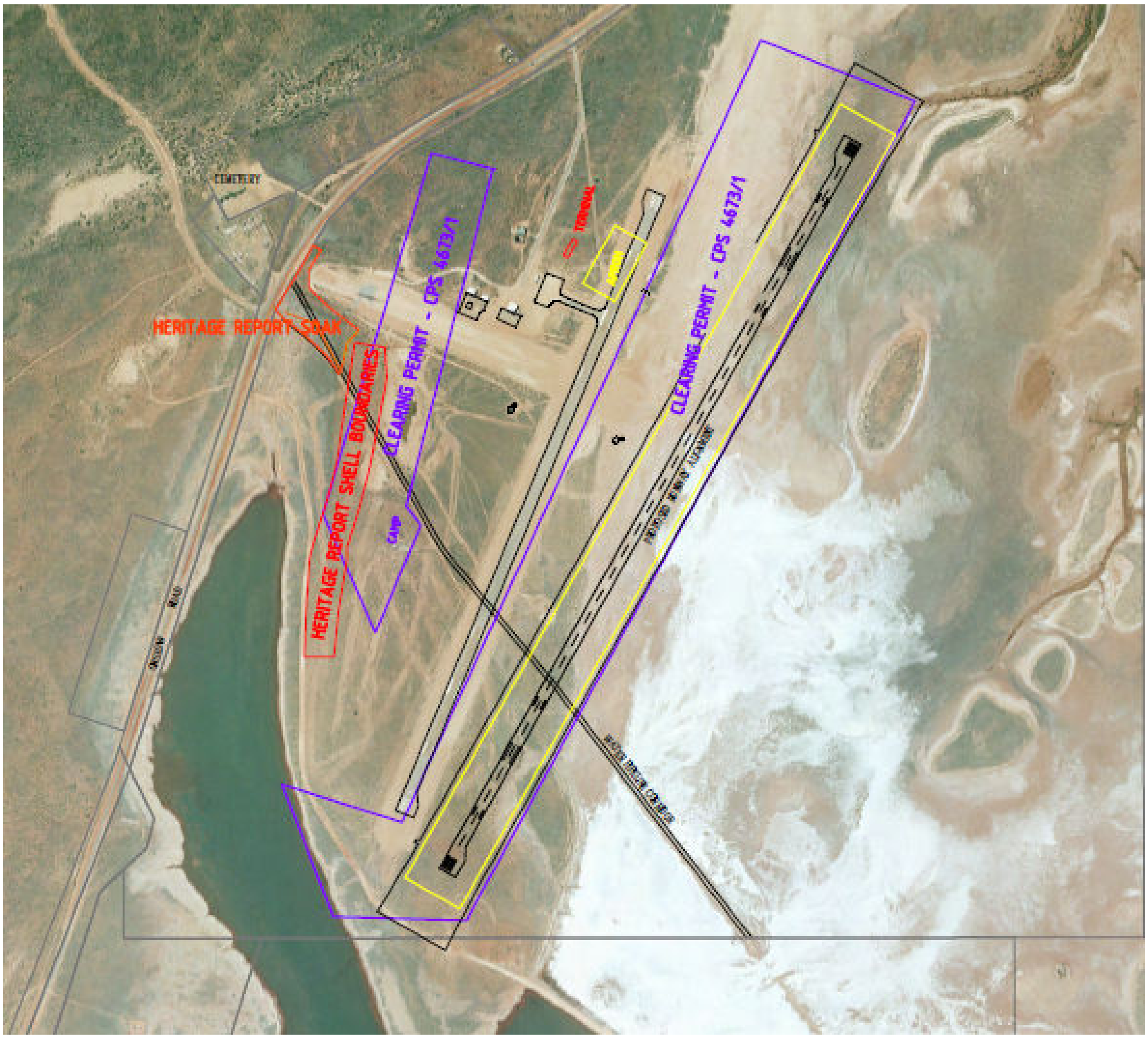
The resulting mean sea level datum surface is termed the **Australian Height Datum**, is nominated as being 0.000 m, and is adopted as the datum to which all vertical control for Australian mapping is to be referred (Geoscience Australia 2012).

Reduced Level (RL) refers to reducing (or equating) levels (elevations) to a common datum, which is either a real or imaginary location with a nominated elevation of zero. On large construction projects such as this one, mean sea level (i.e. AHD) should be used. On small low budget projects, any datum is often assumed and the starting point of a survey is often nominated to be RL 100.000.

3.2 New runway construction

The new runway will be surfaced to 1,900 m long by 36 m wide, and built to CASA Code 3C. The design aircraft are F50 and F100 (Golder Associates 2011).

The location of the new runway with respect to the existing runway is shown in Figure 3.1 The existing runway has remained operational whilst the new runway is being constructed.



Source: Whelans (2012)

Figure 3.1: Location of the new runway relative to the existing runway

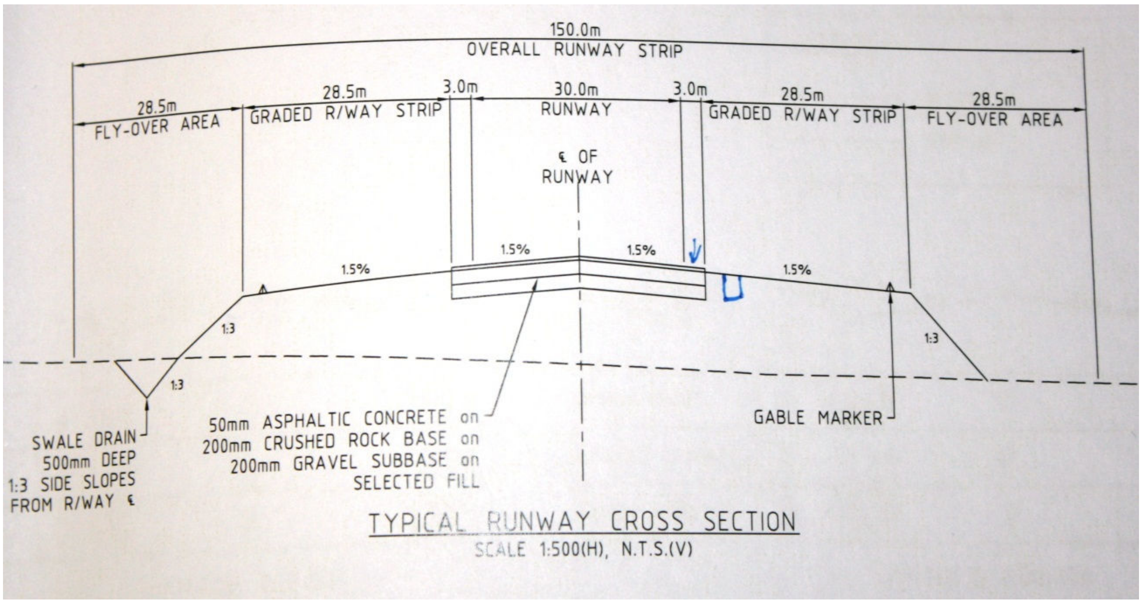
The white area in the aerial photograph (Figure 3.1) is probably salt, and there are commercial salt farms around the aerodrome site. At the time of the site visit, these white areas were inundated with sea water (Figure 3.3). The site visit was essential, to be able to appreciate the conditions in which the runway is being built.

The aerodrome is located in an area that may be described as a salt pan. This is replenished with sea water from a number of inlets, the closest to the site being Beadon Creek. There is also a commercial salt farm nearby. (Figure 3.2).

Source: Google Maps (2013)

Figure 3.2: Aerial view of Onslow aerodrome area showing extent of salt pan

Figure 3.3: Proximity of sea water to the runway earthworks



Source: photographed from an Aerodrome Management Services (2011) hardcopy held at the site office

Figure 3.4: Typical runway cross-section

Figure 3.4 shows the typical runway cross-section. The design level on the runway centreline is RL 4.27, and the vertical grade is 0%. The natural surface is shown as a dashed line, typically at RL 1.0 to RL 1.5 in low lying areas. When the photograph at Figure 3.3 was taken, salt and sea water was seen ponding at this level. (Note that at the time of the site visit, there was a full moon, causing ‘spring’ tides, and Tropical Cyclone Rusty (category 4) approx. 450 km to the north. These may have influenced tidal levels. Refer to Appendix A).

A variation to the original design was the addition of a TX 160 tri-axle geogrid to the natural surface, prior to the placement of the select fill formation. This can be seen in Figure 3.5 (where the sea water is also seen co-existing at natural surface level).

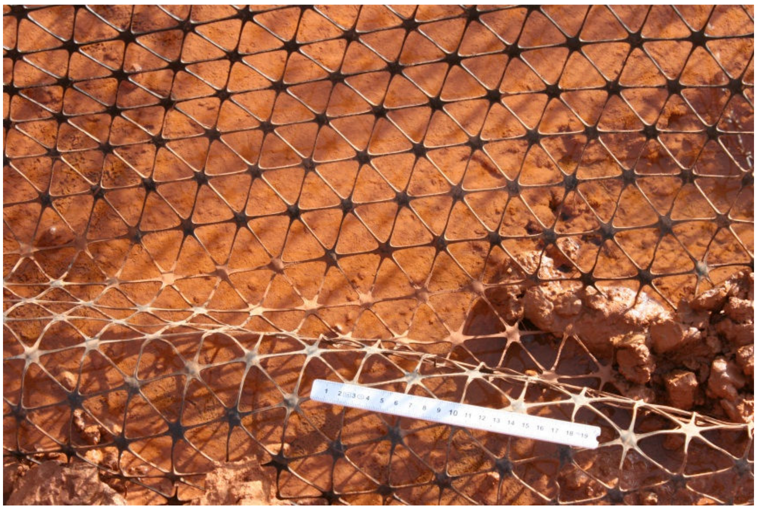


Figure 3.5: Tri-axle geogrid placed over natural surface prior to placement of select fill

Construction of the select fill formation was then observed, with sea water being used for the compaction water. It is extracted as per Figure 3.6, and can be sprayed directly on to the formation as per Figure 3.7

Figure 3.6: Sea water for compaction is extracted from adjacent to the earthworks

Figure 3.7: Sea water applied to formation works

Figure 3.8: Seawater stored at the 'turkeys nest'

Sea water is also transported to a central storage called the 'turkeys nest' (Figure 3.8), where it can be irrigated onto the select fill overnight (Figure 3.9), thus pre-wetting fill to around 5% moisture content prior to transportation to the runway construction site. Once there, more sea water is added until it reaches optimum moisture content (OMC) of around 6½ - 7%.

Source: Ashburton Shire Council (2012)

Figure 3.9: Sprinklers set up near the turkeys nest to pre-condition the select fill

3.3 Existing runways

3.3.1 Runway 03/21

This is the main runway, sealed with a sprayed seal, and is 1,600 m long and 30 m wide. Runway 03 has an end elevation of 5.0 ft. (i.e. 1.53 m AHD) and an alignment of 030 °Magnetic. Runway 21 has an end elevation of 4.0 ft. (i.e. 1.22 m AHD) and an alignment of 210 °Magnetic (Airport-data.com 2013, and CASA 2012).

Discussions with Shire staff indicate this pavement was constructed using fresh water. Even so, salt damage is still present in the form of blistering, and the mitigation approach adopted is to roll periodically with a pneumatic multi-tyred roller. The spray seal could be a single seal, rather than the more usual airfield double or triple seal.

Figure 3.10: Existing runway 03/21, at the 21 end

Figure 3.11: Sprayed seal on existing runway

Figure 3.12: Salt damage on existing runway

Figure 3.13: Apparent salt damage mitigated by pneumatic tyred rolling

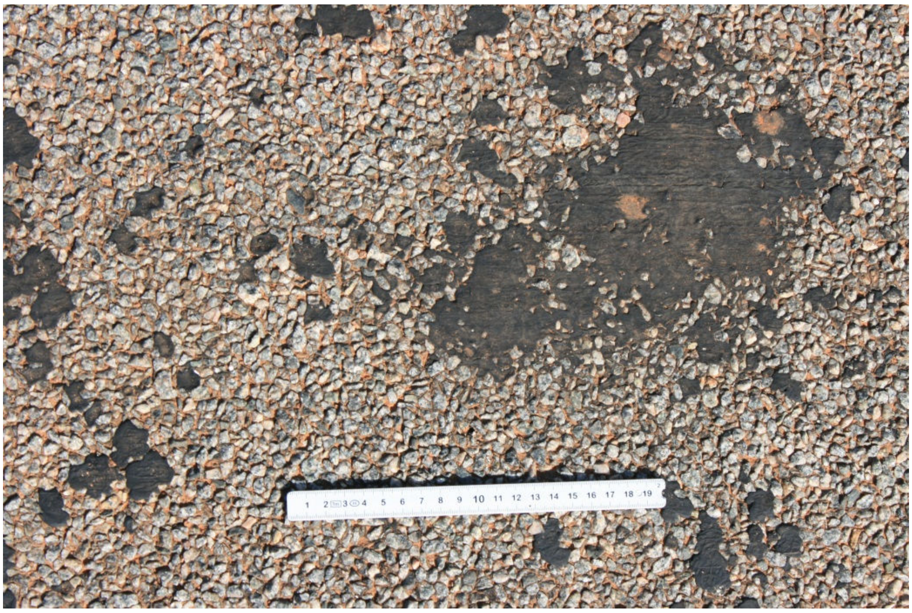


Figure 3.14: Apparent salt damage mitigated by pneumatic tyred rolling

Figure 3.15: Salt damage

The runway surface elevations vary from RL 1.22 to RL 1.53. As calculated in Appendix A, the highest astronomical tide (HAT) at Onslow (Beadon Creek) is RL 1.44 (above one end of the runway). The maximum recorded tide (period 1985 to 2010) is RL 1.77 (above both ends of the runway).

The cause of salt damage on this runway is likely to be migration of sea water through the pavement layers from the water table below, combined with occasional sea water overtopping described below.

The new runway is being constructed to a surface centreline of RL 4.27.

3.3.2 Runway 12/30

This runway was an unsealed cross-strip of 993 m by 30 m, with alignment of 112 °Magnetic and 292 °Magnetic (Airport-data.com 2013, and CASA 2012). It has been scavenged for use as select fill in the new runway construction, and is substantially no longer in existence.

3.4 Pavement material

The subbase (200 mm depth) will be a minus 75 mm crushed limestone, and the basecourse (200 mm depth) will be a 20 mm crushed granite meeting the project specification, which is more stringent than the Main Roads WA specification for basecourse.

The material is being sourced from the WA Limestone Pty Ltd Mt Minnee – Onslow quarry, approx. 80 km SE of the aerodrome.

At a site inspection of the quarry on 26/02/13, the material appeared to be of a very good quality (Figure 3.16 and Figure 3.17). A 20 kg sample of the basecourse material was collected for future laboratory testing for adhesion compatibility with various bitumen emulsion products.

There was not a large quantity of basecourse material in the stockpile, and there is a possibility of delays in material supply after construction commencement in about 4 weeks’ time.

Figure 3.16: Basecourse material (loose)

Figure 3.17: Basecourse material (compacted under the tyre of a front end loader)

Some preliminary test results of the proposed basecourse material were provided to the authors. The test results indicate compliance with the relevant project specifications with the strength exceeding the minimum requirement – measured at 160% and 180% CBR[1] compared to the specification minimum of 140% CBR. It appears that the material's fines content is at the lower end of the specification, with 5% and 6% passing by mass, respectively. This fines contents are encouraging as the literature review indicated that the fines content of materials should be limited.

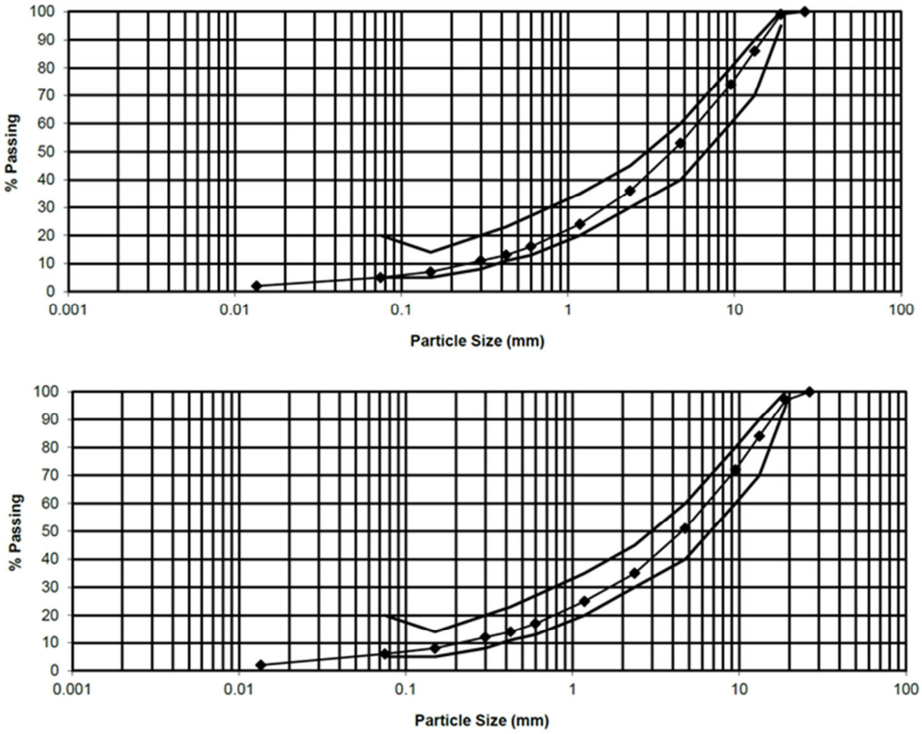


Figure 3.18: Particle size distributions for two crushed granite basecourse samples from Mt Minnee quarry

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[1] California bearing ratio (CBR) is a relative measure of a materials load bearing capacity, and is widely used in design and specifications of pavement structures and materials.

Figure 3.19: Site trial of basecourse material compacted with sea water, primed and asphalted

It was very interesting to see a trial of the basecourse material compacted with sea water, primed, and surfaced (Figure 3.19). This was at a temporary apron extension as part of a cyclone evacuation risk management measure, and will be removed when this aerodrome project is completed.

This has demonstrated that the material can be laid without a slurry of surface fines, and that the prime will adhere to the granite material.

3.5 MRWA bores

Main Roads Western Australia (MRWA) bores are located at distances of 20, 40 and 60 km from the construction site. It is understood that none of these have been used on any regular basis, so that the reliability of supply is unknown. Details of these bores have been sighted, showing salt contents varying from 610 to 3,400 (units not given, but could be ppm or mg/L) of sodium chloride (Na Cl) and 980 to 3,800 units of total soluble salt (TSS). Estimates of yield range from 4,000 L/hr. to >10,000 L/hr.

The bore water closest to the quarry (i.e. 60 km from site) was sampled by Shire staff and tested during the site inspection, but the salinity was beyond the range of the test instrument to hand. This meant that the *Botswana Taste Test* (Obika 2001, page 27) had to be implemented. The water tasted to be about as salty as sea water, and with a sharp, tangy taste. Further sampling was postponed until a different test instrument could be obtained.

Figure 3.20: Field sampling and testing of bore water

4 LABORATORY TESTING

It is proposed that for stage 2 of this consultancy, laboratory testing will comprise:

- determination of total soluble salts (TSS) and electrical conductivity (EC) of the sea water as sampled from the surface of the 'turkeys nest' at the construction site. Test Method WA 910.1, or other method will be used.
- laboratory compaction of the sample of basecourse material obtained, using water of the same TSS as the construction water. Various emulsion prime products to be applied to this sample to observe their ability to adhere to and to penetrate the basecourse.

5 RISK ASSESSMENT

5.1 Climate

Wood bridge et al. (1994) advised that the salt damage phenomenon is not encountered in cooler or wetter climates, and that key elements in the salt damage process are

- rapid evaporation
- high temperatures
- high wind speeds
- low precipitation
- ambient humidity lower than 'equilibrium relative humidity' of sodium chloride (76%). It was noted there was a significant increase in salt crystals as relative humidity decreased, which was amplified at higher temperatures.

Obika (2001) adds that salt damage occurs when

- annual evaporation exceeds annual rainfall
- there is a large variation between day and night temperatures and humidity.

He also comments that Na Cl crystals are stable at relative humidity below 76%, and above this crystals will attract moisture from the air and return into solution.

Australian Bureau of Meteorology climatic data has been obtained, and is shown in Appendix B. For convenience, it has been summarised for Onslow in Table 5.1

Table 5.1: Onslow climatic factors (approximate)

Factor	Wet season (summer)	Dry season (winter)
Evaporation (mm)	1,100 – 1,200	500
Precipitation (mm)	100 -200	25 - 50
Net moisture gain/loss	1,000 – 2,000 loss	450 – 475 loss
Relative humidity 9 am (%)	50 -60	50 -60
Relative humidity 3 pm (%)	30-40	30 -40
Maximum temperatures (°C)	33 - 36	27 - 30
Minimum temperature (°C)	21 -24	12 -15

The biggest climatic risk is the evaporation rate, which can be around 10 times the precipitation rate, year round. This will generate a large capillary action, bringing salty water to the surface where the pure water will evaporate and the residual salt will remain at the surface, with the process repeating in cycles. The maximum daily temperatures are warm enough year round to encourage this.

The relative humidities appear to be lower than 76%, such that salt crystals will form and the crystals will not be dissolved back into solution again.

The relative variations between day and night temperatures do not appear to be large, particularly when compared to desert type climates.

Overall, the biggest risk appears to be in the action of capillary rise.

For a comparison, Sydney airport also has runways built close to seawater, as shown in Figure 5.1. Could any knowledge be gained from this?

Image: Jonathon Rankin, from http://www.ausbt.com.au/sydney-airport-s-latest-plan-add-two-more-runways

Figure 5.1: Sydney Airport parallel runways

The climatic maps from Appendix B show that although Sydney can be in the critical relative humidity zone in the mornings, the temperatures are much lower and rainfall easily exceeds evaporation, as summarised in Table 5.2. This author is not aware of any particular measures taken at Sydney airport to address salt issues, a belief supported after reading Gomes and Richards (1995). *Design of Sydney airports parallel runway,* and Baulderstone's (2009) construction summary.

Table 5.2: Sydney climatic factors (approximate)

Factor	Summer	Winter
Evaporation (mm)	500 - 600	200 - 300
Precipitation (mm)	800 – 1,000	400 - 600
Net moisture gain/loss	300 – 400 gain	200 – 300 gain
Relative humidity 9 am (%)	70 - 80	70 - 80
Relative humidity 3 pm (%)	50 - 60	50 - 60
Maximum temperatures (°C)	18 - 21	24 - 27
Minimum temperature (°C)	15 - 18	6 - 9

5.2 Materials

Apart from the water used for construction compaction, the remaining materials appear to be of acceptable quality.

5.3 Use of potable water for remaining basecourse construction

Having already compacted the select fill with sea water, the literature suggests that even if potable water was used for the subbase and basecourse, mitigation measures would still be required. This means that the use of saline bore water for remaining basecourse compaction would have no real advantage over continuing with sea water.

Given the precedence of Section 2.6, Sua Pan airport runway, the authors see little advantage in reverting to potable water for the remaining basecourse construction, as the same construction risk mitigation procedures, priming, water proofing layer and asphalt design would still be recommended.

5.4 Sea water inundation

The tidal calculations from Appendix A show that the top of the select fill/bottom of the subbase will be 2.4 m above the highest astronomical tide, and 0.9 m above the Cyclone Vance[2] water level. It is not known how far up from the water level the capillary fringe will rise (the 'zone of moisture capillarity' shown in Figure 2.9)

Bore hole testing commissioned by Golders reports that groundwater was encountered in all bores along the new alignment at depths ranging from 0.1 to 3.0 m below natural surface level.

The risk of pavement salt damage by long term capillary action of the underlying water table is not known, but could possibly be less than the immediate risk posed by construction with salt water.

5.5 Summary

The main risk in using sea water for the pavement construction is capillary rise of salt which would be deposited at the interface between the bituminous pavement surface and the basecourse, causing blistering cracking and eventual disintegration of the surface. Previous experience has shown that this risk can be mitigated by placing an impermeable layer at the surface, to prevent evaporation and hence capillary rise of salt.

The placement of the impermeable (in this case bituminous) layers on the pavement surface is the most critical part of the mitigation process.

It is also important to note that some authors assert that an asphalt layer of between 30 and 50 mm would be sufficient to solve the problem. The asphalt layer proposed for this project is 50 mm thick.

A secondary risk would be for the longer term, being inundation of salt into the select fill from high tides, and then subsequent capillary rise into the basecourse.

With engineering mitigation measures in place, and with proper attention to construction timing and detail, there is evidence that these risks can be successfully managed.

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[2] Cyclone Vance was a severe tropical cyclone of category 5 that crossed the coast 80 km west of Onslow in March 1999. It caused severe flooding in the Onslow area.

6 RISK MITIGATION MEASURES

6.1 Primary risk – construction with sea water

6.1.1 Recommended option

The recommended risk mitigation measures for using sea water throughout the aerodrome pavement construction are presented in chronological order, following construction stages.

1. Avoid unnecessary repeated wetting of the pavement material during construction (if possible).

2. Should there be any short delays in supply of base and subbase materials, keep the existing layers moist with *fresh water*, to prevent capillary rise and to avoid the addition of further salt during these delay periods.

3. Do not slurry the basecourse surface. Leave it 'bony', as per the trial section shown in Figure 3.19. Fines aid capillary action and attract salt crystals, and slurried final surfaces are usually provided to meet surface roughness specifications.

4. Advise the asphalt contractor that surface roughness may need to be taken out through the asphalt layer.

5. **Prime** with an emulsion prime as soon as dry-back has been reached.

6. Within (say) one day of priming, apply a polymer modified binder (PMB) **waterproofing seal**. The PMB recommended is a 14 mm S10E, with binder application rate of 2.2 L/m^2 and light aggregate spread rate of (900/average least dimension, ALD) m^3/m^2. Do **NOT** use cutter. The seal will not be open to public traffic and aggregate retention only needs to support the low speed operation of the asphalt pavers, and the asphalt needs to be placed before the time it would take for any cutter to evaporate.

7. Back-roll the waterproofing seal every day with pneumatic multi-tyred rollers until the asphalt is laid.

8. The asphalt needs to be an airport mix, designed to the Australian Airports Association AAA MT 001.

9. **Asphalt** is laid as soon as practicable after the waterproofing seal.

6.1.2 An alternative option

An alternative option is described below, which could have been recommended should construction and opening timings have permitted, or which could still be applied should unforseen long delays eventuate.

1. Avoid unnecessary repeated wetting of the pavement material during construction (if possible).

2. Build in a sacrificial layer of basecourse, minimum 50 mm deep (i.e. construct to 50 mm above design level).

3. Leave un-slurried and unprimed, and exposed to air for as long as is necessary.

4. Salt will naturally accumulate in this 50 mm layer.
5. When construction is about to recommence, remove the 50 mm sacrificial layer. The remaining surface will be rough, but can be smoothed out by the later asphalt layer.
6. Continue with items 4, 5, 6, 7, 8, 9 as per the recommended option.

6.2 Secondary risk – sea water inundation

The asset owner will need to decide whether leaving this unquantifiable risk untreated is acceptable. However, it should also be considered as an additional capillary rise mitigation measure to that described above, i.e. it would give **additional reassurance of protection against the primary risk**.

If resources allow these risks to be further mitigated, an additional impermeable layer placed between the select fill and the subbase is recommended. Note that this will need to be applied *before* subbase and basecourse construction commences.

1. Work select fill to the design level and allow dry back if necessary
2. Cover the select fill with a thick geofabric (PF2 or equivalent). Geofabric is recommended rather than polyethylene sheeting (e.g. Forticon, used in concreting work), as it will maintain pavement friction between the select fill and the subbase course
3. If sufficient quantities of PF2 cannot be obtained in the short lead time available, then instead cover the select fill with thinner geofabric (PF1 or equivalent) and apply a polymer modified emulsion (PME) over the fabric at an application rate of about 1 L/m^2 residual, or as per manufacturer's instructions (the supplier of the geofabric might specify a PME that is most suitable for the fabric)
4. Continue with subbase and basecourse construction as above.

7 CONCLUSION

Although constructing and compacting pavements with salt water is inherently risky, mitigation measures have been identified in past work to manage these risks.

It is believed the risks of using sea water in the construction of the Onslow Aerodrome can be contained to an acceptable level by using the risk mitigation measures as described in Section 6 and applied during the subbase and basecourse construction.

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APPENDIX A CONVERSION OF TIDE GAUGE DATUM TO AHD

The vertical datum at most tide gauges in Australia (including Onslow at Beadon Creek) is set at the lowset astronomical tide[3].

The Bureau of Meteorology has plotted monthly sea levels at Onslow for the period 1985 to 2010, and has determined that:

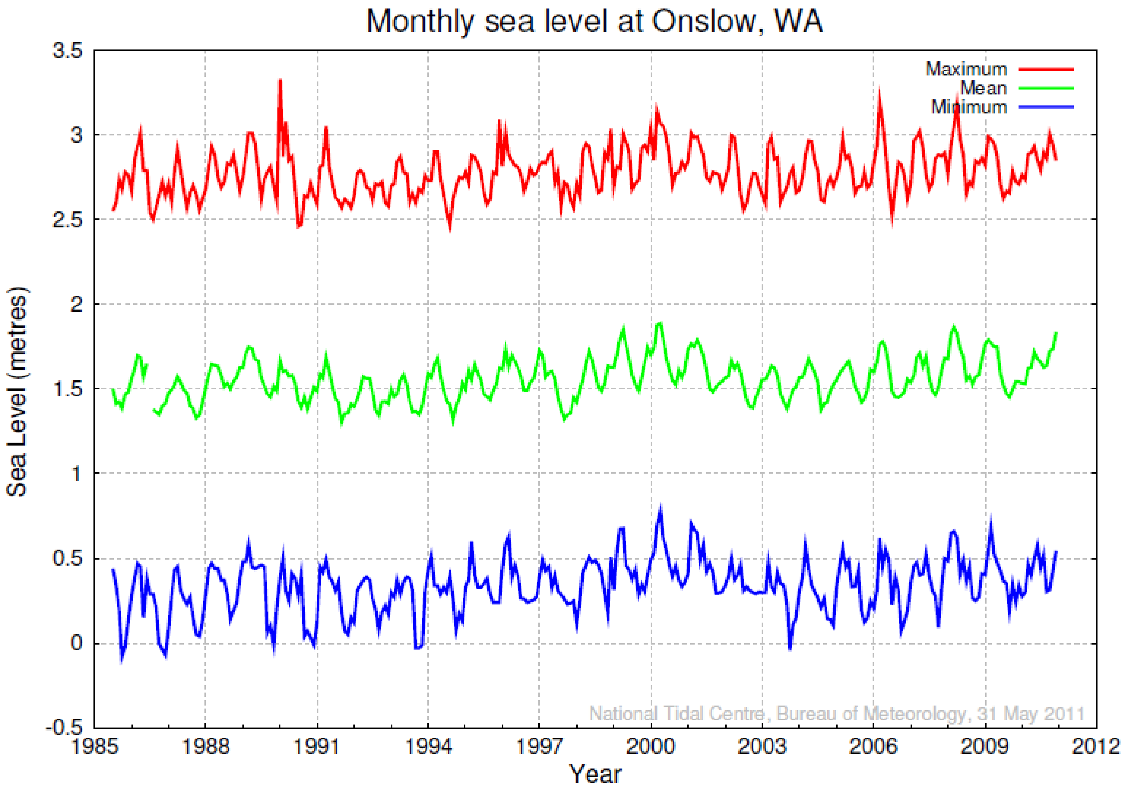
Mean sea level = 1.559 (Average monthly means = 1.559)

Maximum recorded level of 3.330 metres at 1600 hours 27/01/1990

Minimum recorded level of -0.080 metres at 2300 hours 16/10/1985

Standard deviation of the observations = 0.5444 metres

Skewness = 0.0446



Source: Bureau of Meteorology 2011

Figure A.1: Onslow sea levels for period 1985 to 2010

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[3] Setting the tide datum to the lowest astronomical tide reduces the occurrence of a 'negative' tide height, and enables a better perception of tidal range. Lowest astronomical tide (LAT) and highest astronomical tides (HAT) are mathematical calculations based on bodies in the solar system. Actual tides can vary from these depending on local extreme high or low pressure systems, and local strong winds (Note: the author is an experienced sailor and has a coastal navigation qualification).

The Western Australian *Department of Transport - Maritime Safety* (2012) has also published significant heights with respect to the Onslow (Beadon Creek) tide gauge datum. This data, together with data obtained from the aerodrome construction drawings, has enabled a conversion to be made (Table A.1) between tide heights and AHD, hence construction RLs.

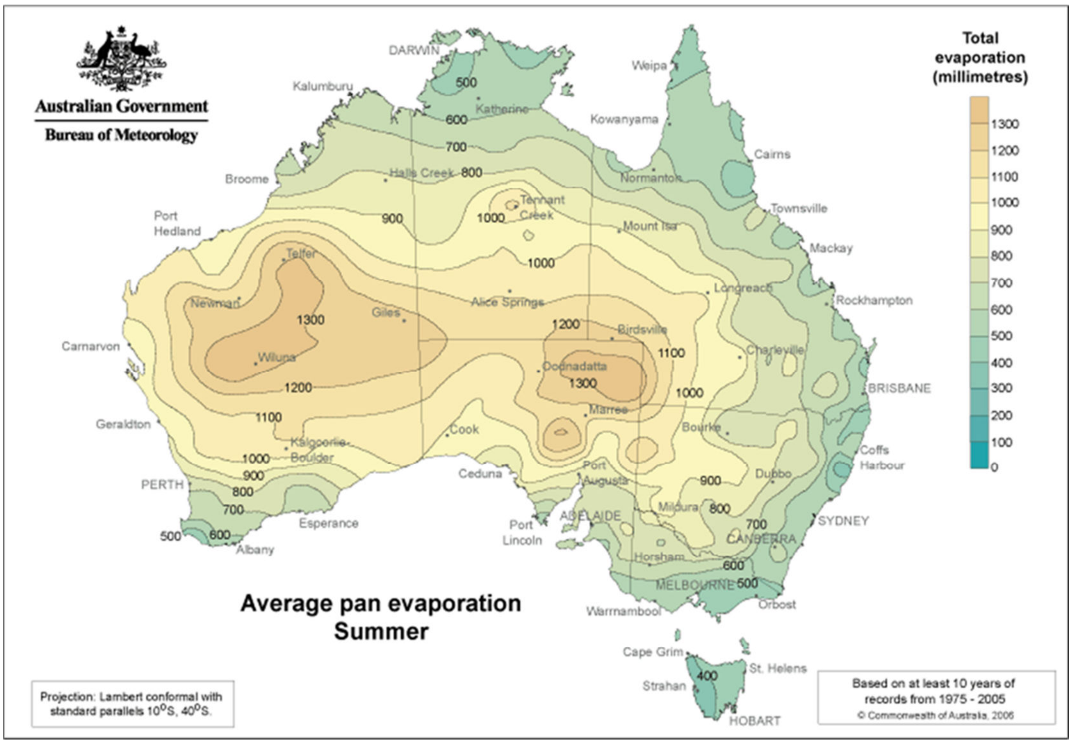
Table A.1: Conversion of various features from local tide datum to Australian height datum

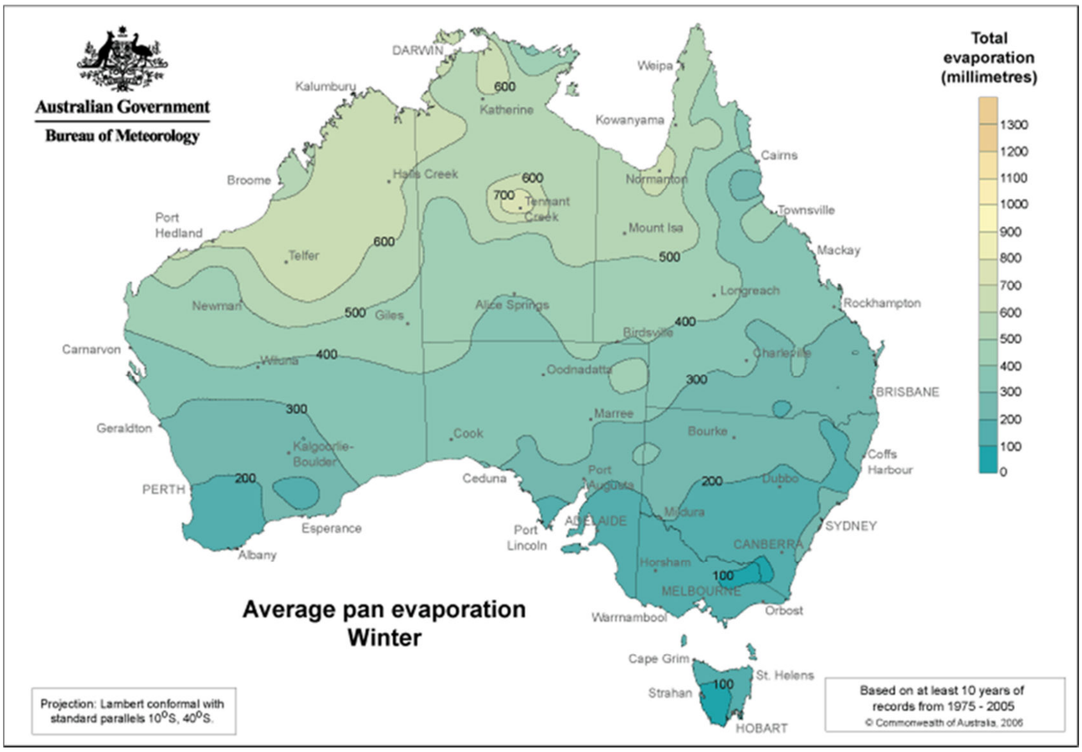
AHD (m)	Feature	Tide gauge datum (m)
4.27	Runway centreline finished level	
4.2	Top of basecourse	
4.0	Top of subbase	
3.8	Top of select fill	
2.9	Cyclone Vance water level	4.5
1.9	Public jetty deck	3.5
1.5	Typical natural surface level below select fill	
1.4	Highest astronomical tide (HAT)	3.0
0.9	Mean high water spring (MHWS)	2.5
0.2	Mean high water neap (MHWN)	1.8
0.0	Mean sea level (MSL)	1.6
-0.4	Mean low water neap (MLWN)	1.2
-1.0	Mean low water spring (MLWS)	0.6
-1.6	Lowest astronomical tide (LAT)	0.0

APPENDIX B CLIMATE

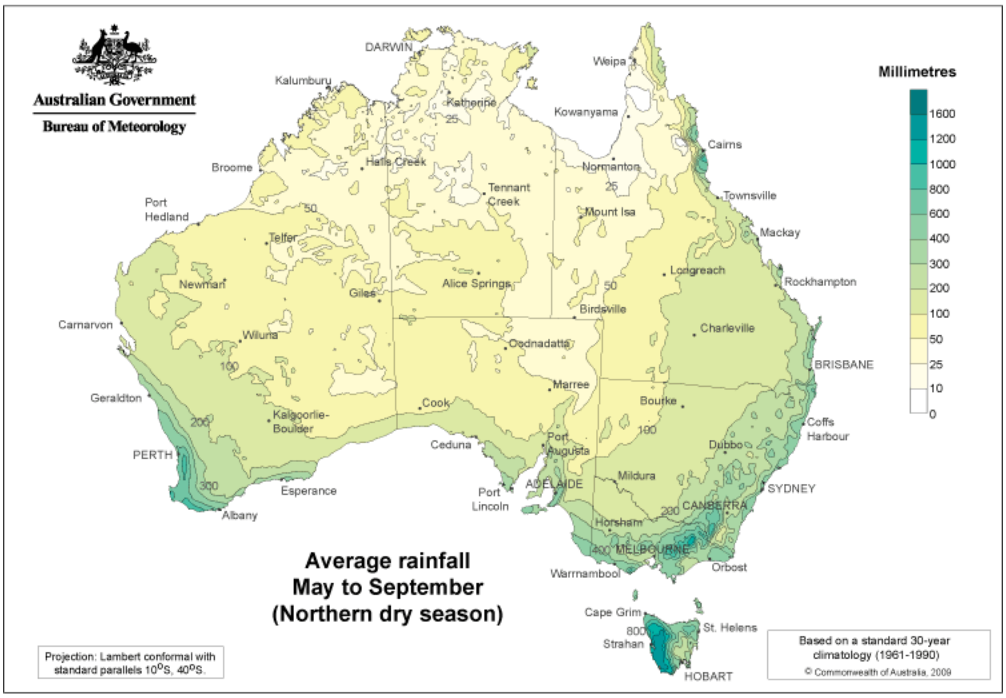
The following climatic maps were all taken from the Australian Bureau of Meteorology Climate data online, http://www.bom.gov.au/climate/data/index.shtml viewed 3/03/13.

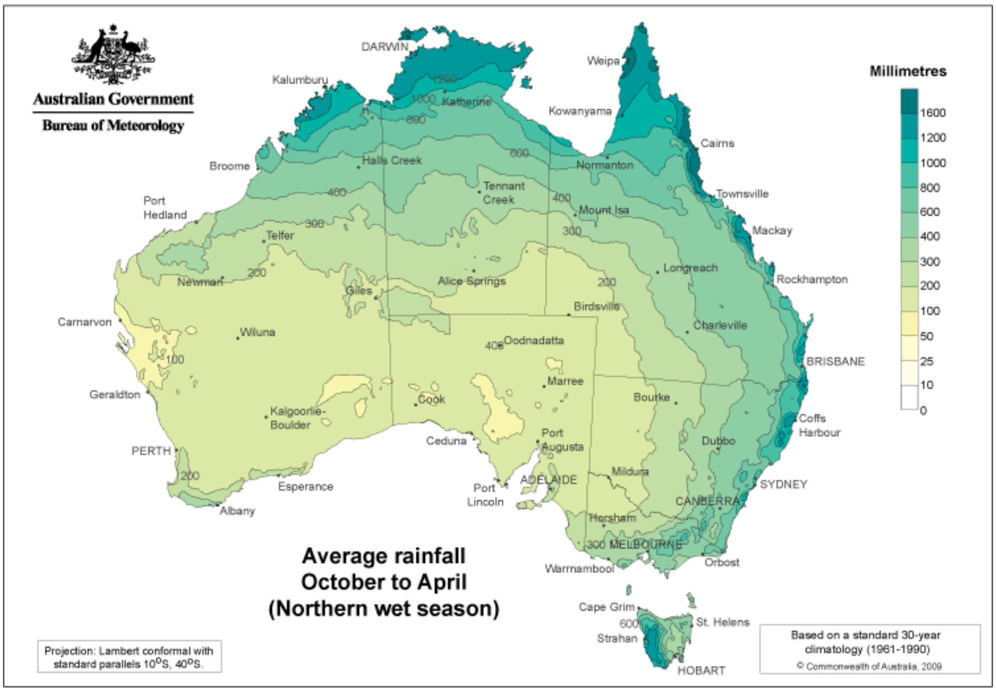
B.1 Evaporation



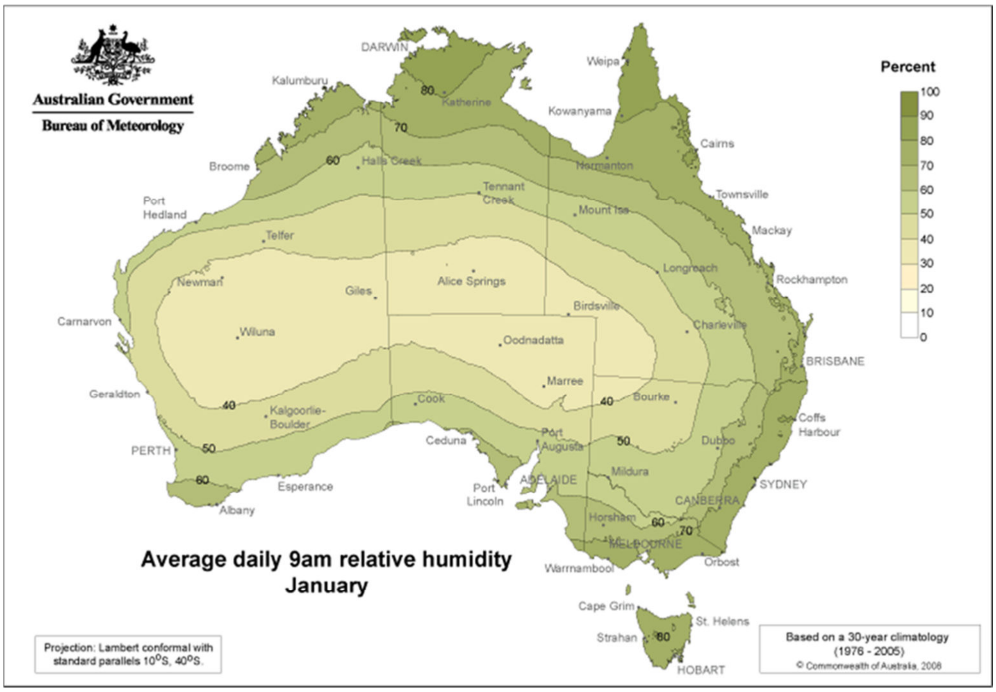


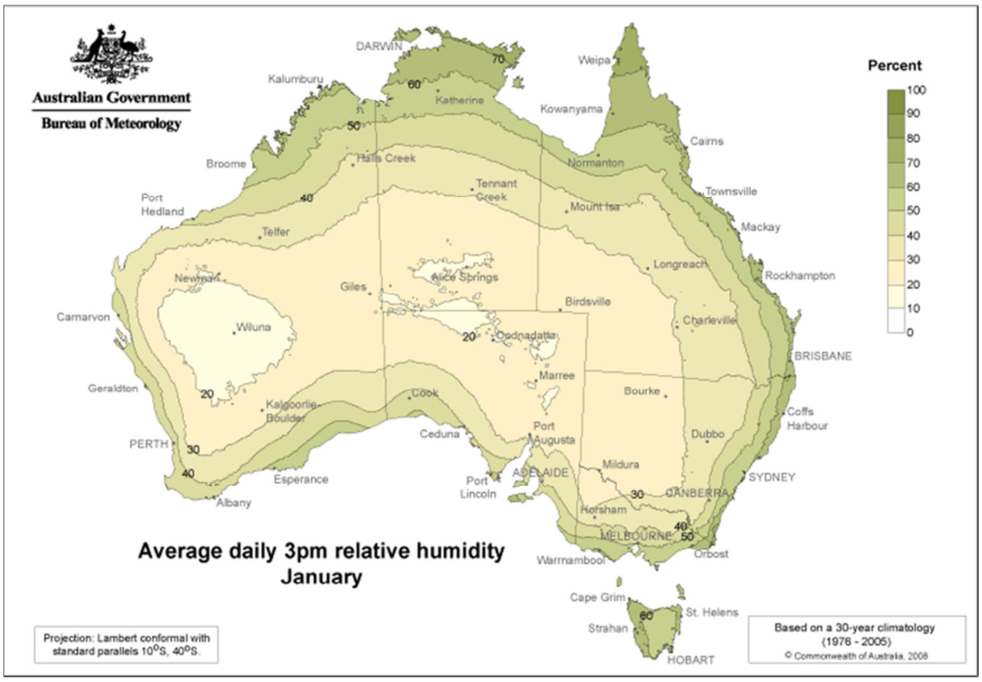
B.2 Precipitation





B.3 Humidity


Australian Government
Bureau of Meteorology
Average daily 9am relative humidity
January
Percent
100
90
80
70
60
50
40
30
20
10
0
DARWIN
Kalumburu
Katherine
Weipa
Kowanyama
Cairns
Broome
Halls Creek
Normanton
Townsville
Port Hedland
Tennant Creek
Mount Isa
Mackay
Telfer
Longreach
Rockhampton
Newman
Giles
Alice Springs
Birdsville
Carnarvon
Wiluna
Oodnadatta
Charleville
BRISBANE
Marree
Geraldton
Kalgoorlie-Boulder
Cook
Bourke
Coffs Harbour
Ceduna
Port Augusta
Dubbo
PERTH
Mildura
Esperance
ADELAIDE
SYDNEY
Port Lincoln
CANBERRA
Albany
Horsham
MELBOURNE
Warrnambool
Orbost
Cape Grim
St. Helens
Strahan
HOBART
80
70
60
40
50
60
40
50
60
70
80
Projection: Lambert conformal with standard parallels 10°S, 40°S.
Based on a 30-year climatology (1976 - 2005)
© Commonwealth of Australia, 2008


Australian Government
Bureau of Meteorology
Average daily 3pm relative humidity
January
Percent
100
90
80
70
60
50
40
30
20
10
0
DARWIN
Kalumburu
Katherine
Weipa
Kowanyama
Cairns
Broome
Halls Creek
Normanton
Townsville
Port Hedland
Tennant Creek
Mount Isa
Mackay
Telfer
Longreach
Rockhampton
Newman
Giles
Alice Springs
Birdsville
Carnarvon
Wiluna
Oodnadatta
Charleville
BRISBANE
Marree
Geraldton
Kalgoorlie-Boulder
Cook
Bourke
Coffs Harbour
Ceduna
Port Augusta
Dubbo
PERTH
Mildura
Esperance
ADELAIDE
SYDNEY
Port Lincoln
CANBERRA
Albany
Horsham
MELBOURNE
Warrnambool
Orbost
Cape Grim
St. Helens
Strahan
HOBART
70
60
50
40
20
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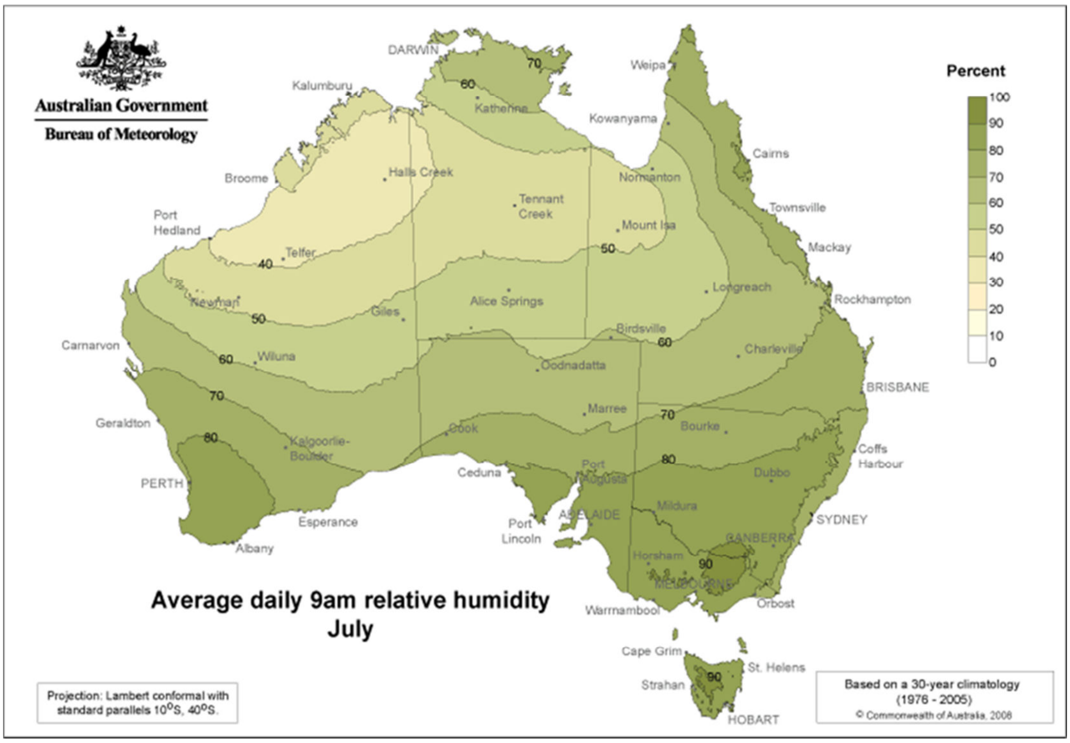
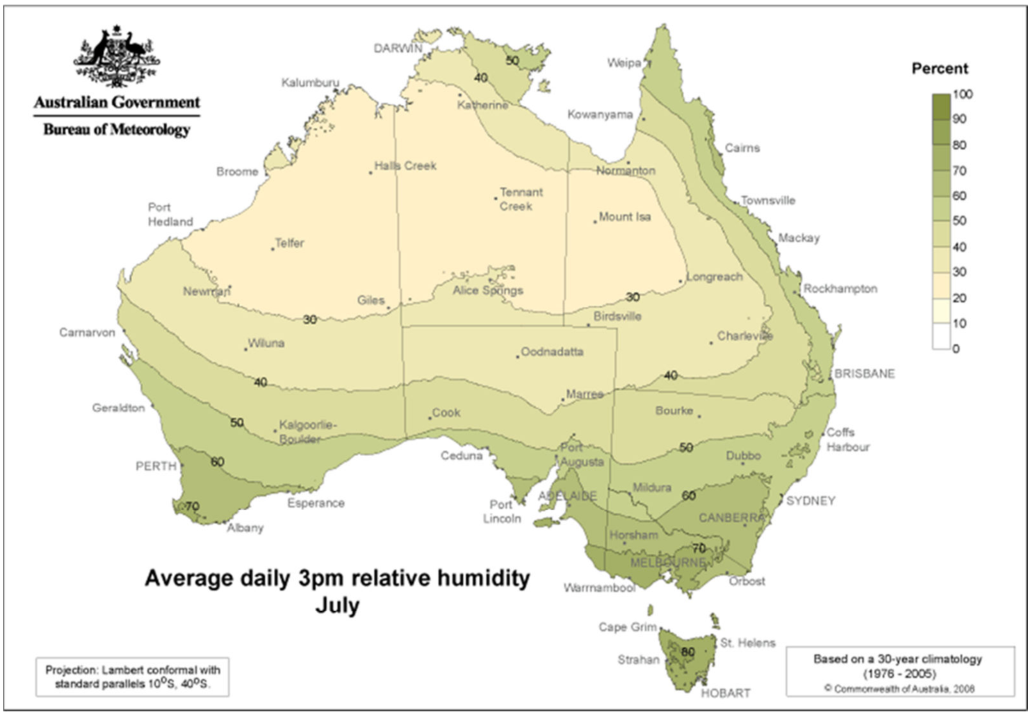
Projection: Lambert conformal with standard parallels 10°S, 40°S.
Based on a 30-year climatology (1976 - 2005)
© Commonwealth of Australia, 2008

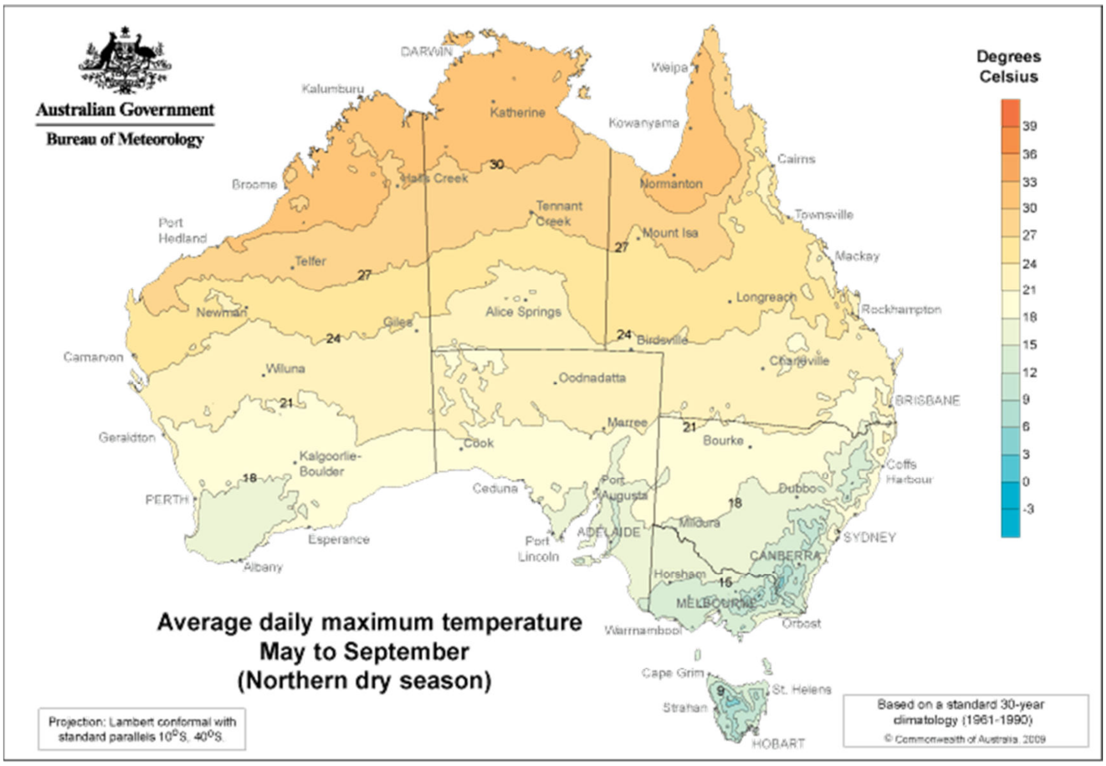


Average daily 9am relative humidity
July

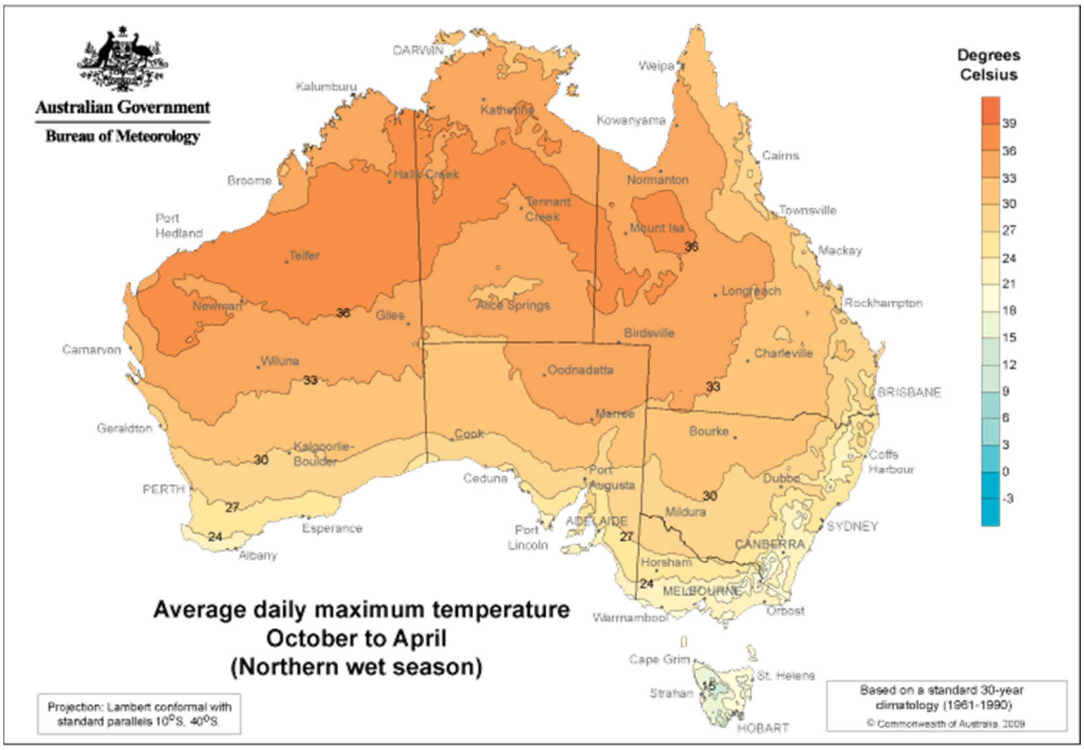


Average daily 3pm relative humidity
July

B.4 Maximum temperature

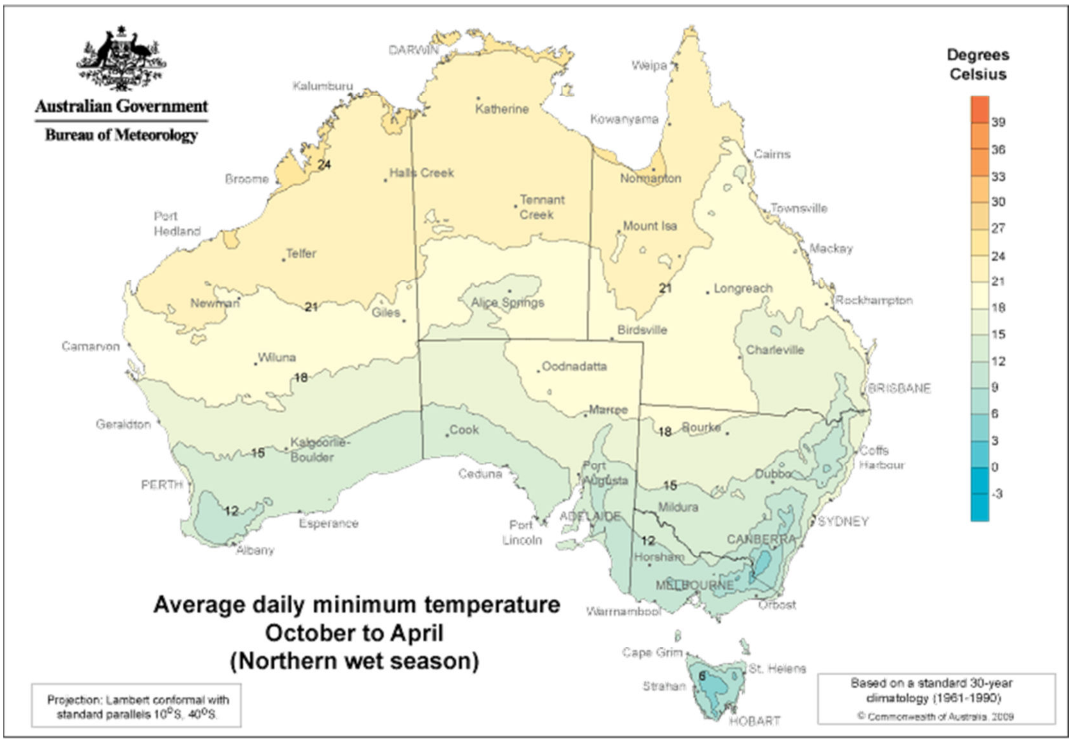


Average daily maximum temperature
May to September
(Northern dry season)



Average daily maximum temperature
October to April
(Northern wet season)

B.5 Minimum temperature

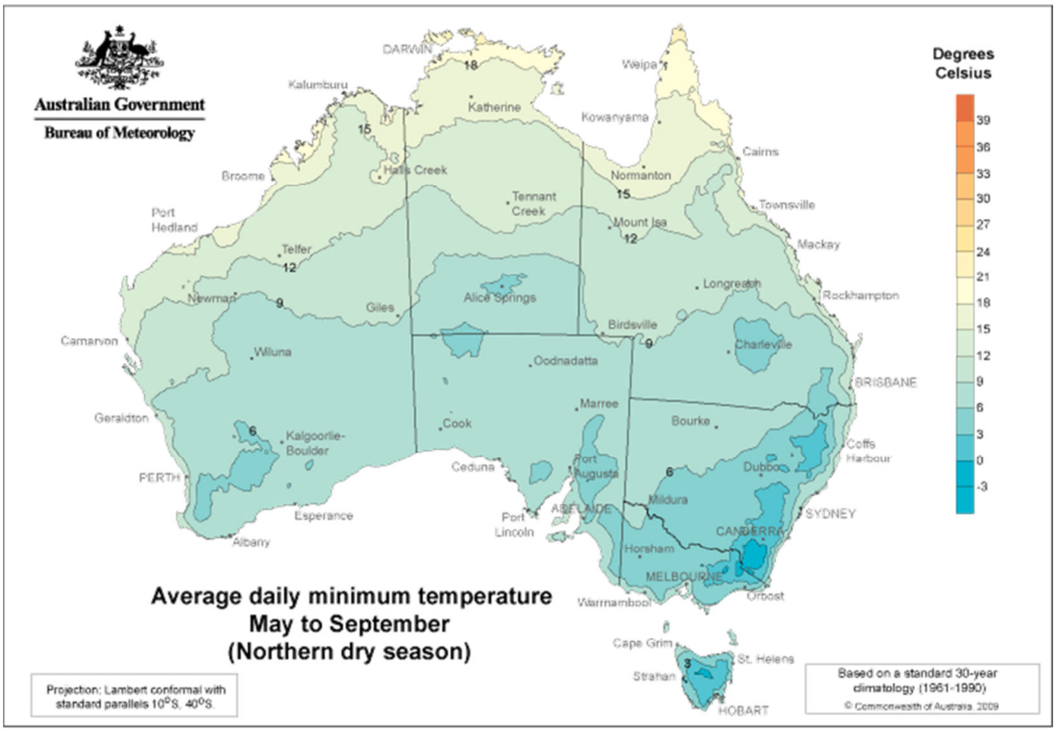


Average daily minimum temperature
October to April
(Northern wet season)

Projection: Lambert conformal with standard parallels 10°S, 40°S

Based on a standard 30-year climatology (1961-1990)

© Commonwealth of Australia 2009



Average daily minimum temperature
May to September
(Northern dry season)

Projection: Lambert conformal with standard parallels 10°S, 40°S

Based on a standard 30-year climatology (1961-1990)

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