Post Construction Golden Sun Moth Monitoring Results

2010 – 2011 Flight Season

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Document History and Status

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0	Sugarloaf Pipeline Alliance	SPA Project Manager	25/07/2011	Final
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Purpose

The purpose of this document is to describe the results of the post-construction monitoring (2010/2011 flight season) of the Golden Sun Moth (*Synemon plana*) (GSM) for the Sugarloaf Pipeline Project.

The purpose of the post-construction monitoring is to:

- Evaluate the impact of the project on the GSM population/s;
- Document the recovery of the GSM population/s (i.e., habitat use and breeding by adults) within impacted areas following completion of construction; and
- Provide information on the distribution and abundance of GSM populations within the Project area.

Abbreviations

Term	Description
Alliance	Sugarloaf Pipeline Alliance
CMP	Conservation Management Plan
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts (now DSEWPC)
DSE	Victorian Department of Sustainability and Environment
DSEWPC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (formerly DEWHA)
EMP	Environmental Management Plan
EMS	Environmental Management Strategy
EPBC	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FFG	Victorian *Flora and Fauna Guarantee Act 1988*
GSM	Golden Sun Moth (*Synemon plana*)
HLPS	High-lift Pump Station
FMP	Fauna Management Program
ROW	Construction Right of Way
SLPA	Sugarloaf Pipeline Alliance (the 'Alliance')

Executive Summary

As part of the approvals process for the Sugarloaf Pipeline Project, the Sugarloaf Alliance was required to undertake at least two seasons of survey for the Golden Sun Moth (*Synemon plana)* (GSM) after the completion of construction activities. The GSM is listed as a threatened species at both the commonwealth and state level. For most of the GSM's life-cycle, the species is present only as larvae, which remain in the soil below the ground surface (DEWHA 2009a). On an annual basis, adult GSM typically emerge from late October through to early January, although each individual adult moth is thought to typically live for only 5 days or less after emerging.

The approved Fauna Management Programs for the Sheoak High-lift Pump Station (SLPA 2009b) and the Yea-to-Devlin Bridge (SLPA 2009c) sections state that the following surveys will be undertaken for both GSM adults and pupal cases:

- Monitoring surveys as part of the Habitat Slab Replacement experiment;
- Monitoring surveys as part of the Grassland Habitat Reinstatement experiment;
- Monitoring surveys within and immediately adjacent to the Construction Right of Way (ROW);
- Monitoring surveys across the broader Sheoak property.

The results of the first season of post-construction GSM monitoring (2009/2010 flight season) were provided within a separate report (SLPA 2010). This report describes the findings of the second season of post-construction monitoring for GSM adults, and the results of pupal case searches.

Based on unpublished information provided by DSE, ecological consultants and other GSM specialists from across Victoria, it was evident that (a) GSM did not emerge in large numbers across the majority of the species' Victorian distribution until mid-December 2010, (b) GSM continued to be seen in flight well beyond early January 2011, which is the typical end to the flight season, and c) that the numbers of GSM observed during this flight season were lower than in recent years at known locations across the state. The surveys undertaken as part of this project support this conclusion, as the numbers of GSM (adults and pupal cases) seen in 2010/2011 were well below those seen in 2009/2010, even within areas that had not been disturbed during construction.

Possible explanations for the lower numbers, delayed emergence and prolonged end to the flight season include above-average rainfall occurring in the local area in the months prior to the commencement of the flight season, and regular periods of heavy rain continuing throughout the typical flight season period. The lack of access in 2010/2011 to a number of private properties where large numbers of GSM were recorded in 2009/2010 may have also contributed to the lower numbers of GSM recorded.

Because the numbers of GSM reported across all of Victoria, including disturbed and undisturbed grassland habitats and including the Sugarloaf Pipeline construction area, were lower in 2010/2011 than in 2009/2010, no conclusion can be drawn on the impact of the Sugarloaf Pipeline Project on the GSM.

1 Introduction

The Golden Sun Moth (*Synemon plana*) (GSM) occurs in grasslands and open grassy woodlands in south-eastern mainland Australia. These habitats used by the GSM are amongst the most threatened of all vegetation types in Australia, with more than 99.5% estimated to have been grossly altered or destroyed (DEWHA 2009a, Kirkpatrick *et al.* 1995, Lunt 1991). The GSM is generally found in grassy habitats that are dominated by native species of grasses, but they have also occasionally been found within areas dominated by non-native species of grasses, such as Chilean Needle-grass. The GSM is listed as 'critically endangered' on the Commonwealth *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999,* 'threatened' on the Victorian *Flora and Fauna Guarantee* (FFG) *Act 1988* and 'critically endangered' on the Department of Sustainability and Environment (DSE) *Advisory List of Threatened Invertebrate Fauna in Victoria 2009* (DSE 2009).

For most of the GSM's life-cycle, the species is present only as larvae, which remain in the soil below the ground surface (DEWHA 2009a). They are thought to feed on the roots of grasses. It is not known how long individual GSM remain as larvae, but it is suspected to be greater than one year and possibly up to three years or more. Larvae eventually pupate into non-feeding adults, which emerge for reproductive activities. On an annual basis, adult GSM typically emerge from late October through to early January, although each individual adult moth is thought to typically live for only 5 days or less after emerging. However, unusual weathers patterns before or during the flight season can delay the time of emergence and the duration of the flight season (adult moths were seen as late as mid-February 2011 at one location near the northern fringes of Melbourne – Ecology Australia, pers. comm.).

In late 2008, targeted surveys undertaken by Alliance Ecologists identified the presence of flying adult GSM at a number of grassland locations within the proposed construction footprint. Most observations were within the 3-5 km stretch of the proposed pipeline alignment south of Yea, including a large population within the property that was proposed for the High Lift Pump Station[1] for the project. Subsequent targeted searches for the presence of empty GSM pupal cases (left at the ground surface by the adult moths as they emerge) were undertaken in January 2009 at locations where adults had previously been seen in flight, and confirmed the presence of breeding activity (from the previous season) by the species at these sites (SLPA 2009a).

The Fauna Management Programs (FMP) for the Sheoak High-lift Pump Station EMP section (SLPA 2009b) and for the Yea-to-Devlin Bridge EMP section (SLPA 2009c) both specify that the Alliance will undertake post-construction monitoring for the GSM. Four types of monitoring (for adult GSMs and pupal cases) were to be undertaken in areas where GSM was found within these two EMP sections. These four types of monitoring are summarized in Table 1 below:

[1] This property, known as the Sheoak property, is owned by Melbourne Water; a member of the Sugarloaf Pipeline Alliance.

Table 1 Monitoring requirements for adult GSM and pupal cases as part of the Sugarloaf Pipeline Project

Monitoring for GSM Adults and Pupall Cases	Sheoak HLPS EMP section (SLPA 2009b)	Yea-to-Devlin EMP section (SLPA 2009c)
Monitoring of Habitat Slab Replacement Experiment	Two slab locations for 2 years, and up to 5 years where permission is obtained from the land-owner	Four slab locations (one each on property 327 and 328, plus two on property 335) for 2 years, and up to 5 years where permission is obtained from the land-owner
Monitoring of Grassland Habitat Reinstatement Experiment	One location for 2 years	Not applicable
Monitoring of ROW and adjacent undisturbed land	In Type 2 and 3 disturbance areas for 2 years[2].	On properties 18/961, 327, 328, 330, 335 for 2 years.
Monitoring of broader Sheoak property	For 5 years, across all parts of the broader property that were not disturbed during construction	Not Applicable

The first season of post-construction GSM monitoring was completed during the 2009/2010 flight season, and the methods and findings from that monitoring were documented in an annual report prepared by the Alliance (SLPA 2010).

This document summarizes the methods and results of the second season of post-construction monitoring during the 2010/2011 flight season of the GSM.

Monitoring for the GSM will occur across the broader Sheoak property for a further three GSM flight seasons. If landowner permission is obtained, monitoring will also continue for a further one to three GSM flight seasons in areas set aside for the Habitat Slab Replacement experiment.

[2] Type 1 disturbance areas include infrastructure such as roads and buildings that permanently replace the grassland habitat that was present prior to the commencement of construction. As such, there is no need to undertake post-construction monitoring within habitat areas that no longer exist.

2 GSM Monitoring Approach and Techniques

2.1 Overview of Approach

The following GSM monitoring was undertaken during the 2010/2011 flight season:

- Monitoring of GSM adults and pupal cases as part of Habitat Slab Replacement Experiment;
- Monitoring of GSM adults and pupal cases as part of Grassland Habitat Reinstatement Experiment;
- Monitoring of GSM adults and pupal cases in all other[3] **known** GSM grassland habitats that were intercepted by the Construction Area (often referred to as GSM monitoring in the 'ROW'); and
- Monitoring of GSM adults and pupal cases across the broader Sheoak property.

The monitoring program and methods for the project were developed as a stand-alone document prior to the commencement of the 2009/10 flight season (SLPA 2009e). The methods were developed in consultation with government authorities, and were therefore consistent with the recently released national guidelines for the minimum acceptable standards for persons or organisations undertaking GSM surveys (DEWHA 2009a). The following important aspects of the national guidelines were incorporated into the Alliance's GSM monitoring methods:

- The main technique for monitoring GSM populations should be the detection of flying adult males. Where possible, the more difficult and time consuming processes of detecting adult females (laying eggs or not), empty pupal cases or living subsurface larvae should be used also to confirm that reproduction is occurring at a site;
- Sites where moths are detected reliably should be visited repeatedly as reference sites to guide survey timing at target sites;
- For reliable results, surveys for flying adult moths should be undertaken:
    - On warm to hot days (where the temperature is at or above 20°C by 1000 hrs) between late October and early January;
    - During the warmest part the day (i.e. 1000 hrs – 1400 hrs);
    - At times when the sky is clear or mostly cloudless;
    - When wind conditions are relatively still; and
    - No sooner than two days after substantial rainfall.

With respect to reference sites for the Sugarloaf Pipeline Project during the 2010/2011 GSM flight season:

- Reliable locations for detecting GSM within the Sheoak property (outside the construction footprint) were used as the primary reference sites to guide survey timing for monitoring;
- On occasions, historically known GSM populations in the local area were also used as reference sites, including roadside locations alongside Careys Rd (off Killingworth Rd, to the north-east of central Yea) and at Pert's Reserve (public land along the Melba Highway, opposite property #336);
- Regular email contact was maintained with other ecologists across the state regarding observations of GSM in flight elsewhere; and

[3] That is, areas not being used for the experiments.

- Regular phone and email contact was also maintained with the DSE officer assigned to address GSM issues in the Goulburn region (Lance Williams, DSE, Benalla office).

In addition to the monitoring of GSM adults and pupal cases at the two experimental areas, Alliance Ecologists also conducted monitoring of floristic characteristics. The methods and results for this monitoring are described in detail in the relevant FMP documents (SLPA 2009b and SLPA 2009c), but not in this document. The results of the floristic analysis may add to existing knowledge in regard to GSM habitat requirements.

2.2 Adaptive management

The monitoring program for GSM (SLPA 2009a, 2009b, 2009c, 2009e) was developed on the basis of the current understanding of the species' biology and seasonal periods of activity, in addition to a suite of survey techniques that have proven to be repeatedly successful in the detection of the species (as described above). However, for a range of reasons, the methods could have needed to be modified or replaced by the Alliance Ecologists due to unforeseen circumstances (e.g. weather). To address this scenario, the project adopted an Adaptive Management system. An adaptive management system is identified as one that "*can absorb and accommodate future events in whatever unexpected form they may take"* (Holling 1973 in Lindenmayer and Burgman, 2005). During the implementation of the Sugarloaf Pipeline Project, Adaptive Management has been used as a measure to manage the project's impact on the environment when an unanticipated issue has arisen (SLPA, 2008b).

Where Alliance Ecologists had identified that GSM monitoring measures needed to be altered, the relevant regulatory authorities were notified and any adaptive management measures discussed. Only after agreement has been reached with regulatory authorities have adaptive management measures been implemented.

During the 2009/2010 flight season, there were no changes to the implementation of the GSM monitoring program that required any adaptive management (SLPA 2010). However, during the 2010/2011 flight season, there were situations that did arise whereby adaptive management was required for the GSM monitoring surveys. In particular:

- Adult GSM emerged later in the season compared to recent years;
- Weather conditions (i.e., temperatures and sunniness) were generally unsuitable for conducting surveys before and during the time of expected adult GSM emergence;
- Adult GSM continued emerging, and were being seen in flight by Alliance Ecologists, beyond the time-period specified in the approved documents (i.e. GSM were seen in flight beyond early January 2011); and
- Access to a number of private properties containing **known** GSM habitat could not be obtained for a substantial portion of the GSM flight season.

For all of these reasons, GSM monitoring surveys during the 2010/2011 flight season were not undertaken in the manner and intensity specified within the approved FMP documents. The extent to which the monitoring surveys deviated from the approved methods is detailed within chapters 3 to 6. Further discussion on the implications of these scenarios upon the intensity of GSM survey that could be undertaken is provided in chapter 7.

3 Habitat Slab Replacement Experiment

3.1 Background

The Habitat Slab Replacement experiment is being undertaken at six locations along the ROW, all of which contain **known** GSM grassland habitat. Two locations occur on the Sheoak property, two occur on property #335, and one occurs on each of properties #327 and #328. At each of these six locations, there are ten delineated rectangular plots (each within an area of 8-9 m x 10 m; 80-90 m^2), which include:

- Four 'slab' plots of replaced slabs within the ROW (one of each of four experimental treatments):
  - 45 cm thick slab that had been placed on geofab material for the duration of construction (G45 Slab);
  - 20 cm thick slab that had been placed on geofab material for the duration of construction (G20 Slab);
  - 45 cm thick slab that had been placed on timber material for the duration of construction (T45 Slab);
  - 20 cm thick slab that had been placed on timber material for the duration of construction (T20 Slab);
- Four 'laydown' plots outside but adjacent to the ROW (one for each of the four treatments),
  - area used for the laydown of the 45 cm thick slab that had been placed on geofab material for the duration of construction (G45 Laydown);
  - area used for the laydown of the 20 cm thick slab that had been placed on geofab material for the duration of construction (G20 Laydown);
  - area used for the laydown of the 45 cm thick slab that had been placed on timber material for the duration of construction (T45 Laydown);
  - area for the laydown of the 20 cm thick slab that had been placed on timber material for the duration of construction (T20 Laydown);
- One 'undisturbed' control plot outside but adjacent to the ROW (control); and
- One 'disturbed' control plot within the non-slabbed area of the ROW (dist. control).

The aims of the GSM monitoring undertaken as part of the Habitat Slab Replacement experiment were to determine whether GSM larvae are able to survive the slabbing process, and whether 'slabbing' improves habitat reinstatement for the GSM compared to the project's standard reinstatement method. The aim of the experiment was not to determine whether there has been a decline in the overall GSM population due to construction activities but merely to determine whether they are able to survive this particular reinstatement technique; however depending on the results obtained, it may have been possible to infer information on a decline .

Monitoring for pupal cases and adult moths was undertaken within each of the 60 plots (= 6 locations x 10 plots) during the 2010/2011 flight seasons. This monitoring is described in more detail below.

3.2 Methods

3.2.1 Monitoring for GSM Adults

For the 2010-11 GSM flight season, it was stated in the relevant FMPs that adult GSM were to be surveyed at every plot on four occasions (each separated by at least one week), using the repeatable method described here. All 10 plots at any one location were to be surveyed for adult GSM on a single day, and preferably all locations were to be visited within a single day (or at least on consecutive days). Surveys were also to be conducted (a) during the suitable time of year only (between late October 2010 and early January 2011), (b) when the weather conditions and time-of-day meet the criteria outlined earlier (in Chapter 2.1 of this document), and (c) preferably when GSM were known to be in flight at nearby reference locations.

For the reasons discussed in Section 2.2, monitoring surveys for adult GSM did not meet these stated survey requirements during the 2010/2011 flight season. In particular, all of the slabs were visited on an insufficient number of occasions (on 2 or 3 occasions instead of 4), and some of them were undertaken outside the approved time of year, or before the GSM had been confirmed in flight from the local area. The number and timing of GSM surveys for each location are summarized in Table 2, with the daily schedule of GSM adult surveys provided in Appendix A.

Table 2 Number of monitoring survey visits for adult GSMs at each of the six Habitat Slab locations during the 2010/2011 flight season

Habitat Slab Location	Survey Effort			SUB-TOTAL (Actual)	Target effort
	Early Surveys	'Acceptable' Surveys	Late Surveys		
326 North (Sheoak)	1	1	1	*3*	*4*
326 South (Sheoak)	1	1	1	*3*	*4*
327	1	1	1	*3*	*4*
328	1	0*	1	*2*	*4*
335 North	1	1	1	*3*	*4*
335 South	1	1	1	*3*	*4*
SUB-TOTAL	*6*	*5*	*6*	17	
Target Effort	*0*	*24*	*0*		24

Key to Table

Early surveys – refers to adult GSM surveys undertaken within the approved weather conditions, but prior to widespread observations of GSM in flight in the local area and across the state (i.e., between late October to ~10 December 2010).

'Acceptable' surveys – refers to adult GSM surveys undertaken within approved weather conditions, at the correct time of the year, and during a period when there were widespread observations of GSM in flight in the local area and across Victoria (i.e. ~11 December 2010 to 10 January 2011).

Late Surveys – refers to adult GSM surveys undertaken within approved weather conditions, and during a period when there were regular observations of GSM in flight in the local area and across Victoria, but also outside of the approved survey period (i.e. from 11 January 2011 to 30 January 2011).

* - Was not conducted due to land access constraints.

For each separate plot during each monitoring visit, one ecologist trained in the identification of adult GSM undertook the searches. The ecologist was positioned approximately 2 m from the edge of the plot and remained stationery. For a set period of 10 minutes, the ecologist recorded:

- Numbers of flying GSM that landed within the plot;
- Numbers of GSM that flew out of the plot; and
- Numbers of GSM that flew over the plot.

Then, for an additional set period of 5 minutes, the ecologist walked slowly around the edge of the plot and also recorded:

- Numbers of male and/or female GSM observed on the ground or on vegetation within the plot.

As far as possible, care was taken not to record the same individual more than once. Opportunistic observations of GSM within or near a plot outside of the designated survey period were also recorded. A copy of the datasheet used to record the results of the adult GSM surveys at the Habitat Slab Replacement experiment is provided in Appendix C.

Typically, at least two (and up to four) trained ecologists were in the field on each day to maximise the number of plots that were surveyed on the same day (and therefore with similar weather conditions). The order in which plots were visited was changed on each occasion to reduce the likelihood of bias.

A total of 15 person-days were spent undertaking adult GSM surveys of the Habitat Slab Replacement Experiment during the 2010/2011 flight season (compared to 17 person-days during the 2009/2010 flight season).

3.2.2 Monitoring for GSM Pupal Cases

For the 2010/2011 flight season, the approved FMP documents state that Alliance Ecologists will search for empty pupal cases within each of the 60 plots once in the middle of the flying season (late November to mid-December 2010) and again at the end of each flying season (early-mid January 2011). For the reasons discussed in Section 2.2, monitoring surveys for GSM pupal cases in the habitat slab plots did not meet these stated survey requirements. Effectively, only one of the two planned pupal case searches was completed within each of the slabs, and these were conducted at a time that was later than proposed according to the approved FMP documents. The number and timing of GSM pupal case surveys for each location are summarized in Table 3, with the daily schedule of GSM pupal case surveys provided in detail within Appendix B.

Table 3 Number of survey visits for GSM pupal cases at the six Habitat Slab locations during the 2010/2011 flight season

Habitat Slab Location	Acceptable mid-season survey	Late mid-season surveys	Acceptable post-season survey	Late post-season survey	SUB-TOTAL	Target Effort
326 North (Sheoak)	0	0	0	1	*1*	*2*
326 South (Sheoak) [4]	1	0	0	1	*2*	*2*
327	0	0	0	1	*1*	*2*
328	0	0	0	1	*1*	*2*
335 North	0	0	0	1	*1*	*2*
335 South	0	0	0	1	*1*	*2*
SUB-TOTAL	*1*	*0*	*0*	*6*	7	
Target Effort	*6*	*0*	*6*	*0*		12

Key to Table

Acceptable mid-season survey – refers to GSM pupal surveys undertaken at the approved mid-season time period (i.e., between late November to mid-December 2010).

Late mid-season surveys – refers to the first GSM pupal surveys undertaken later than the approved mid-season time period (i.e., beyond the late November to mid-December 2010 time-period).

Acceptable post-season surveys – refers to GSM pupal case surveys undertaken at the approved post-season time period (i.e. between early to mid January 2011).

Late post-season surveys – refers to the second GSM pupal surveys undertaken later than the approved post-season time period (i.e. beyond the early to mid January 2011 time-period).

The pupal case surveys for each plot were undertaken over a period of 30 minutes by four trained ecologists, who carefully searched the ground across the whole plot. Pupal case searches were undertaken at varying times of day. All pupal cases found and considered to be potentially GSM were collected in vials and appropriately labelled. Exoskeletons of other insects and spiders were also collected. Relevant data were collected in the field on prepared datasheets.

Collected material was dried, and then sorted into broad groups, including one group that were considered to be potentially GSM. As per the pupal cases collected during the 2009/2010, an external specialist was engaged to identify the specimens identified as being potentially GSM that have been collected from the 2010/2011 flight season.

3.3 Results from Habitat Slab Replacement Experiment Monitoring

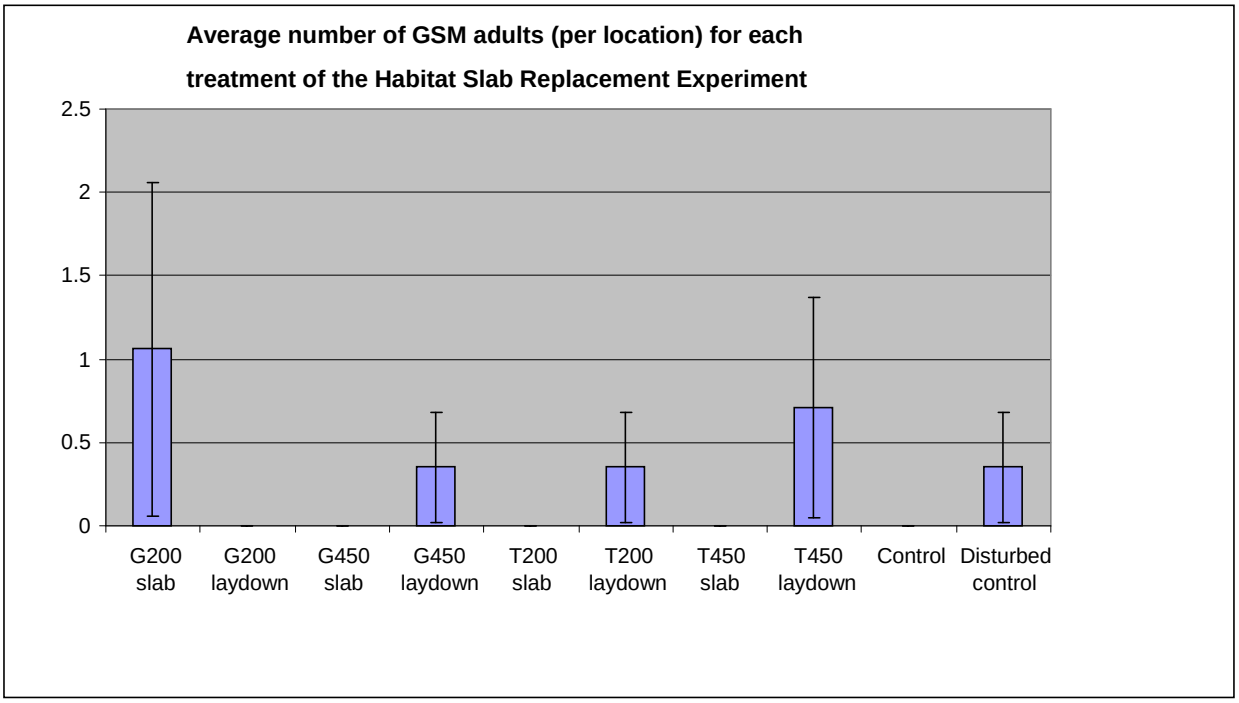
3.3.1 Adult GSM Surveys

Eight GSM were detected at the habitat slabs during the 2010/2011 flight season.

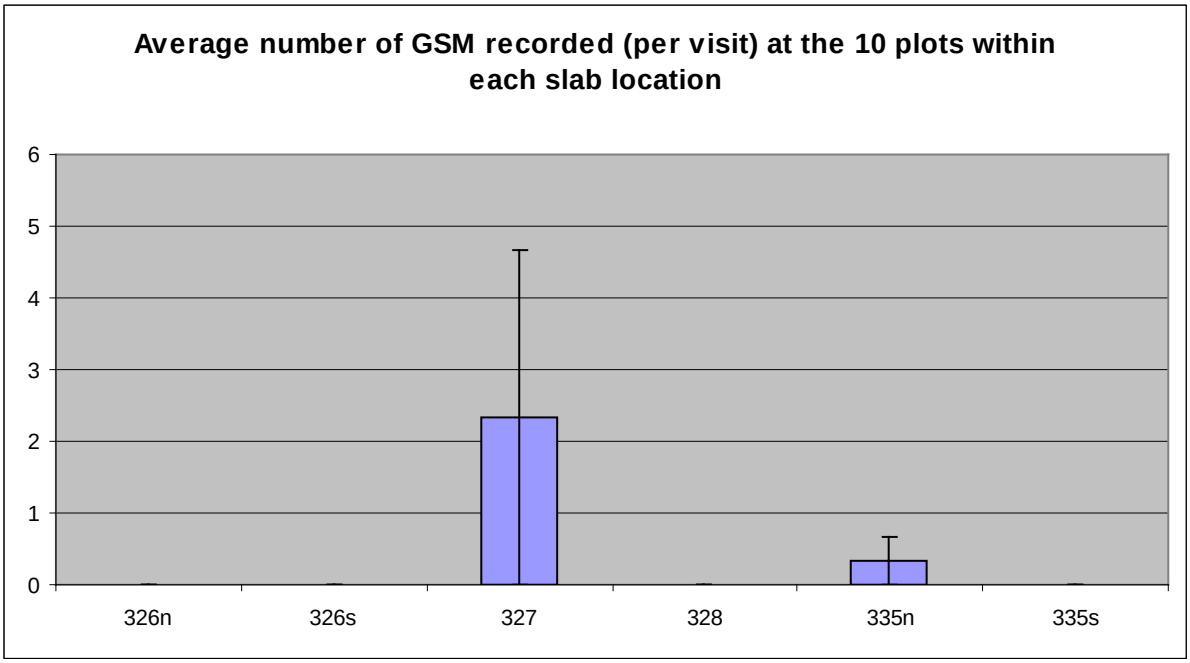
[4] Only 9 of the 10 slabs at 326 south were surveyed for pupa cases during the mid-season survey. The 10th slab (the 'disturbed control'), was partially underwater at the time of surveys, and therefore could not be searched for GSM pupa cases.

Graph 1 presents the average number of adult GSM detected for each of the 10 treatment types, irrespective of the site location or visit number. The standard error is also provided. The 10 plot types were visited over 17 occasions (= 5 locations for 3 visits and one location for 2 visits). There were too few GSM detected to draw any firm conclusions from this data relating to GSM. However, the numbers seen across all treatment types were substantially less than during the 2009/2010 season (SLPA 2010).

Graph 1: Average number of GSM adults seen at each type of habitat slab treatment per location during the 2010/2011 season



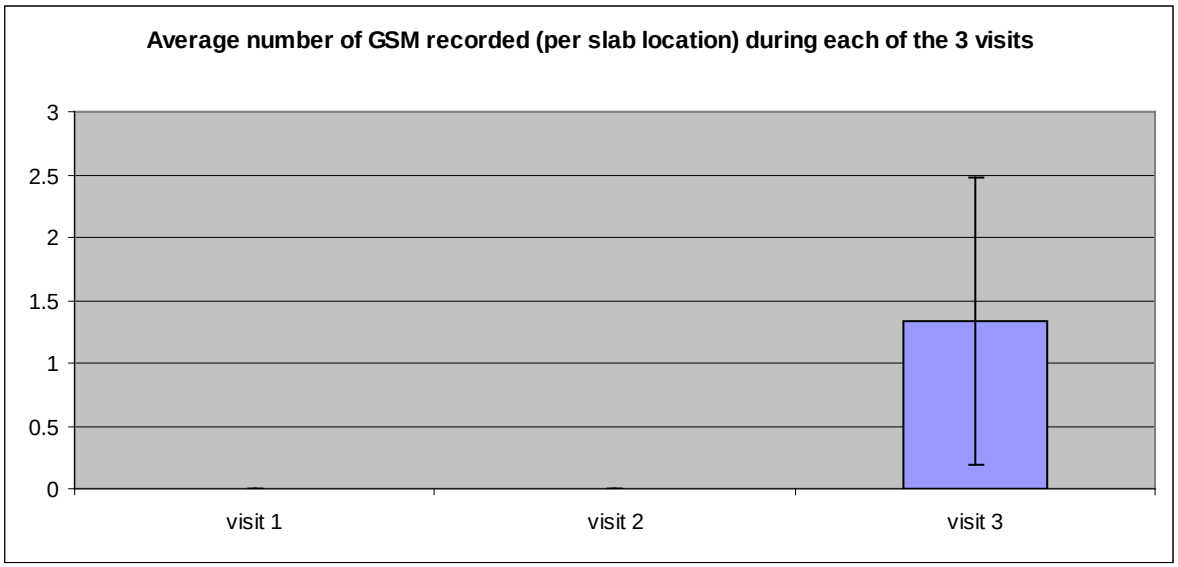
Graph 2: Average number of GSM adults recorded per visit to each habitat slab location, 2010-2011 surveys



Graph 2 identifies the average number (per visit) of GSM detected at each of the six locations, across all ten plots. GSM were not detected at four of the six locations. Very few GSM were detected at the other two locations (slab location at 327 and at the northern 335 slab). However, it is notable that these two locations were also the two locations that had the highest number of adult GSM detected during the 2009/2010 GSM flight season (SLPA 2010).

Graph 3 identifies the average number of adult GSM seen at a slab location during each of the three visits (totalled across all ten plots). No GSM were detected from any of the slabs during the first two visits (one of which was conducted prior to the widespread observations of GSM across the state). GSM were only detected during the third visit, which was conducted at a time later than the time-period for GSM surveys in the approved FMP documents (i.e. beyond early January 2011).

Graph 3: Average number of GSM adults recorded per visit at each of the slab locations 2010-11 flight season



Grazing activity by cattle and sheep had been excluded from habitat slabs during both post-construction flight seasons through the use of permanent fences. However, there was evidence that cattle had been grazing within both of the slab areas on property #335 either before and/or during the 2010/2011 flight season. This may have influenced the results between seasons and between slabs.

3.3.2 Pupal Case GSM Surveys

Across the six slab locations and the two survey time-periods, 3439 items were collected. Of these, 104 (approximately 3%) comprised a pupal case of some type. The initial analysis by Alliance Ecologists and subsequent analysis by Dr Will Osborne (Appendix D), found that none (0) of the pupal cases collected were GSM.

Table 4 details the results of the pupal case surveys within the habitat slabs for the 2010/2011 flight season.

Table 4 **Pupal cases, other invertebrate exoskeletons and remains collected from the habitat slab locations during the 2010/2011 surveys**

Property	Survey 1 (December 2010)			Survey 2 (January 2011)		
	# items total	# pupal cases (all types)	# confirmed GSM	# items total	# pupal cases (all types)	# confirmed GSM
326 Nth	-	-	-	443	13	0
326 Sth	516	7	0	402	15	0
327	-	-	-	372	22	0
328	-	-	-	770	23	0
335 Nth	-	-	-	707	16	0
335 Sth	-	-	-	229	8	0
TOTAL	**516**	**7**	**0**	**2923**	**97**	**0**

'-' indicates that the survey was not undertaken **in that slabbed area** at that time.

4 Grassland Habitat Reinstatement Experiment

4.1 Background

The Grassland Habitat Reinstatement Experiment is being conducted on the Sheoak property (#326), on a sloped section of the ROW which contains the buried pipe leading out from the high-lift pump station southwards to the Sugarloaf Reservoir. The purpose of the experiment is to investigate the effectiveness of different techniques for restoring grassland habitat after it has been removed by construction activities.

A number of variables are being monitored as part of this experiment, including floristic assessment of habitat recovery and the use of these areas by GSM. The aim of the GSM monitoring undertaken as part of this experiment is to determine whether any of these different techniques results in an increased use by the GSM compared to the project's standard reinstatement method, and where possible to compare the use of treatments by GSM. The primary aim is not to determine whether there has been a decline in the GSM population due to construction activities, although some information on a decline may be inferred from the results.

A total of forty experimental plots and twenty control plots were established prior to the 2009/2010 flight season. Each plot covers 3 m x 3 m (9 m^2). Each plot has been assigned one of four experimental treatment types or one of two types of controls. The different treatment types are:

- Subsoil left at the surface after construction, with no replacement of the topsoil or other reinstatement activities (control);
- Topsoil replacement only after construction (experiment treatment);
- Topsoil replacement after construction supplemented with planting of tube stock of locally indigenous plants (experimental treatment);
- Topsoil replacement after construction supplemented with seeds of locally indigenous plants (experimental treatment);
- Topsoil replacement after construction supplemented with grass tussock plantings, using tussocks that had been collected from this site prior to construction and that were maintained through the construction phase (experimental treatment);
- Undisturbed grassland area adjacent to the construction area, i.e., beyond the ROW (control).

Within each of the 60 plots (10 for each treatment or control), monitoring was undertaken for GSM adults and pupal cases, as described below.

4.2 Methods

4.2.1 Monitoring for GSM Adults

For the 2010-11 GSM flight season, it was stated in the relevant FMPs that adult GSM were to be surveyed at every plot in the Grassland Habitat Reinstatement Experiment on four occasions (each separated by at least one week), using the repeatable method described here. Ideally, all 60 plots were to be surveyed for adult GSM on a single day. Surveys were also to be conducted (a) during the suitable time of year only (between late October 2010 and early January 2011), (b) when the weather conditions and time-of-day meet the criteria outlined earlier (in Chapter 2.1 of this document), and (c) preferably when GSM were known to be in flight at a nearby reference location(s).

The adult GSM surveys were undertaken at the Grassland Habitat Reinstatement Experiment on five occasions during the 2010/2011 flight season (exceeding the target of four visits). However, for the reasons discussed in Section 2.2, surveys for adult GSM did not meet the stated survey requirements. In particular, three of them were undertaken at a time not appropriate for GSM survey according to the approved FMP documents (one was conducted outside the approved time of year, and two were conducted before the GSM had been confirmed in flight from the local area). The number and timing of adult GSM surveys conducted are summarized in the table below (Table 5), with the daily schedule of GSM adult surveys provided in Appendix A.

Table 5 Number of visits for surveying adult GSMs at the Grassland Habitat Reinstatement Experiment during the 2010/2011 flight season

Survey period	Early Survey	'Acceptable' survey	Late Survey
12 November 2010	1	0	0
24-25 November 2010	1	0	0
14 December 2010	0	1	0
4&7 January 2011	0	1	0
21 January 2011	0	0	1

Key to Table:

Early surveys – refers to adult GSM surveys undertaken within the approved weather conditions, but prior to widespread observations of GSM in the local area and across Victoria (i.e., between late October to ~10 December 2010).

'Acceptable' surveys – refers to adult GSM surveys undertaken within approved weather conditions, at the correct time of the year, and during a period when there were widespread observations of GSM in the local area and across Victoria (i.e. ~11 December 2010 to 10 January 2011).

Late Surveys – refers to adult GSM surveys undertaken within approved weather conditions, and during a period when there were regular observations of GSM in the local area and across Victoria, but also outside of the approved survey period in the FMP documents (i.e. from 11 January 2011 to 30 January 2011).

Within each plot, one ecologist trained in the identification of adult GSM undertook the surveys. The ecologist was positioned approximately 2 m from the edge of the plot and remained stationery. For a set period of 5 minutes, the ecologist recorded:

- Numbers of flying GSM that landed within the plot;
- Numbers of GSM that flew out of the plot; and
- Numbers of GSM that flew over the plot.

Then, for an additional set period of 2 minutes, the ecologist walked slowly around the edge of the plot and recorded:

- Numbers of male and/or female GSM observed on the ground or on vegetation within the plot.

As far as possible, care was taken not to record the same individual more than once. Opportunistic observations of GSM within or near a plot outside of the designated survey period were also recorded. A copy of the datasheet used to record the results of the adult GSM surveys at the Grassland Habitat Reinstatement Experiment is provided in Appendix C.

Wherever possible, at least two trained ecologists were in the field on each day to maximise the number of plots that were surveyed on similar days with similar weather conditions.

A total of 15 person-days were spent undertaking adult GSM surveys of the Grassland Habitat Reinstatement Experiment during the 2010/2011 flight season (compared to eight person-days during the 2009/2010 flight season).

4.2.2 Monitoring for GSM Pupal Cases

For the 2010/2011 flight season, the approved FMP documents state that Alliance Ecologists will search for empty pupal cases within each of the 60 Grassland Habitat Reinstatement Experiment plots once in the middle of each GSM flight season (late November to mid-December 2010) and again after the end of each flight season (early-mid January 2011).

For the reasons discussed in Section 2.2, surveys for GSM pupal cases within the Grassland Habitat Reinstatement Experiment during the 2010/11 flight season did not fully meet these stated survey requirements. Both of the planned pupal case searches were completed across all 60 plots in a single day, but both were conducted at a time that was slightly later than proposed within the approved FMP documents. The number and timing of GSM pupal case surveys are summarized in the table below (Table 6), with the daily schedule of GSM pupal case surveys provided in detail within Appendix B.

Table 6 Number of survey visits for GSM pupal cases at the Grassland Habitat Reinstatement Experiment plots during the 2010/2011 flight season

Pupal Case Searches	Acceptable mid-season survey	Late mid-season surveys	Acceptable post-season survey	Late post-season survey
2010/11 Flight Season	0	1 (on the 20 December 2010)	0	1 (on the 21 January 2011)

Key to Table

Acceptable mid-season survey – refers to GSM pupal surveys undertaken at the approved mid-season time period (i.e., between late November to mid-December 2010).

Late mid-season surveys – refers to the first GSM pupal surveys undertaken later than the approved mid-season time period (i.e., beyond the late November to mid-December 2010 time-period).

Acceptable post-season surveys – refers to GSM pupal case surveys undertaken at the approved post-season time period (i.e. between early to mid January 2011).

Late post-season surveys – refers to the second GSM pupal surveys undertaken later than the approved post-season time period (i.e. beyond the early to mid January 2011 time-period).

For each plot, the pupal case survey was undertaken over a period of 15 minutes by a single trained ecologist, who carefully searched on the ground across the whole plot. All pupal cases that were found and considered to be potentially GSM were collected in vials and appropriately labelled. Exoskeletons and pupal cases of other insects and spiders were also collected. Relevant data were collected in the field on prepared datasheets. Pupal case searches were undertaken at varying times of day, and were occasionally undertaken in the early morning or mid-late afternoon, (i.e., before or after the completion of adult GSM monitoring surveys).

Collected material was dried, and then sorted into broad groups, including one group considered to be potentially GSM. An external specialist was engaged to identify which of the pupal cases are GSM, if any.

4.3 Results from Grassland Habitat Reinstatement Experiment

4.3.1 Adult GSM Surveys

No adult GSM were seen during four of the five monitoring surveys at the Grassland Habitat Reinstatement Experiment in the 2010/2011 flight season. However, during the third survey period (on the 14 December 2010):

- One male GSM was detected flying over plot #8, which is a treatment plot where the topsoil was replaced and it was planted with tube stock of indigenous flora species;
- Two male GSM were detected flying over plot #52, which is one of undisturbed control plots (i.e., in undisturbed grassland occurring adjacent to the former construction areas); and
- One male GSM was opportunistically detected flying over the broader experimental area, but not over the plot being observed at the time (i.e. the GSM was seen in flight near, but not over, plot #19).

There were insufficient observations to draw any meaningful conclusions from the data collected within each of the different treatment types during the 2010/2011 flight season. As a comparison with the 2009/2010 flight season, substantially fewer GSM were detected during this second season, which is consistent with all of the monitoring undertaken for this project. It is also consistent with GSM observations across Victoria, where relatively few GSM were detected in locations known to support large populations in previous years' surveys.

4.3.2 Pupal Case GSM Surveys

During the searches for GSM pupal cases, all types of pupal cases, other exoskeletons and invertebrate remains were collected. Across the grassland experiment and the two survey time-periods, 307 items were collected. Of these, 14 (approximately 5%) comprised a pupal case of some type. The initial analysis by Alliance Ecologists and subsequent analysis by Dr Will Osborne (Appendix D), found that none (0) of the pupal cases collected were GSM.

Table 7 details the results of the pupal case surveys for the grassland habitat reinstatement experiment for the 2010/2011 flight season.

Table 7 Pupal cases, other invertebrate exoskeletons and remains collected from the Grassland Habitat Reinstatement Experiment during the 2010/2011 surveys

Treatment	Survey 1 (December 2010)			Survey 2 (January 2011)		
	# items total	# pupal cases (all types)	# confirmed GSM	# items total	# pupal cases (all types)	# confirmed GSM
Tussock replacement into topsoil	21	1	0	33	2	0
Seeding in topsoil	17	0	0	42	2	0
Planting in topsoil	19	0	0	31	0	0
Top soil only	26	0	0	30	1	0
Subsoil control	11	0	0	14	0	0
Undisturbed control	15	1	0	48	7	0
TOTAL	**109**	**2**	**0**	**198**	**12**	**0**

5 Within and Adjacent to the ROW

5.1 Background

The Alliance undertook monitoring for GSM within the construction right of way (the 'ROW'), within areas of **known** GSM grassland habitat that are not being used for the two experiments described above. The relevant properties are:

- #18/961 (on the east side of the Melba Hwy, immediately south of the Yea township);
- #324/325/326 (within the Sheoak property, owned by Melbourne Water, on the west side of the Melba Highway);
- #327 (on the west side of the Melba Highway, immediately south of the Sheoak property);
- #328 (on the west side of the Melba Highway, immediately south of property #327);
- #330 (on the west side of the Melba Highway, immediately south of property #328);
- #335 (on the west side of the Melba Highway, south of property #330 and other properties and minor public roads).

Monitoring for GSM also occurred in undisturbed land immediately adjacent to the boundaries of the construction area (i.e., land not disturbed by the Project). For all properties except property #330, permission was obtained from land-owners to monitor GSM in adjacent undisturbed privately-owned grassy paddocks. For property #330, the GSM monitoring within adjacent undisturbed land was undertaken within the adjacent roadside reserve.

The monitoring methods are described in more detail below.

5.2 Methods

5.2.1 Monitoring for GSM Adults

It was stated in the relevant FMPs that adult GSM were to be surveyed within all **known** GSM habitat that was intercepted by the ROW, and in immediately surrounding areas (i.e., adjacent undisturbed properties or road reserve). This was to occur on four occasions, each separated by at least one week, using the repeatable method described here. Ideally for each of the four visits, all sites were to be surveyed on a single day. Surveys were also to be conducted (a) during the suitable time of year only (between late October 2010 and early January 2011), (b) when the weather conditions and time-of-day met the criteria outlined earlier (in Chapter 2.1 of this document), and (c) preferably when GSM were known to be in flight at a nearby reference location(s).

For the reasons discussed in Section 2.2, surveys for adult GSM within and adjacent to the ROW did not meet these stated survey requirements. In particular, all sites (except for the Sheoak property) were visited on two occasions instead of four, and most of the surveys were undertaken at a time of year that turned out to be inappropriate for GSM survey in the 2010/2011 season (i.e., after late October, but before GSM had commenced flying in the local area). The number and timing of adult GSM surveys for each location are summarised in Table 8, with the daily schedule of GSM adult surveys provided in detail within Appendix A.

Table 8 Number and timing of survey visits for adult GSM within and adjacent to the Construction ROW during the 2010/2011 flight season

Property #	Survey Effort			SUB-TOTAL (Actual)	Target effort
	Early Surveys	'Acceptable' Surveys	Late Surveys		
18/961	2	0	0	*2*	*4*
324/325/326 (Sheoak)	2	2	0	*4*	*4*
327	2	0	0	*2*	*4*
328	2	0	0	*2*	*4*
330	2	0	0	*2*	*4*
335	2	0	0	*2*	*4*
SUBTOTAL	*12*	*2*	*0*	14	
Target Effort	*0*	*24*	*0*		24

Key to Table:

Early surveys – refers to adult GSM surveys undertaken within the approved weather conditions, but prior to widespread observations of the species in the local area and across Victoria (i.e., between late October to ~10 December 2010).

'Acceptable' surveys – refers to adult GSM surveys undertaken within approved weather conditions, at the correct time of the year, and during a period when there were widespread observations of GSM in the local area and across Victoria (i.e. ~11 December 2010 to 10 January 2011).

Late Surveys – refers to adult GSM surveys undertaken within approved weather conditions, and during a period when there were regular observations of GSM in the local area and across Victoria, but also outside of the approved survey period (i.e. from 11 January 2011 to 30 January 2011).

The adult GSM surveys within the ROW were undertaken in accordance with the Standard Transect Technique (STT) (as described in SLPA 2009a, 2009e). This technique is endorsed by DEWHA (2009a, 2009b), and is generally consistent with the technique used previously (pre-construction) by the Alliance during the 2008/09 flight season (SLPA 2009a) and is the same as that used within the ROW during the 2009/2010 flight season (SLPA 2010). The STT involved two or more Alliance Ecologists initially standing within the ROW at one end of a property and recording the following details:

- start time;
- weather conditions;
- general description of location (i.e., property identification name or number);
- specific location (GPS coordinates);
- direction of travel; and
- number of ecologists (typically two).

The Alliance Ecologists then walked at a slow and steady pace along the ROW through the property and documented all GSM individuals seen, taking care not to count individuals more than once. The Ecologists walked in parallel 5 m from each other, thereby each maintaining the 2.5 m standard transect width. Each ecologist counted all GSM seen within 2.5 m on either side. Where possible, flying GSM males were recorded separately from females and from moths on the ground.

After every 100 m, the Ecologists stopped to document relevant information (i.e., the number of moths observed in that 100 m section, the new grid reference (using the GPS) and the time, as a minimum), then continued on recording afresh for the next 100 m, and so on until the end of that property. The finish time, and other relevant details, were then recorded on the datasheet at the end of the transect along the ROW through that property.

Where the landowner had granted permission for GSM surveys to be conducted within the undisturbed land outside the ROW (i.e., all properties except 330[5]), then the two Alliance Ecologists repeated the STT in the undisturbed land parallel to the ROW, moving in the opposite direction, thereby returning to the starting point within that property. Wherever possible, this adjacent transect was located no closer than 20 metres from the ROW. The distance between the parallel transects undertaken within and adjacent to the ROW was documented on the data sheet.

Eight person-days were spent undertaking adult GSM surveys within and adjacent to the ROW during the 2010/2011 flight season (which equalled the eight person-days during the 2009/2010 flight season).

5.2.2 Monitoring for GSM Pupal Cases

The approved FMP documents state that Alliance Ecologists will search for empty pupal cases within the ROW in each property that was considered to be **known** GSM grassland habitat. The FMP documents also state that Alliance Ecologists would undertake an equivalent number of searches in adjacent undisturbed grassland habitat. All of these searches were to be undertaken once in the middle of each flying season (late November to mid-December 2010) and again after the end of each flying season (early-mid January 2011). By undertaking two searches, this increased the chances of detecting pupal cases, while allowing for variability in the timing of adult emergence (depending on weather, the period of emergence may occur earlier or later than predicted) and the uncertainty over how long pupal cases last before they begin to disintegrate and become undetectable.

For the reasons discussed in Section 2.2, surveys for GSM pupal cases during the 2010/11 flight season did not fully meet these stated survey requirements for the ROW and adjacent undisturbed areas. The mid-season searches were only conducted at the Sheoak property (properties #324/325/326), and many of the post-season searches were conducted at a time that was slightly later than proposed within the approved FMP documents (i.e. beyond the mid-January, which was taken as being beyond the 20 January 2011). Due to the heavy spring/summer rainfall and flooding within the Yea River floodplain, no searches were conducted within property 18/961 at all. The number and timing of the GSM pupal case surveys for each ROW location are summarized in Table 6, with the daily schedule of GSM pupal case surveys provided in detail within Appendix B.

For each property within **known** GSM grassland habitat, one square plot of 9 m^2 was temporarily established within every 100 m length of along the ROW (outside experimental areas), and then searched for GSM pupal cases using the Standard Pupal Case Technique (SPCT) (as described in SLPA 2009a, 2009e). For each temporary plot established within the ROW, another temporary plot of equal size was established in adjacent undisturbed grassland habitat (i.e., within the adjoining private land for all properties except #330, where the plots were instead established in the adjacent roadside reserve of the Melba Highway).

[5] For property 330, the adjacent transect survey of adult GSM was instead undertaken within the adjoining Melba Highway roadside reserve.

This SPCT involved an Alliance Ecologist searching carefully at ground-level for empty pupal cases within each plot. Search effort was standardised for each plot (i.e. each plot is the same size and is searched by one Ecologist for a set time of 15 minutes). All pupal cases found were collected in vials and appropriately labelled. Exoskeletons of other insects and spiders were also collected. Relevant data were collected in the field on prepared datasheets. Pupal case searches were undertaken at varying times of day, often in the early morning or mid-late afternoon (i.e., before or after the completion of adult GSM monitoring surveys).

Collected material was dried, then sorted into broad groups, including one that was considered to be potentially GSM. An external specialist was engaged to identify which of the pupal cases are GSM, if any.

Table 9 Number of survey visits for GSM pupal cases within the ROW at each of the properties with known GSM habitat during the 2010/2011 flight season

Property #	Acceptable mid-season survey	Late mid-season surveys	Acceptable post-season survey	Late post-season survey	SUB-TOTAL	Target Effort
18/961	0	0	0	0	*0*	*2*
324/325/326 (Sheoak)	0	1 (on 21 Dec 2010)	0	1 (on 28 Jan 2011)	*2*	*2*
327	0	0	1	0	*1*	*2*
328	0	0	1	0	*1*	*2*
330	0	0	0	1 (on 21 Jan 2011)	*1*	*2*
335	0	0	1	0	*1*	*2*
SUB-TOTAL	*0*	*1*	*3*	*2*	6	
Target Effort	*6*	*0*	*6*	*0*		12

Key to Table

Acceptable mid-season survey – refers to GSM pupal surveys undertaken at the approved mid-season time period (i.e., between late November to mid-December 2010).

Late mid-season surveys – refers to the first GSM pupal surveys undertaken later than the approved mid-season time period (i.e., beyond the late November to mid-December 2010 time-period).

Acceptable post-season surveys – refers to GSM pupal case surveys undertaken at the approved post-season time period (i.e. between early to mid January 2011).

Late post-season surveys – refers to the second GSM pupal surveys undertaken later than the approved post-season time period (i.e. beyond the early to mid January 2011 time-period).

5.3 Results from monitoring within and adjacent to ROW

5.3.1 Adult GSM Surveys

No adult GSM were detected within or adjacent to the ROW during the monitoring surveys in the 2010/2011 flight season. In contrast, 272 adult moths were observed during the 2009/2010 flight season, including 25 detected within the ROW and 247 detected within adjacent undisturbed areas (SLPA 2010). This difference may be partially attributable to the lesser amount of survey undertaken at 'appropriate' times of the year during the 2010/2011 flight season. However, other contributing reasons could include the less suitable weather conditions for GSM in 2010/2011 compared to previous years, and also the tall dense grass regrowth along the ROW within some of the properties as a result of intensive post-construction reinstatement. In addition, evidence of cows grazing within the ROW was observed in some of the properties. It is unknown whether this was for part or all of the 2010/2011 flight season, whereas none had grazed in these areas during the 2009/2010 flight season. This may also have influenced the adult GSM results.

5.3.2 Pupal Case GSM Surveys

During the searches for GSM pupal cases, all types of pupal cases, exoskeletons and invertebrate remains were collected. Across all of the properties, and the two survey time-periods, 254 items were collected. Of these, nine (approximately 4%) comprised a pupal case of some type. The initial analysis by Alliance Ecologists and subsequent analysis by Dr Will Osborne (Appendix D), found that none (0) of the pupal cases collected were GSM.

Table 10 details the results of the pupal case surveys for the ROW and adjacent areas for the 2010/2011 flight season.

Table 10 Pupal cases, other invertebrate exoskeletons and remains collected from the properties during the 2010/2011 surveys

Property	Survey 1 (December 2010)			Survey 2 (January 2011)		
WITHIN ROW	**# items total**	**# pupal cases (all types)**	**# confirmed GSM**	**# items total**	**# pupal cases (all types)**	**# confirmed GSM**
326	1	0	0	4	0	0
327	1	0	0	38	0	0
328	-	-	-	51	0	0
330	-	-	-	16	0	0
335	-	-	-	6	0	0
ADJACENT TO ROW						
326	9	1	0	6	0	0
327	9	1	0	58	5	0
328	-	-	-	11	1	0
330	-	-	-	25	1	0

Property	Survey 1 (December 2010)			Survey 2 (January 2011)		
335	-	-	-	19	0	0
TOTAL	**20**	**2**	**0**	**234**	**7**	**0**

6 Broader Sheoak

6.1 Background

The Sheoak property is much more extensive than the area that was required for the construction footprint of the Sugarloaf Pipeline Project. The construction area covers ~10 ha within the total property area of >200 ha. Melbourne Water currently leases the remainder of the property (called 'broader Sheoak' herein) for grazing by cattle and sheep. In accordance with the approved FMP document (SLPA 2009b), broader Sheoak will be protected and managed in perpetuity for grassland conservation purposes. It is understood that a long-term conservation management plan for property is in preparation (K. Beaumont, Melbourne Water, pers. comm.).

GSM was monitored across broader Sheoak, to document the distribution and relative abundance of GSM. As described below, a standard transect-based survey technique was used for adult GSM surveys. Plot-based pupal case searches were also undertaken at a variety of locations across the site to obtain information on GSM breeding activity.

6.2 Methods

6.2.1 Monitoring for GSM Adults

According to the approved FMP documents, Alliance Ecologists were to undertake surveys for the adult GSM on four occasions across broader Sheoak during the 2010/2011 flight season, with visits separated by at least one week. Surveys would be done using the standard repeatable method: (a) during the suitable time of year only (between late October 2010 and early January 2011), (b) when the weather conditions and time-of-day met the criteria outlined earlier (in Chapter 2.1 of this document), and (c) preferably when GSM were known to be in flight at a nearby reference location(s).

During the 2009/2010 flight season, approximately 20 km of transects (STT, see Section 4.2) were surveyed across broader Sheoak during each visit. The transect routes surveyed during the 2010/2011 flight season were aligned to match the previous transect routes as much as possible. This includes transects:

- On the eastern side of the Melba Hwy (part of broader Sheoak extends across the highway);
- That are at a higher density in the vicinity of the former construction area and areas of on-going activity (e.g. pump station building and associated infrastructure).

The layout of transects was modified to fit with the location of fences across the property, which had been slightly altered at some locations between the two flight seasons. Transects also needed to be modified for safety or courtesy on occasions between visits (e.g., in response to the location of bulls or new calves within the various paddocks). Few transects could be undertaken on the parts of Sheoak property on the eastern side of the Melba Highway during the 2010/2011 flight season due to the flooding of the Yea River and filling of the floodplain billabongs (which were dry during the previous flight season). GSM is unlikely to occur in flooded areas in large numbers, if at all.

Full surveys across broader Sheoak were conducted on five occasions, and partially completed on one other occasion. However, for the reasons discussed in Section 2.2, surveys for adult GSM across broader Sheoak did not meet the stated survey requirements. Only three visits were undertaken at a time that turned out to be appropriate for GSM survey (after the GSM had been confirmed in flight from the local area and the state, and in the suitable weather conditions). The number and timing of GSM surveys across broader Sheoak are summarized in Table 11, with the daily schedule of GSM adult surveys provided in detail within Appendix A.

Table 11 Number of visits for surveying adult GSMs across the broader Sheoak property during the 2010/2011 flight season

Survey visit	Level of completion of transects across property	Early Survey	Acceptable Survey	Late Survey
9&10 November 2010	100%	1	0	0
17 November 2010	~65%	1	0	0
23, 24 & 29 November 2010[6]	100%	1	0	0
13 & 14 December 2010	100%	0	1	0
22 & 23 December 2010	100%	0	1	0
4-7 January 2011	100%	0	1	0

Key to Table:

Early surveys – refers to adult GSM surveys undertaken within the approved weather conditions, but prior to widespread observations of GSM in the local area and across Victoria (i.e., between late October to ~10 December 2010).

'Acceptable' surveys – refers to adult GSM surveys undertaken within approved weather conditions, at the correct time of the year, and during a period when there were widespread observations of in the local area and across Victoria (i.e. ~11 December 2010 to 10 January 2011).

Late Surveys – refers to adult GSM surveys undertaken within approved weather conditions, and during a period when there were regular observations of GSM in the local area and across Victoria, but also outside of the approved survey period in the FMP documents (i.e. from 11 January 2011 to 30 January 2011).

The federal government guidelines for GSM monitoring (DEWHA 2009b) acknowledge that, when GSM monitoring surveys using the Standard Transect Technique (STT) are undertaken across large areas, it is not feasible for ecologists to cover all parts of the property. Instead, it is suggested that for large properties transects be spaced up to 200 m apart, and abundance estimates for the site then extrapolated from the data. The Alliance adopted that approach for broader Sheoak.

To conduct a transect survey, two Alliance Ecologists initially stood at one end of a linear transect, and recorded time, weather, location details, then walked along parallel linear transects documenting all GSM individuals seen within a 2.5 m standard transect width, and stopping every 100 m, as described in Section 4.2. The transect routes followed during each of the monitoring visits are displayed in Figures 1 to 6.

A total of 39 person-days were spent undertaking adult GSM surveys of across broader Sheoak during the 2010/2011 flight season (compared to ~32 person-days during the 2009/2010 flight season).

[6] One GSM was seen on the 22 November 2010 at a nearby reference site (Carey's Rd, Killingworth). No moths were seen on-site on this day or other two days. No GSM were seen at this reference site on the other two days. Apart from the sightings in Nhill in early November 2010 and this sighting on the 22 November 2010, we are not aware of any other documented sightings of GSM during this flight season by other ecologists elsewhere in Victoria before the 10 December 2010.

361000 362000

5878000 5878000

962 22 23 24.2 24.1 24 25 26 28 28.1 324 326 327 328

5877000 5877000

361000 362000

Sugarloaf Pipeline Project

Figure 1 - Adult GSM surveys across the broader Sheoak property - Visit 1 of 6 - 9 & 10 November 2010

SUGARLOAF PIPELINE ALLIANCE

GDA94 MGA55

N

0 50 100 200 300

Metres

Legend

GSM Not Detected

NB: Higher density of transects around the construction footprint
NNV = Non-Native Vegetation

361000 362000

5878000 5878000

962 22 23 24.2 24.1 24 25 26 28 28.1 324 326 327 328

5877000 5877000

361000 362000

Sugarloaf Pipeline Project

Figure 2 - Adult GSM surveys across the broader Sheoak property - Visit 2 of 6 (incomplete) - 17 November 2010

SUGARLOAF PIPELINE ALLIANCE

GDA94 MGA55

N

0 50 100 200 300

Metres

Legend

GSM Not Detected

NB: Higher density of transects around the construction footprint
NNV = Non-Native Vegetation

361000 362000

5878000 5877000

962 22 23 24 24.2 24.1 25 26 28 28.1 324 326 327 328

Sugarloaf Pipeline Project

Figure 3 - Adult GSM surveys across the broader Sheoak property - Visit 3 of 6 - 23, 24 & 29 November 2010

SUGARLOAF PIPELINE ALLIANCE

GDA94 MGA55

N

0 50 100 200 300

Metres

Legend

- GSM Not Detected

NB: Higher density of transects around the construction footprint
NNV = Non-Native Vegetation

361000 362000

5878000 5878000

962 22 23 24.2 24.1 24 25 26 28 28.1 324 326 327 328

5877000 5877000

361000 362000

Sugarloaf Pipeline Project

Figure 4 - Adult GSM surveys across the broader Sheoak property - Visit 4 of 6 - 13 & 14 December 2010

SUGARLOAF PIPELINE ALLIANCE

GDA94 MGA55

N

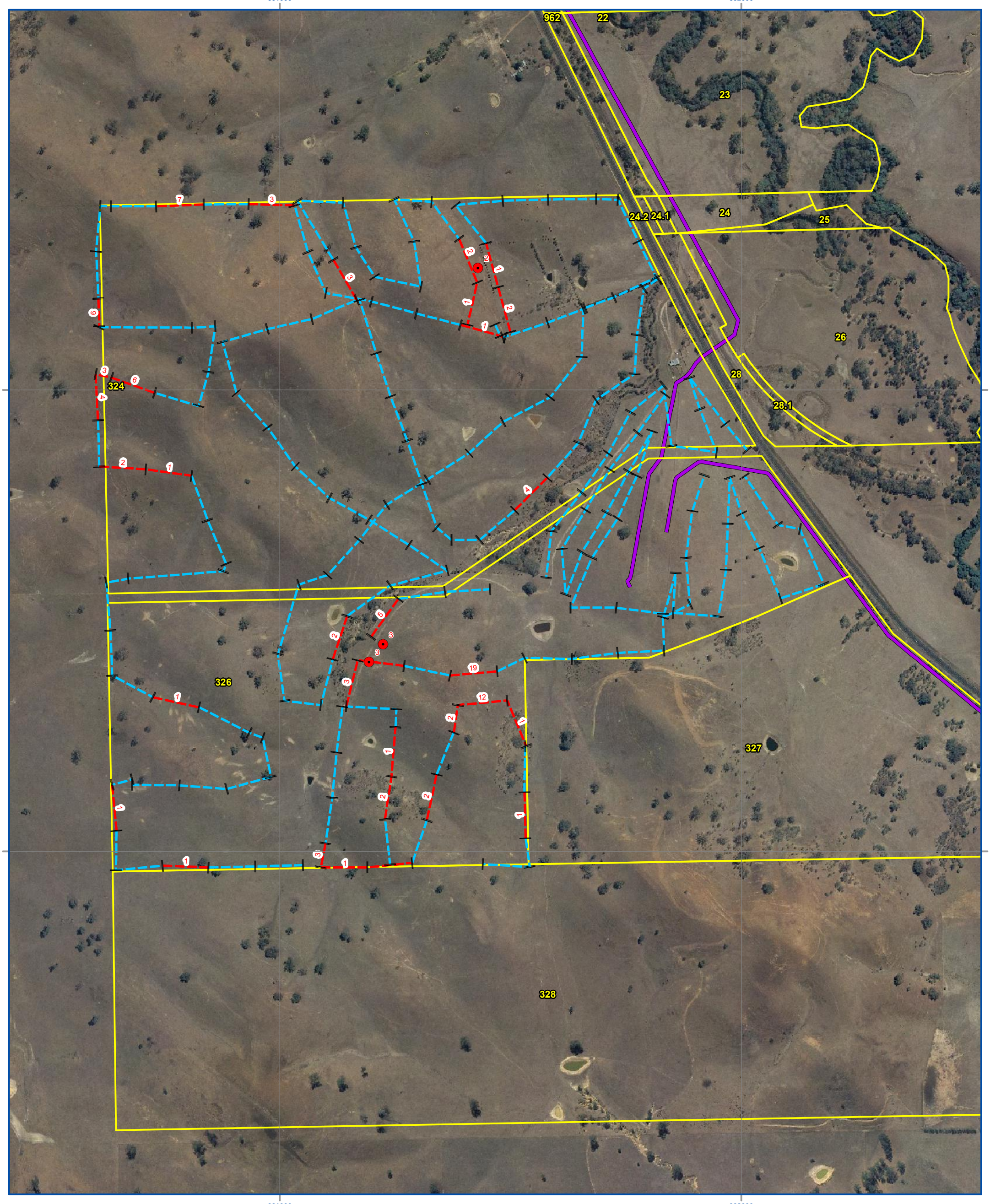
0 50 100 200 300

Metres

Legend

- Incidental GSM Points (count males only)
- GSM Not Detected
- GSM Detected (count males only)

NB: Higher density of transects around the construction footprint
NNV = Non-Native Vegetation



Sugarloaf Pipeline Project

Figure 5 - Adult GSM surveys across the broader Sheoak property - Visit 5 of 6 - 22 & 23 December 2010

Legend

- Incidental GSM Points (count males only)
- GSM Not Detected
- GSM Detected (count males only)

NB: Higher density of transects around the construction footprint
NNV = Non-Native Vegetation

GDA94 MGA55

N

0 50 100 200 300

Metres

361000 362000

5878000 5877000

962 22 23 24 24.2 24.1 25 26 28 28.1 324 326 327 328

Sugarloaf Pipeline Project

Figure 6 - Adult GSM surveys across the broader Sheoak property - Visit 6 of 6 - 4 to 7 January 2011

SUGARLOAF PIPELINE ALLIANCE

GDA94 MGA55

N

0 50 100 200 300

Metres

Legend

- Incidental GSM Points (count males only)
- GSM Not Detected
- GSM Detected (count males only)

NB: Higher density of transects around the construction footprint
NNV = Non-Native Vegetation

Figure 7 Pupal Case Quadrat Locations

6.2.2 Monitoring for GSM Pupal Cases

During the 2009/2010 GSM flight season, approximately 40 plots were established across broader Sheoak, with a higher density of plots established in closer proximity to the construction areas. Each plot was 3 m by 3 m (9 m²), and its location was marked with a GPS. Plots at the same GPS locations were re-surveyed during the 2010/2011 flight season.

The approved FMP states that each plot should be surveyed twice; once in the middle of each flying season (late November to mid-December 2010) and again after the end of each flying season (early-mid January 2011) (SLPA 2009a, 2009b). These pupal case survey times were designed to maximise the chances of detecting pupal cases, while allowing for variability in the timing of adult emergence (depending on weather, the period of emergence may occur early or late in the season) and the uncertainty over how long pupal cases last before they begin to disintegrate and become undetectable.

For the reasons discussed in Section 2.2, surveys for GSM pupal cases during the 2010/11 flight season did not fully meet these stated survey requirements for broader Sheoak. Both the mid-season and post-season surveys were conducted later than proposed within the approved FMP documents (being undertaken on the 21 December 2010 and the 22 February 2011 respectively). Also, the floodplain east of the Melba Highway was under water in December 2010, preventing the mid-season surveys in this eastern section of the Sheoak property. The daily schedule of GSM pupal case surveys across broader Sheoak is provided in Appendix B. A map showing the locations of the pupal case surveys across broader Sheoak is provided in Figure 7.

Each 9 m² plot was thoroughly searched at ground level by an ecologist for a period of 15 minutes. Pupal cases found during the survey were collected and stored in a labelled vial. Evidence of other invertebrate species (e.g., the exoskeletons or cases of beetles, grasshoppers, centipedes, spiders and other invertebrate species) were also collected to provide information on general biota present within the plots. Pupal cases suspected to be GSM were analysed by a specialist for confirmation of their identification.

6.3 Results from Broader Sheoak Monitoring

6.3.1 Adult GSM Surveys

A total of 251 adult GSMs were observed during the six monitoring surveys across broader Sheoak during the 2010/2011 flight season (Table 12). Of these, only one was a female. In contrast, over 1800 GSM, including five females, were detected from four monitoring surveys during the previous flight season.

Table 12 Total number of adult GSMs documented during each survey of the broader Sheoak property during the 2010/2011 flight season

Survey Dates	Number of GSM detected
9&10 November 2010	0
17 November 2010 (partially completed only)	0
23, 24 & 29 November 2010	0
13 & 14 December 2010	100 = 79 male GSM during transects, 21+ incidental male GSM (not during a transect)
22 & 23 December 2010	126 = 117 male GSM during transects, one female GSM during transects, 8+ incidental male GSM (not during a transect)
4-7 January 2011	27 = 22 male GSM during transects, 5+ incidental male GSM (not during a transect)
TOTAL	251

The locations of adult GSMs detected during each of the survey periods are provided in Figures 1 to 6.

6.3.2 Pupal Case GSM Surveys

Across broader Sheoak and the two survey time-periods, 192 items were collected. Of these, 14 (approximately 7.3%) comprised a pupal case of some type. The initial analysis by Alliance Ecologists and subsequent analysis by Dr Will Osborne (Appendix D), found that none (0) of the pupal cases collected were GSM.

Table 13 details the results of the pupal case surveys on broader Sheoak for the 2010/2011 flight season.

Table 13 Pupal cases, other invertebrate exoskeletons and remains collected from Broader Sheoak during the 2010/2011 surveys

Survey Type	Survey 1 (December 2010)			Survey 2 (January 2011)		
	# items total	# pupal cases (all types)	# confirmed GSM	# items total	# pupal cases (all types)	# confirmed GSM
Broader Sheoak	76	3	0	116	11	0

7 Discussion

7.1 Summary of Findings

7.1.1 Adult GSM Surveys

Compared to the previous two GSM flight seasons within and near the Sugarloaf Pipeline Project construction area[7], relatively few GSM were observed by Alliance Ecologists during the 2010/2011 flight season. The overall survey effort during the 2010/2011 season (~77 person-days) was comparable to the previous season (~65 person-days).

As mentioned in Section 2.2, there are multiple lines of evidence that suggest that far fewer GSM emerged during the 2010/2011 flight season than during the 2009/2010 season. The surveys undertaken as part of this project support this conclusion, as the numbers of GSM seen were well below the previous season within areas that had not been disturbed during construction as well as within disturbed areas. As the numbers of moths were depleted all across the state in a variety of disturbed and relatively undisturbed grassland habitat locations, it is not possible to conclusively comment on the relationship between the lower numbers of GSM seen during the second post-construction flight season and the effects of the Sugarloaf Pipeline Project.

Given the differences between the 2009/2010 and 2010/2011 flight seasons, it is meaningless to attempt to draw conclusions about the recovery of GSM populations (or the lack thereof) since the completion of construction. During the first post-construction flight season, ~400 male GSM were observed in flight over parts of the construction area, and an additional ~5 female GSM were observed in the reinstated grassland habitat within the construction areas[8] (plus ~2400 male GSM and ~10 female GSM within areas which were not directly disturbed by construction). In contrast during the second post-construction flight season, only nine male GSM were observed in flight over parts of the construction area, and no female GSM were observed in the reinstated grassland habitat within the construction areas (plus ~260 male GSM and ~one female GSM within areas which were not directly disturbed by construction). The available pre-construction GSM data is too limited to draw any confident conclusions about the extent to which GSM populations may have been affected by the construction process (compared to other variables such as the weather), nor the extent to which they are recovering. However:

- There was a 98% drop in the number of GSM seen flying over construction areas between the first and second post-construction flight seasons. In contrast, there was a 90% drop in the number of GSM seen flying over undisturbed areas between the first and second post-construction flight seasons. This difference may be partially attributable to the differing levels of survey effort between the two seasons; and
- Based on within-season comparisons, the density of GSM present within the former construction areas appears to remain depleted after two post-construction seasons compared with undisturbed control sites[9].

[7] Which include one season before construction and one season after construction.

[8] The 'construction area' excludes observations of GSM from (a) the broader Sheoak property, (b) habitats 'adjacent' to the ROW, and from (c) the undisturbed control plots in the two experimental areas.

[9] Including the undisturbed control plots from the experiments, the surveys from areas 'adjacent to the ROW, and from surveys across the broader Sheoak property.

7.1.2 Pupal Case Surveys

As discussed above in 6.1.1, the evidence from the results of the Sugarloaf Pipeline Project surveys and other historically known locations across the state to suggest that the numbers of GSM observed over the course of this flight season was lower compared to recent previous years. This is further reflected in the pupal case survey results, which for the 2010/11 year yielded no (0) confirmed GSM pupal cases, compared to 50 in the 2009/10 season.

Table 13 details a comparison between the pupal case survey results from each flight season. Of note, while nearly twice as many exoskeletons and invertebrate remains were collected in the second flying season compared to the first, far fewer (16%) pupal cases of all types were collected in the second season compared to the first. This may be a result of the above-average rainfall occurring in the local area in the months prior to the commencement during the second flight season, and the regular periods of heavy rain continuing throughout the typical flight season period. These conditions may have favoured some invertebrate species over others (including the GSM), and lead to the variations in data results observed between the two flight seasons.

Table 13 Pupal case survey results from both flight seasons

	# items total		**# pupal cases (all types)**		**# confirmed GSM**	
	2009/10	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**
Habitat Slab Replacement	1508	3439	505	104	43	0
Grassland Habitat Experiment	237	307	194	14	1	0
ROW and adjacent	279	254	97	9	0	0
Broader Sheoak	235	192	42	14	6	0
TOTAL	**2259**	**4192**	**838**	**141**	**50**	**0**

Lack of GSM pupal cases in the second flight season reflects a similar pattern in adult GSM observations (section 7.1.1). It is not possible to provide conclusive statements about the recovery of GSM populations (or the lack thereof) in the two post-construction seasons since the completion of construction. The available pre-construction GSM data is too limited to draw any confident conclusions about the extent to which GSM populations may have been affected by the construction process (compared to other variables such as the weather), or the extent to which they may be recovering.

7.2 Overall Constraints

According to most published documents, the flight season of the GSM is typically acknowledged as the period from late October to early January (e.g., DEWHA 2009a). Thus, the approved FMP documents for this project state that monitoring for adult GSM will occur during this time period, and monitoring for the discarded pupal cases will occur once in the middle of this time period and again during a short time period (2-3 weeks) after the completion of the flight season.

The first year of GSM monitoring for the Sugarloaf Pipeline Project was successfully completed during the 2009-10 flight season of the GSM, and a summary report has been recently submitted to regulatory authorities (SLPA 2010). Weather conditions were suitable throughout most of the first GSM flight season, and the majority of adult GSM in flight were detected by Alliance Ecologists between early November and early-mid December 2009.

A proposed GSM monitoring schedule was developed by Alliance Ecologists prior to the commencement of the 2010-11 flight season, which included a detailed day-by-day list of tasks to be completed and the indicative staff to undertake these tasks. When implemented, this program would have completed all the GSM monitoring tasks for the 2010/2011 flight season well before early January 2011, even including a 2-3 week contingency for late emergence of GSM and/or some poor weather conditions. The 2010/2011 year of GSM monitoring was problematic, due to:

- Late emergence of GSM adults compared with recent previous years. GSM adults were not consistently observed within the survey locations and reference sites until early-mid December 2010 (the same situation was faced by ecologists attempting to undertake GSM surveys at a number of locations across Victoria). This meant that there were insufficient days remaining within the approved survey period for GSM adults (from late October to early January) to conduct all of the necessary surveys to meet the requirements for the project; and
- Once GSM had begun emerging in mid-December 2010, weather conditions were regularly outside of the thresholds considered to be appropriate for GSM adult surveys. Many days were constrained by one or more of: (a) the weather forecast indicated that the temperature would not reach 20°C by 10am, (b) the weather forecast predicted rain on the day of the survey, (c) there had been substantial rainfall less than two days before a day of potentially suitable weather conditions, and (d) other weather variables such as wind were outside of the preferred survey bounds. This further reduced the number of days in which GSM surveys could be undertaken.

  There is no known precedent for GSM surveys conducted in the conditions experienced during 2010/2011. The GSM has been a focal species to consultants and regulatory authorities in Victoria for the past 5-6 years only, during a period of below average rainfall. As such, there is generally a very poor understanding of how GSM responds to above average rainfall conditions, which occurred through winter and spring of 2010 and into the summer of 2010/11.

  In addition, there were some issues with access to private land during the second half of the month of December 2010 and during the first half of January 2011. No private land was accessed during this period, which affected surveys for both adult GSM and for the discarded pupal cases of the GSM.

7.2.1 Late Emergence of GSM adults

During the summer of 2010/2011, Alliance Ecologists commenced searching for GSM in the first week of November within areas where they had been recorded in the previous two years (see Appendix A for details). The first male GSM was seen in flight in the roadside along Careys Rd (near Killingworth Rd, approximately 3-5 km north-east of Yea) on the 23 November 2010. This location is not within the construction area for the project but is used as a reference site. No more GSM were seen within the Sugarloaf Project Area or surrounds, or in reasonable numbers elsewhere across the state, until 13 December 2010.

Prior to the 13 December 2010, the Alliance undertook considerable effort to detect the commencement of the flight by GSM. In particular:

- The Alliance undertook 32 person-days searching for GSM across the project area and immediate surrounds;
- The Alliance initiated and maintained email contact across the state with a range of other ecologists who were also searching for GSM; and
- The Alliance regularly liaised with DSE via telephone to check if they had heard of any GSM in flight elsewhere in the region or across the state.

The need to undertake each set of the four adult GSM surveys at least one week apart was a further complicating factor, given the short time available between the 13 December 2010 and the 10 January 2011. Between these dates, the Alliance undertook 32 person-days of adult GSM survey and 13 person-days of pupal case searches.

The presence of GSM adults was observed to continue within the study area, and across the state, beyond the approved end date of 'early January' 2011. Early January is typically the time of year when GSM emergence has finished and very few (if any) GSM are observed. Following discussions with DSE (Jill Fleming, pers. comm.), and based on email correspondence received from Mark Winfield of DSE (Group Manager, Biodiversity, Port Phillip Region), it was agreed that monitoring surveys for adult GSM could continue through the remainder of January 2011 on the conditions that (a) the weather conditions were appropriate for survey, (b) the surveys continued to be conducted only at the appropriate time of the day, and (c) that GSM had been seen in flight on the same day at an appropriate reference location.

The Alliance therefore continued with adult GSM surveys within the project area until the 21 January 2010 in accordance with these conditions. Another 12 person-days of survey for adult GSM were undertaken between the 11 and 23 January 2011.

Overall, despite falling short of completing all of the required survey effort for adult GSMs and pupal cases within the 2010/2011 flight season, the Alliance made every reasonable effort to undertake the required surveys. The Alliance (a) made considerable effort to detect the commencement of the GSM flight season for a period of more than 4 weeks, (b) undertook as many surveys as reasonably possible within the flight season once the GSM had commenced flying, and (c) continued to undertake adult GSM surveys beyond the approved completion date in order to obtain extra information.

7.2.2 Unsuitable Weather

It is strongly suspected that the delayed emergence of GSMs during the 2010/2011 flight season was at least partially caused by the above average rainfall during winter and spring preceding the GSM flight season, and which continued throughout the GSM flight season. The impacts of the delayed emergence of GSM upon the survey schedule are described above (chapter 7.2.1). The unsuitable weather conditions also caused havoc with the survey schedule even after the GSM flight season had commenced, as surveys can only be undertaken on days that are within the suitable thresholds for temperature, wind, rainfall, etc (as described in chapter 2.1). In summary:

- There were suitable weather conditions for adult GSM survey on only 17 of the 34 available days[10] between late October and the widespread emergence of adult moths on the 13 December 2010. Alliance Ecologists undertook surveys on 9 of these 17 suitable days;
- From the time that the adult moths emerged until the end of the approved flight season on the 10 January 2011, there were suitable weather conditions for GSM survey on only 13 of the 18 available days[11]. Alliance Ecologists undertook surveys on 10 of these 13 suitable days; and
- From the end of the approved flight season on the 10 January 2011 until the time that adult surveys were halted for this project on the 23 January 2011, there were suitable weather conditions for GSM survey on only three of the nine available days[12]. Alliance Ecologists undertook surveys on all three of these suitable days.

Thus, between late October and 23 January 2011, only 33 of the 60 available days had weather conditions that were suitable for adult GSM surveys (55%). Of these, Alliance Ecologists undertook surveys on 22 of the 33 available days (66%).

Surveys were not undertaken on some of the days with suitable weather due to land access constraints (see chapter 7.2.3 below). In addition, surveys were also not undertaken on some occasions as the forecast conditions indicated that the weather would not be suitable, but the actual conditions ended up being suitable. In contrast, there were also days in which the weather forecast indicated that the day would be appropriate for surveys, but for which the surveys needed to be abandoned part-way through the day due to the poor weather conditions which eventuated.

On some occasions, surveys could not be undertaken due to the consequences of the weather. For example, surveys of the broader Sheoak property for both adults and pupal cases could not be undertaken on some occasions during December 2010 and January 2011 because the areas that had been surveyed during previous season were flooded from the waters of the Yea River, which had broken its banks. Similar, the habitat slabs within Sheoak could not be monitored for pupal case during December 2010 due to pools of water covering parts of the slabs.

Thus, overall, the poor weather conditions reduced the numbers of days in which surveys could be completed considerably. However, within these constraints, Alliance Ecologists undertook surveys on a very high percentage of the relatively few days that contained suitable weather conditions.

[10] Excluding weekends and public holidays.
[11] Excluding weekends and public holidays.
[12] Excluding weekends and public holidays.

7.2.3 Land Access Issues

In mid-December 2010, access to private land for GSM surveys and other Alliance activities became problematic. As a precautionary approach until the matter had been fully resolved, no access to private land was obtained for the GSM surveys from the 16 December 2010 through to the 18 January 2011, which affected all land access except for the Sheoak property. Unfortunately, this also overlapped considerably with the time-frame in which the adult GSM were in flight during the 2010/2011 flight season (GSM were observed flying in the local area from 13 December 2010 to the 21 January 2011). That is, there were less than 10 days available for which we had both access to private land and also that the GSM were observed in flight. The GSM surveys which were deleteriously affected by this included:

- Habitat Slab Replacement experiment - all adult GSM surveys and the mid-season pupal case searches on properties #327, #328 and #335, and
- The monitoring of the ROW - all adult GSM surveys and the mid-season pupal case searches on properties #18/961, #327, #328, #330 and #335.

7.3 Conclusion

Jill Fleming and Lance Williams (of DSE Benalla) were kept aware of the issues that we were facing through the 2010/2011 flight season via email and telephone calls. Many other fauna consultants and other ecologists across Victoria also faced similar difficulties with their GSM surveys.

Within the constraints provided by the delayed emergence, poor weather and lack of access to private land, the Alliance Ecologists undertook their surveys in a manner which aimed as much as reasonably possible to complete the required GSM monitoring surveys. Considering the constraints faced, a relatively high proportion of the required surveys were still able to be completed.

Even though GSM numbers were substantially lower compared to the first post-construction season, and the results of the experimental procedures have not produced clear-cut findings, we believe that there has been some important information learnt about how the species responds during a year of above average rainfall. Namely:

- There can be a substantially differing time of emergence from year-to-year;
- The conclusion of the flight season can occur well beyond ‘early-January’;
- The emergence of adults appears to be reduced in years of above-average rainfall, although it is uncertain if this is due to the rainfall that occurred before or during the flight season (or both); and
- It is possible that GSM had been able to establish in some low-lying areas during consecutive years of below average rainfall, but may have been removed from these areas (or at least considerably depleted) following the flooding and/or heavy rainfall during the present season.

7.4 Next Steps

The project approval documents state that these GSM monitoring surveys are to be conducted for two years (i.e. GSM flight seasons) after the completion of construction with the exceptions (a) of the broader Sheoak property where the monitoring surveys are to be undertaken for five years after construction, and (b) possibly for the Habitat Slab Replacement experiment, where the slabs are to be monitored for up to 5 years where permission is granted from the landholder. Thus:

- Two years of post-construction GSM monitoring has been completed within and adjacent to the ROW for both adults and pupal cases. We do not believe that any further surveys are required for this aspect of the monitoring, as the requirements for two seasons of post-construction monitoring as stated within the FMP documents have been fulfilled (SLPA 2009b, 2009c);
- Two years of post-construction monitoring has been completed within the broader Sheoak property for both adults and pupal cases. Another three seasons of post-construction monitoring is required across this property. In the absence of an approved Conservation Management Plan for the property, we propose that the monitoring for GSM across the property for the following three flight seasons occurs using the same methods as used during the first two seasons of post-construction monitoring in the interim (although it is notable that the Sheoak East property (east of Melba Hwy) is being sold and will not be included in the Conservation Management Plan - Kara Beaumont, Melbourne Water, pers. comm.). When the Conservation Management Plan is developed, some methods which could be useful to include in a revised GSM monitoring program (for one or both of GSM adults and pupal cases) across the broader Sheoak property for future years include:
    - Clear objectives for what the GSM monitoring is aiming to achieve. The monitoring should be designed in a way that real differences in GSM population densities are able to be detected (e.g. power analysis);
    - Undertaking monitoring in a manner which allows different management regimes across the property to be rigorously compared (e.g., cattle versus sheep grazing, high versus low intensity grazing, ridges versus gullies, crash grazing versus continuous grazing, slashed versus unslashed);
    - Undertaking monitoring in a manner which allows the density of GSM using former construction areas to the separately recorded from non-disturbed areas;
    - Undertaking monitoring in a manner which allows comparison with the first two years of post-construction monitoring, and also year-to-year comparisons in future years of monitoring;
    - Flexibility in the GSM monitoring program to allow any alterations in the property management regime to be assessed; and
    - Allowing comparisons to be made with GSM monitoring programs occurring elsewhere in the local area, and/or more broadly across the bioregion or state.

- Two years of post-construction monitoring have been completed for the Habitat Slab Replacement experiment for both adult GSMs and pupal cases. Requests to continue the monitoring on the slabs within private land has been rejected by private landowners. However, Melbourne Water has stated that they will be providing permission for GSM monitoring to continue on the two habitat slab locations occurring within the Sheoak property beyond the current 2010/2011 flight season if required (Kara Beaumont, Melbourne Water, pers. comm.). In accordance with the approved FMP documents (SLPA 2009b, 2009c), and in accordance with the GSM Overarching document (which has been endorsed by both DSE and DSEWPC), a scientific paper will need to be prepared which describes the results of the experiment to a standard that would be suitable for submission to an appropriate journal.
- Two years of post-construction monitoring have been completed for the Grassland Habitat Reinstatement Experiment for both adult GSMs and pupal cases. Based on the approved FMP documents (SLPA 2009b), we do not believe that any further surveys are required for this aspect of the GSM monitoring. In accordance with the GSM Overarching document (which has been endorsed by both DSE and DSEWPC), a scientific paper will need to be prepared which describes the results of the experiment to a standard that would be suitable for submission to an appropriate journal.

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Appendix A

Schedule of Completed Adult Golden Sun Moth Surveys – 2010/2011 Flight Season

Table A1. Daily timetable of actions undertaken for adult GSM surveys during the 2010/2011 flight season, including the weather conditions each day

Timing		Weather			Survey Effort				Adult Golden Sun Moth Activity		
Date	Day	Min (ºC)	Max (ºC)	Rain (mm)	Survey Activity	Type / Location	Repeat	Personnel	Moths Flying on-site?	Moths flying at Reference Site?	Notes on weather and other items for consideration
25-Oct 2010	Monday	5.9	22.1	0	-	-	-	-	-	-	
26-Oct	Tuesday	4.5	23.8	0	-	-	-	-	-	-	
27-Oct	Wednesday	8.7	19.7	0	-	-	-	-	-	-	
28-Oct	Thursday	6.4	22.6	0	-	-	-	-	-	-	
29-Oct	Friday	10.2	26.5	0	-	-	-	-	-	-	No GSM reported flying elsewhere in state.
30-Oct	Saturday	16.9	20.0	1.2	-	-	-	-	-	-	
31-Oct	Sunday	11.4	15.5	35.0	-	-	-	-	-	-	Weekend
1-Nov 2010	Monday	7.3	17.1	0.2	-	-	-	-	-	-	Too cold. No GSM reported flying elsewhere in state.
2-Nov	Tuesday	6.6	19.7	0	-	-	-	-	-	-	Melbourne Cup Public Holiday
3-Nov	Wednesday	6.2	15.8	0	-	-	-	-	-	-	
4-Nov	Thursday	5.7	17.6	0	-	-	-	-	-	-	Too cold. No GSM reported flying elsewhere in state.
5-Nov	Friday	6.6	21.6	0	Scoping Assessment	Sheoak, Killingworth	NA	VJM, CAT	No	No	Checked at Sheoak and other historically known locations nearby. No GSM detected.
6-Nov	Saturday	6.1	22.4	0	-	-	-	-	-	-	
7-Nov	Sunday	10.4	24.9	1	-	-	-	-	-	-	Weekend
8-Nov 2010	Monday	11.2	24.6	0	-	-	-		-		Except for one recent sighting at Nhill, no reports of GSM flying anywhere in state
9-Nov	Tuesday	10.6	27.5	0	Sheoak Broader	1 of 3	1a	VM, OD	No		Except for one sighting at Nhill, no reports of GSM flying anywhere in state
					Sheoak Broader	2 of 3	1b	RR, CT	No		
10-Nov	Wednesday	15.9	28.7	0	Sheoak Broader	3 of 3	1c	CAT, RR	No		Except for one sighting at Nhill, no reports of GSM flying anywhere in state
					ROW	All except Sheoak	1a	VJM, OD	No		
					ROW	Sheoak	1b	CAT, RR	No		
11-Nov	Thursday	11.2	30.8	0	Habitat Slab x 3	326n, 326s, 327	1a	VM, RR	No		Except for one sighting at Nhill, no reports of GSM flying anywhere in state
					Habitat Slab x 3	328, 335n, 335s	1b	CT, OD	No		
12-Nov	Friday	17.9	31.1	1.4	Grassland experiment	all	1	VJM, CAT, OD, RR	No	No	Except for one sighting at Nhill, no reports of GSM flying anywhere in state
13-Nov	Saturday	15.3	20	8.4	-	-	-	-	-	-	
14-Nov	Sunday	12.3	24.4	0.2	-	-	-	-	-	-	Weekend
15-Nov 2010	Monday	10.7	22	0	-	-	-	-	-	-	Weather forecast looked poor. Except for one sighting at Nhill in immediately preceding 1-2 weeks, no other reports of GSM flying

Timing		Weather			Survey Effort				Adult Golden Sun Moth Activity		Notes on weather and other items for consideration
Date	Day	Min (ºC)	Max (ºC)	Rain (mm)	Survey Activity	Type / Location	Repeat	Personnel	Moths Flying on-site?	Moths flying at Reference Site?	
16-Nov	Tuesday	9.5	19.5	0	-	-	-	-	-	-	
17-Nov	Wednesday	5.5	23.5	0	Sheoak Broader	1 of 3	2a (not complete)	VM, NK	no	No	Except for one sighting at Nhill in immediately preceding 1-2 weeks, no other reports of GSM flying anywhere in state.
					Sheoak Broader	2 of 3	2b (not complete)	CT, JE	no	No	
18-Nov	Thursday	7.5	21.6	0	-	-	-	-	-	-	Weather forecast looked poor. Except for one sighting at Nhill in immediately preceding 1-2 weeks, no other reports of GSM flying anywhere in state.
19-Nov	Friday	8.4	23	0	-	-	-	-	-	-	
20-Nov	Saturday	7.7	28.1	0	-	-	-	-	-	-	Weekend
21-Nov	Sunday	11.7	29	0	-	-	-	-	-	-	
22-Nov 2010	Monday	11.5	31.7	0	-	-	-	-	-	-	Field preparation in office
23-Nov	Tuesday	15.8	31.2	0	Sheoak broader	1 of 3	3a	CT, NK	no	yes (1)	One moth found at reference site (Killingworth - Careys Rd) - none on Sheoak
24-Nov	Wednesday	17.9	30.6	19.8	Sheoak broader	2 of 3	3b	CT, JE	no	No	No moths seen at Sheoak or reference sites - heavy rain in afternoon
					Grassland experiment	1 of 2	2a	NK	no	No	
25-Nov	Thursday	18.3	23.8	17.8	Grassland experiment	2 of 2	2b	CT, JE, NK	no	No	Finished Grassland experiment but conditions were poor for surveys by the end - heavy recent rain and cool temperatures (and no GSM seen at reference site)
26-Nov	Friday	16.5	25.5	38.2	-	-	-	-	-	-	No surveys as too much rain in immediately preceding days
27-Nov	Saturday	15.8	24.8	37.6	-	-	-	-	-	-	Weekend
28-Nov	Sunday	12.7	19.3	0	-	-	-	-	-	-	
29-Nov 2010	Monday	11.7	24.6	0	Sheoak broader	3 of 3	3c	KD, JE	no	-	No moths found - light rain from around 1 pm. No GSM reported elsewhere in state.
					ROW	All Sites	2	VM, OD	no	-	
30-Nov	Tuesday	12.1	24.6	8.8	-	-	-	-	-	-	No surveys as poor conditions forecast for GSM survey (cold and rain). No GSM reported elsewhere in state on these days.
1-Dec	Wednesday	16.1	23.4	0.6	-	-	-	-	-	-	
2-Dec	Thursday	15.9	25.9	6.4	-	-	-	-	-	-	
3-Dec	Friday	13	28.9	1.4	-	-	-	-	-	-	
4-Dec	Saturday	14.1	30.3	0	-	-	-	-	-	-	Weekend
5-Dec	Sunday	16.4	31.2	0	-	-	-	-	-	-	

Timing		Weather			Survey Effort				Adult Golden Sun Moth Activity		
Date	Day	Min (ºC)	Max (ºC)	Rain (mm)	Survey Activity	Type / Location	Repeat	Personnel	Moths Flying on-site?	Moths flying at Reference Site?	Notes on weather and other items for consideration
6-Dec 2010	Monday	16.4	30.5	0	-	-	-	-	-	-	Conditions too wet for surveys. No GSM reported from elsewhere in state on these days.
7-Dec	Tuesday	19.8	27.1	23.8	-	-	-	-	-	-	
8-Dec	Wednesday	19.1	24.2	20	-	-	-	-	-	-	
9-Dec	Thursday	15.4	25.4	0.2	-	-	-	-	-	-	
10-Dec	Friday	14.2	21.2	0	-	-	-	-	-	-	
11-Dec	Saturday	9.5	22.8	0.4							Weekend
12-Dec	Sunday	10.7	21.5	0							
13-Dec 2010	Monday	9.2	23.5	0	Sheoak broader	1 of 4	4a	NK, CT	Yes	Yes	Surveys undertaken. Good conditions and GSM documented elsewhere by other ecologists elsewhere in state.
					Sheoak broader	1 of 4	4b	KD, JE	Yes	Yes	
					Sheoak broader	3 of 4	4c	VM, JW	Yes	Yes	
14-Dec	Tuesday	12.5	27.3	0	Sheoak broader	4 of 4	4d	NK, JW	Yes	Yes	Surveys undertaken. Good conditions and GSM documented elsewhere by other ecologists elsewhere in state.
					Grassland Exp	1 of 1	3	VM, JW, NK	Yes	Yes	
15-Dec	Wednesday	13.8	26.3	2.8	Habitat Slab	335n, 335s,	2a	VM, NK	no	no	Some surveys undertaken but average conditions for GSM survey. Surveys abandoned at ~1 pm due to deteriorating weather. None documented records of flight elsewhere in state on this day.
					Habitat Slab	326s, 327	2b	CT, JW	no	no	
16-Dec	Thursday	9.7	22	0	Habitat Slab (not complete - missing 328)	326s, 326n	2c	VM, NK, KD	no	no	Surveys undertaken. Re-surveyed 326 nth as was not fully completed in inappropriate weather yesterday. No surveys in 328 due to land access issues.
					Sheoak ROW	Sheoak	3a	VM,NK	no	no	Surveys undertaken. Good conditions. No private land access allowed.
17-Dec	Friday	6.9	23.8	1.4	-	-	-	-	-	-	Poor forecast conditions for GSM survey. No survey undertaken. No private land access allowed.
18-Dec	Saturday	9.3	20.6	1.4	-	-	-	-	-	-	Weekend
19-Dec	Sunday	11.4	17.5	5.6	-	-	-	-	-	-	
20-Dec 2010	Monday	7.4	20.2	1.2	-	-	-	-	-	-	No adult GSM surveys undertaken as rain was forecast - Undertook pupal cases searches instead. No private land access allowed.
21-Dec	Tuesday	7.1	19.7	0.2	-	-	-	-	-	-	No adult GSM surveys undertaken as rain was forecast - Undertook pupal cases searches instead. No private land access allowed.
22-Dec	Wednesday	6.5	25.5	0	Sheoak broader	1 of 4	5a	NK, JW	Yes	Yes	Surveys undertaken. Good conditions and GSM documented elsewhere by other ecologists elsewhere in state. No private land access allowed.
					Sheoak broader	2 of 4	5b	CT, LvE	Yes	Yes	
23-Dec	Thursday	10.9	23.3	0	Sheoak broader	3 of 4	5c	NK, JW	Yes	Yes	Surveys undertaken. Good conditions and GSM documented

Timing		Weather			Survey Effort				Adult Golden Sun Moth Activity		Notes on weather and other items for consideration
Date	Day	Min (ºC)	Max (ºC)	Rain (mm)	Survey Activity	Type / Location	Repeat	Personnel	Moths Flying on-site?	Moths flying at Reference Site?	
					Sheoak broader	4 of 4	5d	CT, LvE	Yes	Yes	elsewhere by other ecologists elsewhere in state. No private land access allowed.
24-Dec	Friday	9	30.1	0	-	-	-	-	-	-	Christmas/New Year Break
25-Dec	Saturday	14.1	26.8	0		-	-	-	-	-	
26-Dec	Sunday	14.5	23.2	0		-	-	-	-	-	Weekend
27-Dec 2010	Monday	9.4	18.3	0	-	-	-	-	-	-	
28-Dec	Tuesday	6.1	25.7	0	-	-	-	-	-	-	Christmas/New Year Break
29-Dec	Wednesday	8.9	31.5	0	-	-	-	-	-	-	
30-Dec	Thursday	12.7	33.1	0	-	-	-	-	-	-	
31-Dec	Friday	13.1	39.6	0	-	-	-	-	-	-	Surveys originally planned for this period, but were not undertaken due to unresolved access issues on private land.
1-Jan	Saturday	20.2	30.2	0	-	-	-	-	-	-	
2-Jan	Sunday	13	24.8	0	-	-	-	-	-	-	Weekend
3-Jan 2011	Monday	11.2	24.3	0		-	-	-	-	-	Christmas/New Year break
4-Jan	Tuesday	8.8	28.8	0	Sheoak broader	1 of 4	6a	CT, ZH	Yes	Yes	
4-Jan	Tuesday	8.8	28.8	0	Grassland Exp	1 of 2	4a	KD	No	Yes	
5-Jan	Wednesday	12.6	26.2	0	Sheoak broader	2 of 4	6b	CT, ZH	no	Yes	
6-Jan	Thursday	12.6	31.6	0	Sheoak broader	3 of 4	6c	CT, ZH	Yes	Yes	Conditions good for adult GSM surveys. Only undertaken on Sheoak due to unresolved private land access issues.
					Sheoak broader	4 of 4	6d	KD, ZH	Yes	Yes	
					ROW	Sheoak	4	ZH, KD, CT	no	Yes	
7-Jan	Friday	17.5	32.8	0	Grassland Exp	2 of 2	4b	CT	No	Yes	Conditions good for adult GSM surveys. Only undertaken on Sheoak due to unresolved private land access issues.
8-Jan	Saturday	19.4	34.8	0	-	-	-	-	-	-	
9-Jan	Sunday	17	23.2	2	-	-	-	-	-	-	Weekend
10-Jan 2011	Monday	17.1	28.6	8.2	-	-	-	-	-	-	
11-Jan	Tuesday	19.4	23.9	15.6	-	-	-	-	-	-	
12-Jan	Wednesday	20.9	25.1	41.4	-	-	-	-	-	-	
13-Jan	Thursday	22.2	28.9	52	-	-	-	-	-	-	
14-Jan	Friday	20.5	27.4	16.8	-	-	-	-	-	-	No surveys planned as heavy rain forecast
15-Jan	Saturday	16.8	31.5	0	-	-	-	-	-	-	
16-Jan	Sunday	18	33.4	0	-	-	-	-	-	-	Weekend

Timing		Weather			Survey Effort				Adult Golden Sun Moth Activity		
Date	Day	Min (ºC)	Max (ºC)	Rain (mm)	Survey Activity	Type / Location	Repeat	Personnel	Moths Flying on-site?	Moths flying at Reference Site?	Notes on weather and other items for consideration
17-Jan 2011	Monday	14	24	0	-	-	-	-	-	Yes	Windy, overcast and only 17 ºC at 10.30 am - Yea River flooded.
18-Jan	Tuesday	12.3	22.1	0	-	-	-	-	-	-	Rained last night (despite lack of rain data from Mangalore recording station), overcast – 16 ºC at 10 am - not 20 ºC until after 2 pm
19-Jan	Wednesday	11.6	23.6	0	Habitat slab	335N, 335S, 327	3a	VM, JW, NK, KD, OD	Yes	Yes (track in Sheoak)	19ºC and windy at 11 am but 3 male GSMs observed in Sheoak
20-Jan	Thursday	11.6	30.2	0	Habitat slab	326n, 326S, 328	3b	VM, JW, NK, OD	No	Yes	Good conditions for adult GSM surveys. Records from other ecologists elsewhere in state that GSM were still being detected.
21-Jan	Friday	14.1	33.3	0	Grassland Exp	1 of 1	5	NK, JW, OD	No	Yes	
22-Jan	Saturday	16.1	33.7	0	-	-	-	-	-	-	
23-Jan	Sunday	17.7	31.9	0	-	-	-	-	-	-	Weekend
24-Jan 2011	Monday	18.5	25.1	0							No more adult GSM surveys due to forecast cold, rain, and the very late timing compared to 'typical' GSM season. Undertook pupal surveys instead.
25-Jan	Tuesday	12.4	29.1	17							
26-Jan	Wednesday	16.9	25.1	0.2							
27-Jan	Thursday	13.6	28.1	0							
28-Jan	Friday	12.5	26.5	0							
29-Jan	Saturday	11.2	30.6	0							
30-Jan	Sunday	14.7	35.8	0							Weekend

Appendix B

Schedule of Completed Golden Sun Moth Pupal Case Surveys – 2010/2011 Flight Season

Table B1. Daily timetable of actions undertaken for pupal GSM surveys during the 2010/2011 flight season, including the weather conditions each day

Timing		Survey Type	Location	Repeat	Personnel
20-Dec 2010	Monday	Grassland Experiment	all	Mid	VM, JE, JW, KD
21-Dec	Tuesday	Broader Sheoak	all	Mid	KD, JE, JW, NK
21-Dec	Tuesday	ROW	Sheoak	Mid	VM
22-Dec	Wednesday	Habitat Slab	326S (1 of 2)	Mid	CT, NK, JW, LvE
23-Dec	Thursday	Habitat Slab	326S (2 of 2)	Mid	CT, NK, JW, LvE
24-Dec to 31 Dec 2010		-			
1-Jan to 16 Jan 2011		-			
17-Jan 2011	Monday	ROW	327	Post	VM, JW, NK
18-Jan	Tuesday	Habitat Slab	327	Post	VM, JW, NK, KD
19-Jan	Wednesday	Habitat Slab	335 South (6/10)	Post	VM, JW, NK, KD, OD
19-Jan	Wednesday	ROW	328	Post	VM, JW, NK, KD, OD
20-Jan	Thursday	Habitat Slab	335 South (4/10)	Post	VM, JW, NK, OD
20-Jan	Thursday	ROW	335	Post	VM, JW, NK, OD
21-Jan	Friday	ROW	330	Post	NK, JW, OD
22-Jan	Saturday	-			
23-Jan	Sunday	-			
24-Jan 2011	Monday	Habitat Slab	6/10 328	Post	CAT, NK, OD, JW
25-Jan	Tuesday	Habitat Slab	335 North	Post	CAT, NK, OD, JW
26-Jan	Wednesday	Habitat Slab	4/10 328	Post	CAT, NK, OD
26-Jan	Wednesday	Habitat Slab	4/10 Sheoak north	Post	
27-Jan	Thursday	Habitat Slab	326 South	Post	VM, JW, NK, OD
28-Jan	Friday	Habitat Slab	Finish 326 North	Post	VM, JW, NK, OD
28-Jan	Friday	ROW	Sheoak	Post	VM, JW, NK, OD
29-Jan	Saturday	-			
30-Jan	Sunday	-			
31-Jan 2011	Monday	-			
1-Feb	Tuesday	Grassland Experiment	Sheoak	Post	VM, CAT, KD, JW, NK
2-Feb to 21 Feb 2011		-			
22-Feb	Tuesday	Broader Sheoak	2 of 2	Post	VM, CAT, KD, RR

Appendix C

Example data sheet for Adult GSM Surveys – Habitat Slab Replacement and Grassland Habitat Reinstatement experiments

31 21633 13: Golden Sun Moth Adult Habitat Slab Replacement and Grassland Habitat Reinstatement Surveys (season 10/11)

Date:		**Property ID:**		**Observers:**		**Temp at start**		**Cloud Cover %**		Still / Mild breeze / Mod breeze / Gusty	**Survey type:**	Habitat slab / Tussock Reinstatement

Hab slab or tussock rest no.	Treatment type	Size of search area (m^2)	Pax	GPS (mid point)	Time Start	Time Finish	No. fly **over** the plot	No. fly **out** of the plot	No. land **within** the plot	No. **males** observed **on ground**/veg within plot	No. **females** observed **on ground**/veg within plot
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Notes:											

Appendix D

GSM pupal case analysis results

Table D1: GSM pupal case analysis by Dr Will Osborne

Property	Slab / Plot no.	Date	No. of potential GSM	No. confirmed GSM
327	B 450 slab	18/01/2011	1	FRAGMENT - NOT ID
327	B200 lay	18/01/2011	1	NOT GSM
327	G200 Slab	18/01/2011	2	NOT GSM
327	G 200 LAY	18/01/2011	1	NOT GSM
327	B 450 LAY	18/01/2011	2	NOT GSM
327	G 450 LAY	18/01/2011	1	NOT GSM
327	B 200 SLAB	18/01/2011	1	FRAGMENT NOT ID
328	B 200 SLAB	26/01/2011	1	NOT GSM
328	B 450 LAY	24/01/2011	1	NOT GSM
328	B 200 LAY	24/01/2011	2	NOT GSM
328	Disturb control	24/01/2011	1	NOT GSM
326 S	G 200 LAY	22/12/2010	1	NOT GSM
326 S	B 450 slab	23/10/2010	1	NOT GSM
326 S	G 450 LAY	22/12/2010	1	NOT GSM
326 S	G 450 LAY	27/01/2011	2	NOT GSM
326 S	G 200 SLAB	27/01/2011	1	NOT GSM
326 S	B 450 LAY	27/01/2011	2	NOT GSM
326 S	G 450 SLAB	27/01/2011	1	NOT GSM
335 N	G 200 SLAB	25/01/2011	1	NOT GSM
335 N	G 450 SLAB	25/01/2011	2	NOT GSM
335 S	B 450 LAY	20/01/2011	1	NOT GSM
335 S	B 200 LAY	19/01/2011	2	NOT GSM
335 S	G 200 SLAB	20/01/2011	1	NOT GSM
Broader Sheoak	10	22/01/2011	1	NOT GSM
Grassland experiment	27		1	NOT GSM
Grassland experiment	28		1	NOT GSM
Grassland experiment	35		1	NOT GSM
Grassland experiment	41		1	NOT GSM
Grassland experiment	54		1	NOT GSM