Dirk Hartog Island National Park ecological restoration project
Weed management 1 July 2014 to 31 December 2016

1. Introduction

Astron Environmental Services were contracted to complete a baseline weed survey of Dirk Hartog Island (DHI) during 2012 (Astron 2012a). The survey focused on accessible tracks and designated infrastructure areas across the island and was completed over 20 days, from 22 August to 10 September 2012. The survey measured weed occurrence along the tracks in selected transects and at systematic sampling points. As such, there was limited weed survey along the west coast and in the centre of the island. Refer to Figure 2 for Astron's weed survey transects and sample point locations.

Astron Environmental Services prepared the *DHI National Park Weed Management and Action Plan (2013-2018)* (Astron 2012b) during November 2012, which listed 49 weed species for DHI. These 49 species were assessed by Astron according to the department's invasive plant prioritisation process (IPPP) to identify the highest priority species for management. Eight priority weed species were identified with a weed management plan prepared for each; five species were designated for eradication and three species for control. In total 17 weed management areas (WMAs) were identified across DHI National Park. The plan also provided an 'alert weed list' and identified 23 weed surveillance areas (WSAs) that were deemed to be at high risk for introducing weeds to the island.

This weed report covers the weed control and surveillance performed on DHI during the period 1 July 2014 to 31 December 2016.

WMAs were inspected during August 2014, June 2015 and August 2016 with control occurring were possible. Fourleaf allseed, one of the weed species designated for control by Astron, was removed as a WMA during 2015 due to its low ecological impact, low feasibility of control and wider than expected distribution. A new introduction to the island of ruby dock, consisting of one plant, was identified on the cat fence alignment in September 2015 and has been added as a new WMA, designated for eradication. A new castor oil and lupin occurrence, identified in February 2016 and September 2016 respectively, have been added as new WMAs. Refer to Appendix 1 for the revised WMA list and IPPP ranking.

WSAs were inspected in June 2015 and August 2016; with no significant 'new to island' weed species identified. Two WSAs have been removed being Zuytdorp Cliff Lookout (WSA 2e) due to limited vehicle access and Tumbledown Point (WSA 5d) due to low visitation. Additionally, the cat barrier fence (WSA 6), the barge landing site (WSA1b), Sandy Point accommodation (WSA 1c) and the Sandy Point campsite (WSA 3i) have been added as new WSAs. Refer to Appendix 2 for the revised WSA list.

Weed identification card packs for eradicate, control and alert species were distributed to district and project staff working on DHI in 2013 and to DHI's freehold property owners in 2016. The Shark Bay World Heritage Area website was updated in 2015 with the inclusion of biosecurity and weed messages, including identification information and pictures for the islands eradicate, control and alert weed species. In May 2015 a photobook, which included identification information on the alert weed species was provided to the Dirk Hartog Island Shark Bay Lodge for visitor information. A weed article focusing on the prevention and early detection of alert weed species that have been recorded in Shark Bay but not established on DHI was published in the August 2016 issue of the Inscription Post.

There was noticeable variation in meteorological conditions during the reporting period. Total annual rainfall in 2014 and 2016 was less than average with 60mm less rainfall in 2014 (note May is missing two days' worth of data) and 74mm in 2016, whilst 2015 was more than average with 124 mm more rainfall to that historically recorded at Denham during 1893 to 2016 (refer to Table 1). Figure 1 demonstrates that the rainfall recorded on DHI from 1 June 2014 to 31 December 2016 reflects a similar trend to that recorded at the Denham weather station.

Table 1 Mean monthly rainfall (mm) at Denham weather station 006044 (1893-2016)

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Denham	1893 to 2016	7.5	15.1	15.1	14.0	37.0	54.3	40.0	21.8	7.9	6.0	3.1	2.3	224.7
Denham	2014	0	0	1.8	38.0	53*1	14.0	15.2	13.6	22.6	5.2	1.5	0	164.9*1
	2015	0	29.8	143.6	4.0	9.4	55.8	55.6	41.4	2.4	0	5.6	0.8	348.4
	2016	5.6	0	0.4	2.6	8.0	38.4	75.8	14.4	3.6	0.4	1.4	0	150.6

*1 Missing two days data on the 6th and 7th May.

Table 2 Mean maximum temperature (^{0}C) at Denham weather station 006044 (1893-2016)

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Denham	1893 to 2016	30.7	32.0	31.1	28.6	25.6	22.9	21.7	22.6	23.9	25.7	27.8	29.2	26.8
Denham	2014	31.6	34.1	31.7	29.0	24.3	22.8	22.2	26.4	25.8	26.5	27.3	29.6	27.6
	2015	31.8	32.6	31.3	29.2	25.0	23.7	22.4	23.4	26.4	28.0	28.5	28.5	27.6
	2016	30.4	32.3	30.2	28.6	23.8	21.5	21.1	21.8	22.4	25.8	28.3	28.6	26.2

Figure 1 Rainfall and temperature recorded on Dirk Hartog Island (June 14 to Dec 16)

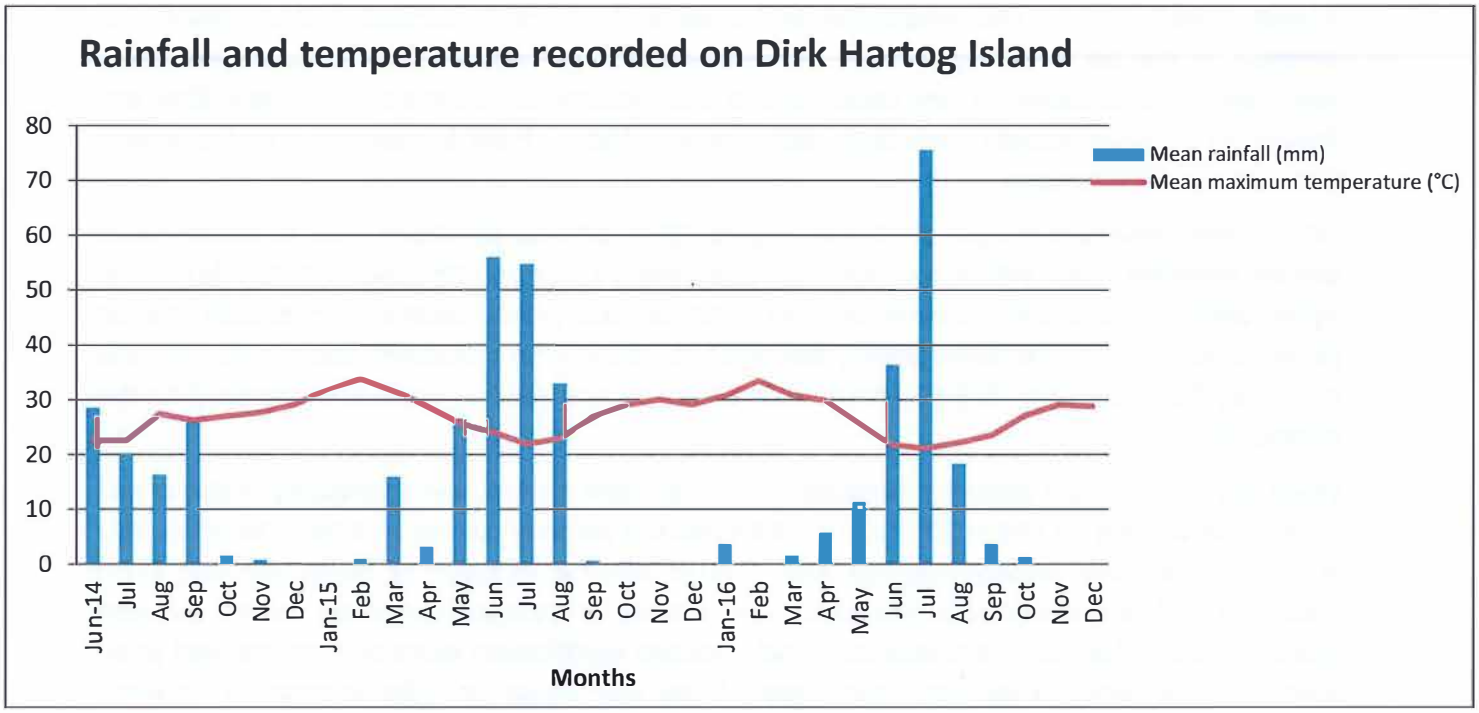
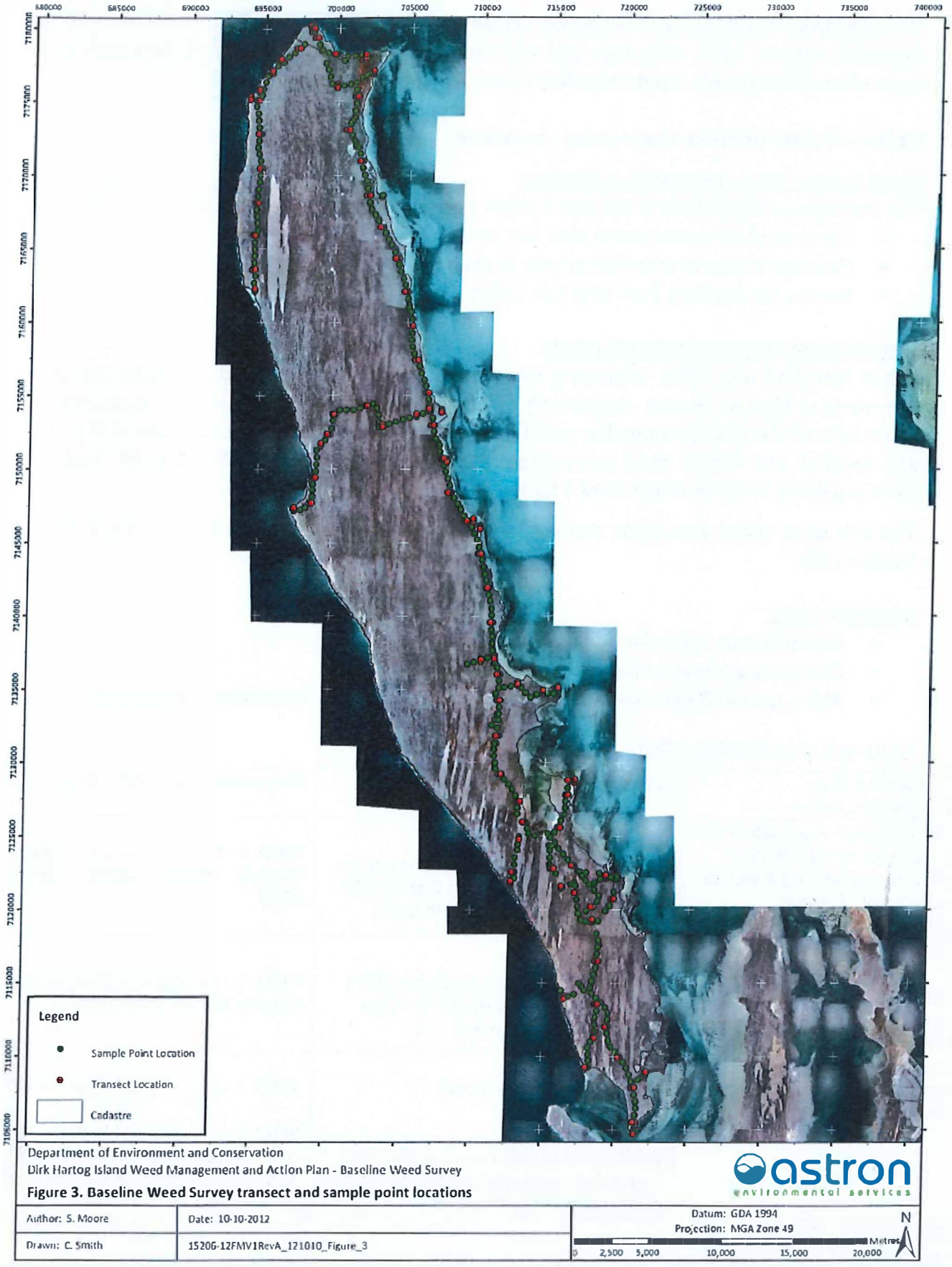


Figure 2 Astron's weed survey transects and sample point locations



2. Weed management areas - methods, output and outcomes

The objective for WMAs is to eradicate identified priority weeds including castor oil, couch, Japanese pepper, lupin, ruby dock and wild radish, and to reduce the distribution and foliar cover of identified priority weeds including false sowthistle and ice plant.

Castor oil plant (*Ricinus communis)* - eradicate

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- Removal of all known plants after two years.
- Removal of any new seedlings prior to seed set.
- Monitor for regrowth from year two to five.

Description of weed management area/s:

Astron identified one WMA, containing two mature plants, in the national park approximately 4km north of Mystery Beach. Additionally, a new WMA was found on the large mobile dunes south west of the airstrip during the aerial goat monitoring operation on 2 February 2016. This site contains one mature plant approximately 2m high and 3m wide, with no other plants in close proximity. Refer to Attachment 1 for the castor oil WMA locations.

The only other known population on the island is at the Dirk Hartog Homestead (freehold North Location 62).

Important notes:

- Seeds remain viable for up to ten years.
- Disturbance triggers mass seed germination.
- Active growth September to April, with optimal treatment September to December.

Summary of eradication effort:

Weed Action Plan Management Action	Action performed	Recommendation for future control
Year 1 (2014) - Application of herbicide to all populations. Follow up monitoring 4 weeks post control. Repeat application if required.	September 2014 WMA 1 - Both plants were treated by basal bark painting using Garlon 600, 1:60 with diesel (refer to Photo 1).	WMA 1 - Eradication considered feasible. Repeat control in winter 2015.
Year 2 (2015) - Application of herbicide to all populations. Follow up monitoring 4 weeks post control. Repeat application if required.	June 2015 WMA 1 - Both plants treated in 2014 were dead (refer to Photo 1). One seedling hand removed.	WMA 1 - All known plants removed. Monitor site in winter 2016.
Year 3 (2016) - Monitor populations for regeneration. Control if required.	August 2016 WMA 1 - No plants found. February 2016 WMA 2 - One mature plant 3m x 2m found during the aerial goat monitoring program (refer to Photo 2).	WMA 1 - Monitor site in winter 2017. WMA 2 - Access site in early 2017 and remove plant (cut and paint stump/basal bark), require motor bike access.
Year 4 (2017) - Monitor populations for regeneration. Control if required.		
Year 5 (2018) - Monitor		

populations for regeneration. Control if required.		

Output and outcomes:

- There were no new occurrences of castor oil outside of WMA 1 during 2014 to 2015. One mature plant (3mx2m) was found on the large mobile dunes south west of the airstrip during the February 2016 aerial goat monitoring operation, with no other plants in close proximity. This site has been added as a new WMA (WMA2).
- Two individuals in WMA 1 were successfully treated by basal bark application in 2014.
- One new seedling was hand removed from WMA 1 in June 2015.
- In total 32 minutes of weed control has occurred at WMA 1; 12 minutes in 2014 and 20 minutes in 2015.
- All castor oil germinates were hand removed from the Wardle freehold in 2015 and 2016 as part of the aerial goat monitoring operation.
- All known plants have been removed, excluding the new individual at WMA 2. All seedlings were removed prior to seed set.

Couch *(Cynodon dactylon)* - eradicate

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- 75% reduction of couch within two years.
- Eradication of couch within 5 years.
- No new occurrences of couch.

Description of weed management area/s:

Astron identified two WMA's in the national park located at Two Wells (couch WMA 1) and Little West Well (infestation surrounds the homestead water supply well, couch WMA 2) (refer to Attachment 1). Couch WMA 1 is approximately 270m2 and WMA 2 is approximately 3,000m2 (refer to Attachments 2 and 3 for boundary shapefiles). The only other known population on the island is at the Dirk Hartog Homestead (freehold North Location 62).

Important notes:

- Reproduce by rhizome, stolon and seed. Seed dispersed by water, ants and wind.
- Seeds remain viable for up to four years.
- Active growth October to May, with optimal treatment November to February.

Summary of eradication effort:

Weed Action Plan Management Action	Action performed	Recommendation for future control
Year 1 (2014) – Application of herbicide to all populations or mechanical removal if possible. Follow up monitoring 4 weeks post control. Repeat application if required.	August 2014 WMA 1 - Population (weed cover 6-75%) was hand sprayed with glyphosate 360 (Wipe-out Bio) 13ml/1L water. Boundary tracked with GPS. WMA 2 - Did not treat as population surrounds homestead water supply well (weed cover 6-75%). Wipe-out label requires 0.5km buffer around	WMA 1 - Eradication considered feasible. Repeat chemical application in November 2015 with follow-up monitoring 4 weeks post control. Set up photo monitoring point. WMA 2 - This site is not able to be treated by chemical and too extensive and impractical for mechanical control. Review eradication technique. Set up

	potable water intake in a standing body of water such as a lake, pond or reservoir. Boundary tracked with GPS.	photo monitoring point.
Year 2 (2015) - Application of herbicide to all populations or mechanical removal if possible. Follow up monitoring 4 weeks post control. Repeat application if required.	WMA 1 - November 2015, the population was hand sprayed with glyphosate 360 (Wipeout Bio) 13mL/1L water. Refer to photo 3. WMA 2 - Site under water during June 2015 inspection.	WMA 1 - Repeat chemical treatment in November 2016 with follow-up monitoring 4 weeks post control. WMA 2 - This site is not able to be treated by chemical and too extensive and impractical for mechanical control. Review eradication technique. Set up photo monitoring point.
Year 3 (2016) - Application of herbicide to all populations or mechanical removal if possible. Follow up monitoring 4 weeks post control. Repeat application if required.	WMA 1 - August 2016, weed cover reduced to less than 5%. Refer to photo 3. WMA 1 - November 2016, only the runners near the periphery required hand sprayed with glyphosate 360 (Wipeout Bio) 13mL/1L water. WMA 2 - Photo-monitoring point installed (refer to Photo 4). Weed cover 6-75%.	WMA 1 - Repeat chemical treatment in November 2016. WMA 1 - Monitor site in February 2017 as part of the goat surveillance program. Re-track boundary in 2017. WMA 2 - This site is not able to be treated by chemical and too extensive and impractical for mechanical control. Re-track boundary in 2017. Review eradication technique.
Year 4 (2017) - Application of herbicide to all populations or mechanical removal if possible. Follow up monitoring 4 weeks post control. Repeat application if required.		
Year 5 (2018) - Application of herbicide to all populations or mechanical removal if possible. Follow up monitoring 4 weeks post control. Repeat application if required.		

Output and outcomes:

- There were no new occurrences of couch outside of the WMAs during 2014 to 2016.
- The boundary for both WMAs was mapped in August 2014, with an estimated weed cover of 6-75% in each area.
- WMA 1 has achieved a significant drop in couch cover from class 2 (6-75%) to class 1 (less than 5%) due to the successful chemical applications in 2014 and 2015.
- WMA 2 has not been treated as the site surrounds the homestead water supply well. Wipe-out label requires 0.5km buffer around potable water intake in a standing body of water such as a lake, pond or reservoir. It is too extensive and impractical for mechanical control.
- In total 120 minutes of weed control has occurred at WMA 1, 30 mins in August 2014, 30 mins in November 2015 and 60 mins in November 2016.

Japanese Pepper *(Schinus terebinthifolius)* - eradicate

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- Removal of all known plants after two years.
- Removal of any additional seedlings prior to seed set.
- Monitor for regrowth from year two to five.

Description of weed management area/s:

Astron identified one WMA in the national park located at the Sandy Point out camp (Japanese pepper WMA1; refer to Attachment 1). The only other known plant on the island is at the Dirk Hartog Homestead (freehold North Location 62). WMA 1 contains one mature tree.

Important notes:

- Separate male and female trees, with only the female bearing fruit (May to August).
- Seed remains viable for approximately five months once dispersed.
- Regrowth and root suckering may occur for up to six months after the tree is cut down. Re-sprouting can occur as much as 26 months after physical disturbance.
- Active growth December to March, with optimal treatment December to February.

Summary of eradication effort:

Weed Action Plan Management Action	Action performed	Recommendation for future control
Year 1 (2014) - control all known plants. Follow-up monitoring 4 weeks post control.	September 2014 WMA 1 - Did not treat as the only specimen is a large multi stem tree which is unable to be effectively controlled by basal bark treatment.	Control to coincide with removal of old cook house as invasiveness is low (require male and female tree for pollination). Set up photo monitoring.
Year 2 (2015) - control all known plants. Follow-up monitoring 4 weeks post control.	June 2015 WMA 1 - Photo monitoring taken, tree healthy with no berries (refer to Photo 5).	Control to coincide with removal of old cook house as invasiveness is low (require male and female tree for pollination).
Year 3 (2016) - Monitor populations for regeneration. Control if required.	August 2016 WMA 1 - Tree healthy with no berries.	Control to coincide with removal of old cook house as invasiveness is low (require male and female tree for pollination).
Year 4 (2017) - Monitor populations for regeneration. Control if required.		
Year 5 (2018) - Monitor populations for regeneration. Control if required.		

Output and outcomes:

- There were no new occurrences of Japanese pepper outside of WMA1 during 2014 to 2016.
- One individual exists in WMA 1 with control to coincide with removal of the old cook house as invasiveness is low (require male and female tree for pollination).
- The Japanese pepper at the Wardle residence is believed to be a single mature tree. Berries have not been sighted by the Wardle's or by department staff during the aerial goat monitoring programs.

Lupin *(Lupinus cosentinii)* - eradicate

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- Removal of any new seedlings prior to seed set.
- Monitor for regrowth from year one to five.

Description of weed management area/s:

Astron identified one WMA in the national park located approximately 7km north of Sandy Point in an old holding paddock (Lupin WMA 1; refer to Attachment 1). Only one plant was recorded and subsequently removed by Astron during the baseline weed survey.

In September 2016 one new lupin WMA was identified approximately 1.4km north of lupin WMA1, and 100m west of the track, during the threatened avifauna survey (Lupin WMA 2; refer to Attachment 1).

Important notes:

- Seed can remain viable for up to twenty years.
- Stubble and large quantities of seed can be poisonous to stock.
- Annual; active growth June to November, flowering August to November and fruiting October to November. Optimal control June to September.
- Grazing by native animals usually keeps lupins under control in healthy bushland.

Summary of eradication effort:

Weed Action Plan Management Action	Action performed	Recommendation for future control
Year 1 (2014) – Inspect site and control any emergences.	September 2014 WMA 1 - No plants found.	WMA1 - Inspect site June 2015 hand pull any seedlings.
Year 2 (2015) - Inspect site and control any emergences.	June 2015 WMA 1 - No plants found.	WMA1 - Inspect site in June 2016, hand pull any seedlings.
Year 3 (2016) - Inspect site and control any emergences.	August 2016 WMA 1 - No plants found. September 2016 WMA 2 - New infestation found during the avifauna survey. Some plants were hand removed but the infestation was too large for the time available.	WMA1 - Inspect site in winter 2017, hand pull any seedlings. WMA 2 - Inspect site in September 2017. Map infestation and hand remove plants. Follow-up control in October 2017. Write weed action plan if control is considered feasible.
Year 4 (2017) - Inspect site and control any emergences.		
Year 5 (2018) - Inspect site and control any emergences.		

Output and outcomes:

- There were no new occurrences of lupin inside WMA 1 during 2014, 2015 and 2016; or outside of WMA 1 in 2014 and 2015.
- An infestation of unknown size, containing plants of 30cm height with no flowers, was located approximately 1.4 km north of WMA 1 (100m west of the track) during the September 2016 threatened avifauna survey. This site has been added as a new WMA

(WMA2) and will be inspected in 2017. The site was unable to be inspected in September or October 2017 due to leave obligations.

Ruby dock *(Rumex vesicarius* formally *Acetosa vesicaria*) - eradicate

Management objective:

The management objectives are:

- Removal of any new seedlings prior to seed set.
- Monitor for regrowth from 2015 to June 2018.

Description of weed management area/s:

One ruby dock plant was identified in the national park on the cat fence alignment approximately 660m east of the main access gate on 11 September 2015 (ruby dock WMA1; refer to Attachment 1).

Important notes:

- Seed can remain viable for up to twenty years.
- Annual; active growth June to November, flowering July to September and fruiting October to November. Optimal chemical or manual control June to September.

Summary of eradication effort:

Management Action	Action performed	Recommendation for future control
Year 1 (2015) - Inspect site and control any emergences.	September 2015 WMA1- hand removed one plant prior to seed set (refer to photo 6).	Inspect site monthly in winter/spring 2016 and hand pull any seedlings.
Year 2 (2016) - Inspect site and control any emergences.	September 2016 WMA1 – no plants found.	Inspect site monthly in winter/spring 2017 and hand pull any seedlings. Write weed action plan.
Year 3 (2017) - Inspect site and control any emergences.		
Year 4 (2018) – Inspect site and control any emergencies.		

Output and outcomes:

- There were no new occurrences of ruby dock either inside or outside of the WMA in 2015 or 2016.

Wild radish *(Raphanus raphanistrum)* - eradicate

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- Removal of any new seedlings prior to seed set.
- Monitor for regrowth from year one to five.

Description of weed management area/s:

Astron identified one WMA in the national park located approximately 1km east of the airstrip, in close proximity to Yabbra Well (wild radish WMA1; refer to Attachment 1). One individual plant was recorded and subsequently removed by Astron during the baseline weed survey.

Important notes:

- Annual, active growth year round, flowering April to November, and fruiting June to December. Optimal chemical treatment year round, optimal hand removal prior to fruiting (June).
- Seed can remain viable for up to twenty years.

Summary of eradication effort:

Weed Action Plan Management Action	Action performed	Recommendation for future control
Year 1 (2014) – Inspect site and control any emergences.	August 2014 WMA 1 -No plants found.	Inspect site June 2015 hand pull any seedlings.
Year 2 (2015) - Inspect site and control any emergences.	June 2015 WMA 1 - No plants found.	Inspect site in winter 2016, hand pull any seedlings.
Year 3 (2016) - Inspect site and control any emergences.	August 2016 WMA 1 - No plants found.	Inspect site in winter 2017, hand pull any seedlings.
Year 4 (2017) - Inspect site and control any emergences.		
Year 5 (2018) - Inspect site and control any emergences.		

Output and outcomes:

- There were no new occurrences of wild radish either inside or outside of the WMA during 2014 to 2016.

False sowthistle *(Reichardia tingitana)* - control

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- 50% reduction of the extent of false sowthistle in WMAs within 2 years.
- Minimum 75% reduction of the extent of false sowthistle in WMAs within 5 years.

Description of weed management area/s:

Astron identified three WMAs in the national park located approximately 1km north-east of the northern extent of the airstrip (false sowthistle WMA 1), and 2.4km (false sowthistle WMA 2) and 3.4km (false sowthistle WMA 3) south of the West Point 'The Block' turn off. WMA 1 is approximately 205 m2 (refer to Attachment 4). The extent of WMA 2 and WMA 3 is unknown as plants have not yet been identified at these sites.

Important notes:

- Seed viable for up to two years, spread by wind and water.
- Short lived annual, flowering August – October.

Summary of eradication effort:

Weed Action Plan Management Action	Action performed	Recommendation for future control
Year 1 (2013/14) – Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide	August 2014 WMA 1 – Not controlled as plants had already flowered and starting to senesce (weed cover less than 5%).	WMA 1 - Inspect site in June 2015, earlier in the season. Commence hand removal / chemical application with follow-up monitoring 4 weeks post control. Set-up photo monitoring.

action if required.	1 September 2014 WMA 2 – Could not locate any plants, too late in season. WMA 3 – Hand pulled only plant found which was going into seed, too late in season.	WMA 2 - Inspect site in June 2015, earlier in the season. Commence hand removal / chemical application with follow-up monitoring 4 weeks post control. Map infestation and set-up photo monitoring. WMA 3 - Inspect site in June 2015, earlier in the season. Commence hand removal / chemical application with follow-up monitoring 4 weeks post control. Map infestation and set-up photo monitoring.
Year 2 (2014/15) - Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.	June 2015 WMA 1 – Not able to access due to flooding. WMA 2 – No plants found. WMA 3 – Potential seedling to be checked in 4 weeks.	Follow-up monitoring was not completed in 2015. Inspect all sites in winter 2016. Commence hand removal / chemical application with follow-up monitoring 4 weeks post control. Map infestation and set-up photo monitoring.
Year 3 (2015/16) - Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.	August 2016 WMA 1 – No plants found. WMA 2 – No plants found. WMA 3 – No plants found.	Inspect all sites in winter 2017. Commence hand removal / chemical application with follow-up monitoring 4 weeks post control. Map infestation and set-up photo monitoring.
Year 4 (2016/17) - Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.		
Year 5 (2017/18) - Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.		

Output and outcomes:

- No new occurrences of false sowthistle outside of the WMAs during 2014 to 2016.
- The distribution of the weed management areas were not mapped as the extent of the populations could not be accurately determined as the plants had started to senesce.
- Weed control did not occur during 2015 or 2016.

Ice plant *(Mesembryanthemum crystallinum)* - control

Weed Action Plan's management objective:

The management objectives in the weed action plan (for the national park) are:

- 50% reduction of the extent of ice plant in WMAs within 2 years.
- Minimum 75% reduction of the extent of ice plant in WMAs within 5 years.

Description of weed management area/s:

Astron identified five WMAs in the national park located along the coastline at Cape Ransonnet (Ice plant WMA 1), at the turn off to the airstrip (behind windmill; Ice plant WMA 2), 1.9km south of the turnoff to Quoin Bluff South (Ice plant WMA 3), at Herald Bay (Ice plant WMA 4) and Sandy Point out camp (behind old shed; Ice plant WMA 5) (refer to Attachment 1).

WMA 1 is approximately 6,000m2, WMA 2 is approximately 60m2, WMA 3 is 65m2, and WMA 4 is 3,000 (refer to Attachments 5, 6, 7 and 8 for boundary shapefile).

A further four infestations have been found on the rocky coastline at Herald Bay cat camp (WMA 6), Withnell Point (WMA 7), Charlies Harbour Lookout (WMA 8) and Sunday Island Bay (WMA 9) (refer to Attachment 1).

Important notes:

- Seed viability can be over 20 years.
- Abundance varies from year to year depending on climatic factors, particularly winter-spring rainfall.
- Annual or biennial, active growth until spring with flowering September to December, fruiting October to January; optimal treatment June to September.

Summary of eradication effort:

Weed action plan management action	Action performed	Recommendation for future control
Year 1 (2014) – Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.	September 2014 WMA1 – Did not control (weed cover 6-75%). One more infestation found on the rocky headland at Sunday Island Bay. Boundary GPS tracked. WMA 2 – The population (weed cover less than 5%) was hand sprayed with glyphosate 360 (Wipe-out Bio) 13ml/1L water and pulse penetrant 2ml/1L of spray solution. Boundary GPS tracked. WMA 3 – Part of population (weed cover 76-100%) was hand sprayed with glyphosate 360 (Wipe-out Bio) 13ml/1L water and pulse penetrant 2ml/1L of spray solution. Boundary GPS tracked. WMA 4 – Hand pulled individual plants and small clumps (weed cover less than 5%). Outcompeted by dense buffel. All young plants. Boundary GPS tracked. WMA 5 – Hand pulled a few individual small plants around old	WMA 1 - Large area, impossible to control with existing resources. Possibly further populations along the coast that were not mapped by Astron. Control is not considered feasible along the coast. WMA 2 - Repeat chemical application in June 2015 with follow-up monitoring 4 weeks post control. Set up photo monitoring point. WMA 3 - Infestation too large to treat with resources available. Reconsider management options. Set up photo monitoring point. WMA 4 - Repeat hand removal or chemical application in June 2015 with follow-up monitoring 4 weeks post control. Set up photo monitoring point. WMA 5 - Repeat hand removal or chemical application in June 2015

	shed site (weed cover less than 5%).	with follow-up monitoring 4 weeks post control. Set up photo monitoring point and map infestation.
Year 2 (2015) - Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.	June 2015 WMA 1 – Not inspected as too widespread and not feasible for control along the coast line. Boundary tracked in 2014. WMA 2 – Not inspected as the site was flooded. WMA 3 – Not inspected as the site was flooded. WMA 4 – No plants found as site covered in dense buffel grass. Not suitable for photo monitoring. WMA 5 – Some new germinates on shed pad surrounded by dense buffel.	 WMA 2 – Inspect in 2016. Set up photo monitoring point. Boundary tracked in 2014. WMA 3 - Control not feasible, set up photo monitoring point. Boundary tracked in 2014. WMA 4 – Control feasible, particularly as adjacent to vehicle access track. Repeat control in 2016. WMA 5 – Reconsider if control feasible and set up photo monitoring.
Year 3 (2016) – Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.	August 2016 WMA 1 – Hand removed plants from the barge landing/vehicle access area (weed cover less than 5%). Did not inspect cliff area as too widespread and not feasible for control along the coast line. WMA 2 – The population (weed cover less than 5%) was not treated as control is under re-evaluation. WMA 3 – The population (weed cover 76-100%) is too large to be effectively controlled. WMA 4 - Hand pulled individual plants (weed cover less than 5%). Outcompeted by dense buffel. All young plants. WMA 5 – No plants found. WMA 6 (new) – No plants found. WMA 7 (new) – The population	WMA 1 - Large infestation not in visitation area, control to be re-evaluated. Exception being the removal of any plants on the beach barge landing/vehicle access area. Inspect in winter 2017, hand removal any seedlings. WMA 2 - Infestation not in visitor area, control to be re-evaluated. Boundary tracked in 2014. WMA 3 – Large infestation not in visitation area, control to be re-evaluated. Boundary tracked in 2014. WMA 4 - Infestation is alongside visitor and management access tracks. Inspect in winter 2017, hand remove any seedlings. WMA 5 – Infestation not in visitor area, control to be re-evaluated. WMA 6 – Recommend for control in the Herald Bay cat camp to prevent spread. Inspect in winter 2017, hand removal any seedlings. WMA 7 – Recommend for control in

	(weed cover 6-75%) on the carpark was not treated as too large for hand removal and control being re-evaluated. Refer to photo 7. WMA 8 (new) – The population (weed cover less than 1%) around old shed site (10m x 3m area) was hand removed. WMA 9 (new) – The population was not inspected as limited visitor access until the area is developed and control is under re-evaluation.	the Charlies Harbour carpark area due to high visitation. Inspect in winter 2017 and complete chemical treatment. WMA 8 – Recommend for control as small infestation in Withnell Point campsite. Inspect in winter 2017, hand removal any seedlings. WMA 9 – Infestation not in visitor area, control to be re-evaluated.
Year 4 (2017) – Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.		
Year 5 (2018) – Application of herbicide to all populations. Follow-up monitoring 4 weeks post control. Repeat herbicide action if required.		

Output and outcomes:

- Four new occurrences of ice plant were located outside of the known WMAs in 2014 to 2016. In 2014 one population was identified on the rocky headland at Sunday Island Bay (WMA 9) and in 2015 three populations were found at the Herald Bay cat camp (WM A6), Charlies Harbour Lookout (WMA 7) and Withnell Point (WMA 8) (refer to Attachment 1).
- In 2014 weed control took 1 hour 45 mins in three WMAs, with an accumulative 3080 m^2 area being treated. Weed control was not implemented in 2015. In 2016 weed control took 35 minutes in two WMAs, with an accumulative 120m^2 area treated.

3. Weed surveillance areas – methods, outputs and outcomes

The weed management plan's objective for WSAs is to identify 'new to island' weed species or new populations of the eradicate/control species on DHI and to prevent the establishment of those weed species. The plan recommended that surveillance should be undertaken twice a year at a time when weeds are actively growing and easily detectable in the field, optimally between May-August when rainfall is historically at its highest for the year. A quick response to capture weeds with a short life cycle is required, as many will rapidly senesce and set seed if warm dry conditions follow significant rainfall.

Systematic weed surveillance was performed in June 2015 by four Parks and Wildlife personnel and in August 2016 by three Parks and Wildlife personnel. Each WSA was thoroughly traversed by foot and inspected for any weed species that were new to the island; and for control or eradicate species. 19.4 hours (excluding travel) was spent traversing the designated WSAs

over 2015 (9.7 hours) and 2016 (9.7hrs). Weed surveillance did not occur in 2014 as it was considered to be too late in the season to reliably identify weeds.

No significant 'new to island' weed species were identified during the systematic weed surveillance programs during 2015 and 2016. However, four new ice plant locations were identified in front of Sunday Island Bay Lot 304 (WMA 9), the Herald Bay cat camp (WMA 6), Charlies Harbour Lookout (WMA 7) and Withnell Point (WMA 8).

Opportunistic weed surveillance is ongoing, particularly as part of other project elements. One 'new to island' weed species and two new WMAs were located during 2015 to 2016 as follows:

- On 11 September 2015 one ruby dock plant, a 'new to island' species, was identified on the cat fence approximately 660m east of the main access gate (ruby dock WMA1; refer to Attachment 1) during the cat eradication program. The plant was removed prior to seed set.
- On 25 May 2016 one poor immature plant of *Amaranthus viridis* was found near the end of the cat fence line track by Greg Keighery. He doubted the species would establish on the island except where it could obtain extra water. The species has been ranked as low priority for control using the IPPP matrix due to its low current and potential distribution, low ecological impact and slow invasiveness. It has however been included as an alert weed to prevent spread and establishment on the island.
- On 2 February 2016 one mature castor oil plant (3mx2m) was found on the large mobile dunes south west of the airstrip during the aerial goat monitoring operation, with no other plants in close proximity (castor oil WMA2; refer to Attachment 1).
- In September 2016 one new lupin WMA was identified approximately 1.4km north of lupin WMA1, and 100m west of the track, during the threatened avifauna survey (lupin WMA 2; refer to Attachment 1).

4. Discussion

The weed management program is progressing well, with the majority of the objectives in the weed management plan on target to being met as follows:

- All castor oil plants identified by Astron have been removed within two years, with WMA 1 and the Dirk Hartog Homestead being checked annually for new seedlings. No seed has been produced since the last mature plants were removed in September 2014. Eradication cannot be confirmed until 31 December 2024 as seed can remain viable in the soil for up to 10 years. Additionally, a new castor oil location (WMA 2) was found in February 2016, consisting of a mature plant 2m high x 3m wide on the mobile dunes south west of the airstrip, during the aerial goat monitoring operation. This plant will be removed (cut and paint) in early 2017 with regrowth and new seedlings being controlled on an annual basis until eradication can be confirmed.
- Couch WMA 1 is on target for removal in five years (30 June 2019) as per the objectives in the weed management plan. However, seed can remain viable for up to four years in the soil delaying eradication until four years after the original infestation is removed. Couch WMA 2 is being treated for containment (monitor and prevent spread) as it surrounds the homestead water supply well and is unable to be chemically treated, and mechanical control is not feasible.

- Japanese pepper WMA1 is not on target for removal after two years as the removal of the only known plant in the national park is planned to coincide with the demolition of the old cook house, which it is growing alongside. Invasiveness is low as a male and female tree is required to enable reproduction.
- Lupin WMA 1 is on target for eradication with no seedlings noted during 2014 to 2016. Eradication cannot be confirmed until 31 December 2034 as seed can remain viable in the soil for up to 20 years. A new weed management area (WMA 2) was identified during the September 2016 threatened avifauna survey. This site will be inspected during winter/spring 2017 with the aim of removing any new seedlings prior to seed set until eradication can be confirmed.
- Ruby dock WMA 1 is on target for eradication with no seedlings noted since the last was removed in September 2015. Eradication cannot be confirmed until 31 December 2035 as seed can remain viable in the soil for up to 20 years.
- Wild radish WMA 1 is on target for eradication with no seedlings noted during 2014 to 2016. Eradication cannot be confirmed until 31 December 2034 as seed can remain viable in the soil for up to 20 years.
- False sowthistle is considered to be on target for control even though specimens of the plant have not been identified in great quantities to date. A more concerted effort in monitoring the sites to enable detection will be applied during 2017.
- Ice plant is not on target for control as it is more extensively spread across the island then reported by Astron, who focused their weed survey along tracks and in the existing infrastructure areas. Four new infestations have been located during 2014 and 2015 with many more anticipated, particularly along the coastline. The seed has a long viability period in the soil of over 20 years. For these reasons, it is considered that ice plant is not a priority for control and as recommended from the reviewed IPPP ranking process the objective should be to improve general weed management to prevent spread to priority sites.
- The systematic and opportunistic weed surveillance programs are meeting the objectives to identify new weed species to DHI and to prevent the establishment of those weed species. One 'new to island' weed species being ruby dock was identified in September 2015; it is being managed for eradication to prevent establishment on DHI.

5. Recommendations

The following recommendations are advised for future management and surveillance operations:

- The management objective for ice plant be changed to, 50% reduction in the extent of ice plant in priority WMAs including campsites and high visitor access areas within 2 years, due to its more extensive spread, long seed viability period of 20 plus years and low feasibility of control. This objective reflects the lowering of the species IPPP ranking to low (C), improve general weed management to prevent spread to priority sites. WMAs to be controlled include Herald Bay cat camp, Charlies Harbour Lookout, Withnell Point, WMA 4 alongside access track in Herald Bay and the barge landing area at Cape Ransonnet.
- Due to the current low visitation on DHI the recommendation is to inspect the majority of the WSA's once per year, other than the areas deemed to be at high risk of introducing weeds including the Herald Bay operation base (WSA 1a), barge loading site (WSA 1b),

Sandy Point field base (WSA 1c), airstrip (WSA 4a), Cape Ransonnet (WSA 4b), Sunday Island Bay Lot 305 (WSA 5a), and the Dirk Hartog Island Lodge and current rubbish dump (WSA5c and 5e(i)), which are to be done twice per year in winter and spring and after significant summer rainfall.

- The 2017/18 milestones committed in the revised project plan need to be rescheduled in the 2017/18 annual report to the NCB Advisory Board as eradication is not achievable due to the length of seed viability in the soil.
- Note the recommendations for each WMA in section 2 above.

Photo 1 Castor oil plant WMA1 pre-basal bark control September 2014 and post control June 2015

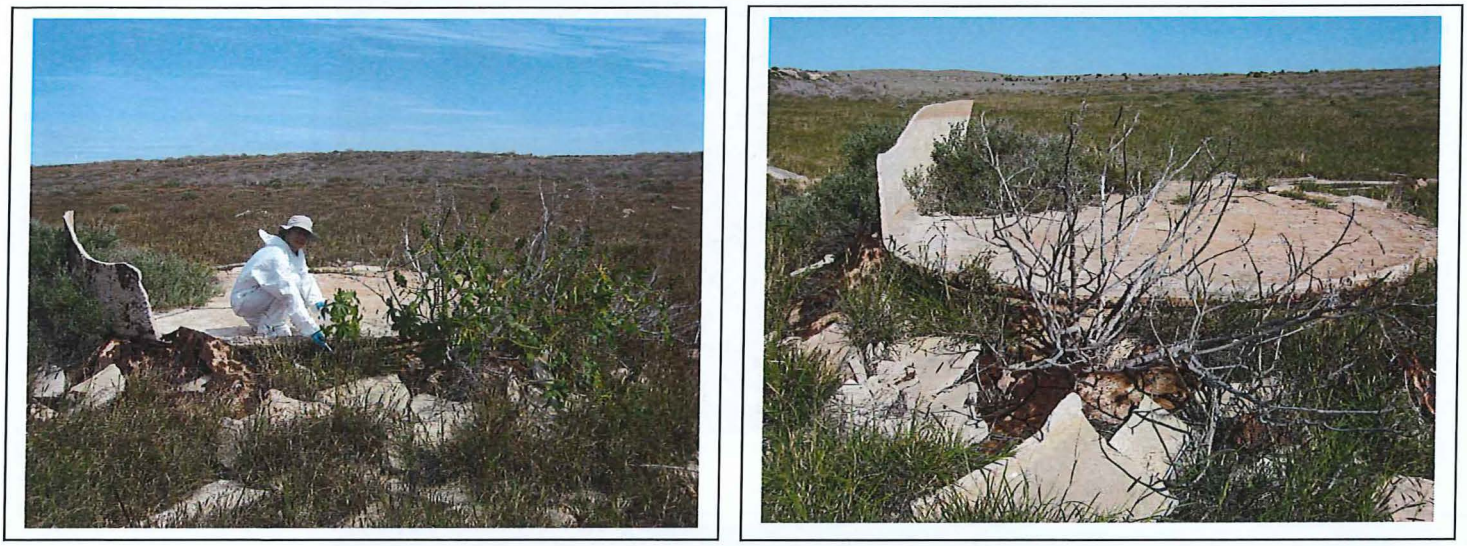
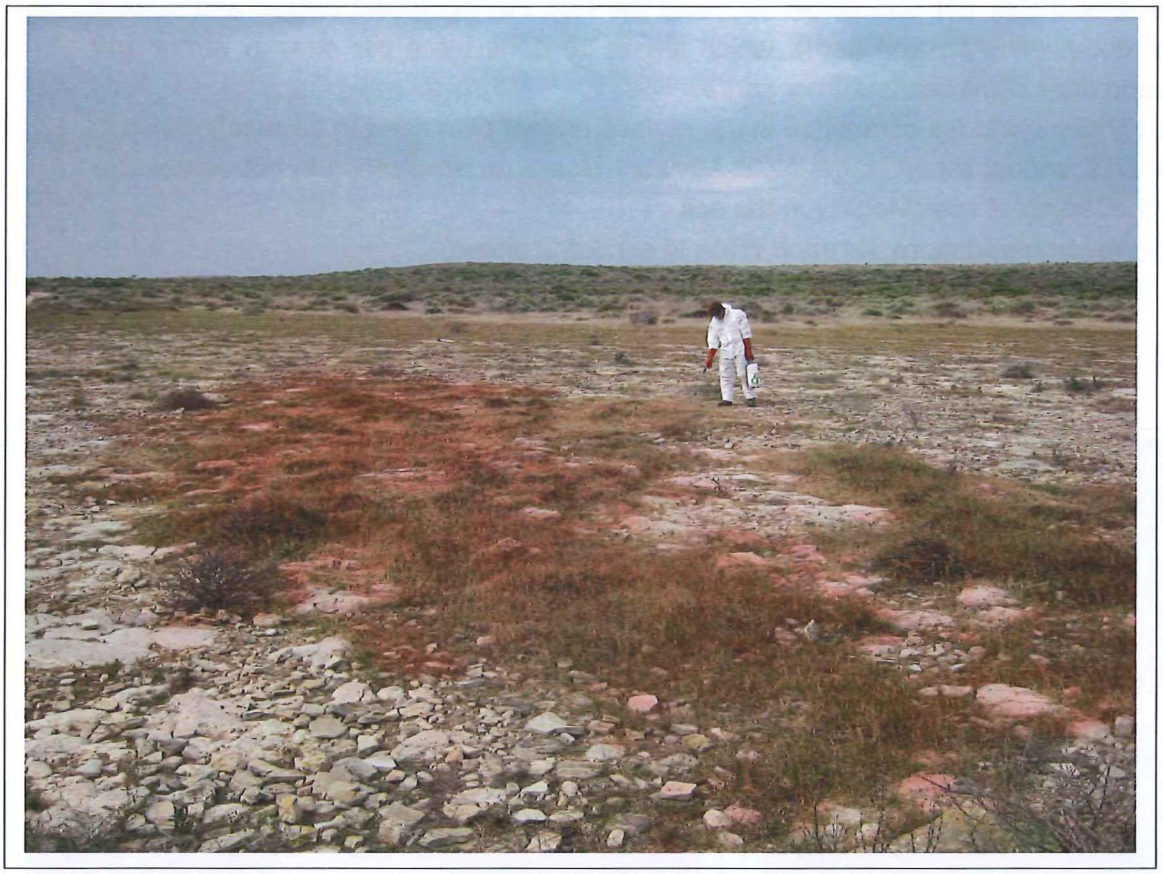


Photo 2 Castor oil plant WMA2 February 2016

Photo 3 Couch WMA1 November 2015



Couch WMA 1 in August 2016

Photo 4 Couch WMA2

Photo 5 Japanese pepper WMA1, June 2015

Photo 6 Ruby Dock WMA1 pre and post control September 2015

Photo 7 Ice plant WMA 7 Charlies Harbour Lookout

References

Astron Environmental Services, 2012a, 'Dirk Hartog Island Baseline Weed Survey', unpublished document prepared for the Department of Environment and Conservation.

Astron Environmental Services, 2012b, 'Dirk Hartog Island National Park Weed Management and Action Plan (2013 – 2018)', unpublished document prepared for the Department of Environment and Conservation.

Bureau of Meteorology (BOM), 2012, Climate averages for Denham, viewed 31 January 2017.

Western Australian Herbarium, 2012, FloraBase – the Western Australia Flora, Department Parks and Wildlife, Perth, viewed 31 January 2017.

Appendix 1 Weed management areas in DHI National Park, as at 31 December 2016

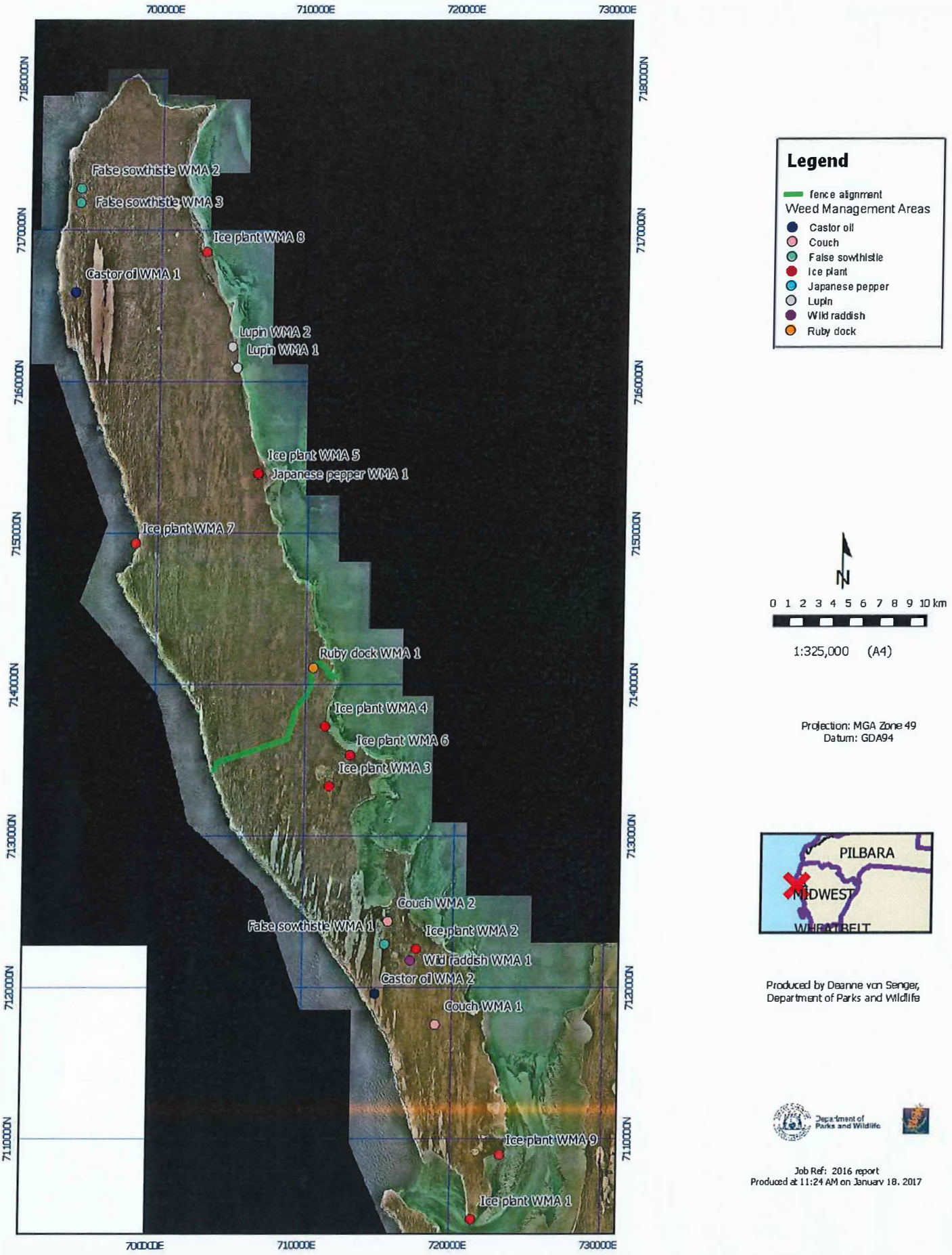
Name	Weed management areas	Current distribution	Potential distribution	Ecological impact	Invasiveness	Feasibility control	IPPP ranking	Objective
Acetosa vesicaria (Ruby Dock)	1	Low	High	High	Rapid	High	High (H,I)	Eradicate
Cynodon dactylon (Couch)	2	Low	Low	High	Moderate	High	Low (B,C,D)	Eradicate
Lupinus cosentinii (Lupin)	2	Low	High	Moderate	Moderate	High	Low (B,C,D)	Eradicate
Raphanus raphanistrum (Wild radish)	1	Low	High	High	Rapid	High	High (H,I)	Eradicate
Ricinus communis (Castor oil plant)	2	Low	Medium	High	Moderate	High	Low (B,C,D)	Eradicate
Schinus terebinthifolius (Japanese pepper)	1	Low	Low	High	Moderate	High	Low (B,C,D)	Eradicate
Mesembryanthemum crystallinum (Ice plant)	8	Low	Low	High	Moderate	Low	Low (C) (revised)	Control at key sites only (revised)
Reichardia tingitana (False sowthistle)	3	Low	High	High	Rapid	High	High (H,I)	Control

A= no action
B= monitor only - detect significant change in species weed risk or management ability
C= improve general weed management - prevent spread
D= protect priority sites - prevent spread to key priority sites
E= target control to reduce infestations at priority sites - significantly reduce impact on key sites/high biodiversity assets
H= regional eradication
I= state wide eradication

Appendix 2 Weed surveillance areas in DHI National Park, as at 31 December 2016

Weed surveillance area	Weed surveillance area locations	Site	Site name	Frequency
WSA 1	Parks & Wildlife operations base/entry point	WSA 1a	Herald Bay operations base	winter and spring
		WSA 1b	Barge landing site	winter and spring
		WSA 1c	Sandy Point field base	winter and spring
WSA 2	Existing tourist destinations	WSA 2a	Cape Inscription (including walk trails)	winter
		WSA 2b	Turtle Bay Lookout (including walk trails)	winter
		WSA 2c	Charlies Harbour	winter
		WSA 2d	Quoin Bluff South (including walk trails)	winter
		WSA 2f	Blowholes	winter
		WSA 2g	Surf Point	winter
WSA 3	Campsites	WSA 3a	Mystery Beach	winter
		WSA 3b	West Point	winter
		WSA 3c	Urchin Point	winter
		WSA 3d	Dampiers Landing	winter
		WSA 3e	Withnell Point	winter
		WSA 3f	Louisa Bay	winter
		WSA 3g	Quoin Head	winter
		WSA 3h	Notch Point	winter
		WSA 3i	Sandy Point	winter
WSA 4	Current visitor entry points to Dirk Hartog Island	WSA 4a	Airstrip	winter
		WSA 4b	Cape Ransonnet	winter and spring
WSA 5	Freehold/lease	WSA 5a	Sunday Island Bay (Lot 304)	when developed
		WSA 5b	Sunday Island Bay (Lot 305)	winter and spring
		WSA 5c	Dirk Hartog Island lodge	winter and spring
		WSA 5e(i)	Dirk Hartog Island Lodge current rubbish dump	winter and spring
		WSA 5e(ii)	Historic rubbish dump	winter
WSA 6	Cat fence	WSA 6a	Cat fence	winter

Attachment 1 Weed Management Areas 2016



Legend

- fence alignment

Weed Management Areas

- Castor oil
- Couch
- False sowthistle
- Ice plant
- Japanese pepper
- Lupin
- Wild raddish
- Ruby dock

N

0 1 2 3 4 5 6 7 8 9 10 km

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Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: 2016 report
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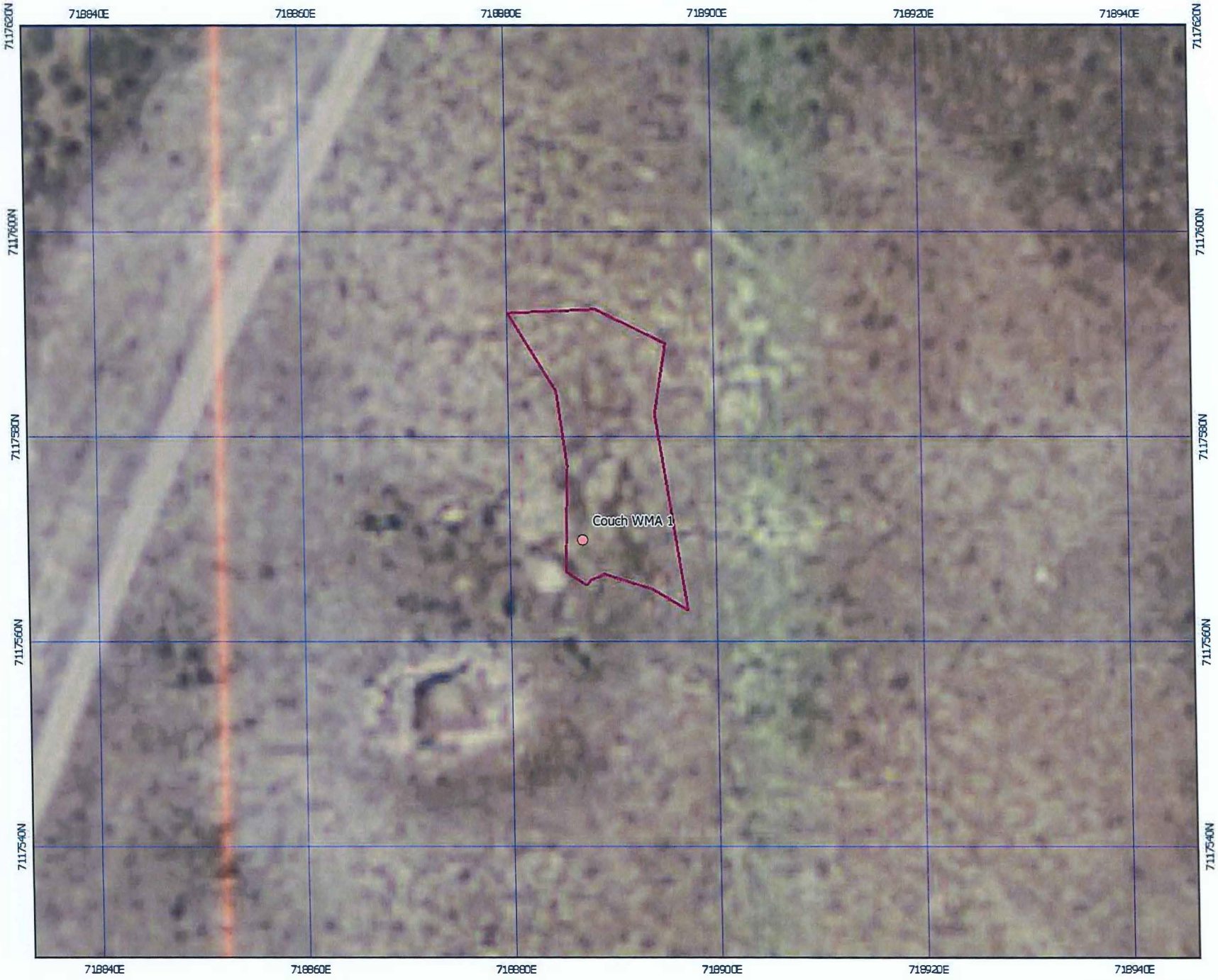

Attachment 2
Couch WMA 1

Legend

Couch WMA 1, 2014

N

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Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: Couch WMA 1
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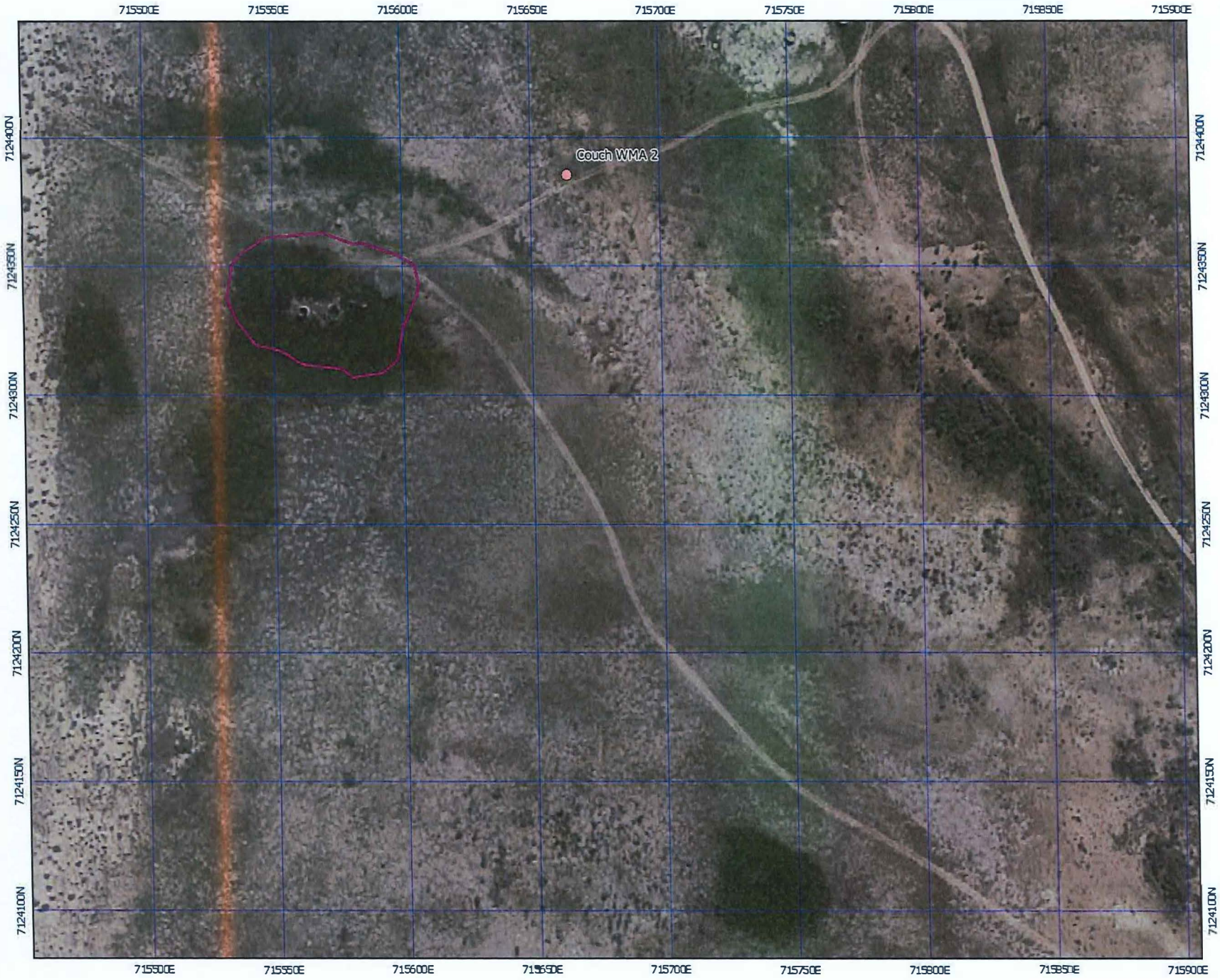
Attachment 3
Couch WMA 2



Legend

Couch WMA 2, 2014

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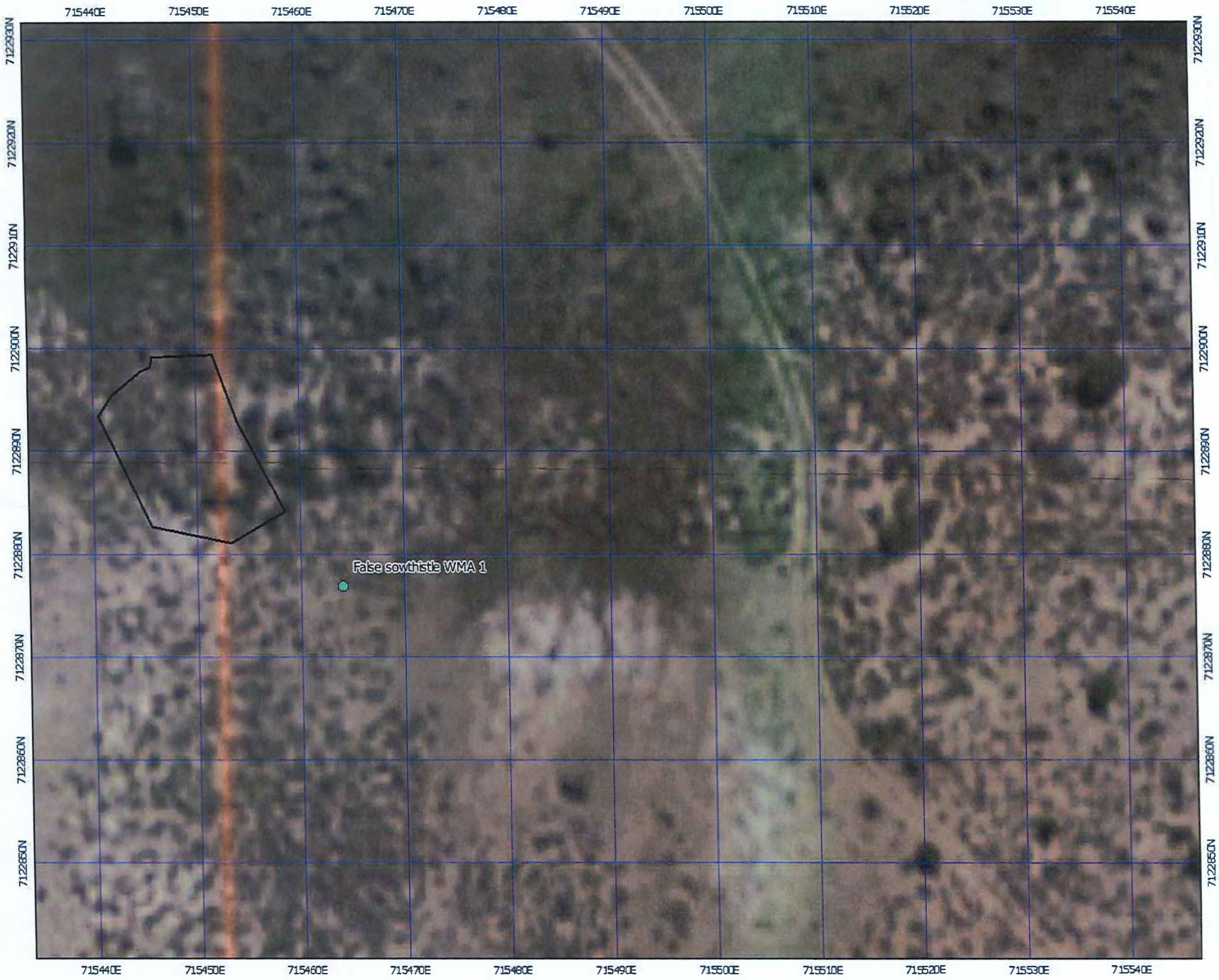
Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: Couch WMA 2
Produced at 02:15 PM on January 18, 2017

Attachment 4
False sowthistle WMA 1



Legend

Weed Management Areas

- False sowthistle
- false sowthistle WMA 1, 2014

N

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0 2 4 6 8 10 12 14 16 18 20 m

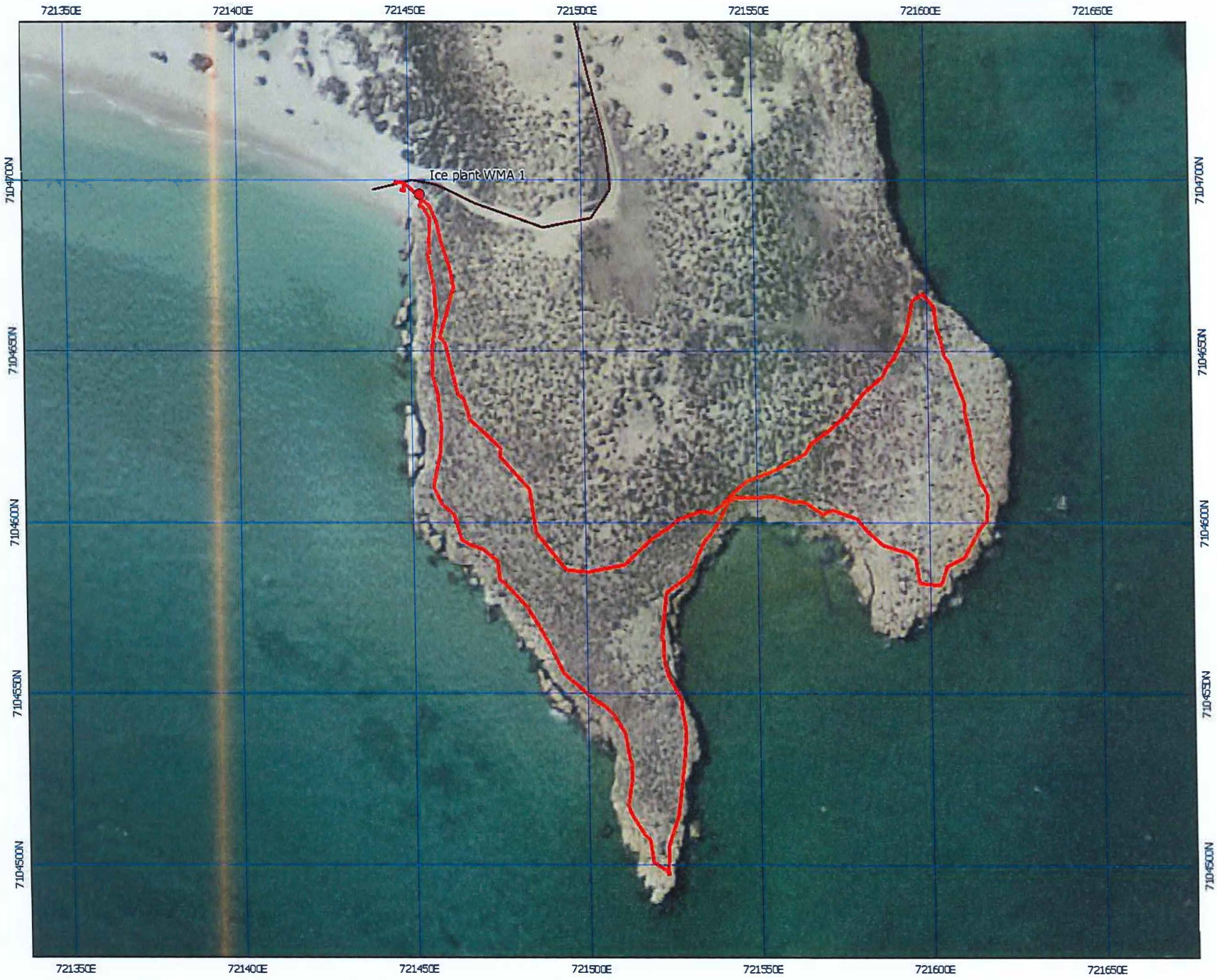
Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: False sowthistle WMA 1
Produced at 10:25 AM on January 25, 2017

Attachment 5
Ice plant WMA 1



Legend

- Iceplant WMA 1, 2014
- Dirk Hartog Island tracks

N

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0 10 20 30 40 50 m

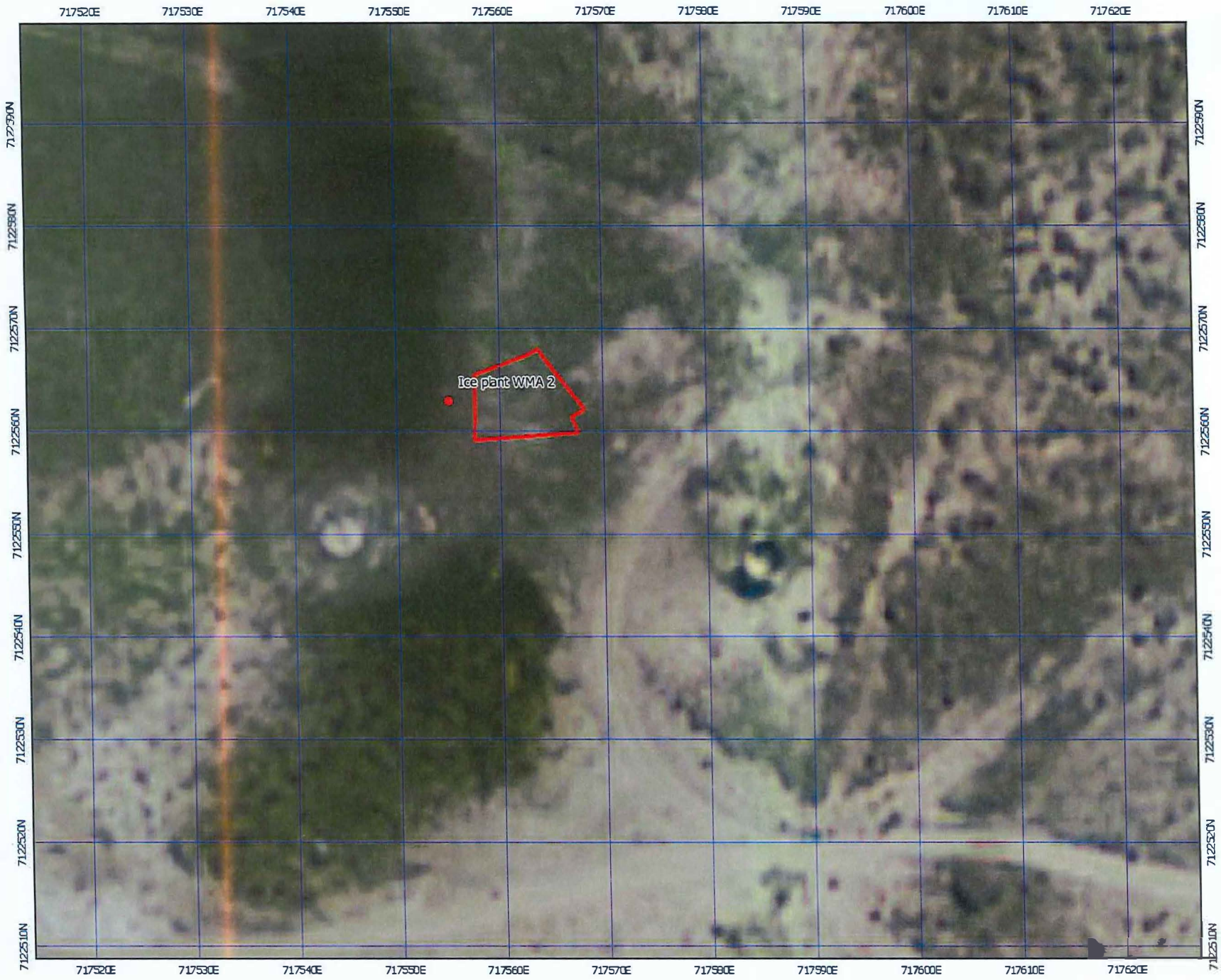
Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: WMA 1 shapefile Sept 2014
Produced at 01:54 PM on May 02, 2017

Attachment 6
Ice plant WMA 2



Legend

Ice plant WMA 2, 2014

N

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Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: Shapefile September 2014
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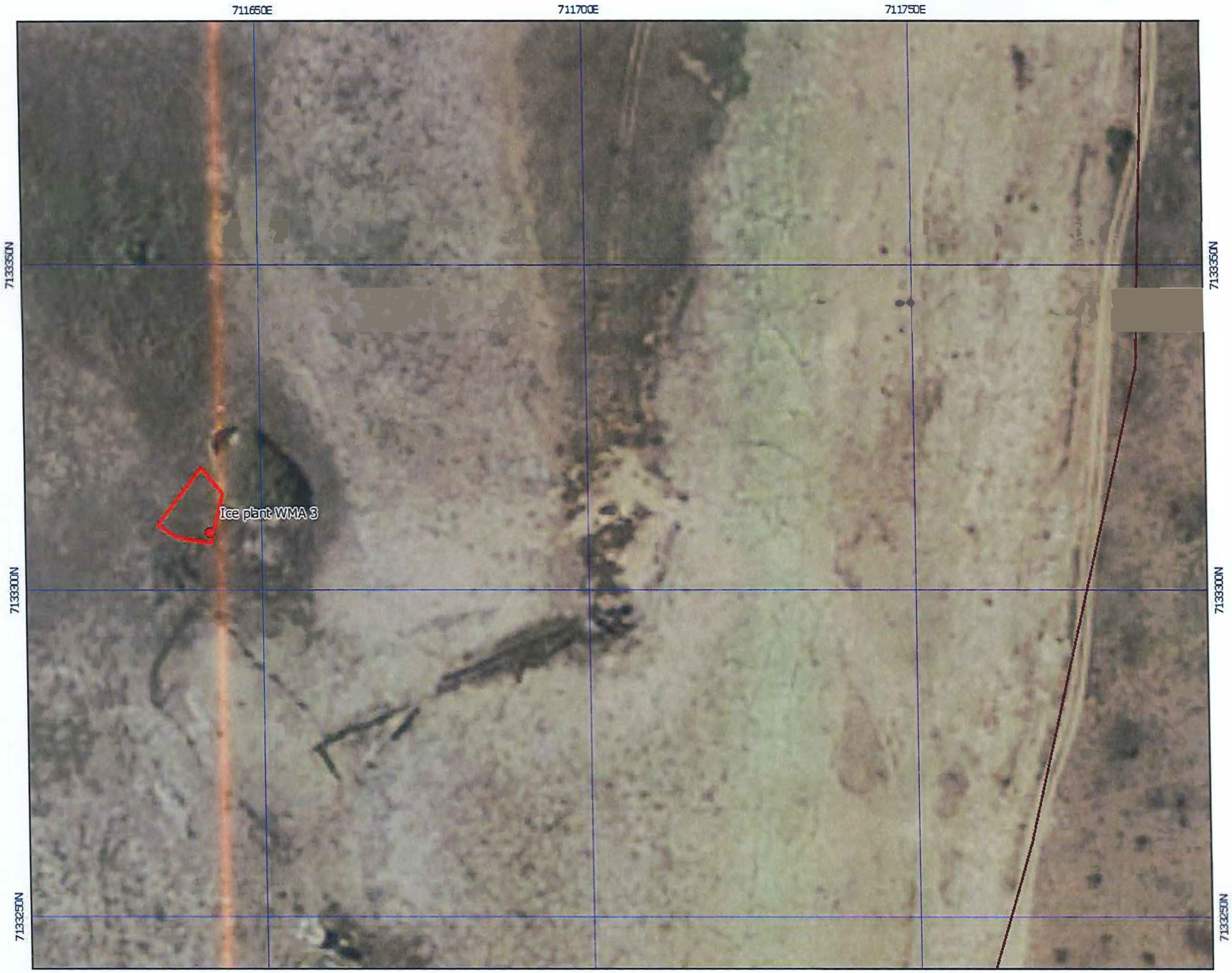
Attachment 7
Ice plant WMA 3



Legend

- ice plant WMA 3, 2014
- Dirk Hartog Island tracks

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Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: Shapefile September 2014
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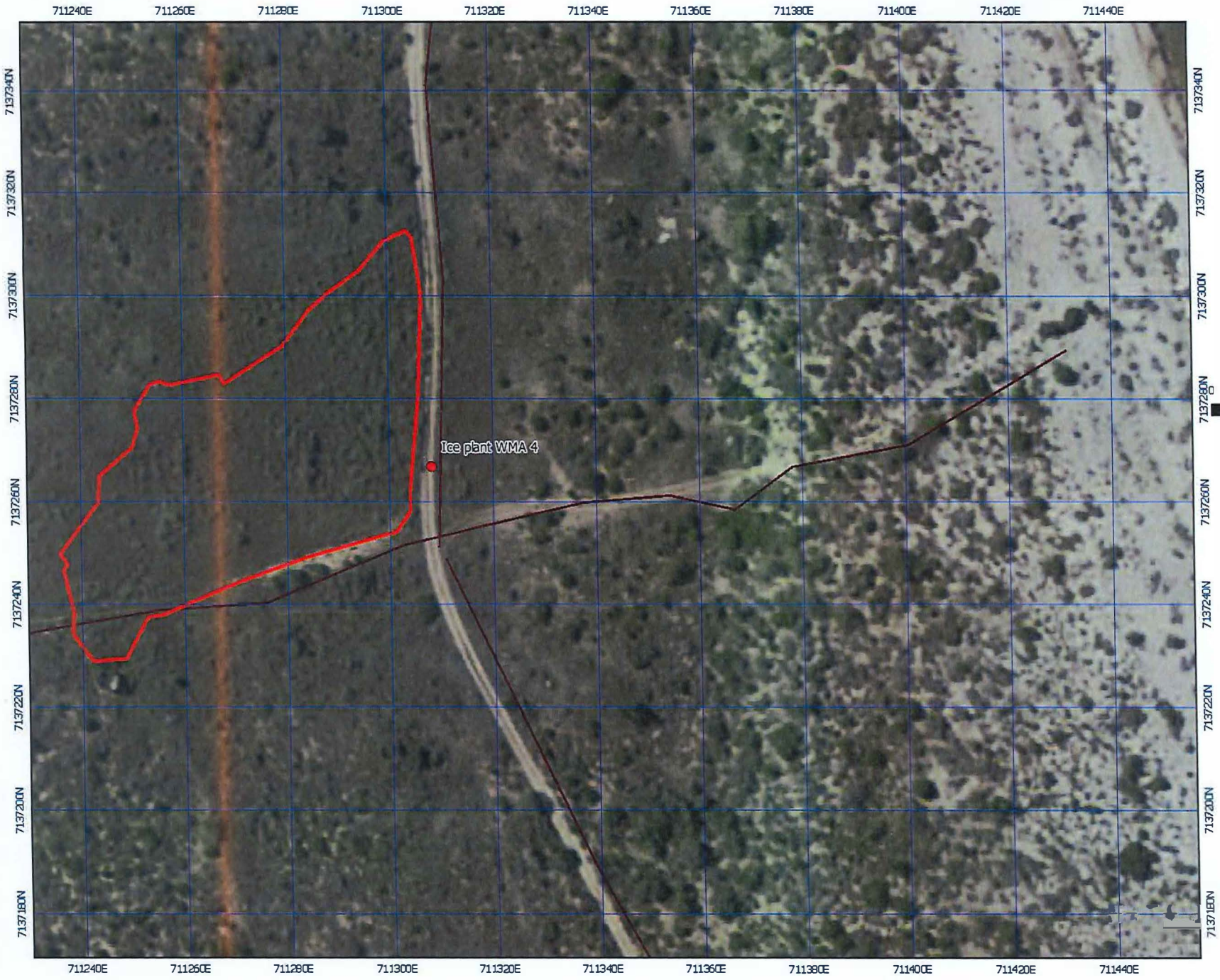
Attachment 8
Ice plant WMA 4



Legend

- Ice plant WMA 4, 2014
- Dirk Hartog Island tracks

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Projection: MGA Zone 49
Datum: GDA94

Produced by Deanne von Senger,
Department of Parks and Wildlife

Job Ref: Shapefile September 2014
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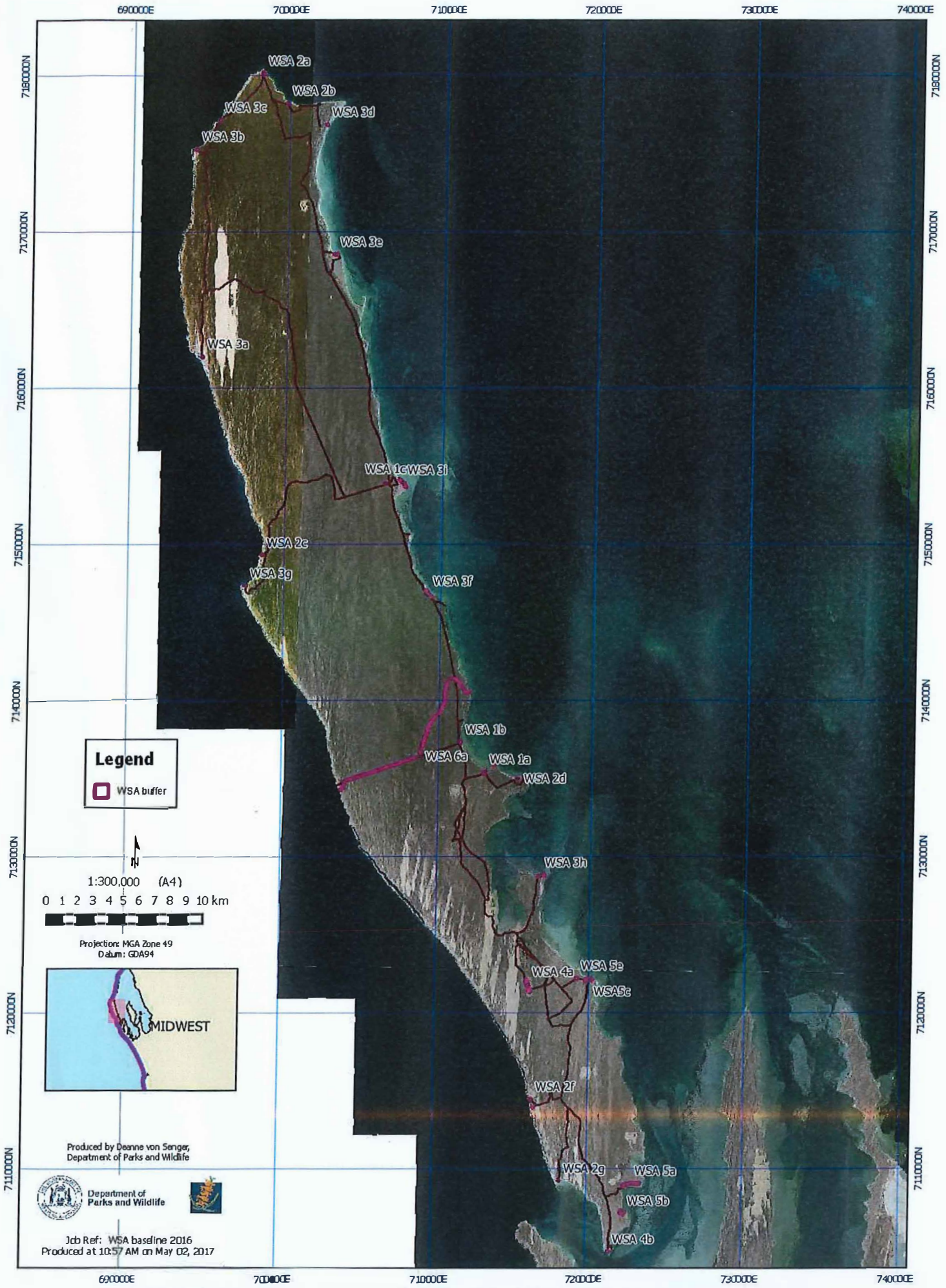
Attachment 9 Weed Surveillance Areas 2016



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