Australian Litter Measure Specification

VERSION CONTROL		
VERSION	STATUS	DATE
3.5	Phase 1 final version for public release	3/12/2021
3.6	Phase 2 first draft to incorporate changes based on feedback from NSW AusLM field work. Specific changes documented in 'AusLM version control' document.	16/6/2022
4.0	Phase 2 final version for version 4.0 release.	20/6/2022

Table of Contents

1 Introduction

Sustainability Victoria in conjunction with NSW EPA and the Department of Environment and Science Queensland in consultation with the AusLM project working group and key stakeholders have developed a new litter monitoring methodology called the Australian Litter Measure (AusLM). This specification document outlines two aspects of the AusLM:

- **The AusLM methodology**. This is a detailed description of sites the AusLM can be used at, how litter is measured/counted at these sites, the types of litter items counted, and the typology used to categorise them. This method can be used by any organisation or individual interested in monitoring litter and developed for use by state and territory governments, government agencies, councils, community groups and volunteers to monitor litter.
- **Guidance on monitoring programs using the AusLM.** The methodology can be used in a range of ways for a range of questions relating to litter prevention and management. This section outlines some of the considerations for government organisations in using the AusLM for jurisdiction-level monitoring and recommendations for how a 'core' cross-jurisdictional program might be structured.

2 AusLM requirements

This section of the report summarises the requirements for the AusLM identified by AusLM Project Working Group (PWG) members (represented by all Australian states and territories) ranked from highest to lowest priority. These guiding requirements are summarised below and described in more detail in Annex 1. The requirements are listed in order of priority from highest to lowest.

1. Transparent
2. Affordable
3. Scalable
4. Context-aware
5. Simple
6. Future-proofed
7. Compatible with other litter studies
8. Backwards compatible (if possible)
9. Extensible
10. Accessible to the public

Stakeholder feedback was collected via a consultation process that included interviews and informal online feedback sessions. Although there are a range of ways stakeholders are seeking to use and apply AusLM the priorities include monitoring litter prevalence, evaluating the performance of litter interventions and understanding litter distribution and abundance to inform program design (Table 1). These uses, along with the ten requirements above, have been considered throughout the design of AusLM.

Table 1. Key uses of AusLM across jurisdictions

High-level indicator of litter prevalence	Measure the extent of litter at the jurisdiction-level and report if the extent of litter is getting better or worse over time.
Evaluation	Evaluate the effectiveness of jurisdiction-wide litter prevention and policy interventions
Design	Design litter prevention programs and inform the need for new or revised policies to address current and emerging litter issues.

3 AusLM specification – The AusLM methodology

3.1 Overview

This section of the document includes our approach to the AusLM methodology and the broader monitoring program. Our approach responds to the ten guiding AusLM requirements (Annex 1), the three key objectives areas (high-level litter indicators, evaluation, and design) and relevant questions, as well as the requirements from secondary stakeholders that can be included in the scope. The approach takes into consideration good practice identified through a desktop review of local, national and international litter measurement methodologies.

The AusLM consists of a standard methodology (described in this section). This methodology has been designed for use by each state and territory to serve their individual monitoring and litter data needs (Figure 1). It is expected that, across the jurisdictions, at least some of this monitoring will be shared (an AusLM Core Monitoring Program) to enable cross-jurisdiction comparison and benchmarking (discussed in section 4). Section 4 also has detail about a site selection process that is useful for the AusLM Core Monitoring Program and for establishing jurisdiction-specific monitoring.
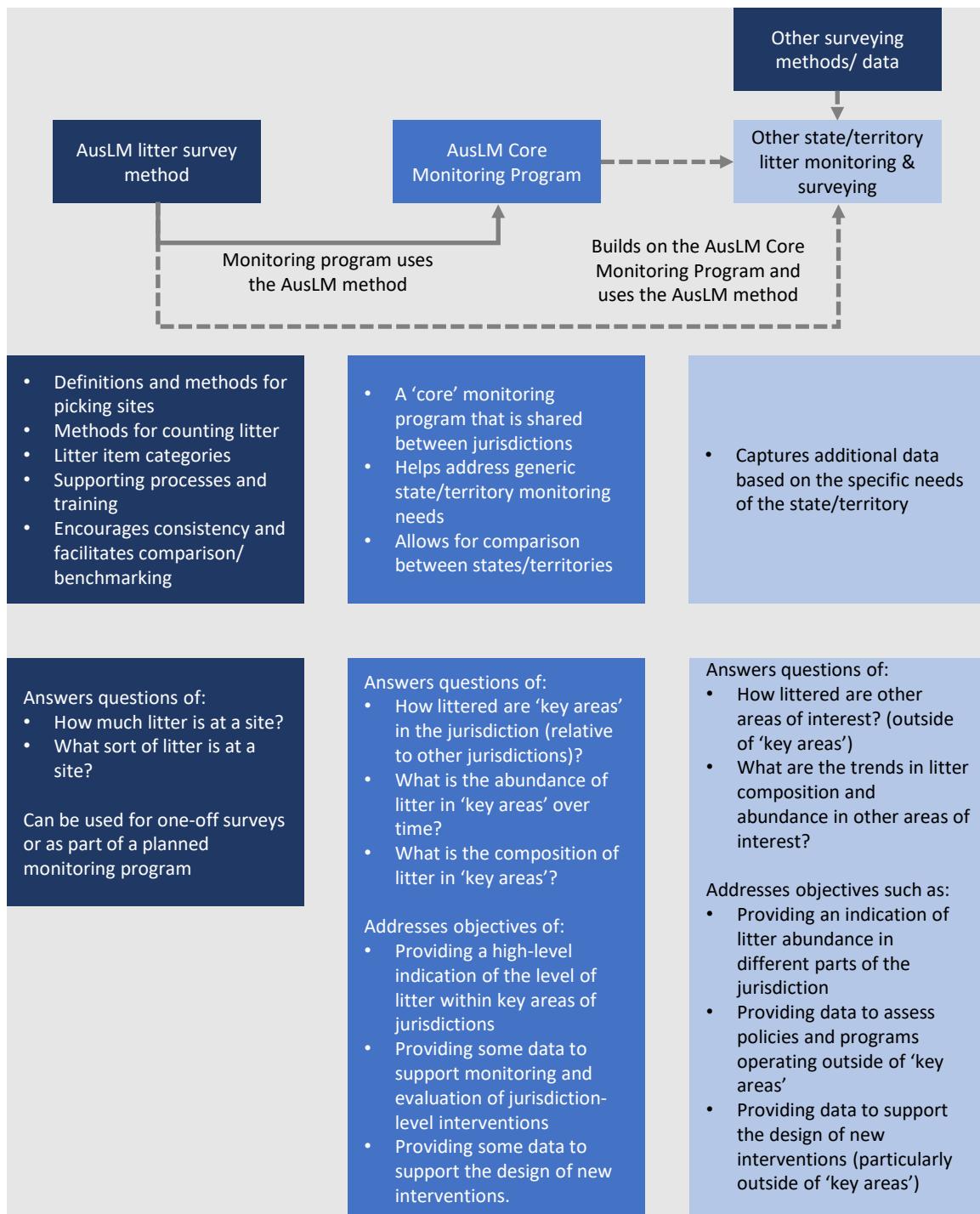
Figure 1. Relationship between the AusLM methodology, AusLM Core Monitoring Program and the individual monitoring needs of each state/territory.

3.2 Overarching method - A standing stock count

Given the objectives proposed for the AusLM, it is recommended the AusLM be focused on a standing stock visual litter count (i.e. litter will be counted but not collected). This is considered to be the most appropriate way of answering questions about the broad trends and achievements at the jurisdiction scale.

This contrasts with an accumulation methodology, which removes litter at each survey. If done sufficiently frequently, an accumulation methodology can provide useful information on the flow of litter into a site and can be a more targeted method for understanding, for example, litter behaviour. However, accumulation methodologies:

- Are more resource intensive. They require surveys to be repeated frequently to ensure that any accumulation of litter is not confounded by cleaning. They also take more time to physically collect the litter, which introduces more health and safety considerations.[1]
- Answer questions on the flow of litter into a site. But, because they alter the site by collecting litter, they are more difficult to compare to surveys of new site (e.g. that might only be surveyed as a one-off. They also do not provide information on the flow of litter out of a site.

A summary of the key pros and cons to different litter measurement approaches is included in Annex 2.

The core jurisdictional monitoring using the AusLM would not involve collecting litter. However, recognising that community groups and volunteers may want to collect litter as part of the AusLM, it is possible to adapt the method to incorporate collection at certain 'non-core' sites, provided this is clear in the data.

3.3 Site types

Overview

The site types represent the key types of area where the AusLM is intended to be used. Having clearly defined site types is important in developing a methodology that can be used consistently and that generates data that is comparable between areas. Importantly, it means that litter will not be counted 'everywhere' but, instead, in a selection of areas that are considered to be most interesting and informative to litter managers. This helps focus effort and provide a stronger analysis of trends through time.

Table 2 summarises the site types that are included in the AusLM. These site types are discussed in more detail later in this section. These descriptions include details on the areas within sites where litter is counted. In all cases, three or more fixed transects are used to sample sites. This provides an ability to characterise the variability within a site. The size and location of these transects vary between site types.

In addition to these site types **two additional site types/surveying methods have been included for consideration in the future: carparks and generic sites**. These are presented in Annex 7. Note that they are draft methods only and will require further piloting and integration into the training materials. Importantly, they should be considered as 'non-core' methods that can

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[1] Lippiatt, S., Opfer, S., and Arthur, C. 2013. Marine Debris Monitoring and Assessment. NOAA Technical Memorandum NOS-OR&R-46.

be used by jurisdictions to help them address their individual surveying needs/interests, but that are not necessarily integrated into any national/core AusLM monitoring program.

Table 2. Site types for AusLM.

Site type	Simple description
Beach	A mostly sandy beach frequently visited by people for activities such as recreation and relaxation.
Residential	A street in a residential zone as specified by the jurisdictions planning scheme that has homes/units/apartments on both sides of the street.
Industrial	A street in an industrial zone as specified by the jurisdictions planning scheme.
Retail	A street in a commercial zone as specified by the jurisdictions planning scheme with retail stores on at least one side of the street.
Recreational Park	A public outdoor space frequently visited by individuals and groups for recreation and leisure.
Main roads	Main roads include straight open stretches of sealed road with wide verges and that, typically, act as an arterial for traffic between and around population centres.
Generic site type	Can be applied to a range of sites, particularly sites with complicated structures (e.g. transport interchanges). Not included in detail in this Specification or considered part of any core AusLM monitoring, but a suggested scope outlined in Annex 7.
Carpark	Samples the boundary of carparks. Not included in detail in this Specification or considered part of any core AusLM monitoring, but a suggested scope outlined in Annex 7.

These sites have been selected as part of the AusLM methodology because:

- they are reflective of broad types of land use and situations where litter is likely to be found
- they are considered to be interesting and informative to litter managers
- they enable some backwards compatibility with other methodologies.

The AusLM does not include car parks and shopping centres as they were considered problematic in terms of sampling and their exclusion allows for additional effort to be put into monitoring other sites. A summary of reasons for their exclusion is provided in Annex 3, with a modified methodology for carparks outlined in Annex 7 as an optional add-in.

Residential, retail and industrial sites

Table 3 below provides more details on the nature of residential, retail and industrial sites. This includes what defines the site and how transects are used to sample it. These site types are grouped together because they are all broadly focused on surveying the area between private properties and the road (i.e. footpaths, nature strips and gutters). Other general features common to assessment in residential, industrial and retail site-types are:

- **Inclusion of gutters and other features:**
  - Litter in the gutter is counted. The gutter is demarked either by the concrete gutter itself, or 50 cm into the road from the edge of the road shoulder if the structure of the gutter is not clear. Litter on the edge of stormwater drain entry points is included (or stuck in the entry point), but litter inside drains is not (i.e. surveyors do not look inside drain entry points).
  - Some transects might include areas within the sampling area that may either make it difficult to count litter or act as accumulation points. These include planter boxes/garden beds, bushes, barbeque areas, seated eating areas, bus stops and bus shelters. These are recorded on the datasheet. These areas should be audited where possible. Garden beds and planter boxes should be audited up to 1 m in from the outside edge. Areas that are not able to be surveyed are estimated and recorded. This might include areas where people are sitting, areas covered by parked cars, etc.
- **Transect placement**:
  - The same transects are returned to each sampling period.
  - Transects can span intersections and go around corners.
  - Ideally, transects would end 50 m or more before the border with a different site type (e.g. residential transitioning to retail).
  - Transect lengths are provided as ideals but may need to be adjusted to suit local conditions and align with natural boundaries etc. Site/transect selectors should aim for transects no more than 10% +/- from these guidelines but smaller transects may sometimes be required.
- **Survey area:**
  - Aerial photography and GIS may be used to calculate the survey area in cases where transect width is variable (i.e. the footpath/nature strip width varies).
  - While start/end coordinates might be set remotely during planning, they should be updated in the field to align with natural markers such as property boundaries, curb edges etc. Photos and descriptions of transect start/end points should take precedence over coordinates as the 'source of truth' of where transects are run.

In terms of the search pattern in residential, industrial and retail transects, the transect width (e.g. around 3-5 m in residential areas) will require surveyors to follow a meandering S-shaped search pattern (Figure 2). This pattern requires the surveyor to wind their way back and forth along the transect to ensure that they walk within at least 1.5 m of all areas on the transect (a 3-m wide transect, for example, would allow the surveyor to walk in a straight line down the middle of the transect). In cases where long grass or other features obscure sight lines, the surveyor should search no more than 1 m away. Bounding of the transect by natural features (the gutter and property boundaries) will help ensure the search area is kept consistent.

In some cases, there might not be a clear property boundary – in this instance, resampling should occur to select an alternative transect.

Figure 2. Example of S-shaped search pattern for surveying litter on residential transect >3 m wide.

Table 3. Detailed site-type descriptions for residential, retail and industrial sites.

Component	Residential	Retail	Industrial
Basic description	A street/collection of streets in a residential area. There are homes/ units/ apartments on both sides of the street.	A street/collection of streets within a retail precinct (i.e. shopfronts).	A street/collection of streets in an industrial area.
Inclusions	Must be residences on both sides. Dwellings can be houses, multi-unit developments, apartments, townhouses etc.	The focus here is on shops, including retail and food stores. This might also include a street that has a small fraction of other building types (e.g. a library, a small office frontage) though this should be <10% of the building/business types. The retail strip might be only on one side of the road or both. Buildings that have retail fronts/at ground level and residential above can be included. While ideally sites should be large enough to fit 3 x 100 m transects (noting that they can go on both sides of the road if it is also retail), smaller sites are possible if they are representative of retail precincts in that location. In these cases, transects should be a minimum of 50 m.	The expectation is that these sites will have factories, industrial offices, warehouses, workshops, etc. While ideally sites should be large enough to fit 3 x 100 m transects (noting that they can go on both sides of the road if it is also retail), smaller sites are possible if they are representative of retail precincts in that location. In these cases, transects should be a minimum of 50 m.
Exclusions	Streets with maximum speed limits of greater than 60 km/h. Blind-ended streets (e.g. courts) to be excluded. Streets with schools or other significant public amenity to be excluded (though these can be nearby in neighbouring streets).	A strip that is dominated by restaurants/pubs (i.e. more than 80%) over the entire site's transects (noting that there could be parts of the site that have a high density of these venues, but they should not be the exclusive type). Attempt to avoid areas that are cleaned on a daily basis.	Industrial areas that are accessed by a private road are not applicable (i.e. in industrial parks where the listed address is the main road at the front of the estate). It is not uncommon for some retail sites to be included in industrial areas but sites with more than 10% retail by street length should be excluded.

Component	Residential	Retail	Industrial
Audit timing	Anytime, however surveyors should note if sites are being sampled on the day of council waste collection so that it can be integrated into future analysis.	After 4pm to reflect a 'worst-case' litter load, however, after 2pm is acceptable.	Anytime
LGA zoning	Residential	Commercial	Industrial
ALUM classification	5.4.1 Urban residential	5.5.1 Commercial services	5.3.0 Manufacturing and industrial
Sampling area/ transects	The sampling area is a strip (transect) along the street between the property boundary and the outer edge of the gutter (i.e.~2-5 m). Fences that run along the property boundary should be included in the transect. Litter in the gutter is counted. If there is no clear property boundary or the boundary line is very inconsistent/not straight, then resampling should occur to select another transect. Litter is counted along this strip for 100 m. Only one side of the road is included in the transect, however, the 6 transects are laid out in adjacent pairs covering both sides of the street (allowing 'up and back', promoting efficiency).	The sampling area is a strip (transect) along the street between the shopfronts and the outer edge of the gutter (i.e. ~3-5 m). Litter is counted along this strip for 100 m (1 transect). Litter in the gutter is counted. Only one side of the road is included in the transect.	The sampling area is a strip (transect) along the street between the property boundary and the outer edge of the gutter (i.e. ~3-10 m). Fences that run along the property boundary should be included in the transect. Litter in the gutter is counted. If there is no clear property boundary or the boundary line is very inconsistent/not straight, then resampling should occur to select another transect. Litter is counted along this strip for 100 m (1 transect). Only one side of the road is included in the transect.
Number and placement of transects	6 x ~100 m Transects are separated by ~50 m and ideally cover more than a single street (see Figure 3). A single transect includes one side of the road. Transect	3 x ~100 m	3 x ~100 m Transects are separated by at least 50 m and ideally cover more than a single street (see Figure 5).

Component	Residential	Retail	Industrial
	pairs (1 & 2, 3 & 4, 5 & 6) are on opposite sides of the same street. Transects are placed haphazardly within a ~200 m radius of the site coordinates using aerial imaging/maps.[4]	Transects are separated by at least 50 m [3] and ideally cover more than a single street (see Figure 4). Transects are placed haphazardly within a ~200 m radius of the site coordinates using aerial imaging/maps (see footnote)	Transects are placed haphazardly within a ~200 m radius of the site coordinates using aerial imaging/maps (see footnote).

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[4] Once a central site marker is established (see Section 4.5), a 200 m radius can be drawn on a map and start points haphazardly identified using random coordinates or blind placement of a marker on the map. These will likely need to be moved around to accommodate each other and any parts of the site that are not able to be surveyed.

[3] Retail and industrial transects may be separated by as little as 10 m in cases where the site is too small to accommodate larger, more spread-out transects.
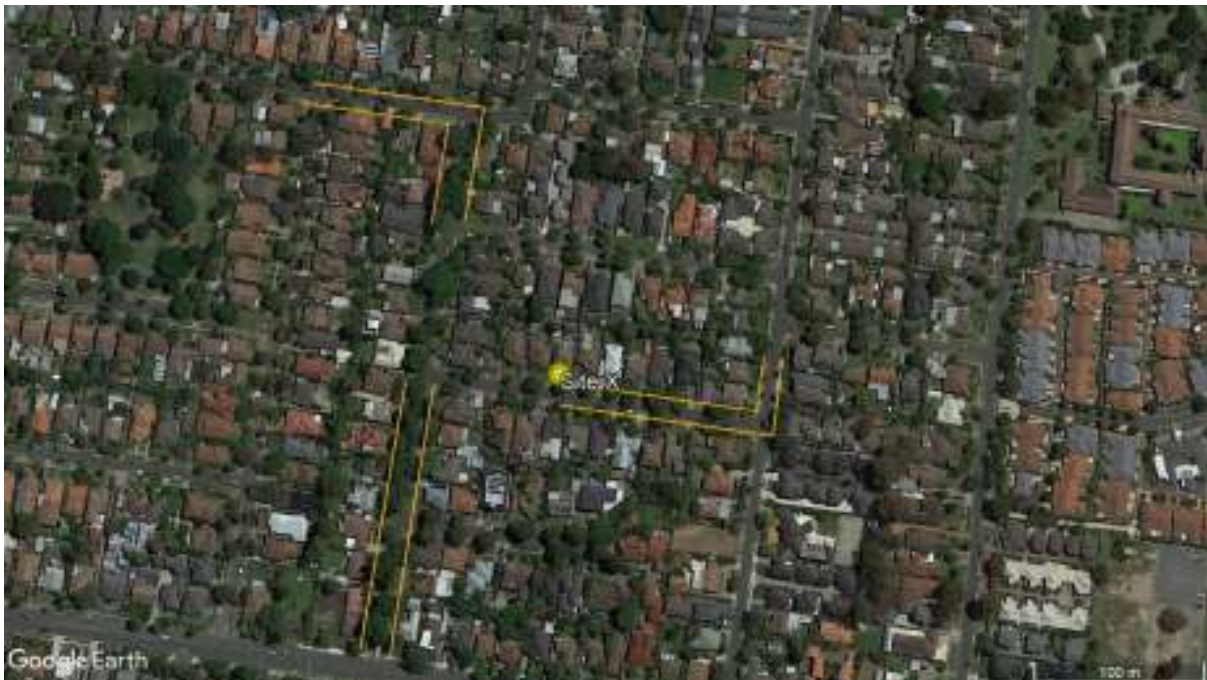
Figure 3. Example of how three transects (orange lines) could be surveyed at a residential AusLM site. Note that each pair of lines represents one transect.

Figure 4. Example of how three transects (orange lines) could be surveyed at a retail AusLM site.

11

Figure 5. Example of how three transects (orange lines) could be surveyed at an industrial AusLM site.

Parks

Table 4 below provides more details on the nature of park sites. This includes what defines the site and how transects are used to sample it.

In terms of the search pattern in parks, the transects are 3 m wide and the surveyor walks the centreline. These transects do not have to be marked, but surveyors will be trained in point-to-point straight-line sampling: identifying a bearing/point to walk towards, moving towards it, then searching left and right out to 1.5 m for litter before moving forward towards the marker again. The aim is to prevent them searching ahead of themselves and potentially creating a meandering transect. Surveyors will have a 1.5 m measure to ensure they do not count litter more than 1.5 m either left or right of them.

Table 4. Site description for park sites.

Component	Recreational park
Basic description	A public outdoor space frequently visited by individuals and groups for recreation and leisure.
Inclusions	The area should have a playground OR covered eating area (e.g. a rotunda) OR barbeque OR similar substantial piece of infrastructure. The area requires at least one but can have any combination of these things. The site will need to be more than 50% open area (i.e. grass, paths) that is not playgrounds or dense vegetation. The total area that can be surveyed should be at least 2000 m².
Exclusions	The site would not include sports ovals, skateparks or bike parks, though it can be adjacent to these areas.

Component	Recreational park
	Parks with food retail outlets (kiosks, takeaway stores etc.) within the site or immediately adjacent to the sampling area (within 50 m) are to be excluded.
	Excludes national and state parks.[4]
Audit timing	Anytime
LGA zoning	Public park and recreation zone (or similar)
ALUM classification	5.5.3 Recreation and culture
Sampling area/ transects	The sampling area is ideally bounded by roads, fences, vegetation or other natural boundaries. If paths are used as boundaries the path itself should be sampled.
	The site boundaries should be no more than 100 m from the key piece of infrastructure (playground, BBQs, picnic tables) and no more than 200 m along its longest axis. This might mean a site border is using mapping software in the absence of 'natural' boundaries.[5]
	The sampling area should be mapped using aerial imagery.
	This area is sub-sampled using 3 m wide transects.
Number and placement of transects	5 x ~25-200 m
	Transects should be placed parallel and oriented to ensure the area sampled is representative of the site (examples in Figure 6 and Figure 7). If it suits the site orientation, transects can be run straight east-west or north-south to make site layout and surveying more straightforward. Transects should be evenly inset from the site boundaries.
	Transects will be of variable length. Length can be identified from mapping and confirmed in the field.
	Transects can be moved if they are on sloping ground (>45°) or have more than 50% of their length unable to be sampled. Playgrounds should be avoided and transects can be moved to avoid playgrounds. If transects are moved to avoid playgrounds or similar, the remaining transects should be re-distributed evenly (on the part of the site that the transect is moved to). Areas to be excluded are any dense vegetation that cannot be walked through (either because of its density or because of fences) and other inaccessible areas.

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[4] National and state park reserves are not the intended focus of recreational parks in AusLM.
[5] A general process is to identify the park site, identify the main infrastructure and then and then mark the edges of the site using 'natural boundaries' such as fences, paths and areas of vegetation, ensuring it is less than 200 m across. This could include drawing a 100 m radius circle in GIS, centring on the key infrastructure, as a guide.

Figure 6. Example of a recreational park site showing how the site boundaries (blue lines and shading) might be defined using the carpark and tennis courts to the east, the dense bushes to the south and the northern fence line. The western boundary is set by the property boundary ending in the northwest. Red shading indicates areas that transects should not cross (play equipment). Original layout of transects (orange lines, left image) showing transects are spread evenly using the northern border for reference. As one transect crosses the play equipment (grey line) the transects have been moved in the right image so that they are evenly spaced to the west of the playground and do not cross it.

Figure 7. A second example of a recreational park site showing how the site boundaries (blue lines and shading) might be defined using the roads as natural borders to the areas. Red shading indicates areas that transects should not cross (play equipment). Original layout of transects (orange lines, left image) showing transects are spread evenly across the widest part of the park. As one transect crosses the play equipment (grey line) the transects have been moved in the right image so that they are evenly spaced to the east of the playground and do not cross it.

Beaches

A detailed description of beach sites and sampling is outlined in Table 5. Of note is that the focus for the AusLM core monitoring program (see Section 4.5) is on sandy beaches and areas adjacent to major access points. Other beaches can be surveyed using the AusLM methods, but these will need to be identified as being of a qualitatively different nature in any database.

The transects at beaches will be laid out using measuring tapes to ensure transect lengths are measured each time and ensure transect widths are standardised. A compass can be used to set a bearing towards the water from the back of beach starting point. Litter surveyors should walk 1.5 m to the side of the tape measure, allowing them to scan a 3 m swathe of ground. This is repeated on the other side of the transect, for a total width of 6 m.

Table 5. Detailed site-type descriptions for beach sites.

Component	Description for beaches
Basic description	A mostly sandy beach frequently visited by people for activities such as swimming, walking, other recreation and relaxation.
Inclusions	The beach should have a minimum length (i.e. parallel to the water) of 100 m.
	On long beaches, there can be multiple sites, but they must be separated by at least 2 km. If there are multiple points of entry, the sampling location should be near the 'main entry' (normally a formal carpark versus backroads/tracks) (Figure 8).
	Sampling should occur within 2 hours of low tide.
	The majority (i.e. 90% or more) of the beach area to be sampled is sand (or sand covered in seaweed etc.), though there may be clumps of rock or similar.
Exclusions	Beach areas to be sampled should be at least 100 m away from any piers, jetties, wharves or boat ramps.
	Beaches with food retail outlets (kiosks, takeaway stores etc.) within the site or immediately adjacent to the sampling area (within 50 m) are to be excluded.
LGA Zoning	Public park and recreation zone (or similar)
ALUM classification	6.6.0 Estuary/coastal waters
Sampling area/ transects	The sampling area should be approximately 100 m long (parallel to the water). It is bounded by the water's edge (+/- 2 hr from low tide) and the natural back of the beach, which could be demarked by vegetation, dunes, a fence, a wall or similar. The area for sampling is located approximately 25 m along the beach away from a main entrance and in a direction away from other nearby main entrances (e.g. away from another path from the same carpark). The sampling area should be mapped using aerial imagery. Key points for locating the site again are the high-shore corners. This area is sub-sampled using five, 6-m wide transects.
Number and placement of transects	5 x ~15-100 m (transect length depends on the beach width) Transects are 6 m wide (3 m either side of the measuring tape) and separated evenly across the 100 m sampling area (i.e. every 25 m; see Figure 9). These transects run perpendicular to the shore slope towards the water's edge (the highest extent to which water is reaching on that tide). A compass can be used to take a bearing that will help lay the tape in a consistent direction each time. As transect length is variable across the site and time (tidal differences and dune movement), transects will need to be laid out each time using measuring tapes and the length recorded. Litter is recorded 2 m into vegetation at the back

Component	Description for beaches
	of the site, as per CSIRO's beach monitoring methods for each transect and surveyors should not enter this area to prevent damage to sensitive vegetation. The transect length measured and recorded should not include the 2 m section at the back of the beach. This additional 2 m will be added on during the data analysis stage. If this 2 m area cannot be monitored due to physical barrier such as a fence, then the area will not be surveyed, and this will be recorded. If there is a hard engineered structure such as a raised path or boardwalk at the back of the beach instead of vegetation/dunes, then do not sample the area and record its presence on the Transect Information form (Physical barrier at rear of beach).

While transects are effectively fixed, they can be moved slightly to avoid running over people and their possessions on the beach, though there may be some cases where this cannot be avoided. In these situations, transects may need to be walked without the tape measure and any area not surveyed estimated and recorded. In warmer months, preference should be to monitor beaches in the morning (while still considering the tides) to reduce the challenges associated with avoiding people on the beach.

Only the GPS coordinates of the first transect on the high-shore side of the site are required as the transect layout is standardised.

Figure 8. Choice of access point on large beaches. Many beaches have multiple access points within a small area. The sampling area for AusLM should be located relative to the 'Main access point' relative to other access points that might be smaller paths or tracks. A carpark is usually a distinguishing feature. Where there are several main access points the one at outside of the carpark should be chosen to avoid sampling across an access point itself.

Figure 9. Example of a beach site showing the boundaries to the sampling area (blue lines and shading). The area is approximately 25 m away from the main access point. The high shore (top, along the vegetation) site boundary is 100 m. Transects (orange lines) are spaced every 25 m and run perpendicular to the slope of the beach, down to the waterline (the top of where the waves are washing up to). Each transect is 6 m wide.

Main roads

Main roads are expected to be the key roads linking urban centres, generally have large open verges and that are not lined with residential, commercial or other buildings. Depending on each jurisdiction's needs with respect to monitoring main roads, the location of roads can be different (see Section 4.5). **There are particular dangers associated with surveying roadsides with higher traffic volumes and speeds** (i.e. in contrast to residential, retail and industry sites). As such, the AusLM recommendations are for roads to be surveyed in:

- 60-80 km/h zones
- straight stretches with good lines of sight
- areas with wide, open verges.[6]

This does not preclude surveys along other roadsides as per jurisdictions needs, however, such sites should be identified carefully and in consultation with jurisdiction-level road authorities to ensure appropriate levels of safety.

Table 6 below provides details of how main road sites are defined and sampled. The primary transect layout is a 100 m long strip, 3 m wide, and that surveyors walk down the centreline.[7] The surveyor regularly uses a tape measure to check they are the appropriate

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[6] Wide, open verges with minimal vegetation would allow surveyors to be more visible, but also: help standardise site types; are expected to be more frequently used by pedestrians; are more readily and accurately surveyed (as compared to, for example, heavily vegetated sites).

[7] Note this is an updated version of the methodology that removes the need for laying transects and, in turn, substantially reduces the amount of effort required at each site.

distance from the edge of the road and to ensure that any litter counted is no more than 1.5 m from the centreline.

Table 6. Detailed site-type descriptions for main roads.

Component	Description for main roads
Basic description	Main roads include straight, open stretches of sealed road. They have one or two lanes for traffic traveling in either direction bordered by vegetation/open land.
Inclusions	The intent is for 'main' roads to be sampled but specific definitions will need to vary on a case-by-case basis according to the needs of jurisdictions.
Exclusions	Any parts of main roads with bridges, overpasses, rest stops, turn-offs, intersections (except driveways), and slipways. Main roads may have a median strip; however, this area is not included in the litter survey. Areas with steeply sloped verges (i.e. >45^0) are excluded – the land alongside the highway needs to be relatively flat and at a reasonably similar height to the road surface. Curved sections of road are excluded (noting that very slight curves are okay, but sight lines should be appropriate to the speed zone for safety reasons).
LGA Zoning	They may be classified as a road zone, road void or similar.
ALUM classification	5.7.2 Roads
Sampling area/ transects	The sampling area is a strip (transect) that runs parallel to the roadside on both sides of the road. The transect is 3 m wide and 100 m long. Both sides of the road form a transect pair (1 & 2; 3 & 4; or 5 & 6), similar to residential sites. The centre of the transect sits 4 m from the edge of the road lane (the road line at the edge of the road; see Figure 10)[8]. This allows a surveyor to walk this centreline, searching 1.5 m either side (similar to residential or industrial transects where there is no footpath). If there is not enough room for a 3 m wide transect, another transect, or site should be selected.
Number and placement of transects	6 x 100 m. Transects are placed along an appropriate stretch of highway with an approximately 50-m (or more) gap between them. Transects are paired in the same manner as for residential sites. Ideally, they will be immediately opposite each other, but can be offset, depending on the availability of space.

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[8] As the centreline is 4 m from the road, the surveyor is more than the minimum 3 m from the edge of the road as required by some road authorities for safety. This conforms with (at minimum) Victorian and West Australian Road Authority requirements.

Figure 10. Example of how a highway transect would be surveyed. The blue line shows the transect centreline, which is 4 m in from the edge of the road lane. The surveyor walks this line and counts litter 1.5 m either side (blue shaded area). A single transect includes both sides of the road.

Figure 11. Example of how the three transects (orange lines) at a highway site are positioned, with a 50-m gap between them. Note a single transect includes both sides of the road.

Site type assessments

The characteristics of sites can change over time. For example, an industrial area may be rezoned and redeveloped into a residential area, or a recreational park might be developed to include a café. These changes may be of significance for AusLM in terms of either changing the site type category of a site or making a site eligible or ineligible for inclusion in the monitoring program. It is recommended that sites be assessed every two years at a minimum to ensure that key defining characteristics or criteria about the site have not changed. The assessment could be undertaken by surveyors using a checklist whilst undertaking their auditing work.

3.4 Litter items

The specific litter items types to be measured by AusLM takes into consideration the various needs of as many stakeholders as possible. Whilst it may have some time and cost implications, **having a more detailed selection of litter item types is likely to meet the needs of more stakeholders and allow for greater flexibility in future uses.** The following sections outline the proposed approach to:

- Litter items
- Container sizes
- Small items and fragments
- Special and specific items.

Litter item and material types

AusLM's core litter item categories were developed after a review of lists used by other projects such as the NSW Key Littered Items Study (KLIS); LitterWatch Victoria; and National Litter Index (NLI). The Australian Marine Debris Initiative (AMDI) Database was also reviewed, however, most items in this list were present in the KLIS.

Using KLIS as a base, the AusLM developers revised and refined the litter items brought forward for use in AusLM. Items perceived to be less relevant or associated more with illegal dumping were removed whilst what were considered commonly littered items were retained.[9] It was also adjusted to better align (where possible) with LitterWatch Victoria. The revised litter items list is documented in the AusLM Field Manual with descriptions and photos of items that may need additional explanation. The AusLM development team have added a small number of additional litter item types to the existing lists of items that were reviewed to reflect emerging items of interest, including:

- Other – Face mask - disposable
- Other – Face mask - reusable
- Glass – Wine bottle
- Glass – Spirit bottle
- Single use and reusable plate/bowl
- Other – Plates and bowls (other non-plastic material)
- Plastic - Single use plastic cup
- Plastic - Reusable plastic cup
- Other – Cutlery non-plastic (includes all non-plastic alternatives)

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[9] There was broad agreement that AusLM should not focus on illegal dumping and focus on more commonly visible littered items.

- Other – Straws non-plastic (includes all non-plastic alternatives)
- Other – Unknown item
- Plastic – Stirrers
- Plastic – Whipper-snipper cord
- Plastic – Lid (other)
- Paper & Cardboard – Bread bag tag
- Other – Stirrers non-plastic (includes all non-plastic alternatives)
- Other – Fruit/vegetable/food
- Other – Dog poo
- Other – Vape pen – single use
- Other – Vape packaging
- Other – Wooden item

Many of the additional items were added in response to a requirement to be able to measure the impact of single-use plastic item bans. Instead of adding in a list of every single alternative to a single-use plastic items, one non-plastic entry was created. For example, "Other – Straws non-plastic (includes all non-plastic alternatives)" is the alternative litter item category for plastic straws. Jurisdictions have the option to add in additional categories into their AusLM Litter Count forms, provided the items added can be aggregated back up to the items in the agreed AusLM list. For example, Queensland have expressed interest in adding paper straw as a separate litter item category.

As documented below, AusLM has chosen to include a more granular list of container sizes than the categorisations used by KLIS.

The revised list contains 101 litter item types which are categorised by material types (Table 7). Additionally, there are 25 types of beverage containers, each with five size options and there are eight unidentified fragment categories, each with three size options.

Table 7. Litter item material types

High level categories[10]	Number of items
Plastics	46
Expanded polystyrene	4
Other materials	24
Glass	2
Cloth	2
Metal	5
Paper/Cardboard	13

[10] Wood was removed as a material category due to the very low number of items. Relevant items were merged into the Other Material category. It was noted that one common wood item, ice cream stick, could also easily be confused by plastic ice cream sticks which influenced the moving of this item to the Other Materials category

Rubber	5
Total general litter items	**101**

The typology of litter-item categories and the way litter items are associated with one category is important to ensure reporting is useful in evaluating current and future questions about litter intervention policy effectiveness.

Whilst one common core typology would be used for official reporting, it is anticipated the AusLM may enable different typologies to be applied to the litter data collected. Applying a different typology or 'lens' over the data can reveal different information to help inform decision-making. For example, applying a 'plastics policy lens' may more quickly and clearly articulate if the number of plastic items being littered is increasing or decreasing. Different states could define their own 'lens' that categorises litter items differently.

Container sizes

AusLM categorises litter item containers using a detailed set of categorisation sizes. These sizes are guided by the common container item sizes and the container sizes commonly referred to in container deposit schemes (CDSs). AusLM will differentiate between the container sizes according to the following classifications:

- <150 ml
- 151-499 ml
- 500-999 ml
- 1000-3000 ml
- 3000+ ml – All CDS exclude items greater than 3L.

There are separate litter item categories for different container material types: (Metal, Paper/Cardboard (Liquid paperboard (cartons)), Plastic (HDPE, PET, other) and glass). Container sub-item types are defined based on container contents (e.g. milk, water, beer).

Litter surveys undertaken in Queensland in 2020 to assess CDS effectiveness used similar size categories[11]. The additional level of detail will assist in informing more accurate estimates of container volumes. In the future, if there is less interest in this level of container size detail, then size categories can be merged together.

Minimum item size

The minimum size of the items counted in visible litter survey is limited by what an average surveyor can see from standing height. The literature review identified the minimum size is thought to be between 2.5 cm and 5 cm[12]. Small fragments are often responsible for high

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[11] A. Prince Consulting. 2020. Post Container Refund Scheme litter monitoring March 2020. Report for Queensland Department of Environment and Science.

[12] Cutter, S., Tiefenbacher, J., Birnbaum, S., Wiley, J., Solecki, W., 1991, 'Throwaway societies: a field survey of the quantity, nature and distribution of litter in New Jersy', Rutgers University, Applied Geogrpahy, Edition 11, pp125 – 141.

Institute for Environment and Sustainability, 2013, 'Guidance on Monitoring of Marine Litter in European Seas', European Commission, https://mcc.jrc.ec.europa.eu/documents/201702074014.pdf

variability in litter counts between sites and ignoring these smaller items (or de-emphasising them) helps to reduce this variability.[13]

AusLM has selected a minimum item size of 2.5 cm. Individual items smaller than 2.5 cm will not be counted. Exceptions to this minimum size rule include specific items of interest that may be smaller than 2.5 cm. These items are:
- cigarette butts (by item count, cigarette butts are the most commonly littered item in Australia)
- metal bottle caps
- plastic bottle lids and caps
- can ring pull.

The AusLM resources will include an object that is 2.5 cm in size that can be used as a guide to assess the inclusion/exclusion of items.

Special rules for partial items or one litter item broken into multiple pieces

When counting litter, it is common to find only one part of a littered item, or one item broken into multiple pieces within a small area of the transect. For example, a confectionary wrapper that is missing the top component, or you might find an aluminium can that has been broken into three or more different parts spread across a small area of the transect. The following rules should be applied to consistently and accurately categorise litter items in these scenarios:

- If half or more of a litter item is found and you can identify the item, then treat it as a whole item.
- If you find several parts of the same litter item (judged based on material/colour/size/brand etc.) within approximately 1 square metre, that if joined together would represent half or more of the litter item and you can identify the item, then treat it as a whole item.
- To be classified as whole items, containers must have a label attached to one or more of the pieces.
- If less than half of the litter item is found in one piece or multiple pieces, **or** you are not able to identify what the item is, or you are unsure if the above criteria are met, then classify the item as Unidentified Fragments.

These rules were made as a result of stakeholder feedback during the AusLM pilot. There was no one best practice identified in the literature that guided the approach that should be taken. Without these rules, broken items would generally be categorised as fragments, however, this approach means that with the exception of the material type, all context about the litter item are lost.

Unidentifiable Fragments

Items are categorised as unidentifiable fragments when a piece of litter is either no longer identifiable as a whole item, or there is less than half of the whole item found in one or multiple contributing pieces within one square meter. The rules above in section titled 'Special rules for partial items or one litter item broken into multiple pieces', provides clear rules for when items are to be categorised as whole items or unidentifiable fragment. Some examples of unidentifiable fragments are:

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[13] Lippiatt, S., Opfer, S., and Arthur, C. 2013. Marine Debris Monitoring and Assessment. NOAA Technical Memorandum NOS-OR&R-46.

- One quarter of a chocolate bar wrapper. There are no other pieces of the same wrapper within 1 square metre that would create half or more of the wrapper. This would be categorised as one soft plastic fragment.
- Five pieces of what could be the same plastic bottle are found spread over 10 metres of the transect. Each piece would be categorised as five separate plastic fragments.

It can be useful to gain some understanding about the size of the fragments found at sites. Fragment size and numbers may provide an indication or stronger confirmation that a site has been mown. The fragment size also provides additional context to the number of items counted. For example, five large fragments may be higher in volume than 20 smaller fragments.

AusLM will use a Fragment Size Guide (Annex 5) to help surveyors categorise litter fragments of:

- hard plastic
- soft plastic
- expanded polystyrene
- glass
- paper and cardboard
- metal
- cloth
- rubber

These material fragments will be categorised into the following sizes: [14]

a) >2.5 cm to ≤ 8 cm
b) > 8 cm to ≤ 16 cm
c) Larger than 16 cm

Fragments smaller than 2.5 cm will not be counted as individual fragments.

Microplastics

Microplastics are very small pieces of plastic that pollute the environment. They are typically defined as a plastic fragment that is less than 5 mm in length. There are two sources of types of microplastics:

- Primary microplastics – Plastic Resin Pellets or Nurdles used in plastics manufacturing
- Secondary - breakdown of larger plastic into smaller items over time.

Whilst there is an increasing level of interest in microplastics in the marine and terrestrial environment, **AusLM will not monitor the presence of microplastics**. Jurisdictions that do have an interest in microplastics can add on other methods, such as the Australian Microplastic Assessment Project (AUSMAP) methodology to the core AusLM method.

Estimation - High numbers of litter items

Counting very high numbers of litter items is time consuming. Two estimation technique are recommended for use in AusLM.

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[14] These approximately align with CSIRO and KLIS size categories. AusLM does not include the smallest 1 x 1 cm category, nor does it include CSIRO's A4 page size.

1. Visual estimation of cigarette butts – Used where there are one or two small areas of highly concentrated litter fragments or cigarette butts
2. Sub-sampling – Used where there are very high numbers of litter items spread out across the entire transect.

1. Visual estimation of cigarette butts

Surveyors will estimate the number of butts within a smaller area – such as an area the size of their mobile phone. The number of 'mobile-phone-sized-areas' is then used to estimate the total number of cigarette butt in that part of the transect. Cigarette butts will be counted in the standard manner for other areas in the transect.

2. Sub-sampling – Used when there is high density litter across the entire transect

Sub-sampling is another technique that can be used to estimate the amount of the litter present within a transect. Sub-sampling is only to be used in exceptional circumstances where a visual inspection of the transect to be surveyed reveals there are more than 5 litter items (fragments, cigarette butts or whole items greater than 2.5cm in size) per square metre across most of the transect area. If there are 5 items or less per square metre, or only a small portion of the transect is heavily littered, then it is required to count all items of litter within the transect.

CSIRO's recommended sub-sampling in the Handbook of Survey Methodology (Schuyler et al., 2018) was not used for AusLM due to concerns that without significant training and oversight of surveyors, the application of this sub-sampling approach may lead to unintended errors being made.

AusLM's approach to sub-sampling involves surveyors counting litter in 1 m^2 quadrats placed every 3-metre length of transect. The quadrats should be alternated on the left and right-hand side of the transect.

The data collection form will record that whole items, fragments or cigarette butts have been estimated or sub-sampled. This will trigger appropriate action during data entry. Sub-sampled quadrat areas and numbers of quadrats will be captured for completeness.

Special rules for plastic bags

AusLM acknowledges that jurisdictions have a special interest in measuring single-use plastic litter items. Plastic bags are one example where there is a need for AusLM to separately report both:

- Lightweight, single use HDPE plastic bags
- Thicker reusable LDPE plastic bag.

In response to feedback from the AusLM PWG, Lightweight, single use HDPE plastic bags were further broken down into different colours (white, blue, grey, other) to help identify their source. There are many other types of plastic bags circulating in Australia that are marketed as degradable, biodegradable and compostable. Given the complexity of identifying and differentiating between the different types of plastic bags, they are not listed as separate sub-items. If found, they should be categorised based on the existing list of litter item plastic bag categories (See Litter items listed in the Field Manual). If unsure of which bag-related item category to choose, you can allocate the bag to the category 'Bag – Other'.

Litter Brand data

Recording brand data (company/brand associated with the production of the item littered) would require additional time, and the majority of jurisdictions did not view this as an essential requirement.

AusLM will therefore not record brand data as part of the core methodology. If brand data is desired by any jurisdiction, the AusLM system has been designed in such a way that this could be captured by surveyors using a modified transect litter count form.

Hazardous items

AusLM surveyors will be advised to carefully remove items that pose an immediate danger to the general public and place them in suitable protective containers (e.g. "sharps" containers). Examples of hazardous items that will be removed include:

- Needles & syringes
- Broken glass at a park or beach site.

Surveyors will be asked to call their supervisor who, in turn, can contact the relevant land manger if the task of removing hazardous items is dangerous or overly time consuming (more than 10 minutes). Data collection sheets will record the presence of hazardous items.

Illegal dumping

Illegal dumping is a form of medium to large-scale littering of household and retail waste or industrial type litter. For the purposes of AusLM, discarded shopping trolleys will be classified as illegal dumping. Most jurisdictions already have systems in place to monitor illegal dumping and, whilst there are issues with data collection, data quality and data consistency captured by councils and land managers, there is often sufficient data to estimate the extent of the problem.

AusLM will record the presence of illegal dumping at monitoring sites. An estimated volume of the dumped rubbish will be recorded. The presence of illegal dumping may be an explanatory factor for the extent of litter present at a specific site as it may be blown or fall from the illegal dumping pile onto other areas of the site. The AusLM research design will not focus on site types and sampling methods that seek to measure the extent of illegal dumping in a jurisdiction.

Other litter item exclusions

This section will help clarify some additional items that will not be counted in AusLM.

Excluded item	Justification
Leaves & branches	Naturally occurring item in the environment.
Chewing gum	In nearly all cases, this item would be < 2.5cm in size. It has been added here to provide greater clarity.
Items within plastic bags that can't be identified without opening the bag.	Avoids the need and potential hazard of opening and inspecting the bag (and double counting).

Excluded item	Justification
Items in clearly labelled hard rubbish piles that have been put out for collection.	Hard rubbish piles should be collected by Council or a service provider.
Litter in or within 1 m of formal and informal commemorative sites.	Items within these sites are deliberately left by individuals as a means to commemorate, celebrate or remember an individual or event. They are likely to return to the location to remove litter and place fresh commemorative items.
Items in or on the fringes of piles of illegal dumping.	AusLM is not designed to assess the extent of illegal dumping. AusLM notes the presence of illegal dumping within a transect.

Additional litter counting rules

The following additional rules inform where litter is to be counted.

- Litter on the ground and up to 2 m above the ground in trees or on hard surfaces should be counted.
- Litter on the transect line edge is included. In situations where an item of litter touches or crosses the edge of a transect, then it should be counted. In situations where multiple passes of a transect are made and the litter is crossing over a centre line between the two passes, then, count the litter during the first pass of the transect and ignore items that cross the centreline on the second pass.
- Only litter that is observable from standing height should be counted.
- Commemorative sites within transects may be present and noted by bouquet of flowers, wreaths or signs. Litter related to commemorative sites should not be counted within 1 metre of the site.
- Where a litter item contains or is attached to multiple other litter items, then you should count each recognisable item (cup, lid, carton, wrap, straw) as separate items. For example, if a cup has a lid and a straw, count each as a separate item.
- Litter found within seated eating areas, tables and benches, barbeque areas, bus stops and bus shelters within a transect should be counted provided it is safe to do so and the personal space of the general public is not encroached upon. For example, if people are seated at café cables in the street or a park bench, then you should not survey the area under their tables/seats. The area not audited should be recorded.
- Litter under advertising signage (e.g an A-frame sign) and outdoor retail displays can be surveyed if it is safe and the areas underneath are visible from a standing position.
- Litter should not be counted under parked vehicles on the natures strip or other areas within a transect. These areas should be estimated and recorded as areas not audited.
- Litter in bushes, gardens, garden beds and planter boxes should be counted for areas up to one meter in from the edges of these features. This distance allows for a surveyor to look in for the edges using a litter poking stick (or similar). It avoids the need for surveyors to walk in or on garden beds which reduces possible damage and reduces exposure to hazards (snakes/spiders).
- Any areas within a transect that can't be audited should be estimated and recorded.

The two images below illustrate the above two points.
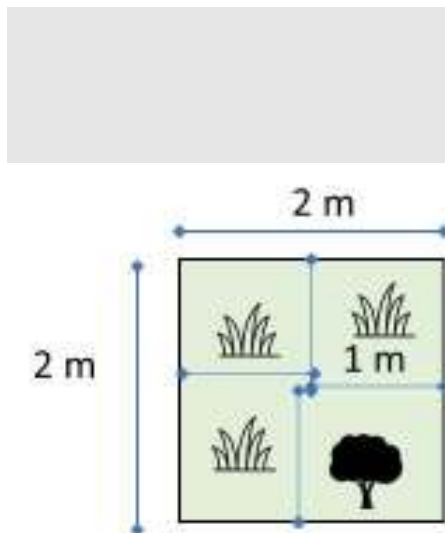
All areas of the 2 m x 2 m garden bed can be audited by reaching in 1 m from each side.

After reaching in 1 m from each side, the internal clear (white) 1 m x 2 m section of the garden bed is left unaudited. This area would be estimated and recoded for the transect so it can later be subtracted from the overall transect areas audited.

Figure 12. 2 x 2 m garden bed

Figure 13. 4 x 3 m garden bed

3.5 Site context & metadata

Site context data can help explain the presence or absence of litter at a site. Stakeholder feedback and good practices from other studies as well as some original inputs have led to the list of site context indicators and metadata to be collected (see Table 8). These indicators will be captured at each site or transect. Some indicators may not be relevant for all site types. These indicators are defined in more detail in Annex 4.

Table 8. AusLM site context variables

Site level context
Audit date
Arrival time
Surveyor names/number of surveyors
Site ID
Site name
Site type
Site type assessment (pass/fail)
Number of people at site
Visibility assessment rating (pass/fail)
Indication if Litter will be picked up
Site photos
Post-litter count data after all transects counted
Site cleanliness rating
Evidence of graffiti present at the site

Recent activities (evidence site has been cleaned, public event, storm/flood, strong wind, kerbside bin collection, other)
Evidence that grass area at site was recently mown
What is nearby (fast food restaurants, convenience stores, construction site, public building, public transport stop)
Presence of bins (waste, recycling, cigarette butt)
Evidence bins found were overflowing
BBQs present at site
Illegal dumping present at site
Scale of illegal dumping
Age of litter at site
Significant hazard or risk observed
Site notes
Departure time
Transect Context & details
Audit date
Start time
Site ID
Site name
Transect number
Transect GPS coordinates Start
Transect GPS coordinates End
GPS accuracy
Compass bearing from start point to end point (optional for recreational parks and beach sites)
Indication if the transect width is mostly constant
Transect width at start and end points of the transect
Transect length
Photos of the start and end points. Photo looking from the start point towards the end. Photo looking from the point towards the start point.
Transect context to capture after litter count
Which of the following items were included within the transect (BBQ area tables/benches/seating, bins, playground, mow line (were shorter mown-grass borders taller grass that can 'trap litter'), fence/temporary fence, bins, ditch or drain, garden beds, raised planter boxes, public transport stop/transit centre, hard rubbish)
Average grass length
Indication if any estimation techniques were used in the Litter Count at the transect.
Presence and scale of illegal dumping within the transect
Transect notes
Time the audit of the transect ended.
For beaches only – Indication if 2 m into the dunes/vegetation behind the start point was audited
For beaches only – Indication if there is a hard engineered structure at the rear of the beach.

Transect context to capture as part of the litter counting process
Audit date
Site ID
Transect number
Estimated area of the transect not audited

3.6 Estimating litter item volumes

Jurisdiction representatives have expressed a desire to be able to measure the volume of litter at sites, site types and within the jurisdiction. This requirement has evolved due to the interest in the extent of visible litter at sites that might be seen by tourists and influence their perceptions about a jurisdiction. A negative perception about the cleanliness of a jurisdiction may have longer-term negative impacts on tourism.

AusLM acknowledges the time-consuming activity of measuring the volume of specific litter items is contrary to the requirement for AusLM to be cost-effective. To accommodate the need to report litter volumes, AusLM proposes to estimate these volumes based on litter item count data. AusLM provides a staged strategy to achieve this objective.

Stage 1: Indicative conversion factors

The AusLM project development team have created an initial set of conversion factor estimates for all litter items included in AusLM. These estimates are not based on actual field data or researched volumes. They are provided as a starting point for future work, updates and verification.

Stage 2: Progressive refinement of indicative estimates using a sub-sample of litter items

It is recommended that the first round of AusLM monitoring should include an element of measuring the volume of specific litter items based on actual data captured in the field across a sample of sites with different jurisdictions and different site types. This sampling should include partial litter items, squashed or crushed litter items as well as whole items that have not been compacted.

The newly assessed litter item volumes can be integrated into AusLM to replace the existing indicative estimates. These updated conversation factors should be used in the analysis of data from the first monitoring period.

Stage 3: Ongoing review

It is recommended that the process of updating litter item to volume conversion factors should be performed every five years to account for changes in consumption patterns and changes to materials used in packaging.

3.7 Deferring site monitoring

There may be situations where it is necessary to defer the monitoring of a number of sites at a location due to events that may significantly impact upon litter loads. For example, some Councils have predetermined periods of the year where residents can place their hard rubbish items on the nature strip for collection. This mass collection of waste items combined with scavenging can create significant litter loads. If a monitoring cycle for sites within a specific

location overlaps with this hard rubbish collection period, then it is strongly advised that the sites within the location be audited at a later or earlier time.

The AusLM implementation contractor should check the dates for hard rubbish collection within the council areas sampled to ensure they fall outside of the planned monitoring period.

It is noted that other events such as bin collection days or the incidence of small volumes of hard rubbish put out as part of booked collection services may also influence litter loads, however, bin collection is a very frequent event and working around it would be impractical. The small amount of hard rubbish put out as part of booked collection services is deemed relevant, but not significant enough to warrant the deferral of auditing. Both of these potential explanatory factors (bin collection day - many residential waste/recycling bins present on the street and the presence of hard rubbish) should be captured as part of context data associated with the site and/or transect.

4 AusLM – guidance for monitoring program design

4.1 AusLM framework and the objectives of the core AusLM monitoring program

Each of Australia's states and territories have different needs and resources with respect to litter monitoring. The AusLM, as outlined above, provides a transparent, flexible and scalable method for measuring litter at key site types of interest to litter managers and other stakeholders. The method can be used in a range of contexts and for a variety of purposes. In the absence of national guidance, it is effectively 'up to the jurisdiction' to decide on what they want to use it for.

Table 9 outlines an 'AusLM framework' that can be used to think about the different needs of jurisdictions and their interrelationships. At a national level, there is interest in a 'core' monitoring program using the AusLM. This would enable some comparison between jurisdictions. This core AusLM monitoring program sits within each jurisdiction's own monitoring program, which is tailored to their individual needs and interests (Figure 14). The AusLM method itself can be used by jurisdictions as part of this monitoring program or separately as part of specific projects, or by councils, waste management organisations and others for their individual needs.

This section of the Specification provides guidance about how an AusLM monitoring program might be structured. This includes the core monitoring that is common across jurisdictions, but also considerations for jurisdictions in building their own tailored monitoring programs.

Table 9. Components of an AusLM framework for considering monitoring needs, methods and interrelationships.

AusLM framework component	Description
The AusLM methodology	This is a detailed description of what sorts of sites the AusLM can be used at, how litter is measured/counted at these sites, the types of litter items counted, and the typology used to categorise them. This method can be used by surveyors, auditors, project staff and volunteers to measure litter at relevant site types. The AusLM methodology is documented in Section 3 and training materials, noting: • There was an explicit focus during design on a methodology that can be used to track trends through time and for monitoring at a jurisdiction-scale, so there has been an emphasis on reducing variability and costs where possible. • This does not preclude adjustments to the AusLM methodology (with some elements noted in this Specification). However, these adjustments will influence how comparable results are. It does not mean that results are not comparable (for example, between the 'standard AusLM' and a modified version used by community groups where litter is collected, not just counted), but that comparison will need to be done with these differences in mind.

Jurisdiction-specific monitoring	This is how the AusLM is applied at the jurisdiction-level by respective state/territory governments.[15] It is based on each jurisdiction's particular objectives, interests and available resources. The guidance in this section relating to site selection and the hierarchy of sites, locations and regions to distribute sampling effort and improve sampling/resource efficiency is relevant to jurisdiction-specific monitoring programs.
Areas of national comparison (the 'Core AusLM Monitoring Program')	These are where there is overlap in how the AusLM is applied in each state/territory. In theory, these areas should be reasonably comparable (because of the design of the AusLM and the approaches used to select sites, etc.). These comparisons should be done keeping in mind the inherent differences between jurisdictions and the areas surveyed, meaning there will be a range of factors driving any differences. Note that there may be other components of jurisdiction-level monitoring that are broadly comparable but where additional care will need to be taken in comparisons because of differences in, for example, what regions are surveyed and how often. Likely areas of overlap are outlined in Section 4.7.
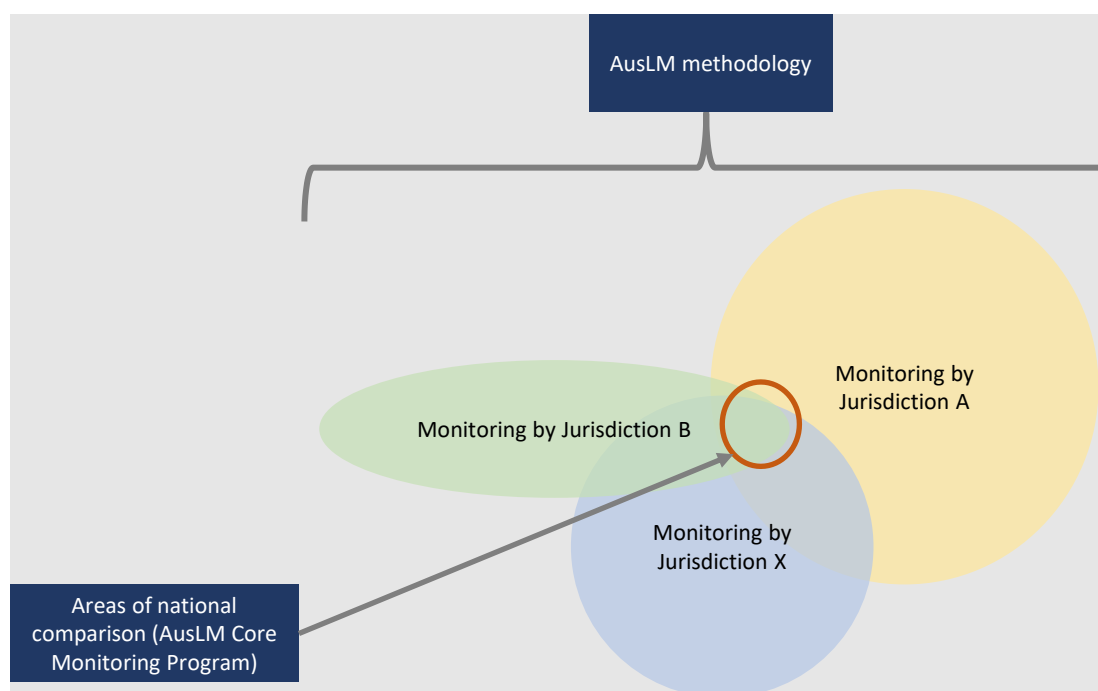
Figure 14. Representation of how each jurisdiction's use of the AusLM will be different, but there will be a core area of overlap.

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[15] This only refers to state/territory government-implementation because there may also be, for example, council use of the AusLM but this would not necessarily be planned, funded or coordinated at a jurisdiction scale.

As per Section 2, the AusLM method and the guidance in this section have been designed with consideration of three primary objectives (which are also framed as questions – Table 10)**:**

1. Providing a high-level indication of the level of litter at a jurisdiction scale
2. Providing data to support monitoring and evaluation of jurisdiction-level interventions
3. Providing data to support the design of new interventions.

Because of the nature of these objectives, the core AusLM monitoring program guidance focuses on understanding trends through time.

This is inherent in the repeated nature of the program and **is distinct from, for example, quantifying overall litter loads or providing detailed assessments of litter distribution**. While the AusLM method could be used for these purposes, they are not the primary focus of the monitoring program.

It is also worth noting that **the general focus of the AusLM methodology, and of the core AusLM monitoring program, is on**:

- Areas where littering is likely to occur and where litter is likely to be present. This acknowledges there is little value in doing extensive surveying of areas where there is a low likelihood of encountering litter. This would make trends more difficult to detect and does not support decision-making.
- 'Community' littering as opposed to litter that might be generated from commercial activities or through deliberate, large-scale dumping (illegal dumping). This is not to say that commercial sources of litter are excluded (e.g. litter from building sites) but that it is not the aim of the monitoring program to understand or target these sources.
- Littering on publicly managed land. While litter on privately managed land (e.g. shopping centres or private carparks) causes similar impacts to litter on public land, it is managed differently and can be driven by factors that are outside the control of government.
- Generic monitoring needs – that is, the design here is based on overall trends and contributing data to evaluations etc. **It is not designed with specific materials/policy evaluation questions in mind** – e.g. the evaluation of a CDS scheme or a plastic bag ban. These need to be considered within jurisdictions based on their specific questions and with careful assessment of the level of confidence and precision – and therefore effort and replication – required. In some cases, because of its generic structure, AusLM may not be the most cost-effective tool.

Table 10. Key objectives for the core AusLM monitoring program and additional questions that help to elaborate on these objectives. References to 'abundance' in these questions includes consideration of a) number of litter items; b) type of litter items; and c) estimated volume of litter items.

Objective	Indicative questions to answer	Considerations
High-level indicator of litter prevalence	• How littered is this state/territory? • What is the abundance of litter now, compared to last year/period? • What is the trend in litter abundance across the jurisdictions? • How does the average litter abundance for a site type or a	The AusLM is well suited to addressing this objective with the monitoring program described below focusing on identifying trends through time and providing comparability between samples and against a national average.

jurisdiction compare against the national average?

Evaluation	• What change has there been in the abundance of litter items targeted by an intervention? • To what extent is the change in the abundance of litter items targeted by an intervention attributable to the intervention(s)?	The AusLM could be useful for providing information against this objective. However, the generic monitoring program outlined below may not have the required level of granularity or replication for questions about specific materials or policies. Core AusLM monitoring data could complement jurisdiction-specific monitoring programs designed with any policy-evaluation requirements in mind (including geographic spread and level of resourcing).

Design	• Which litter items should future interventions focus on at the jurisdiction, site type level and at specific sites?
	
	   o Which litter item types are most prevalent?
	
	   o Which litter item types are most prevalent and have the greatest potential to create harm/negative impacts?
	
	   o Which litter items are increasing in prevalence over time?
	
	• Where should we focus future interventions?
	
	   o Which are the most littered areas (metro/regional) within a jurisdiction?
	
	   o Which are the most littered site types within a jurisdiction?
		The AusLM and the core monitoring program will be useful here in providing a consistent data set to understand trends through time at particular sites. There may be an interest in collecting additional data from different geographic areas to any core monitoring program to help better understand the distribution of litter throughout a jurisdiction. This does not necessarily have to be done regularly or as part of an ongoing monitoring program (which is the focus of the discussion below).

4.2 Overview of sampling structure

The typically heterogenous spread of litter (i.e. that it is not evenly distributed across the landscape) means that the approach to sampling needs to be targeted and considered to make the best use of monitoring resources.

In this context, our sampling frame[16] of interest is, at a high-level, 'areas frequented by people and where litter and littering is likely to occur'. The sampling frame is further defined by six types of sites at which monitoring will occur:

- beaches
- parks
- residential areas
- retail precincts
- industrial areas
- main roads.

These site types have been selected as they:

- provide insights on major land use classes
- helps focus effort on areas where litter is at medium or high levels of abundance and, therefore, where trends through time will be most apparent.

To help improve the efficiency of AusLM monitoring, sites are clustered according to a nested sampling structure, which operates at different scales within a state/territory (Table 11). This structure provides a means of:

- monitoring trends through time at different scales (within a particular site, at a location, within a region, etc.)
- coarsely comparing between areas at different scales (sites, locations, regions, jurisdictions).

More detail is provided in the following sections on each of these elements of the sampling structure.

Table 11. Overview of the different sampling units for the AusLM monitoring program.

Sampling unit	Description
Jurisdiction	Litter is sampled in all six Australian states, the Northern Territory and the Australian Capital Territory. The structure of sampling in each jurisdiction is similar but expected to be scaled down for smaller jurisdictions with lower population levels and resources.
Regions	Sites are surveyed in both metropolitan and non-metropolitan regions. Sampling effort can be weighted towards metropolitan regions to reflect their higher population densities and thus expected litter loads. There are four 'groups' of site that exist across these regions:

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[16] i.e. the extent of areas that we want to make inferences about

- urbanised areas in non-metropolitan regions, consisting of residential, retail, industrial and recreational parks
- urbanised areas in metropolitan regions, consisting of residential, retail, industrial and recreational parks
- beaches, which may or may not be linked to urbanised areas
- main roads, which may or may not be linked to urbanised areas

Urbanised locations	Residential sites, retail sites, industrial sites and recreational park sites are clustered within urbanised 'locations'. This provides a way of making the sampling more efficient by reducing travel time. This is particularly important for non-metropolitan sites. A location is defined as an urbanised area within a Local Government Area (LGA). Selection of appropriate locations is discussed in section 4.4.
Site types	The AusLM methodology has been developed for six site types. Four of these are sampled in urbanised locations: • residential areas • retail precincts • industrial areas • recreational parks. A recommendation was made that beaches are only sampled in the metropolitan region to reduce variability and manage sampling effort, but it is possible to sample regional beaches too. Main roads are sampled depending on the needs of jurisdictions. The nature of these sites is described in more detail in Section 3.3. The intent is that these sites capture a reasonably representative reflection of litter associated with public areas, allowing an understanding of trends through time and of litter abundances and types to inform management decisions. It is important to note that this site-list aims to strike a balance between being representative and being narrowly defined to help reduce variability through time.
Sites	A site consists of a well-defined area in which litter sampling can occur. There are different types of sites, with specific guidelines for how each of type is selected and sampled.
Transects within sites	A minimum of three transects are surveyed within a site. These transects provide a means of understanding within-site variability. They also help in controlling the search patterns and effort put into assessing a site.

4.3 Regions

At the highest level within a state or territory, sampling is divided between 'metropolitan' and 'regional' areas (Figure 15). In line with the objectives of the AusLM monitoring program and the interests of litter managers and policy staff, this division aims to:

- Provide an indication of litter abundances and trends within the areas of greatest population (i.e. metropolitan regions), which are expected to create the greatest litter loads, and potentially expose more people to litter.
- Provide an indication of litter loads and trends in a sample of non-metropolitan areas.

A State's or Territory's capital city is its default 'metropolitan region'. The boundaries of this region are defined using the Australian Bureau of Statistics (ABS) 'urban centres and localities' geographic classification, which provides a boundary to the urbanised area of the city.[17]

Regional areas are defined as urban centre/locality outside the metropolitan region. Early thinking around the AusLM monitoring program suggested focussing on those urban centres/localities with a population between 10,000 and 49,999. The rationale for this at a national level is outlined below. However, it is important to note that this does not necessarily meet the needs or interests of individual jurisdictions, which may have their own priorities for monitoring non-metropolitan regions. As such, the size and location of what constitutes regional areas for the AusLM will likely vary between jurisdictions.

Urban centres/localities with a population between 10,000 and 49,999 were suggested as a 'standard' regional area for all jurisdictions because they provide balance between:

- Larger regional centres (i.e. with populations of 50,000 or more) can have a substantial fraction of the jurisdiction's population but are, overall, fewer in number and are less representative of the multitude of smaller townships. These larger regional centres are assumed to be more similar to capital cities.
- Smaller urban centres/localities (i.e. less than 10,000 population) tend to represent similar fractions of a jurisdiction's overall population (towns with populations between 1,000-9,999 represent an average 8% of the total population, as do towns with populations between 10,000-49,999). However, these smaller towns are more numerous, meaning they may be less well-represented by a small number of samples.
- This approach directly samples areas representing approximately two-thirds (68%) of the Australian population (i.e. capital cities and urban centres with populations of 10,000-49,999). Assuming that capital cities are broadly representative of other large population centres (i.e. 50,000+), then this approach applies to approximately 82% of the Australian population.

With these points in mind, ultimately, **it was recommended jurisdictions define their regional areas using ABS urban centres/localities based on population size categories and geographic locations of interest.** Some examples of this are outlined in Section 4.6.

It is expected that under the 'core' AusLM monitoring program, **more sampling effort would be put into metropolitan areas than regional areas.** This recognises that a larger proportion of the population lives in these areas (Table 12). However, strict stratification by population is not

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[17] https://www.abs.gov.au/websitedbs/D3310114.nsf/Home/2016%20search%20by%20geography

necessary for the design, because jurisdictions may be interested in understanding trends and differences between regions independently of population.

Figure 15. Example of potential sampling locations in Victoria and northern Tasmania (blue bordered areas). Melbourne (marked) is Victoria's metropolitan region. All other marked areas are potential regional sampling locations (in this case, ABS-defined urban centres/localities with populations of 10,000-49,999.

Table 12. Proportion of jurisdiction population in capital city (metropolitan region) and in regional areas surveyed by the AusLM.

Jurisdiction	Proportion of jurisdiction population in urban centres with population 10,000-49,999	Proportion of jurisdiction population in capital city
Australian Capital Territory	0%	100%
New South Wales	10%	58%
Northern Territory	10%	52%
Queensland	5%	44%
South Australia	11%	70%
Tasmania	11%	35%
Victoria	7%	71%
Western Australia	7%	76%
Overall	**8%**	**63%**

4.4 Locations (urbanised areas within Local Government Areas)

Within regions (metropolitan and regional), **residential, retail, industrial and recreational park sites are clustered together in 'locations'**. An AusLM location is 'an urbanised area within a randomly selected LGA/ABS statistical area'. There are multiple locations in the metropolitan region and multiple locations in the non-metropolitan region.

In comparison to a completely random sampling approach, clustering samples in locations:

- Reduces travel time and improves the efficiency of the sampling program
- Helps facilitate analysis of litter trends at the LGA/ABS statistical area-level, a scale at which different socio-economic and litter-management factors might play a role.

Because the size of metropolitan areas differs across Australia, LGAs are sometimes the most appropriate scale for locations and sometimes ABS statistical areas are the most appropriate scale. Our suggestions for each jurisdiction are outlined in Table 13.

In metropolitan regions a location is typically an entire LGA/statistical area (Figure 16). This is because LGAs in metropolitan regions tend to have a high abundance of suitably urbanised land that fits the ABS definition of a 'major urban centre'. Sites are randomly selected across suitable parts of the entire LGA (see Section 4.5).

In regional areas, populations are more dispersed. This means potential sites need to be clustered in urbanised areas (i.e. towns). Building on the definition of regional areas (Section 4.3), **an AusLM regional location is an 'urban centre' (as defined by the ABS and of a size and geographic location that is of interest to jurisdictions)**. Sites are selected randomly within this location (Figure 17).

Table 13. Potential definition of 'AusLM location' for different jurisdictions.

Jurisdiction	Metropolitan locations	Regional locations[18]
ACT	ABS Statistical Areas Level 3 or electoral boundaries	Not applicable
NT	ABS Statistical Areas Level 3	ABS urban centres/localities of a size and distribution of interest to NT
NSW	LGAs	ABS urban centres/localities of a size and distribution of interest to NSW
QLD	LGAs	ABS urban centres/localities of a size and distribution of interest to QLD
SA	LGAs	ABS urban centres/localities of a size and distribution of interest to SA
TAS	ABS Statistical Areas Level 2	ABS urban centres/localities of a size and distribution of interest to TAS
VIC	LGAs	ABS urban centres/localities of a size and distribution of interest to VIC
WA	LGAs	ABS urban centres/localities of a size and distribution of interest to WA

[18] see also 4.6 for preliminary suggestions based on priorities/interests of jurisdictions.

Figure 16. Example of an AusLM location in a metropolitan region. Note the blue shaded area and yellow border defines a LGA, throughout which sites (yellow markers) are randomly selected.

Figure 17. Example of an AusLM location in a non-metropolitan region. Note the yellow border defines the LGA but the potential sampling area (blue shaded area) is limited to the 'urban centre' as defined by the ABS. Sites (yellow markers) are randomly selected within these locations.

Within metropolitan regions, locations (i.e. LGAs/Statistical Areas) are selected randomly, weighted by the relative area of potential sites (i.e. excluding areas that are not an AusLM site type, such as national parks etc.). Random selection of locations could be done by:

- Using GIS datasets such as catchment-scale Australian Land Use and Management data maintained by ABARES[19] to identify the area of an LGA/Statistical Area that is comprised of either industrial, residential, commercial, parkland or main roads. The aim is to ensure that LGAs/Statistical Areas with large tracts of urbanised land are proportionally more likely to be selected than smaller LGAs or LGAs that are mostly non-relevant land.
- Alternatively, locations could be identified by randomly selecting coordinates across a map of the region. If there is an applicable site-type within 100 m of the coordinates, then the LGA/Statistical Area should be selected as a location for further sampling. If not, another set of coordinates should be selected and the process repeated. This should be done until the appropriate number of LGAs/locations have been selected (see Section 4.6). This process aims to sample locations in proportion to their area of urbanised/surveyable land.
- While there is no formal stratification, it may be worth qualitatively assessing for reasonable geographic distribution and spread across socioeconomic status (i.e. the Index of Relative Socio-economic Disadvantage (IRSD)[20])

In regional areas, the boundaries of urban centres define the location (as opposed to the whole LGA being the location). The process for selecting these regional locations will depend on the interests/needs of the jurisdiction and its particular geography. As guiding principles, it is suggested:

- Regional locations be selected randomly from a pool of all potential regional locations (potentially stratifying by features of interest, such as population size or distance from metropolitan regions) – noting that in some jurisdictions, there may be a limited pool of regional locations of a particular size to sample.
- To ensure effort is distributed, it may be useful to only sample one location (urban centre) per LGA.

There is also potential to reassess the distribution of the samples after the initial random allocation process to ensure that travel times and other logistical considerations allow monitoring to proceed reasonably efficiently. **It is important that the process for identifying locations is clearly documented and ideally, coordinated/clearly communicated across jurisdictions.**

4.5 Sites – considerations for the monitoring program and site selection

Site types and sampling at the site level have already been discussed in Section 3.3. This section briefly outlines the rationale for the site types in the context of the monitoring program and how sites should be selected in relation to the nested design above.

The AusLM methodology defines six site types (Table 14). These site types help to characterise and distinguish between different areas in which litter is commonly found in terrestrial environments. Site types help:

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[19] https://www.agriculture.gov.au/abares/aclump/land-use/data-download
[20] https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2033.0.55.001~2016~Main%20Features~IRSD~19

- Categorise sites and understand variability between sites.
- Ensure sites are sampled consistently, with methods tailored to different types.
- Create consistency in sites and what is sampled, supporting comparison between areas.
- Align the AusLM with methodologies that have similar sites.

The site types used in the AusLM broadly correspond to key sections of the Australian Land Use and Management (ALUM) classification system.[21] It is important to note, however, that they are not necessarily representative of these classifications in a statistical sense. Urban residential land use, for example, comprises the private land on which people have houses, the footpaths, nature strips, roads and other associated parts of the landscape that make up a residential area. The AusLM[22] only samples the strip of public land between private properties and the road, not any of the other areas. This is important to consider in analysis (including extrapolation) and interpretation.

With the above in mind, sites have been defined to be broadly representative of what a member of the public might experience in a particular land-use type (e.g. in an industrial area) and to facilitate cross-area/cross-jurisdiction comparison. Some of the sites/site types also tend to favour areas of high use (e.g. main roads versus regional roads; sampling near beach access points). This is to reduce variability at low litter abundances and, instead, support more robust assessments of trends through time to support management and policy decision-making.

Simple descriptions for each site type are provided in Table 14 with more details about site selection and within-site sampling in the sections below.

Note that some jurisdictions may not sample all of these site types (or at least not as part of a regular AusLM monitoring program). By not sampling some of these site types, jurisdictions can allocate more resources elsewhere, such as increasing levels of replication for specific site types of interest or monitoring questions. As of June 2022, there was broad agreement among jurisdictions that a core set of sites types should include residential, retail and recreational parks.

Table 14. AusLM site types.

Site type	Simple description	Alignment to Australian Land and Management classification
Residential street	A street/collection of streets in a residential zone as specified by the jurisdiction's planning scheme or ALUM mapping. The street has homes/units/apartments on both sides of the street and is not a major road. The sampling area is a strip along the street between the property boundary and including the gutter.	5.4.1 Urban residential

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[21] https://www.agriculture.gov.au/abares/aclump/land-use/land-use-mapping
[22] as with most other litter methods

Site type	Simple description	Alignment to Australian Land and Management classification
	These sites are nested within a location, as per Section 4.4.	
Industrial street	A street/collection of streets in an industrial zone as specified by the jurisdiction's planning scheme or ALUM mapping. The sampling area is a strip along the street between the property boundary and including the gutter. These sites are nested within a location, as per Section 4.4.	5.3.0 Manufacturing and industrial
Retail area/precinct	A street/collection of streets within a retail precinct (i.e. shopfronts). This is a specific type of area within a commercial zone as specified by the jurisdiction's planning scheme or ALUM mapping. The sampling area is a strip along the street between the property boundary and including the gutter. These sites are nested within a location, as per Section 4.4.	5.5.1 Commercial services
Recreational Park	A public outdoor space frequently visited by individuals and groups for recreation and leisure. The sampling area is the entire park, sampled using randomly placed transects. These sites are nested within a location, as per Section 4.4.	5.5.3 Recreation and culture
Main road	Main roads include straight open stretches of sealed road with one or two lanes for traffic traveling in either direction and vegetation bordering each side. They are defined as 'major' roads based on jurisdiction-by-jurisdiction definitions. They are expected to be arterial roads that form connections within or between urban centres (as defined in Regions, Section 4.3). The sampling area is a strip parallel to the roadside.	5.7.2 Roads

Site type	Simple description	Alignment to Australian Land and Management classification
	A 'core' approach to sampling main roads is identifying key roads that connect urban areas (or form connections within urban areas). However, each jurisdiction may have its own interests and needs associated with main roads that require tailored site selection.	
Beach	A mostly sandy beach frequently visited by people for activities such as recreation and relaxation. The AusLM monitoring program was originally scoped to just sample beaches in metropolitan regions (thus minimising the effort required to sample regional beaches). However, jurisdictions may also sample regional beaches based on their specific needs and interests.	6.6.0 Estuary/coastal waters

Residential, retail, industrial and recreational park sites are sampled randomly within locations (i.e. urbanised areas within LGAs). As described in Section 4.4, clustering sites within a location/LGA improves sampling efficiency.

A general procedure for selecting sites (within either the metropolitan or non-metropolitan region):[23]

1. Randomly select locations/LGAs/Statistical Areas as per Section 4.4.
2. Select random coordinates in this location. Using remote imagery (e.g. Google Earth), ALUM mapping or council-level zoning, check if a potential site is within 50 m of the coordinates.[24] If not re-randomise until an appropriate site is located. Ensure that sites are at least 500 m from each other.
3. Repeat step 3 within that location until the minimum number of sites are identified for each site type (as per Section 4.6).
4. Return to Step 2 and select a new location. Select the minimum number of sites and site types for that location as per Step 3 and 4.
5. Repeat Step 5 until all locations have their minimum quota of sites and site types.

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[23] With appropriate spatial data, this procedure could be automated, or at least semi-automated, using GIS software to contain the random selection of points to appropriate land-use types/zones.
[24] Limiting the area around the coordinates reduces the potential to bias samples towards selecting sites on the edges/near non-targeted land (e.g. national park, water, etc.).

6. To allocate any remaining sites, randomly select a location and randomly select coordinates. If that point does not match a needed site type, re-select a location and set of coordinates.[25]

Beaches potentially could just be sampled in metropolitan regions if they are a site type of interest to jurisdictions. Non-metropolitan urban areas often do not have nearby beaches and travelling to specifically sample regional beaches could substantially increase travel time. It is not clear this would provide value-for-money for decision-makers.[26] However, if regional beaches are of interest to jurisdictions, the AusLM can be applied without issue.

In terms of sampling sites within metropolitan regions, it is recommended sites are selected randomly using aerial images and random coordinates:

- The approximate location of a beach site can be identified if a beach falls within 2 km of a random point placed within the metropolitan region (or within a beaches GIS layer if available).
- The nearest point on the beach to those coordinates is identified. The main point of access to this point should be identified along the beach, or within a 1-km radius. The 'main access point' is relative to other access points. A carpark is usually a distinguishing feature that contrasts with smaller paths or tracks (Figure 8). Where there are several main access points, the one closest to the original point that avoids overlap with other main access points (if possible) should be chosen. The objective is to avoid a situation where litter will be monitored near access points
- On long beaches, there can be multiple sites, but they must be separated by at least 2 km.

It is suggested that main roads are sampled on the outskirts of metropolitan regions and on the outskirts of regional urban centres, but that jurisdictions may have their own particular interests in sampling these sites (such as a specific interest in regional tourist roads, etc.). **In terms of selecting main road sites one process could be:**

- Potential main roads/roads exiting metropolitan and non-metropolitan urban centres are identified or main roads linking parts of urban centres identified – land use maps and/or aerial imagery can be useful here.
- An appropriate number of these roads are randomly selected (as per the sample size in Section 4.6).
- A site is identified along an appropriate stretch of road within the boundary of the urban centre (as per ABS boundaries). Selecting a site within the urban boundary means that the road is more likely to be of an appropriate (i.e. safe) speed limit and with an appropriately open verge (see recommendations for Main Roads on p.17).

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[25] This is important to help ensure that sites are representative across the region, rather than being 'forced' into a location.
[26] Less frequent sampling of regional beaches could be an additional component of monitoring for some jurisdictions, or they could rely on other monitoring programs such as that of Tangaroa Blue (tangaroablue.org).

4.6 Sample sizes, frequency and options for structuring AusLM monitoring

Sample size is a key consideration for the monitoring program as it will influence the precision of the data and the overall costs of program implementation. The design of the monitoring program is also important here as the distribution of sites also has implications for costs and the level of precision possible for a given resource.

This Specification document, together with two additional discussion papers[27], have provided a preliminary set of considerations for the AusLM Project Working Group. Of particular note is the balance between sampling a diverse range of site types and locations and the intensity with which they are sampled to provide robust trend data. Some of the data considered in establishing suggested sample sizes are:

- Data from the AusLM pilot, which sampled 23 sites across Queensland, Victoria and Western Australia (Table 15). While these estimates are based on small sample sizes, they provide a broadly consistent picture to the Queensland CDS analysis – i.e. higher levels of variability at beach and park sites, lower at residential and industrial. The differences in the pilot data are the higher level of variability in main roads and the lower variability for retail sites. Note that these data should be used cautiously because of the low replication level and that the sites are spread across three jurisdictions.
- The area of different land-use types as defined by the ALUM categories (see Section 4.5). While the AusLM has limitations for generalising site-types to land-use categories, the relative area of these categories at a jurisdiction scale provides a coarse indication of how much sampling effort might be reasonable for each (Table 16). Acknowledging the limitations of the data presented, it shows clearly the very high area of residential land relative to other types.

Table 15. Mean litter density, standard deviation and coefficient of variation for different site types.

Site type (all jurisdictions)	Mean density of litter items (#/1000 m^2)	Standard deviation	Coefficient of variation
Beach (n=3)	189	260	1.38
Main road (n=4)	337	369	1.09
Industrial (n=4)	313	244	0.78
Park (n=4)	345	350	1.01
Residential (n=4)	43[28]	30	0.68

[27] Jurisdiction-level monitoring programs – Discussion paper. 14 February 2021. Developed by PREA for the AusLM Project Working Group.
Options for the AusLM Core Monitoring Program – Discussion paper. 19 January 2021. Developed by PREA for the AusLM Project Working Group.
[28] Indicative mean density may increase after June 2022 change to residential transect layout to extend from the gutter to the property boundary – thus including possible litter traps such as fences.

Retail (n=4)	277	116	0.42
All sites (n=4)	253	252	1.00

Table 16. Proportion of Victorian land uses as relevant to the AusLM. (Sourced from http://vro.agriculture.vic.gov.au/ dpi/vro/vrosite.nsf/pages/landuse-home).

Land use category	Area of state (%)	% area of land based on all land types surveyed in AusLM
Residential	4.56	88%
Commercial (a fraction of which is retail)	0.11	2%
Industrial	0.2	4%
Roads	0.12	2%
Sport, rec and culture (a fraction of which is parks)	0.18	3%

Considering these data together, along with feedback from the PWG, leads us to present three different approaches to sampling (which also reflect an evolution in thinking through time):

- **Table 17 outlines our original proposal for a standard/generic sampling strategy that could be applied across the country, to deliver a 15% error margin.** In this model sites are sampled in all regions in the same proportions[29] and the focus is on metropolitan regions. Note, however, that around one-fifth of the effort is suggested to go into regional surveys, in line with jurisdictions' noted interests in undertaking regional sampling. Other points to note about this structure is that:
  - o There were attempts to balance increased sampling for some site types with decreased sampling in others, in line with variability, area size and litter loads. While the error margins are arbitrary at this stage (as there is not clear guidance on the level of precision required), they provide a rough guide as to where more- or less-precise data might be collected.
  - o The current program has been scoped with the expectation that sites will be sampled twice per year to account for seasonal variability. Monitoring program timing could be considered in spring (November) and autumn (May) if there is a desire for data collected to be somewhat backward compatible with other methodologies used from a timing perspective. To the extent possible summer and winter should be avoided as these are anticipated as representing periods of high and low littering rates linked to the increase/decrease in the human outdoor

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[29] with the expectation that these proportions would be scaled-back in TAS, NT and ACT in line with their available resources.

human activity associated with each season (Perchard, 2008). Spring and autumn are therefore the mid-points between these two extremes. Avoiding summer and winter, also decreases risks of heatstroke and hypothermia for people auding litter in the field.

- Feedback from the project working group suggested that while the above model worked for some jurisdictions, **it might be too resource-intensive for some and, for others, it did not necessarily fit with their interests in regional areas**. In light of this, we developed a discussion paper on focusing on a simple 'core' monitoring program upon which jurisdictions could do more tailored sampling (see an extract of this paper in Section 6.6). **The recommended 'core' program is outlined in Table 19 below**:
  - o Focusing on a smaller range of site types (residential, retail and recreational parks) is likely to provide the most value as a consistent set across jurisdictions, noting that each state/territory could sample additional sites as they required. This meant that resource requirements went down, while still retaining levels of replication for key site types.
  - o Just surveying metropolitan region as part of the core program, with states and territories free to choose how they want to sample regional areas.

Maintaining twice-yearly sampling for the core sites to help ensure data is useful for understanding the impacts of policy changes in the short- to medium-term (see rationale in section titled '

- o   Frequency of the AusLM Core Monitoring Program' on p.103).
- A third approach to structuring AusLM monitoring is, rather than specifying a generic monitoring strategy, **developing a tailored strategy for each jurisdiction based on their individual priorities/context/needs** (Table 20).[30] The 'core' monitoring program then becomes the area of overlap between these individual monitoring program (as per Figure 14 on p.33).
    - o   **2-3 different scenarios are provided for each jurisdiction**. These are indicative only and are outlined to give a sense of what different approaches might be possible. The number and balance of sites are based on the feedback on the interests of jurisdictions, discussion in the AusLM Core Monitoring Program Options paper (see Section 6.6) and this AusLM Specification.
    - o   In most cases, the numbers have been presented here in a 'modular' way (i.e. groups of site types at the location level) to help broadly scope how effort might be structured and distributed. The distribution/number of sites of each type could be adjusted to better stratify effort in line with area of land use or specific jurisdiction interests (for example reducing the overall number of beach sites, increasing the number of retail sites).
    - o   Of particular note, in comparison to other monitoring structures proposed above, is that **there is less emphasis on residential sites**. This is for three key reasons:
        - ▪   The AusLM pilot highlighted the low abundance of litter at residential sites[31], but also their relatively low variability. While they are still likely to be an important contributor to overall litter loads (because of their very high area compared to other land uses), the low variability between sites means that fewer sites would be needed to get reliable estimates.
        - ▪   The litter types found in residential sites tended to be of less relevance to contemporary policy decisions–i.e. low proportions of takeaway materials and CDS containers.
        - ▪   Also based on the types of litter observed (e.g. small plastic and paper fragments), it is anticipated (but not confirmed) that a substantial proportion of the litter in residential areas is from unintentional littering (e.g. spillover from bins or mailboxes that has been mowed into small pieces, scraps from garden maintenance) rather than intentional littering of cigarette butts, plastic bottles or takeaway containers that might be seen elsewhere, and that is the focus of management/policy interventions.[32]
        - ▪   Putting less effort into residential sites allows for resources to be distributed elsewhere – either sampling other locations or more intensively sampling sites that have higher litter densities and that might show responses to policy interventions (e.g. retail sites).

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[30] identified through a survey distributed to all jurisdiction representatives seeking feedback on priority uses of the AusLM, priority site types and priority regions

[31] This may increase after the June 2022 decision to change the residential transect that now extends to the property boundary – thus including possible litter traps such as fences.

[32] Irrespective of this observation, the low abundance and relatively low variability mean that sampling in similar sample sizes to other site types will still yield reliable results.

Overall, it is suggested jurisdictions use Table 20 as a starting point for thinking in more detail about their monitoring programs. The thinking and data that informs the other approaches below can also be used to inform development of their monitoring programs.

It is also important to note that, where there are specific monitoring questions of interest, jurisdictions will need to consider how much precision they require in answering those questions. In some cases, there may be the need for trade-offs in what is surveyed and/or consideration of other methodologies that might better address key questions. For example, data on the efficacy of CDSs in reducing container litter may be more efficiently monitored by surveying accumulation points, such as drains or estuaries (e.g. see the KLIS), where larger numbers of containers are often recorded.

The final recommendation is for the sampling program and number of sites be reviewed after two years to better estimate levels of variation within sites through time (as we do not yet have data). This includes checking with jurisdictions whether the level of precision meets their needs.

Table 17. Initial suggestions for the number of sites that could be sampled as part of a standardised/generic AusLM monitoring program. This translates into a suggested number of locations to be sampled and a minimum number of site types to be sampled within each of these locations (Table 18).

Site type	# sites for 15% error margin[33]	Suggested # sites per jurisdiction	# metropolitan sites	# regional sites	Comments
Beaches	52	**16**	16	0	Beaches appear highly variable, generally have low litter loads and are a very small fraction of land. They are, however, popular recreational venues and very commonly surveyed as part of litter programs. It is recommended sampling be restricted to metropolitan areas.
Parks	58	**20**	16	4	As with beaches, parks are variable but preliminary AusLM piloting has shown them to have moderate litter loads. They are also a well-represented feature of many urban landscapes and may be a good example where amenity values can be heavily impacted. As they can be sampled in similar locations to residential sites, it was suggested jurisdictions retain a similar level of effort to beaches.
Residential	21	**30**	25	5	Residential areas make up the majority of land in urbanised areas and carry low to medium litter loads. Given their importance, the number of samples has been set here so that urban areas have at least a 15% error margin.

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[33] Post container refund scheme litter monitoring. March 2020. Report for Queensland Department of Environment and Science. A Prince Consulting Pty Ltd

Retail	47	**50**	45	5	Retail areas are often heavily littered. A substantial number of sites are suggested for this type given this and the need for relatively high levels of sampling to accommodate for variability.
Industrial	16	**20**	16	4	As with retail, industrial sites often have heavy litter loads. They are less variable than retail sites, however, and so fewer samples are required here to obtain similar levels of confidence in estimates.
Main roads	7	**20**	10	10	Main roads appear to be the least variable site type. Given they are surveyed on the outskirts of urbanised regions, sampling effort has been split between metropolitan and regional areas while still allowing for reasonable levels of confidence.
	201	**156**	**128**	**28**	

Table 18. Number of locations and minimum number of sites per location based on total sample size per jurisdiction in Table 17. Any additional sites at the jurisdiction level are to be allocated randomly across LGAs.

Component	Metropolitan region	Non-metropolitan region
Number of locations	8	4
Min # park sites per location	2	1
Min # residential sites per location	3	1
Min # retail sites per location	4	1
Min # industrial sites per location	1	1

Table 19. Second suggested monitoring program based on reduced site types and sampling only in metropolitan regions. This is also discussed in Section 6.6. This core program could be built on with additional sites/locations/regions as per the needs of individual jurisdictions. An alternative approach, building up from jurisdiction's individual needs, is outlined in Table 20.

Site type	# sites for 15% error margin[34]	# sites for 10% error margin	Suggested # sites - Vic, QLD, WA, NSW, SA	Suggested # sites – ACT, NT, TAS	Rationale (noting updates to sample size considerations)
Beaches	52	117			As discussed in Section 6.6, beaches are highly variable, have low litter loads and have questionable value given they are cleaned frequently and there are other monitoring programs.
Parks	58	129	**18**	**12**	Parks have moderate litter loads and are relatively large areas of land use and represent a common open space in which people might litter, or encounter littering and may be a good example where amenity values can be heavily impacted While they are reasonably variable the sampling suggested here should provide acceptable precision.

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[34] Post container refund scheme litter monitoring. March 2020. Report for Queensland Department of Environment and Science. A Prince Consulting Pty Ltd

Residential	21	47	**30**	**24**	Residential sites are easy to survey and highly representative of urban land use and overall litter loads. As such, a large proportion of sampling effort is targeted to these sites. Together with their medium level of variability, they should provide a reasonably powerful and representative assessment of trends.
Retail	47	104	**18**	**12**	Retail sites have medium to high litter loads and are places where people may be commonly exposed to litter, making them a good representation of amenity impacts. While they are reasonably variable the sampling suggested here should provide acceptable precision.
Industrial	16	35			Though highly littered, industrial sites are not commonly visited by the general public and may not be a good use of core monitoring program resources.
Main roads	7	15	**8**	**8**	Main roads tend to be heavily littered and represent a substantial area of land use. Their low level of variability means they are also well suited to monitoring trends through time, even with fewer sites. Note, however, they may need to be sampled in different locations in different jurisdictions depending on access/availability and interest.
Total			**74**	**56**	

Table 20. Potential approaches to jurisdiction-specific monitoring. Note there are multiple scenarios presented for each jurisdiction.

Jurisdiction	General notes[35]	Scenario	Regions	Potential mix of sites	Frequency & implications
ACT	ACT is, effectively, a single metropolitan region.	1 –68 sites. Focus on getting representation from across the Territory.	Canberra	10 Parks 20 Residential 20 Retail 10 Industrial 8 Main roads[36] Split across ~4-8 locations[37] (68 sites in total)	All done 2x per year to provide a reasonable time-series for any CDS evaluation
		2 – Similar to scenario 1 but done less frequently and cost will be lower.	Canberra	10 Parks 20 Residential 20 Retail 10 Industrial 8 Main roads Split across 4-8 locations (68 sites in total)	Done only 1x per year. This would provide less robust data for any policy evaluation but be suitable for tracking longer-term trends in litter. Alternatively, some of the savings could be put into surveying additional sites, while still keeping costs manageable.
NT	NT is much less urbanised than other jurisdictions with ~60% of the population in Darwin and the remainder in	1 –66-70 sites. Focus on Darwin only.	Darwin	20 Parks 20 Residential 20 Retail Split across Greater Darwin,	All done 2x per year to provide a reasonable time-series for any policy evaluation, noting that the

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[35] As at April 2021 and noting that jurisdictional data needs may change over time.

[36] Main roads can be defined according to jurisdiction's needs. The updated AusLM specification outlines a series of recommended criteria for selecting main road sites (e.g. 60-80km/h, wide verges, acts as an arterial for traffic).

[37] Potentially electoral boundaries or ABS Statistical Areas Level 3 (e.g. 'North Canberra', 'Belconnen', 'Gungahlin', etc.).

	regional/remote area. Litter monitoring objectives appear to be focused on evaluating NT policies, but that there may be other sources of data to complement the AusLM. Note that there may be advantages in procuring local surveyors to reduce travel costs/improve localised economic benefits.			potentially, using ABS SA3 Areas to group sites together in locations (i.e. ~6-8 Parks, 6-8 Residential, 6-8 Retail in each of Darwin City, Darwin Suburbs and Palmerston). 6-10 Main roads (66-70 sites in total)	focus is only on Darwin. Suggest this option is probably an over-investment in Darwin given the monitoring objectives.
		2 –Similar # sites as above but split across Darwin and other major towns. Cost may be higher (given travel etc.)	Darwin Katherine Alice Springs	6 Parks 6 Residential 6 Retail 3 main roads In each of three major towns (63 sites in total)	All done 2x per year to provide a reasonable time-series for any policy evaluation. Suggest this is probably a reasonable spread of effort.
		3 – Similar # sites to Scenario 2, but done 1x year to contain costs. Costs may be lower than scenario 2.	Darwin Katherine Alice Springs	6 Parks 6 Residential 6 Retail 3 main roads In each of three major towns (63 sites in total).	Done 1x per year. Would provide reasonable data for longer-term trend monitoring but less robust/timely data for policy evaluation. Alternatively, Darwin could be sampled 2x per year and the other sites could be sampled every second year.
NSW	A monitoring program that covers the state is likely to cost substantially more	1 – ~150 sites. Focus on getting representation	Sydney +other large cities (i.e.	1 Parks 1-3 Residential 1-3 Retail	All done 2x per year to provide a reasonable time-series for

than current expenditure.

Given policies are evaluated by other data sources, the precision of data may be less important as compared to having a good spread of sites across the state.

Any integration with the KLIS will need specific sites to be selected, as will any region-specific or other KPIs.

There is possibility to do more careful stratification to determine the balance of sites across regions based on population.

	from across the state.	Wollongong, Newcastle) + sample of mid-size regional towns (e.g. Dubbo, Coffs Harbour)	1 Industrial 1 Beaches (where relevant) 1 Main Road At each location, with ~16-20 locations spread across the state (~150 sites in total)	policy evaluation Note the limited replication of non-Residential sites within locations will make cross-location comparison of those site types less robust.
2 – ~250-300 sites done only once per year. This would allow for greater coverage. Similar cost to scenario 1.	Sydney +other large cities (i.e. Wollongong, Newcastle) + sample of mid-size regional towns (e.g. Dubbo, Coffs Harbour)	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) 1 Main Road At each location, with ~30-40 locations spread across the state (~250-300 sites in total)	Done once per year. Would provide good breadth across the state but be less useful for evaluating policy interventions over short time periods
3 – Broad regional coverage as per Scenario 2, but a more intense, focused monitoring of a key area (e.g. Sydney) for monitoring key policy impacts.	Sydney (intensively) +other large cities (i.e. Wollongong, Newcastle) + sample of mid-size regional towns (e.g. Dubbo, Coffs Harbour)	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) 1 Main Road At each location, with 8-10 locations sampled twice-yearly in Sydney and	More frequent sampling (twice yearly) within a select region (or 2-3 regions), with less frequent sampling done at a broader range of locations (e.g. every 1-2 years).

59

					~15-20 locations sampled across the state annually or every second year (for example)
QLD	QLD is a large state with dispersed communities. It also has a strong interest in collecting data from metro, regional and remote areas. A monitoring program that covers the state is likely to cost substantially more than current expenditure. Feedback suggests the AusLM is will be an essential data source in evaluating CDS, single-use plastic and plastic-bag bans, but its use in evaluating these initiatives should be considered carefully to ensure it is sufficiently precise and cost-effective. There is currently a comprehensive CDS monitoring program in place. The overlap/alignment with the AusLM will need to be considered carefully. There is possibility to do more careful stratification to	1 –~150 sites. Focus on getting representation from across the state.	Brisbane +other large cities (i.e. Goldcoast, Cairns) + sample of mid-size regional towns (e.g. Gladstone, Maryborough) + sample of other regional/remote towns	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) 1 Main Road At each location, with ~18-20 locations spread across the state (~150 sites in total)	All done 2x per year to provide a reasonable time-series for policy evaluation. Note the problem may be that there is not enough replication within different regions to address specific policy evaluation needs. Note the limited replication of non-Residential sites within locations will make cross-location comparison of those site types less robust.
		2 – Similar to CDS monitoring (266 sites in March 2020 survey) Cost likely to be similar to current CDS monitoring and higher than under scenario 1.	Brisbane +other large cities (i.e. Goldcoast, Cairns) + sample of mid-size regional towns (e.g. Gladstone, Maryborough) + sample of other regional/remote towns	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) 1 Main Road At each location, with ~30-35 locations spread across the state	All done 2x per year to provide a reasonable time-series for policy evaluation. The level of surveying for the CDS monitoring was designed with policy evaluation in mind and is likely to be reasonable.

	determine the balance of sites across regions based on population.			(ideally stratified by population) (~260 sites in total)	
		3 - Broad regional coverage as per Scenario 2, but a more intense, focused monitoring of a smaller number of areas for monitoring key policy impacts. Cost likely to be similar to CDS monitoring.	Brisbane +other large cities (i.e. Goldcoast, Cairns) + sample of mid-size regional towns (e.g. Gladstone, Maryborough) + sample of other regional/remote towns	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) 1 Main Road At each location, with 10-15 locations sampled twice-yearly and ~20-25 locations sampled across the state annually or every second year (for example).	More frequent sampling within 2-3 regions, with less frequent sampling done at a broader range of locations (e.g. every 1-2 years).
SA	Feedback emphasises a need for the AusLM to be an essential element of CDS evaluation, as well as monitoring general litter trends and issues. It will need to do this regularly across major metropolitan regions - at least twice a year and potentially quarterly as has historically been the case. Its use in evaluating the CDS should be considered carefully to ensure it is sufficiently precise, though	1 – ~140-150 sites. Focus on getting representation from across the state.	Adelaide + Mt Gambier, Whyalla (other urban areas 20-50k pop) + Murray Bridge, Port Augusta, Port Lincoln, Port Pirie, Victor Harbour (other urban areas 10-20k pop)	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) All done across ~9-10 locations in Adelaide (LGAs) and ~7-8 locations outside of Adelaide (ABS Urban Centres). Depending on interest in statewide coverage, it may be reasonable to	All done 2x per year to provide a reasonable time-series for policy evaluation. [Or 4 x per year if this is the current frequency with NLI and this is expected to continue] Note the limited replication of non-Residential sites within locations will make cross-location comparison of those site types less robust.

given the CDS is already well established and was monitored using other methods, this is unlikely to be problematic.

Note there may be value, if possible, in identifying where other methodology sites are located and doing some AusLM sites at these to help promote data continuity.

have 2 locations (i.e. 2 Parks, 6 residential sites etc.) within larger regional cities (e.g. within Mt Gambier).

Plus, 15-20 Main Roads[38]

(~140-150 sites in total)

Scenario	Locations	Site types	Frequency
2 – Less frequent but broader regional sampling. Similar cost to scenario 1.	Adelaide + Mt Gambier, Whyalla (other urban areas 20-50k pop) + Murray Bridge, Port Augusta, Port Lincoln, Port Pirie, Victor Harbour (other urban areas 10-20k pop) + sample of smaller regional 'other urban areas' with populations <10k	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) All done across ~9-10 locations in Adelaide (LGAs) – surveyed 2x per year and ~10-15 locations outside of Adelaide (ABS Urban Centres) surveyed 1 x per year. Plus, 15-20 Main Roads	Adelaide sites surveyed 2x per year [or 4x per year if this is current level] to allow for policy evaluation etc. Regional sites surveyed less frequently (1x per year).
3 –As per Scenario 1 but less frequent regional sampling to contain costs.	Adelaide + Mt Gambier, Whyalla (other urban areas 20-50k pop) + Murray Bridge, Port Augusta, Port Lincoln, Port	1 Parks 1-3 Residential 1-3 Retail 1 Industrial	More frequent sampling (twice yearly) within Adelaide with less frequent sampling done in regional locations to

[38] Potentially balanced between sampling 'near towns' in 60-80 km/h zones, as well as more remote highways (as per jurisdictional interests).

62

				1 Beaches (where relevant)	reduce overall costs.
			Pirie, Victor Harbour (other urban areas 10-20k pop)	All done across ~9-10 locations in Adelaide (LGAs) – surveyed 2 x per year and ~7-8 locations outside of Adelaide (ABS Urban Centres) – surveyed 1 x per year. Plus, 15-20 Main Roads	
TAS	Only about a third of the population live in Hobart, emphasising the importance of surveying other parts of the state if possible. Feedback on monitoring objectives suggest the AusLM will be important in CDS evaluation and monitoring litter trends but there may be other sources of data to complement the AusLM. Given this, it may be more valuable to have monitoring with broad coverage done less-regularly. It is also important to note a particular interest in including tourism roads as part of the	1 –~70-74 sites. Focus on Hobart only.	Hobart	1 Parks 1-3 Residential 1-3 Retail 1 Industrial At ~10 locations (~3 locations per LGA or potentially 10 x SA2[39] areas) 4-6 Beaches (where relevant) 6-8 Main Roads (potentially targeted at tourism roads on the outskirts of Hobart (~70-74 sites in total)	All done 2x per year to provide a reasonable time-series for any policy evaluation. Suggest this option is probably an over-investment in Hobart given the monitoring objectives.
		2 –Similar # sites as above but split across Hobart and other major towns.	Hobart Other major regional cities: Launceston	1 Parks 1-3 Residential 1-3 Retail	All done 2x per year to provide a reasonable time-series for any policy evaluation.

[39] ABS Statistical Areas Level 2, which in this case equate to examples such as 'Sandy Bay', 'Newtown' or 'West Hobart'.

	monitoring program.	Cost may be higher than scenario 1 (given travel etc.)	Other medium regional centres: Devonport, Burnie, Ulverstone	1 Industrial All done at ~3 locations in Hobart, ~3 locations in Launceston and 1 set each in remainder 0-1 beaches in each location (where relevant) 6-10 Main Roads (potentially targeted at tourism roads) (~70-76 sites in total)	Note that spreading effort may make it difficult to do precise comparisons between regions (if this is an objective). Note the limited replication of non-Residential sites within locations will make cross-location comparison of those site types less robust.
		3 – Similar approach to Scenario 2, but done 1x year to contain costs. Costs may be similar to or less than scenario 1.	Hobart Other major regional cities: Launceston Other medium regional centres: Devonport, Burnie, Ulverstone	1 Parks 1-3 Residential 1-3 Retail 1 Industrial All done at ~3 locations in Hobart, ~3 locations in Launceston and 1 set each in remainder 0-1 beaches in each location (where relevant) 6-10 Main Roads (potentially targeted at tourism roads) (~70-76 sites in total)	All done 1x per year to contain costs. This will reduce the precision of monitoring results and make policy evaluation more difficult. Alternatively, Hobart could be sampled 2x per year and the other sites could be sampled every second year.
VIC	With a CDS and single-use plastics ban set to be in place by 2023,	1 –~140-150 sites.	Melbourne	3 Parks 3 Residential	All done 2x per year to provide a reasonable time-series for

			3 Retail	any policy evaluation.
AusLM will be a relevant data source in planning and evaluating these. Its use should be sufficiently tailored to ensure it is precise and cost-effective, and other data sources may provide important complementary data.	Focus on Melbourne only.		All done across ~14-15 LGAs[40]	
			10-15 Main Roads	
			Potentially supplemented with ~6-10 beaches if of interest.	
			(~140-150 sites in total)	
Otherwise, Victoria appears to have an interest in surveying fewer site types more comprehensively.	2 –Similar # sites as scenario 1.	Melbourne + sample of other regional centres (e.g. Geelong, Ballarat, Warrnambool, Traralgon)[41]	2-3 Parks	All done 2x per year to provide a reasonable time-series for policy evaluation.
	Melbourne plus some regional coverage.		3 Residential	
Also an interest in surveying not just Melbourne, but other large regional areas			1-3 Retail[42]	Beaches have been excluded in this scenario to allow for more robust regional coverage, but could be included by decreasing the number of locations surveyed.
	Cost likely higher because of travel		All done across ~9-10 locations in Melbourne (LGAs) and ~9-10 locations outside of Melbourne (ABS Urban Centres[43]).	
			10-15 Main Roads (spread between Melbourne and regional locations)	
			(~140-150 sites in total)	
	3 – Similar approach to Scenario 2, but	Melbourne + other regional centres (e.g. Geelong,	2-3 Parks	All done 1x per year to contain costs.
			3 Residential	

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[40] Additional replication of parks and retail as compared to other jurisdictions because of fewer site types – allows for more granular comparison at the LGA level (noting, as above, that this may still be an over-investment in Melbourne).

[41] Selection may be done in a range of ways, such as simply surveying the largest cities outside of Melbourne, urban centres that that are physically spread around the state or urban centres that are 'mid-sized' (and therefore may have resourcing constraints in comparison to larger cities).

[42] Replication reduced for this level to allow for greater regional coverage. While this may impact the reliability of comparisons between locations for this site type, the reality is that regional urban centres often only have a single retail area.

[43] as described in AusLM Specification

		done 1x year to contain costs. Costs may be similar to or less than scenario 1 or 2.	Ballarat, Warrnambool, Traralgon)	1-3 Retail All done across ~9-10 locations in Melbourne (LGAs) and ~9-10 locations outside of Melbourne (ABS Urban Centres). 10-15 Main Roads (spread between Melbourne and regional locations) (~140-150 sites in total)	This will reduce the precision of monitoring results and make policy evaluation more difficult. Alternatively, a small number of locations (potentially just in Melbourne) could be sampled 2x per year and the other sites could be sampled every year or second year.
WA	There is an interest in the AusLM being an essential (i.e. the primary) data source in evaluating policies such as the CDS. This will need careful consideration of sample sizes to ensure they meet evaluation needs, but also whether the AusLM is the most cost-effective tool for this. There is an interest in surveying outside of Perth in mid-sized regional centres, noting that the state is large and the costs of regular monitoring across its length and breadth could be substantial.	1 – ~140-150 sites. Focus on getting representation from both Perth and regional areas.	Perth + sample of other regional centres (e.g. Broome, Esperance, Port Hedland)	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) All done across ~9-10 locations in Perth (LGAs) and ~9-10 locations outside of Perth (ABS Urban Centres). Depending on interest in statewide coverage, it may be reasonable to have 2 locations (i.e. 2 Parks, 6 residential sites etc.) within each regional town (e.g. within Broome).	All done 2x per year to provide a reasonable time-series for policy evaluation Note the limited replication of non-Residential sites within locations will make cross-location comparison of those site types less robust.

		Plus, 10-20 Main Roads[44] (~140-150 sites in total)	
2 – Similar to Scenario 1 but done only once per year. This would allow for greater coverage. Similar cost to scenario 1.	Perth + sample of other regional centres (e.g. Broome, Esperance, Port Hedland)	1 Parks 1-3 Residential 1-3 Retail 1 Industrial 1 Beaches (where relevant) All done across ~9-10 locations in Perth (LGAs) and ~9-10 locations outside of Perth (ABS Urban Centres). Depending on interest in statewide coverage, it may be reasonable to have 2 locations (i.e. 2 Parks, 2-6 residential sites etc.) within each regional town (e.g. within Broome). Plus, 10-20 Main Roads (~140-150 sites in total)	Done once per year. Would provide good breadth across the state but be less useful for evaluating policy interventions over short time periods
3 – Broad regional coverage as per Scenario 2, but a more intense, focused	Perth + sample of other regional centres (e.g. Broome,	1 Parks 1-3 Residential 1-3 Retail 1 Industrial	More frequent sampling (twice yearly) within Perth, with less frequent sampling done at a broader

[44] Potentially balanced between sampling 'near towns' in 60-80 km/h zones, as well as more remote highways (as per jurisdictional interests).

monitoring of a key area (e.g. Perth) for monitoring key policy impacts. Similar cost to scenarios 1 and 2.	Esperance, Port Hedland)	1 Beaches (where relevant) All done across ~9-10 locations in Perth (LGAs) - surveyed 2x per year and ~9-10 locations outside of Perth (ABS Urban Centres) surveyed every second year. Plus, 10-20 Main Roads (~140-150 sites in total)	range of locations (e.g. every 2 years). Alternatively, 1x yearly surveying (Scenario 2) could be complemented with intense, policy-specific monitoring (e.g. stormwater drain monitoring of containers).

4.7 Likely overlap between jurisdictions – the 'core AusLM monitoring program'

Based on the feedback from jurisdictions and what site types and regions are likely to be included in their jurisdiction-specific monitoring (see Section 4.6 above), **there are a range of elements that should be able to be reasonably comparable across all states and territories:**

- Residential, retail and recreational park sites that are within capital cities. All jurisdictions will likely survey these three site types in their capital cities at least once or (more likely) twice yearly.
- Some states and territories will also be able to compare beaches and industrial sites within capital cities. It is less clear how comparable road sites will be as they offer more flexibility in where they are located according to the needs of jurisdictions.
- Outside of capital cities, **there is greater diversity in how extensive and how intensively regional sites will be surveyed.** However, for at least most jurisdictions, **there is likely to be some overlap in surveying residential, retail and park sites in medium-to-large regional centres.** That said, the way that some of these regional centres are selected is likely to vary between jurisdictions – some may be driven more by an interest in population stratification, others by geographic dispersion and others by convenience. They will thus vary in the extent to which they are 'representative' of regional areas in each jurisdiction.

This reinforces the point, as noted earlier, that any comparisons should be done keeping in mind the inherent differences between jurisdictions and the range of factors driving differences. It will also be important to consider that different jurisdictions will likely have different levels of precision and that the national level may be the most appropriate level for comparisons/benchmarking.

4.8 Reporting

Descriptive statistics and summary data tables will be produced after each AusLM monitoring period. These tables will provide timely access to the AusLM data for jurisdictions that have a need for more frequent data to inform decision making.

It is proposed that an AusLM narrative report will be produced and released on an annual basis after the second monitoring period during the year. This decision reflects our understanding of jurisdiction requirements and balances the need for timely reporting against cost effectiveness, noting the time and cost required to draft, review, finalise and publish reports.

5 Other elements of the AusLM and AusLM monitoring program

5.1 Monitoring program coordination

Jurisdictions have identified the desire to have a governance and coordination mechanism to support AusLM. At present, this role is being fulfilled by Project Working Group members with at least two representatives from each jurisdiction with relevant knowledge, skills, and experience.

The purpose of the coordination mechanism is to:

- Coordinate the timing of the AusLM. Whilst noting that litter monitoring should occur at the same time(s) every year, there may be a need to adjust the timing if there are unexpected events (cyclones, severe storms, monsoonal rain, bush fires, unexpected national days of celebration or holidays)
- Facilitate an annual or multi-year AusLM review process (see Section 5.9 Review cycle)
- Oversee an AusLM change approval process if modifications are proposed.
- Manage procurement of services to conduct litter counts, undertake base analysis and reporting.

5.2 Transparency of site locations once selected

Litter count data will be publicly available and, as a minimum requirement, be accessible via a download link on a webpage associated with an appropriate jurisdiction Government department/agency.

It is expected the geographical location of sampling sites will be available, at minimum, to key government representatives.[45] Site locations could be made available to researchers and other external parties for specific use. Full public access is perhaps not warranted, however, discussions with key stakeholder groups is ongoing on this topic. [46]

5.3 Implementation

There are a number of considerations to how AusLM is implemented that are worthy of comment and exploration.

It is recommended that each cycle of litter counts should be conducted by the same surveyors where possible for the following reasons:

- avoids the need for time-consuming and costly training, with the exception of refresher training
- ensures familiarity with the sites and the process
- reduces the need to fund and invest time in recruitment processes.

This might be through a contract for, for example, three to five years. Any contracted arrangement should allow for a high level of oversight by government staff or nominated

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[45] For example, the physical site location of a park, or the name of streets for retail/industrial/residential areas.
[46] The AusLM peer review process strongly recommended that the **location of sites not be made available to the public.**

contractors to help audit processes and ensure that incumbent surveyors maintain transparency and sharing of methodological lessons.

Feedback from some stakeholders has, in this initial phase, discouraged AusLM from recommending that community organisations could be engaged to resource the official AusLM count. Reasons given for this position were in relation to quality issues of the litter counts, categorisation and data entry. Engaging community organisations to conduct litter surveys at additional sites could be explored for jurisdictions that want a cost-effective way to scale up, or to provide information at smaller spatial scales that are relevant to specific management needs. Community groups and NGOs, through their access to large numbers of volunteers, are noted as having potential to contribute large volumes of litter monitoring data to supplement the core AusLM method. The accuracy and quality of data from community litter surveyors could be tested over time. Community surveyors could be invited to survey a sample of the official AusLM sites on the same day, close to the same time as the official AusLM survey takes place. The results collected by the two groups could be compared to make an assessment. Any actual or perceived data quality issues with engaging volunteers to audit sites could be in part mitigated by additional supervision.

5.4 Team size and safety

Pending cost implications, it is recommended a team of two people be allocated to conduct litter monitoring at targeted sites. This acts as a safety measure where if one surveyor experiences any injury or is involved in an accident, then the second surveyor will be present to assist. The approach may also provide additional safety in rural settings where a single person may be more vulnerable and isolated.

Teams can either work individually on transects or in pairs, with one searching and identifying and one recording (this may only be more efficient on heavily littered sites).

The AusLM Field Manual includes a risk matrix that identifies and lists responses to potential hazard and risks that might be encountered by surveyors in the field. Hazards, risks and responses should be covered during the AusLM surveyor training.

5.5 Training and supporting resources

The AusLM package includes the following resources to support training and field work:

- AusLM facilitators' guide that can be used by trainers to train surveyors. The facilitator guide provides a high-level outline of agendas for each day, session learning objectives, key content and topics that will be covered, and required resources
- AusLM training slide pack used to train surveyors
- Activity sheets that include instructions for conducting field simulations of site set-up, litter counting, data entry and dealing with exceptional circumstances
- AusLM field guide manual that includes detailed step-by-step instructions to follow. The field manual will include a Frequently Asked Questions section that will be informed by questions asked during training and findings from the evaluation of field work
- AusLM checklists that summarise key items in the field guide manual. Checklists will be developed key activities such as site setup (including OH&S and any COVIDSafe measures), counting and data entry. Checklists, or summary overview pages, will be essential as not all surveyors will likely refer to the detailed manual post-training.

Face-to-face training of surveyors is important to ensure there is a consistency of approach and application of the methodology. The physical practice of surveying tasks will enable a trainer to

assess that the surveyor(s) can competently demonstrate the necessary skills. Simulation field exercises can be used to assess if the correct decisions are made in relation to identifying and measuring transects, litter item categorisation, dealing with obstructions and recording results. Surveyors can be observed following the correct protocols and procedures from preparation checklists, compliance with OH&S guidelines, completing paperwork (or online forms), and following the methodology.

A basic eyesight test should be undertaken during training to ensure that surveyors have average of above average vision capable of detecting the litter items of the minimum size from a distance of 2 metres away on the ground, from a standing position.

To keep the AusLM cost effective, it is recommended that yearly refresher training be provided via online learning. This may involve watching video footage from a recording of the face-to-face training, online multiple-choice-quiz tests, or combining these two concepts in an interactive video which prompts viewers to answer questions *in situ* whilst watching the videos.[47] Electronic versions of the training materials, checklists and AusLM field guide manual could be packaged into a course built using an Online Learning Management system such as Moodle.[48] The AusLM Moodle site could be a central repository for all the AusLM resources. It would facilitate the easy upgrading of resources by authorised parties without the need for expensive IT/web support. Developing the recommended online learning component of AusLM is out of scope for this specific development project. It is recommended that online learning resources be developed after more traditional training resources have matured and proven to be effective.

5.6 Safety

Occupational health and safety

A Hazard Risk Matrix has been inserted in the AusLM Field Manual to align with a Site Safety Assessment Checklist. The contractor implementing AusLM will be responsible for developing a detailed risk assessment (Job Safety Assessment) of litter monitoring activities across the different site locations. Measures to mitigate and respond to risks should be included within the assessment and new hazards and response measures should be reflected in the Hazard Risk Matrix and Site Safety Assessment checklist in Field Manual. Jurisdiction specific requirements for work on main roads and roads should be followed.

COVIDSafe

There is a high degree of uncertainty on the length of time that COVID-19 related risks will need to be considered by the AusLM project. A COVIDSafe plan that was developed for the AusLM pilot can be repurposed and customised for planned AusLM data collection cycles. The plan aims to identify potential COVID-19 hazards and risks and mitigate against these to reduce the risk of COVID-19 transmission and take appropriate action when COVID-19 cases are suspected or confirmed.

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[47] HTML 5 integrative videos can be easily created with tools such as H5P. Integrated with an online learning platform, users can be scored and graded based on their responses to quiz questions.
[48] Moodle is a low-cost, easy to set-up and use learning management system. A site can be hosted on behalf of a client for a low cost, or Moodle can be installed on a Government server and run free of charge: https://moodle.com/

First Aid

It is recommended at least one surveyor at each site being monitored should have a current Level 2 First Aid certificate and access to a First Aid kit. This requirement is essential in remote and regional locations.

5.7 Data collection

AusLM data will be collected by litter surveyors and entered into a central database in a manner that makes it as easy and efficient as possible whilst ensuring measures are in place to reduce errors and inconsistency.

It is recommended that an AusLM App be developed for use on mobile phones and tablets with GPS functionality, which can work in remote locations without mobile network coverage[49]. The App will enable the capturing of site context data (see Section 3.5) which will save time by avoiding paper form completion and later data entry. A paper form will be available as a back-up contingency should the App fail for any reason.

The AusLM App will be used to capture transect dimensions and any relevant transect context data. A paper form will be available as a back-up contingency should the App fail for any reason.

It is recommended the surveyors use a clipboard and paper form instead of the App to categorise and mark the number of litter items. Without a custom-made App, the process of entering litter count data using a phone or table may be slow and cumbersome with touch screens and lead to unintentional data entry whilst counting. At the completion of the transect count, the litter items will be tallied up on the paper form and the summary results entered into the AusLM App. The data captured will include a photo of the litter count form as a quality control measure and to ensure surveyors use the form in the first instance.

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[49] A prototype was in place to support the AusLM pilot using free opensource software SMAP: https://smap.com.au/ and FieldTask: https://play.google.com/store/apps/details?id=org.smap.smapTask.android&hl=en_AU&gl=US

5.8 Data storage

Some criteria and considerations that will be assessed for the AusLM data storage are documented in Table 21, below. An initial list of data storage requirements has been defined in the Prototype Database Structure document that was produced as part of the final AusLM package of deliverables.

Table 21. Data storage considerations.

Criteria	Comments
Reliability	System is available all the time outside of planned maintenance and upgrade cycles.
Data integrity	Data stored, manipulated and retrieved in a manner that keeps the data in a valid state.
Data security	Data with any personal identification information will be encrypted and only accessible to people with appropriate authority. Alternatively, personal identification information could be stored externally to the database in a secure location.
Redundancy and recovery (back-up and restore)	System can be automatically backed up and conveniently restored to a previous point in time whilst retaining data integrity.
Performance	System responds within a timeframe deemed appropriate for end-users.
Maintainability	Fixes and patches and be easily applied.
Extensibility	Data storage solution can be expanded to meet new requirements (new data, larger volumes of data)
Compatibility	Data storage system is compatible with a large number of other front and back-end products.
Cost (upfront and ongoing)	Costs are well defined and within scope as specified by AusLM PWG.
Existing solutions	The ability to leverage existing technology solutions and platforms of SV and PWG members will be considered.

5.9 AusLM review cycle

It is recommended that the AusLM include a review cycle. There should be annual reviews for the first two years to make timely adjustments to the AusLM in response to the actual implementation experience. After the initial two years, a three to five-year review cycle is recommended. The extent of revisions required during the first two years may inform if a three or five-year review period is more appropriate. Reviews will require jurisdictions invest time and/or funds, thus they should not be conducted more frequently than necessary.

Whilst litter composition will change over time in response to the introduction of new packaging materials and consumption patterns, the new packaging products introduced will generally take some time to gain market share and become a litter item of significance that may require specific adjustments to AusLM. For example, it may be necessary to add a new litter item type or disaggregate (split) an existing item type for a more refined granularity. The recommended review cycle duration does not preclude more frequent reviews, but it does set a minimum standard for planning by an oversight committee/jurisdiction.

The purpose of the review cycle is to:

- identify the need for new site types, litter item types, litter categories. The number of items in 'other categories' should be reviewed. Interviews should be conducted with surveyors to assess the general composition of 'other categories' and to identify if new item types should be created
- identify sites that may need to be reassessed or removed from the sample due to a change in surrounding context
- Recommend and approve other methodological recommendations
- Trigger an update of the litter item to litter item volume conversion factors.
- (optional) Host a presentation of AusLM data/findings

If there is evidence of interference at a site due its location being known, then a resampling activity will be undertaken to replace the compromised site with a newly sampled site. The determination of whether or not a site has been compromised should be made based on firstly, empirical analysis and secondly, direct correspondence with the land manager of the site to identify any changes in cleaning routine or litter prevention activity. This needs to be addressed in a professional manner with the desired outcome to uncover if any deliberate or unintentional alternations have been made so appropriate measures, such as site replacement can be implemented.

5.10 Quality control measures

It is proposed that AusLM will include a number of quality control measures to increase data quality and increase the consistency in how AusLM is being applied.

Training

- Face-to-face training of trainers and refresher training to ensure common understanding of AusLM guidelines so that the methodology is applied consistently across sites and jurisdictions. It has been proposed that an initial national 'training of trainers' be conducted to bring trainers in from all jurisdictions to a central location so that a consistent interpretation of the methodology is shared and experienced.
- Successful completion of AusLM training in a face-to-face modality is a requirement for surveyors involved in the official AusLM monitoring program.
- Face-to-face training of surveyors and online/face-to-face refresher training. Attending an initial face-to-face with yearly online refresher training should be a mandatory requirement for surveyors involved in the office AusLM Monitoring Program.

Equipment checks/calibration

- Test phone/GPS accuracy. Older or budget phones may not be as reliable or accurate as newer more expensive phones. Phone age and quality should be considered when assessing the suitability of mobile devices used by surveyors.
- Test measuring equipment if prone to inaccuracy. For example, a tape measure that uses tape that may be stretched, or a measuring wheel which may be faulty.
- For a small sample of sites, use a measuring wheel to cross-check distances between GPS points on maps.

Walking at a similar speed

- Recording the time, it takes for a surveyor to walk a transect in some instances to ensure the walking speed is within the recommended range. The specific recommended speed and range has been estimated at between 30 seconds and 60 seconds to cover a straight-line distance of 20 metres (what might be characterised as an amble). The faster speed may be appropriate in situations where the ground surface is easy to see such as when walking on concrete or low-cut grass, and when the site is relatively free from litter. The slower speed may be appropriate when there is greater difficulty in observing litter on the ground or other surfaces such as in tall grass where the litter poking stick (or similar) is needed to part the grass to observe items, or on a beach with high quantities of shells and seaweed. This recommended time range should be reviewed after more field data is available. The time/speed range should be used to inform reporting of surveyors that appear to be completing transect audits too fast or too slow.

Avoiding fatigue and disincentivising rushing

- Recording the time taken to survey each site
- Limiting the number of sites that a surveyor can survey in one day, or alternatively, having a review mechanism in place to investigate instances where surveyors are auditing a higher-than-average number of sites. This alternative approach can be useful in situations where sites audited have low litter loads and thus can be audited relatively rapidly.

Litter count quality checks

A quality control team will:

- Observe a small sample of surveyors in each jurisdiction every monitoring period to identify potential non-conformity to the guidelines and highlight areas where more training is needed, or the guidelines/training materials need strengthening. The specific surveyor can be coached as required at the end of the observation.
- Conduct an additional litter count at a small sample of sites across each jurisdiction that have already been surveyed to assess the accuracy of the initial count. Sites of different types with different surveyors should be selected and conducted within 24 hours of the initial survey to account for litter dynamism.

Quality rating scores

AusLM will assign two data-quality-rating indicators to uploaded litter monitoring data. This approach will help facilitate other user groups such as citizen scientists to upload data to the centralised AusLM repository whilst providing the option for including or excluding supplementary data they have uploaded during analysis and reporting.

1. A data quality rating will be assigned to AusLM data based on the type of user that submits/uploads the data. A quality rating will be applied to users based on their involvement in AusLM and the extent of training they have received:
   - Official AusLM surveyors involved in the work related to the AusLM monitoring program will be assigned a high-quality rating based on their requirement to be trained and undertake refresher training
   - Unofficial AusLM users from Local Government, land managers or civil society who have participated in some form of AusLM training will be assigned a medium-quality rating
   - Unofficial AusLM users who have not received any AusLM training will be assigned a low-quality rating.
2. When uploading data, users will be asked to indicate what level of confidence they have that the data uploaded is accurate and was collected in a manner that is compliant with the AusLM methodology. A high, medium and low self-assessment rating can be selected.

These quality ratings scores will be useful when creating reports. It will be possible to apply filters to include or exclude data based on the two quality rating criteria.

Unplanned litter monitoring

An optional quality assurance measure that could be employed involves undertaking a small number of unplanned/unscheduled litter counts at existing sites from the AusLM sample at a time outside of the normal litter monitoring cycle. If the geographical location of monitoring sites are made public, or widely known, these additional counts might help detect if any stakeholders are intervening around the time of planned monitoring activities to bias the results. This measure is not currently in scope for the core AusLM monitoring program but is proposed here for consideration and discussion.

6 Annex

6.1 Annex 1. Response to the ten key AusLM requirements

Table 22 below lists the ten guiding AusLM requirements provided by the PWG and our responses to these requirements.

Table 22. Response to AusLM requirements

Requirement	Actions
1. It should be open and transparent	- AusLM Recommendations Report references sources and other methods/tools and sources that were used to inform the AusLM monitoring program or method. This will enable some traceability back to the knowledge base used to create the AUsLM. - Reuse permission will be sought, secured and documented before reusing or customises any existing tools, methods or proprietary knowledge that may infringe upon existing copyright or intellectual property ownership. - AusLM will be registered under an appropriate creative commons licence. For example, CC BY-NC-ND 4.0 allows for open use of AusLM in its unaltered form for non-commercial purposes. If others were allowed to modify and re-share the AusLM, then the following license type would be used: CC BY-NC-SA 4.0 - The location of sites where litter will be measured will be documented be available for sharing with members of the proposed AusLM Coordination Group comprises of state government representatives from each jurisdiction. - Data privacy considerations will protect the identify of specific individuals (surveyors) who contact litter monitoring. It will be recommended that surveyors will be required to sign a data privacy consent form to enable the storage of their data in a central repository and that this could be accessed by the proposed AusLM Coordination Group to contact the surveyor to ask specific questions about a specific site.
2. Delivery of the methodology should be affordable	- AusLM monitoring program (sampling strategy and sample sizes) & methodology will take into consideration the work effort required to implement the AusLM with a view of ensuring implementation costs approximately the same or less than the amount invested in other monitoring programs. - The cost of tools and equipment required to implement the method will be considered in decisions.

3. It should be scalable	• The monitoring program and methodology will enable the core AusLM method to be scaled up by a) increasing the number of sites samples in a jurisdiction; b) increasing the frequency of sampling. This additional data can be used to inform jurisdiction-based analysis and reporting. • The application of technology to collect, store and report the AusLM will support its scalability.

4. Data should be specific, context-aware, and a realistic reflection of littering	• Data collection and litter surveys will capture not just the extent of litter, but the context within which the survey took place. The specific context variables are still being defined, but will likely include:
	    ○ Site context – presence/absence of litter infrastructure
	    ○ Weather at the time of litter monitoring and any extreme weather events (floods, storms, gale-force winds) in the month leading up the litter monitoring
	    ○ Ease of access to general public through vehicle access or walking.
	    ○ Proximity of the site to areas or sites that are known to generate litter such as convenience stores, fast food outlets, retail areas, building sites, landfills/resource recovery centres, transit points (public transport stops).
	
	Beyond site-level data, the AusLM will require a process that enables regional and jurisdiction-level litter interventions, litter-related policies and campaigns to be captured along with the extent of their geographic reach so that this information can be overlaid on the litter monitoring data at specific sites impacted by these interventions and policies/campaigns. For example, the presence or absence of container deposit schemes may explain the extent of container litter in some jurisdictions.

5. It should be simple to implement, and easily explainable to non-expert stakeholders	• The method and user guide must be easy to follow using examples and diagrams and plain English to describe the method. • The importance of following the method to achieve accurate and comparable results will be highlighted. • There will be limits to the simplicity requirement. For example, some intermediary skill may be required to use a smart phone to record GPS locations or find a physical location based on GPS coordinates. • Options to explore creating a simplified, shorter litter items category will be explored for citizen science users, however, there is a risk that those using the simplified approach may create data that is less useful other stakeholders seeking to utilise it to inform analysis and decision making. If included, there will be a mechanism to include/exclude data captured via this simplified manner.

6. It should be future-proof – able to inform future policy needs as required	• The method will enable the addition of new site types and new litter item types into the monitoring program and methodology without compromising the ability to compare data over time. • Reflecting on the 'design' objective questions (see page 4), the AusLM will help identify problem litter items and areas (site types, urban/rural) which require either policy or other forms of intervention to address.
7. Data collected should be compatible and integrable with data gathered from other litter studies (eg community-level studies)	• The use of littering densities (i.e. per m²) as opposed to total volumes or numbers of littered items will enable greater compatibility with other litter data studies. • Litter item counts and item type data can be used to estimate litter volume and weight. This may help create data (volume and weight) that is compatible with other litter studies. Evidence suggests that the assumptions that underly conversions need to be regularly tested and this may impact upon Requirement 2. Affordability. It is not proposed that AusLM will estimate on the weight of littered items.
8. Data collected should be backwards-compatible (if possible)	• The reporting and required data collection requirements of the AusLM will dictate the extent to which the AusLM is backwards compatible with other methodologies. For example, the majority of litter item types would need to remain unchanged or be mapped back for definition. For example, the NSW KLIS project has undertaken some good work to map their expanded litter item list back to NLI and could be referenced as an example of how this can be done and to explore the challenges experienced in this process. The general timing and frequency of litter counts would also need to be aligned. • Existing sites should be included in ongoing surveys where the location of sites is known • If sites are able to be identified a subsample could be included in the first AusLM survey to allow for direct estimating a correction factor and/or ongoing monitoring. • In general, the AusLM is compatible on a range of features (particularly when comparing litter density) and it may be possible to estimate a 'correction factor' just from AusLM sites once a temporal trend has been established, similar to the one observed with NLI over the last 10 years. • Ultimately, the methods are different and there will need to be some analytical and interpretative considerations going forward.
9. It should be extensible – flexible to allow simultaneous collection of other data to inform other policy needs as required	• Considerations of this requirement are captured in requirements 3 and 6.

10. Data should be accessible to the public.

- In future, AusLM reports should be publicly available for download.
- Public access to AusLM data will be provided. The specific mechanism has not been defined, but it would, at its simplest form enable the AusLM database to be exported as a spreadsheet through a simple website interaction.
- Pending future funding and resourcing litter data collected using AusLM could be used via an interactive website with dynamic dashboard reporting functionality that enables users to search and interact with data could be created. Geospatial mapping functionality would add to the richness and ability to visualise the AusLM data. Mapping layers could show physical areas covered by certain policies, campaigns and interventions to place context on top of litter survey data.

6.2 Annex 2. Approaches to measuring litter

There are a number of approaches commonly used to count or measure litter or littering (Table 23) and each has pros and cons. As such, the surveyor needs to determine the most appropriate method to use based on the specific questions being posed.

Table 23. Pros and cons of different approaches to assessing litter and littering.

Litter measurement methodologies	Strengths	Weaknesses
Standing stock visual litter count. Litter items are counted and categorised in a defined area. Litter is left in place. (Ribbink, Baleta, 2018)	Relatively fast and cost effective. Indicates the extent and composition of litter at a site at a point in time.	Litter remains in the environment. Assesses the balance litter into the system minus litter out of the system and thus makes it difficult to tease out differences between, for example 'more littering' and 'less cleaning'.
Accumulation litter count An initial litter count and litter clean-up is undertaken to provide the long-term accumulation rate or the long-term typical litter load carried by the site. One or more subsequent litter count and clean-up activities are taken at regular intervals to provide the litter accumulation rate over time.	The combination of long-term litter loads and accumulation counts can provide insights into the effectiveness of litter clean up services and provide some indication of littering behaviour. Provides trends in litter accumulation over time. Provides composition of litter.	Requires two or more visits to the site. Requires more time to pick-up the litter. Can cost up to 50% more than a visual litter count.[50] Need to monitor and prevent site clean-up activities that may be scheduled as part of routine maintenance or community effort. [51] Addition of new sites is difficult as the measure is a rate, rather than a simple abundance.
Behavioural observation An observer watches and categorises the waste disposal behaviours of individuals at the site. Waste disposal behaviours are categorised in either a littering or desirable behaviour category (putting waste in a bin or taking it home)	Records the actual extent of littering behaviour and not just the amount of litter present at a site. Could enable an assessment of targeted behavioural change program	Time consuming. Litter count data is likely still needed to gain a fuller understanding of the extent of litter and its composition at a site. For example, litter blown into a site from other sources will not be captured by a behavioural observation study. Captures overt/observable littering behaviour but may miss unintentional/accidental littering
Site user survey Users at or passing through a site are asked to participate in a short survey that asks as a minimum about	Captures site user perceptions about the scale of general cleanliness or litter at the site. Where users' perceptions matter (e.g. in understanding	It is a subjective assessment that is susceptible to a range of contextual factors. Interviewing site users is fast, but it can still take considerable time to collect a sufficient sample if there are not many willing participants at the site.

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[50] Developing a baseline estimate of amounts, types, sources and distribution of coastal litter – an analysis of US marine debris data. 2017. Hardesty BD, Wilcox C, Schuyler Q, Lawson TJ and Opie K. CSIRO. https://marinedebris.noaa.gov/sites/default/files/publications-files/An_analysis_of_marine_debris_in_the_US_FINAL_REP.pdf
[51] AusLM Peer review noted that accurate accumulation studies are generally only feasible at remote sites.

how they perceive the level of cleanliness/litter at the site.	amenity impact) this can be useful.	A litter count of some sort will likely still be needed to gain a deeper understanding of litter at the site. e.g. composition of litter.
Photometric index A set of photos showing different extents of litter at a typical site are provided and used to compare with the actual visible litter at a site being surveyed. Commonly results in a 1 to 5 rating scale.	Simple and fast	Despite the presence of photos to help select the correct rating, the assessment is still subjective and does not provide data about accumulation rates or litter composition. The two-dimensional nature of the photos compared to the actual observation can also create bias.

6.3 Annex 3. Reasons for excluding site types

Table 24 summarises the reasoning for excluding car park and shopping centre site types from the recommended core AusLM monitoring program. A draft alternative method for car parks has been proposed (see Section 6.7) in response to requests from some jurisdictions, however, it is still not recommended this be included in the core AusLM monitoring Program. The absence of these two site types in the core AusLM monitoring Program should be noted in considering the extent that AusLM data can be made backwards compatible with other methodologies.

Table 24. site types that are out of scope

Site type	Comments
Car parks (open space public car parks)	Removed from scope for AusLM in consultation with the AusLM project working group for two key reasons: 1. Auditing in carparks is challenging as car parks are often full or mostly full during daylight hours. It is not possible to safely audit under parked cars and therefore the areas of occupied parking bays should be subtracted from the total site area, leaving only very small areas for auditing. Auditing early in the morning or late in evening when not heavily utilised is not practical and low-light situations limit effective counting. 2. Auditing in carparks with moving traffic poses unnecessary risks to surveyors. Noting these limitations, the carpark method is not included or tested in this version of the AusLM or the AusLM monitoring, however an alternative carpark survey method has been included (see Section 6.7).
Shopping centres	Removed from scope for AusLM in consultation with the AusLM project working group for three key reasons: 1. Not considered a major land use of interest. 2. Mostly privately owned and managed with active cleansing occurring throughout the day which makes litter rates highly variable. 3. If auditing in front of an entrance, then it is the 'transit point', not the shopping centre that is being audited.

6.4 Annex 4. Site context indicators and metadata

This Annex contains a list of site context indicators and metadata that is intended to be captured by AusLM. Jurisdictions have flexibility to add additional context indicators that are relevant to their needs.

Table 25. Site context indicators and metadata

Context indicators and metadata	Applicable site types						Comments	Values
	Beach	Residential street	Industrial area	Retail area	Park	Main Rd		
Site level context - Start[52]							Data in this sub-section of the table is captured at every site.	
Arrival date and time	✓	✓	✓	✓	✓	✓	Date and time the surveyors arrive at the site.	
Surveyor names/number of surveyors	✓	✓	✓	✓	✓	✓	Used to estimate auditing effort (time x # surveyors)	
Site ID	✓	✓	✓	✓	✓	✓	Unique identifier for the site	
Site name	✓	✓	✓	✓	✓	✓	Meaningful name of the site.	
Site address	✓	✓	✓	✓	✓	✓	Physical street address of the site, or closest address that can be provided for main road/beach site types.	
Site type	✓	✓	✓	✓	✓	✓	AusLM currently caters for the six core site types. A 'other' site type option has also been provided to create some flexibility	bch res ind ret

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[52] Current weather, wind direction and wind speed were recorded in a draft version of AusLM, however, these were removed due to concerns about AusLM capturing too much context data and that this data could to an extent be captured from other sources (Bureau of Meteorology) at a later date.

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Site type assessment	✓	✓	✓	✓	✓	✓	Land use change checklist completed. Included is a checklist that requires surveyor to run through the inclusion and exclusion criteria for each site. Used to inform if site type is still valid for the site or if it has changed.	Pass Fail
Number of people visible at the time of the survey	✓	✓	✓	✓	✓	✓	Indication of how many people are using the site. Indicator of potential litter generation. Parks & beaches: Observation taken from the park or beach entry point. Estimate the number of people across a clearly visible area of the site that is approximately 50m x 100m in size. Streets: This is an estimated count made from the footpath location that is closest to the site GPS point. On the footpath surveyors should face the street and turn right. Estimate the number of people you see in the first 50m of street. If your view is blocked within the 50m or the street changes from retail/residential/commercial to some other type of site, before 50m, then turn around and face the other direction and make your estimate.	If there are hundreds of people on the street, walk to the kerb and mark out a 5 m length with chalk marks at each end. Estimate how many people are within the 5 m length of the street at one point in time. Multiple that by 10 to obtain an estimate for a full 50m length of street.
Site photos	✓	✓	✓	✓	✓	✓	Photos of the site for quality control and follow-up investigation into anomalies/outliers Park & beach: Take photos from the park/beach entry point. All site types. Take a photo from the first transect start point.	

Visibility	✓	✓	✓	✓	✓	✓	Visibility is an indication of conditions and how well the surveyor can see in those conditions. Poor visibility would raise concerns about the quality/accuracy of the count. If surveyor can see approximately ~ 50 m, then visibility is rated as acceptable, and a pass rating is given	Pass Fail
Indication if litter will be picked up	✓	✓	✓	✓	✓	✓	This is not a valid option for the sites being audited as part of the official litter monitoring program. For other groups and sites, this box can be selected to indicate that litter will be picked up during or after the audit.	Yes No
Post-litter count data after all transects counted							Some data is best captured after the surveyor has been at the site and undertaken the litter counts.	
Cleanliness Rating	✓	✓	✓	✓	✓	✓	Subjective, but some indication of overall litter load at the site Can help flag examples where litter count data does not match what is generally observed at the site. Assessment is made after all transects have been audited. Photographic examples of each rating will be provided to guide the assessment.	No litter Scattered litter Lots of litter Very high litter rate that may include illegal dumping.
Graffiti present	✓	✓	✓	✓	✓	✓	Indicates the presence of obvious graffiti at the site on infrastructure (bins, BBQs), roads and footpaths. This was a request from ACT.	Yes No
Evidence the site was recently cleaned up	✓	✓	✓	✓	✓	✓	This is still subjective but improved by reframing. This item is captured by other litter studies. **For parks/beaches and open spaces**, some studies have observed the presence of fresh tyre tracks on the ground, perhaps specifically near bins that are empty as an indicator that the site may have recently been cleaned. If we were looking in bins and they were empty - that could be another sign.	Yes No

							For **Parks and Main roads**, contractors are often 'supposed' to remove litter from grassed areas before mowing. If there has been recent mowing and there is an absence of smaller shredded items, then this may be an indicator that the site was cleared before mowing.	
Recent public event	✓	✓	✓	✓	✓	✓	Public events refer to organised public gathering involving approximately 100 or more people. The objective is to capture this context to explain potential very significant increases in the number of litter items present or changes in litter composition. A well-managed public event may also include a post-event clean-up activity that may explain the absence of litter at the site. The presence of promotional flyers and banners around the site, or in littered items may also provide information to inform the presence of a recent public event. Recently is defined as within the last 7 days	Yes No
Recent storm/flood damage	✓	✓	✓	✓	✓	✓	Observable by erosion, washed out areas, areas under water, high concentrations of litter at the entrance to storm water drains. May indicate the movement of litter to or from the site. May invalidate the litter count.	Yes No
Strong wind	✓	✓	✓	✓	✓	✓	Recent strong wind may explain the absence of litter within transects, or in some situations, it might explain litter loads from litter that has been blown onto a site. Signs of recent strong wind include a site that is mostly free of litter with the exception of high build-up of litter along one boundary or catchpoints in one side/corner of the site. Fallen trees and tree debris on the ground may also be a sign of strong wind.	Yes No

Kerbside bin collection	✓	✓	✓	✓	✓	✓	If kerbside MSW bins have been recently emptied, the this can explain higher litter loads on residential streets due to spillage and tipped bins. This activity is acknowledged when the majority of households at residential sites have their bin left out on the kerb and the bins are empty. This this is an indication that the bins have recently been emptied.	Yes No
Other (recent event)	✓	✓	✓	✓	✓	✓	An opportunity for surveyors to flag other recent events or activities that might explain increased or decreased litter loads at the site. The event, activity or reason can be documented in the Site Notes field.	Yes No
Site grass area recently mown[53]		✓	✓	✓	✓	✓	Observable fresh cut grass (v's dry grass, or not cut) with medium to high level of confidence. Litter is often supposed to be cleared from a site before mowing. If not cleared, mowing can explain many smaller fragments of litter. Recently is defined as within the last 7 days. There will be instances were only a portion of the grass at a site has been mown. An additional indicator will capture an estimate of the site area that has been mown.	Yes No
Fast food restaurants nearby	✓	✓	✓		✓	✓	As above. Nearby is defined as with visible distance from the general site boundaries. For example, 50m from the first transect location or from the entry to a park or beach. Surveyors are not expected to walk from the site to identify the nearby presence of these site types.	Yes No

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[53] Context variable 'approximate percentage of grass of the site that was recently mown' was included in an early draft and later removed to address concerns of capturing too much context data.

							Whilst fast food restaurants and convenience stores produce similar types of litter, it can be useful to differentiate between them	
Convenience stores nearby	✓	✓	✓		✓	✓	As above	Yes No
Near a construction site	✓	✓	✓	✓	✓	✓	As above	Yes No
Public transport stop	✓	✓	✓	✓	✓	✓	As above	Yes No
Public buildings: schools, churches, libraries, hospitals, aged care facilities or other	✓	✓	✓	✓	✓	✓	As above	Yes No
Bins present at the site (waste, recycling , cigarette butt)	✓	✓	✓	✓	✓		**Beach and park:** Count the number of bins within 100m from the beach and park entry point **Streets:** Count the number of bins on both sides of the street within 50m from the site GPS point. Start from the side of the street closest to the GPS point. From the footpath, surveyors should face the street and turn right to the make the first observation. On the other side of the street, surveyors should face the street and turn left to the make the observation. The number of bins from both sides of the street should be totalled and entered into the form. Bins may be present on main roads at truck-stops/rest areas. These areas would be 'exclusion' criteria for a site.	Yes/No for General waste, recycling, cigarette butt bins
Bin full or overflowing	✓	✓	✓	✓	✓		Full or overflowing bins in the site area may be a source of litter within transects.	Yes No
BBQ facilities present					✓			

Illegal dumping present at site	✓				✓		**Beach & park:** Look for dumping within 50m from the beach and park entry point	Yes No
Scale of illegal dumping	✓	✓	✓	✓	✓	✓	Provide some data on the scale of dumping on the site. If there are multiple occurrences of dumping on the site, aggregate all the dumped rubbish together to make a judgement on the scale of dumping. A simple series of photos can be included in the AusLM Field Manual to assist surveyors make an assessment about the quantity of illegal dumping present.	Small - About 1 wheelbarrow or 1 or 2 garbage bags full Medium - About one utility vehicle (ute) tray Large - Truck load
Age of litter at site	✓	✓	✓	✓	✓	✓	If mostly new litter, this may indicate there is a cleaning routine present or there has been a recent clean-up at the site. If mostly old litter, this may indicate the site is not being frequently used or that the clean-up services are not very effective/thorough Whilst there is some subjectivity in this judgement, the new/old status can be informed by: - how clean litter items are - how clear or faded litter item packaging is - how decomposed fruit scraps are	New Equal amounts of new and old Old Unsure
Significant hazard or risk observed	✓	✓	✓	✓	✓	✓	Flag the need to report to land manager any hazard that needs attention. Also flag if site notes need updating. Hazard details can be written in site notes section.	
Site notes	✓	✓	✓	✓	✓	✓	Other observations/comments from surveyor that may help with additional context information that explains the extent of litter if investigation needed.	
Departure time	✓	✓	✓	✓	✓	✓		

Transect Context & details							This subsection of the table lists context indicators that will be captured for each transect with a site that is audited.	
Start time	✓	✓	✓	✓	✓	✓	Time the transect audit starts.	
Transect number	✓	✓	✓	✓	✓	✓	All transects have a unique number at each site. Transects are typically numbered 1 – 6.	
Transect GPS coordinates Start	✓	✓	✓	✓	✓	✓		Lat & Long
Transect GPS coordinates End	✓	✓	✓	✓	✓	✓		Lat & Long
GPS accuracy	✓	✓	✓	✓	✓	✓		+/- m
Compass bearing	✓				✓		For recreational parks and beach sites it has been suggested that using a compass bearing from the start GPS point may be more efficient means of setting a course to the end point. The compass bearing that the transect follows should be captured during the first audit of the site. A true north bearing should be used.[54]	compass bearing
Indication if the transect width is mostly constant							To calculate litter density (x items per 1000m2) AusLM needs to be able to calculate the area audited within each transect. Whilst start and end width and length can be measured (on site or via GPS coordinates) and used to calculate the area, there are instances where the shape of a transect may not be a uniform rectangle or trapezoid shape. This can happen when a property boundary or shop frontage (industrial site/retail site) or footpath (residential site) are curved or have significant variance across the length of a transect. The width may also be	Yes No

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[54] A basic background of true north can be found here: https://adventure.howstuffworks.com/survival/wilderness/true-north.htm#pt1

							non-uniform where a transect goes around a corner and the other street/road has a different width. Transect widths at Beaches, Parks and Main roads are fixed and therefore should be constant. Transects have a fixed width. You should select 'Yes'. If there is a fairly uniform/straight transect edge, but the start and end widths vary by +/- 1 m or less, then we can still say the width is fairly constant. If the difference between the start and end width is greater than 1 m, then it safer to mark the transect is not mostly constant – see bottom image on next page.	
Transect width at start and end points	✓	✓	✓	✓	✓	✓	Some transects will have a fixed defined width (parks/roadsides). Street footpaths will have variable widths. Measurements are to be taken at the beginning and end (and any other key points where the width might change) to supplement/ground-truth GIS calculations.	
Transect length	✓	✓	✓	✓	✓	✓	transect length is supposed to be fixed based on the site type. This is a redundant field. Quality control measure to ensure correct distance measured. (Metres)	
Photos of the start and end points. Photo looking from the start point towards the end. Photo looking from the end point towards the start point.	✓	✓	✓	✓	✓	✓	Photos of start/end points taken on the initial audit can help surveyors find the exact start/end point on subsequent audits. Landmarks or features should attempt to be captured in the photos. Ideally, digital photos would be marked up to mark the exact start/end point (circle or cross the location). Photos taken from the start/end points looking forward/backward over the transect can help with quality control and future enquiry if results are questioned.	

Transect context to capture after litter count							Some transect specific data might be best collected after the count.	
Which of the following items were included within the transect	✓	✓	✓	✓	✓	✓	Identifying specific transect features will help explain variance in the amount of litter within transects of the same site. These features may explain the type of litter within the transect (e.g. BBQ), or the amount of litter (catch points such as mow lines). Hard rubbish typically refers to household items (furniture, white goods) that has been deliberately placed on the nature strip by households in an orderly manner with Council requested to come and collect the items. Hard rubbish is often labelled with a collection sticker. Some Councils have specific week(s) dedicated to hard rubbish collection and this scenario is dealt with in Section 3.7 Deferring site monitoring).	BBQ area Tables/benches/seating Playground Mow line (were shorter mown-grass borders taller grass that can 'trap litter') Fence/temporary fence Ditch or drain Garden beds Raised planter boxes Public transport stop/transit centre Hard rubbish
Length of grass		✓	✓	✓	✓	✓	Grass acts as a catch point. Longer grass may catch more litter. Length of grass may help explain variance in the amount of litter counted. Length of grass may vary across the site and it has been recommended by the peer reviewer that this be moved to be captured at the transect level. This indicator will capture a subjective average grass height.	Short (0 - 9 cm) Medium (10 - 19 cm) Long (20+ cm) N/A – Select if there is no grass within the transect.
Indication if any estimation techniques were used in	✓	✓	✓	✓	✓	✓		

|								
the Litter Count at the transect.								
Presence and scale of illegal dumping within the transect	✓	✓	✓	✓	✓	✓		
Transect notes	✓	✓	✓	✓	✓	✓		
Time the audit of the transect ended.	✓	✓	✓	✓	✓	✓		
For beaches only – Indication if 2 m into the dunes/vegetation behind the start point was audited	✓						The first 2 m of vegetation/dunes at the rear of the beach is noted to be a litter catchment point those other methods (CSIRO beach litter survey methodology, AusLM Peer reviewer) that should be included in the transect (where possible). This field records if the 2-metre area at the rear of the beach behind the measured transect start point was surveyed.	Yes No
For beaches only – Indication if there is a hard engineered structure at the rear of the beach.	✓						Sea walls or boardwalks are some common hard engineered structures that may be at the rear of the beach. These may also act as a physical barrier that trap litter.	Yes No
Litter count form photos	✓	✓	✓	✓	✓	✓	Capturing a photo of the front and back sides of the litter count form is useful for record keeping purposes and is most useful when site and transect context data is captured directly on a mobile device whilst in the field. It may be more efficient to enter data captured on Transect Litter Count forms at a later time to reduce time spent in the field.	

94

Transect context to capture as part of the litter counting process								
Audit date	✓	✓	✓	✓	✓	✓		
Site ID	✓	✓	✓	✓	✓	✓		
Transect number	✓	✓	✓	✓	✓	✓		
Estimated area of the transect not audited	✓	✓	✓	✓	✓	✓	Areas of the transect may not be audited due to exclusion criteria (e.g. a hazard or exclusion criteria, parked car within transect). The total area not audited should be estimated in m2. Description of area not audited can be added to site notes. Can be used during analysis to more accurately calculate the transect area audited to more accurately determine the litter density at the site.	

Stakeholders in Queensland have expressed an interest in adding an additional contextual indicator to flag if a beach area being audited is covered with shells, rocks or sediment that makes the area difficult to accurately audit and see littered items, specifically small plastic items. Whilst this is a valid concern, the AusLM minimum item size is 2.5 cm, this should minimise the difficulty identifying littered items amongst debris.

95

6.5 Annex 5. Litter Fragment Size Guide

Sample guide only. This guide is not at the correct scale

AusLM Fragment size guide

Size 3. Large
> 16 cm

Size 2. Medium
> 8 cm to 16 cm

Size 1. Small
> 2.5 cm to 8 cm

Ignore
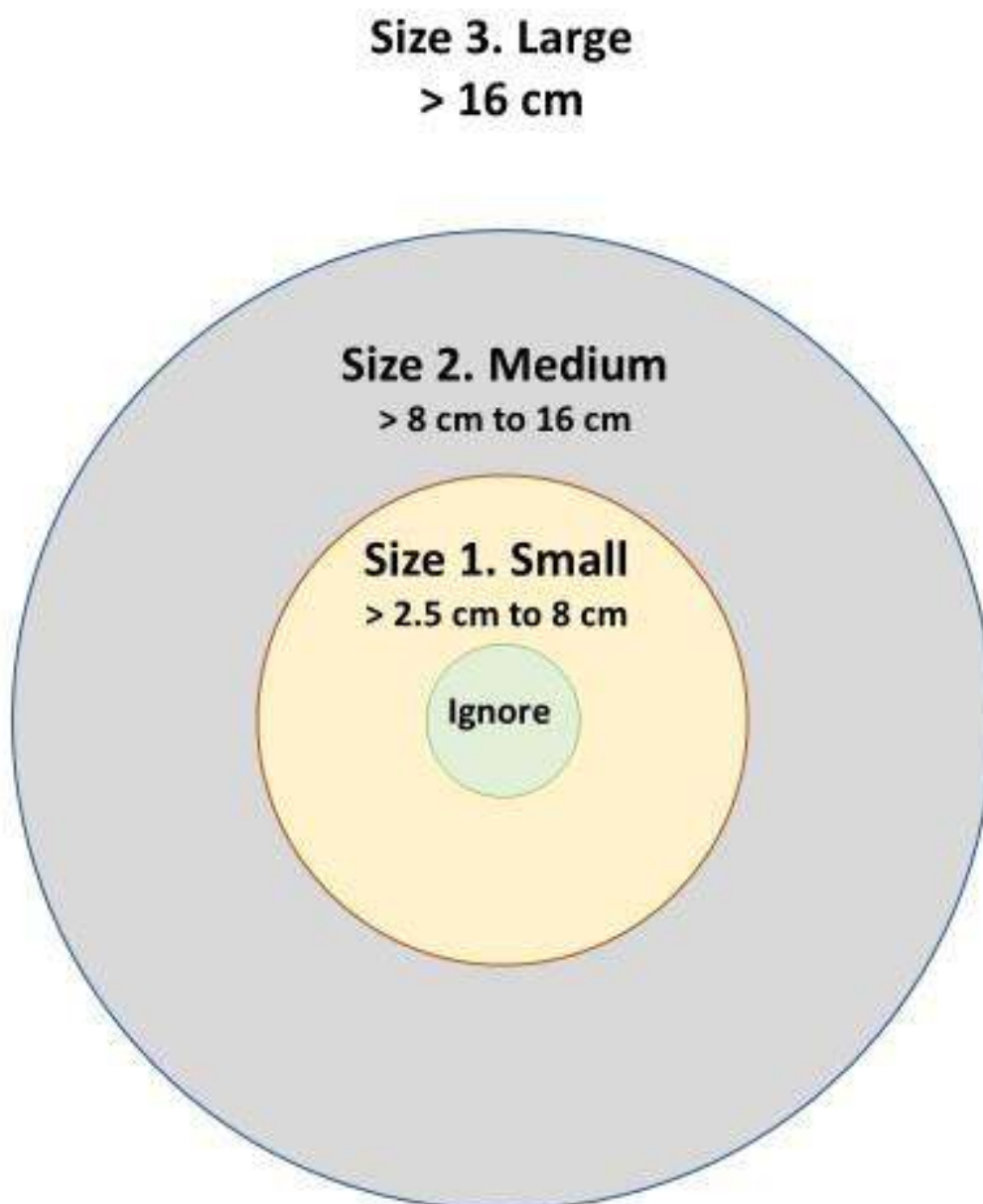
The centre circle is 2.5cm in diameter. This is the minimum size of items included in AusLM (noting some exceptions such as cigarette butts, bottle lids, bottle caps and can ring pulls).

6.6 Annex 6. Extract from AusLM Core Monitoring Program discussion paper

The extract below is from the *Options for the AusLM Core Monitoring Program – Discussion paper*, developed for the PWG.[55] It relates to the material on sample sizes and the structure of the AusLM monitoring program in Section 4.6 of this Specification.

Elements of the AusLM Core Monitoring Program for discussion

The main elements of the AusLM Core Monitoring Program that could be modified to accommodate the interests and constraints (i.e. resources) of different jurisdictions are:

- **What sites are surveyed** – not all the AusLM site types need to be part of the Core Monitoring Program
- **What regions are surveyed** – both metropolitan and regional areas do not necessarily need to be part of the program.
- **How often monitoring occurs** – monitoring might be able to be done more or less frequently, depending on jurisdictions' needs.
- **How many sites are surveyed** – is a question of how much confidence jurisdictions want in the results each survey period.

Each of these are summarised in Table 26 and discussed more in the sub-sections below.

At its most simple, the AusLM Core Monitoring Program could be a single sample at a single site. This would require very limited resources. It is unlikely, however, to address the objectives of the monitoring program and be a reliable basis for decision making. At the other end of the spectrum, the AusLM Core Monitoring Program could include extensive sampling of a very wide array of sites through time. While this would produce robust data, it is not clear whether it would necessarily be any more useful for decision making, despite having substantial resourcing implications.

To address this tension, the methodology outlines the pros and cons of different approaches to the various monitoring program elements in the sections below. Our suggestion for the AusLM Core Monitoring Program is summarised in Table 26 below.

Table 26. Summary of recommendations/discussion points for the AusLM Core Monitoring Program.

Element	Proposal	Rationale
Sites	Residential Parks Retail	These provide a good mix of sites that are readily surveyed and are representative of large areas of urbanised land (residential), have moderate to high litter loads (retail, highways) and open spaces that are sensitive to amenity impacts (parks).

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[55] Options for the AusLM Core Monitoring Program – Discussion paper. 19 January 2021. Developed by PREA for the PWG

Regions	Capital cities	This allows for trends to be tracked within jurisdictions, compared between jurisdictions. States/territories can then develop a tailored program for understanding and monitoring outside of capital cities.
Frequency	Twice-yearly	Accounts for seasonal variability and provides additional data points for short- to medium-term analysis of new policies
Sample sizes	Adjusted based on cut-down site types	see Section 4.6

What sites are surveyed

The AusLM is currently designed to be used at six different site types. These were selected, initially, because:

- they enabled some backwards compatibility with other methodologies
- they were reflective of broad types of land use and situations where litter is likely to be found
- they were considered to be interesting and informative to litter managers.

Carparks and shopping centres were excluded from the AusLM in the interests of safety, public access and consistency.

The six sites currently scoped for the AusLM could be scaled back to a smaller group of sites. This would reduce the resourcing required for the AusLM Core Monitoring Program.

To inform discussions about what sites could be included or excluded, it is worth considering a range of existing data (Table 27):

- the area that sites might be representative of
- the level of litter likely to be at sites
- the overall litter load the sites represent (i.e. the area by the density of litter)
- the level of variability typical of a site type.

Table 27. Land use, litter prevalence and litter variability at different AusLM site types (based on NLI and other existing data).

Site type	Approximate area in metropolitan regions[56]	# of NLI sites	NLI load (volume / pieces)[57] per 1000 m2	Overall load[58]	Relative variability[59]
Beach	0.1%	16	1.86 / 47	Medium	High (52)
Park	0.6%	13	0.83 / 20	Medium	High (58)
Residential	89%	26	2.45 / 29	High	Medium (21)
Retail	0.2%	15	2.61 / 97	Medium	High (47)
Industrial	0.2%	17	5.65 / 73	Medium	Medium (16)
Highway	2%	27	5.50 / 34	High	Low (7)

Other criteria that are worth considering are:

- whether sites (and the litter at those sites) represent areas that people commonly encounter (i.e. contribute to amenity impact)
- whether sites are available in all jurisdictions
- the relative effort to survey sites
- the information gained from sites for decision-making.

Table 28 integrates these considerations with the data from Table 27 to consider the usefulness and challenges of each site type for the AusLM Core Monitoring Program.

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[56] Based on sample of Melbourne LGAs using 2016 land use mapping data from the Victorian Land Use Mapping Information System (https://discover.data.vic.gov.au/dataset/victorian-land-use-information-system-2016). Beach estimates relate to 'Protected seascapes'. Park data is based on parks and gardens, reserved land and nature reserves (this may be an overestimate). Retail and industrial is thought to be an underestimate as some commercial and industrial land has been classified as residential. Nevertheless, the data is indicative of the broad scale of land use types.
[57] Based on national NLI data from 2017-18.
[58] Based on the product of area and average litter load
[59] As indicated by the number of surveys required to get a 15% confidence interval. Source: Post container refund scheme litter monitoring. March 2020. Report for Queensland Department of Environment and Science. A Prince Consulting Pty Ltd

Table 28. Criteria (pros and cons) for assessing the value of different site types for the AusLM Core Monitoring Program.

Site type	Potential for amenity impact (based on use)	Relative litter density (see Table 27)	Contribution to overall litter load (Table 27)	Available in all jurisdictions	Relative effort	Other considerations
Beach	High – people regularly attend beaches for recreation; beaches have an 'iconic' status	Low-Medium	Medium	No	Medium – require transect placement and timing of surveys around tides	Metro beaches are regularly cleaned, there are other monitoring programs that can provide information on litter in the marine environment
Park	High – people regularly attend for recreation; litter may be particularly impactful on children	Low	Medium	Yes	Medium – requires surveying along multiple transects	A good example of an 'open space' recreation environment that is dissimilar to residential, retail etc.
Residential	Medium – residential areas are likely to be frequented by people as part of their day-to-day activities	Low	High	Yes	Low – easily established and surveyed	As representative of a large area of land that is easily surveyed, residential areas are important from a monitoring perspective
Retail	Medium – people are likely to visit retail areas as part of their day-to-day activities	Medium	Medium	Yes	Low – easily established and surveyed	Publicly visited areas with reasonable litter loads that could be useful for tracking trends through time
Industrial	Low – these areas are likely to receive lower levels of traffic and are	High	Medium	Yes	Medium – easily established but surveying can take	The high litter load at these sites means they may be more sensitive to litter trends, but their size and

	often in less visually appealing areas				longer because of loads	demography raises questions about how representative they are
Main Road	Medium –likely to have lots of people use them, but visual impacts may be reduced because of speeds	High	High	Yes, but differences between jurisdictions are difficult to standardise	High –higher danger, more complicated transect layout	As they have low variability, even a smaller sample could provide good value.

It is also important to note there is interest in expanding the six AusLM site types to encompass a broader range of site types for surveying/monitoring:

- transport interchanges/stations
- inland waterways (rivers/lakes)
- commercial/office areas (e.g. central business district)
- carparks (at tourism venues, recreational areas, etc.).

Jurisdictions will consider developing site types for the AusLM to enable surveying of these sites, or a flexible 'generic site' that can be applied in other contexts. They have not been assessed for inclusion in the AusLM Core Monitoring Program because of:

- a lack of compatibility with previous datasets
- they are not a substantial land-use type at the scale of a city (in terms of area).

Regions

In its first iteration, the AusLM Core Monitoring Program proposed to:

- focus sampling on the capital cities of each state/territory
- have a smaller level of sampling in 'regional' areas of the jurisdiction.

This aimed to recognise that litter trends may be different in non-metropolitan areas and that states and territories have had limited data in the past.

The challenge with sampling regional areas as part of the AusLM Core Monitoring Program, however, is:

- the additional level of effort involved (particularly for large states)
- the variety of types of regional areas (size, remoteness etc.) and the comparability of regional areas between jurisdictions.

Whilst jurisdictions developed and agreed to a standardised approach for identifying and surveying regional areas, this might not be the best use of resources for all jurisdictions – it might be 'shoe-horning' the sampling program into areas that are not necessarily of greatest interest to jurisdiction-level stakeholders.

An alternative is for the AusLM Core Monitoring Program to focus just on capital cities (they become the 'core area' that is comparable between jurisdictions) **and for jurisdictions to develop their own monitoring program for regional areas** based on their individual needs. This could include:

- more extensive sampling across the entire jurisdiction, including to regional and remote areas that might not have good litter infrastructure
- less frequent sampling that means that long-term data is still collected, but the costs are more manageable.

Frequency of the AusLM Core Monitoring Program

It was initially proposed the AusLM Core Monitoring Program should be implemented twice per year. This was to:

- pick up on seasonal variability – particularly given seasonal changes can work differently in different parts of the country (e.g. summer may lead to higher litter loads in southern states as people become more active, but lower litter loads in northern states as hotter, wetter weather keeps people inside)
- provide more data points for trend-analysis over the short-to-medium-term.

There was also a strong recommendation from peer-reviewers to maintain the twice-per-year surveys (for the above reasons).

There is good rationale to maintain this frequency of sampling, at least for the AusLM Core Monitoring Program:

- the suggestions in this paper to move towards a smaller, more focused AusLM Core Monitoring Program will reduce the resourcing requirements required for the program overall
- there is a general interest across the jurisdictions in annual (or more frequent) reporting on litter, meaning twice-yearly samples will provide more confidence in the data
- there are a range of policy initiatives being applied across the country (single use plastic bans, container deposit schemes, etc.) that will benefit from having more frequent sampling data to detect trends, at least in the short- to medium term (3-5 years) while these initiatives are implemented and bedded down.

Less frequent monitoring could be done at sites that are not part of the core monitoring program – for example, if jurisdictions wish to sample regional locations or different site types.

Sample sizes

The specification for the AusLM method and monitoring program provides a more extensive discussion of the original considerations and data used to determine sample sizes. **Table 29 below provides a revised assessment of sample sizes for the AusLM Core Monitoring Program** that:

- accounts for a reduced range of site types
- focuses more on having better, more cost-effective data from a smaller geographic area.

As with all of the commentary above, the suggestions below are for a 'minimum' or core sampling program that should provide useful data for all jurisdictions. If, however, jurisdictions require greater levels of confidence or insight, then this level of sampling can be increased. Alternatively, there may be cases where jurisdictions cannot justify the level of resourcing required and may have to reduce the level of sampling accordingly.

A key recommendation is to review the program and methodology periodically with the aim of identifying whether the level of variability in the data is sufficient for decision-makers.

Another suggestion is that sites below be spread across six locations in larger jurisdictions and four locations in smaller jurisdictions. It may be desirable for the specific location of highways to be tailored to the needs and interests of individual jurisdictions.

Table 29. Revised sample sizes proposed for the AusLM Core Monitoring Program

Site type	# sites for 15% error margin[60]	# sites for 10% error margin	Suggested # sites for AusLM - Vic, QLD, WA, NSW, SA	Suggested # sites for AusLM – ACT, NT, TAS	Rationale
Beaches	52	117			As noted previously, beaches are highly variable, have low litter loads and have questionable value given they are cleaned frequently and there are other monitoring programs.
Parks	58	129	**18**	**12**	Parks have low litter loads but are relatively large areas of land use and represent a common open space in which people might litter, or encounter littering. While they are reasonably variable the sampling suggested here should provide reasonable precision.
Residential	21	47	**30**	**24**	Residential sites are easy to survey and highly representative of urban land use and overall litter loads. As such, a large proportion of sampling effort is targeted to these sites. Together with their medium level of variability, they should provide a reasonably powerful and representative assessment of trends.
Retail	47	104	**18**	**12**	Retail sites have medium to high litter loads and are places where people may be commonly exposed to litter, making them a good representation of amenity impacts. While they are reasonably variable the sampling suggested here should reasonable precision.
Industrial	16	35			Though highly littered, industrial sites are not commonly visited by the general public and may not be a good use of core monitoring program resource.

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[60] Post container refund scheme litter monitoring. March 2020. Report for Queensland Department of Environment and Science. A Prince Consulting Pty Ltd

Main Roads	7	15	**8**	**8**	Main roads are heavily littered and represent a substantial area of land use. Their low level of variability means they are also well suited to monitoring trends through time, even with fewer sites. Note, however, main roads may need to be sampled in different locations in different jurisdictions depending on access/availability and interest.
Total			**74**	**56**	

6.7 Annex 7. Additional methods

Overview

The two methods outlined below have been developed in response to additional interest from the PWG:

- Generic sites – which could be transport interchanges (bus stations, train stations), public areas within retail precincts, foreshores, piers, campgrounds or any other publicly accessible area that users might want to assess litter abundance.
- Carparks – a site type that was originally excluded from the AusLM because of sampling challenges, safety issues and a desire to streamline the site types. It has been rescoped here to provide it as a further 'extensible' component of the AusLM.

Both methods sit outside the 'core' AusLM monitoring and the suggested jurisdiction-specific monitoring program suggested in this Specification. They have been scoped to be applied entirely at the discretion of jurisdictions or other stakeholders/organisations.

Importantly, the methods have not been field tested. There are likely to be a range of refinements/improvements to this method that will need to be made and fed back into the documentation of the AusLM.

Generic site

This approach to sampling could apply to a wide variety of sites. It was originally conceived in the context of a railway station when considering methods for transport interchanges. The station highlighted the high level of variability in the layout and structure of such sites – multiple entries and exits, waiting areas, gardens, crossings, access ramps, stairs, carparks, etc. Linear transects, such as used at other AusLM sites, would be difficult to apply consistently or representatively. It indicated the need for a generic method that allows different types of sites to be representatively sampled in a flexible but relatively simple way.

We suggest using a larger number of circular quadrats, randomly or haphazardly placed, to sample such sites. The basic process would be:

- **Define the site**. It is expected, as with other AusLM sites, the focus would be on areas that people are likely to use and/or that litter is likely to occur, potentially around a feature of interest (such as a station, a tourist attraction, etc.).
    - ○ Aerial imagery can be used, or the site defined on the ground and mapped later.
    - ○ Similar to AusLM 'Park' sites, natural boundaries such as fences, dense vegetation, paths and roads can be used for this.
    - ○ We suggest sites are of a similar order of magnitude in terms of size at about 200 m across their largest axis. Ideally, the 'tighter' the site the better – for example, if the feature of interest is a station, then ideally the site should not extend into the carpark, into residential or retail environments or across roads without clear reason (Figure 18; Figure 19).
- **Within the site, randomly (or haphazardly if fully random allocation is not possible) identify 20-30 locations for circular quadrats**.
    - ○ This could be done using GIS and identifying 20-30 sets of coordinates within the site. It could also be done at the site using a combination of random bearings and distances from an initial, haphazardly selected start point.

- o These coordinates/locations can be marked with a piece of chalk or small object (e.g. a rock) to identify the centre of a circular quadrat.
- o Quadrats have a radius of 1.5 metres and an area of 7.1 m^2.
- **For each quadrat, the surveyor stands on the marker and turns around a full 360°, identifying any litter that falls within 1.5 metres of the marker** (Figure 20). A tape measure or measuring stick can be used to confirm whether items are in or out of this radius (from the marker) – any items that are partly within the quadrat (partly within 1.5 m and partly outside of 1.5 m – i.e. touching the measuring instrument) are included.

Other considerations are:

- Sites that pose an unacceptable risk to the health and safety of surveyors that cannot be mitigated should not be surveyed.
- Areas to be excluded are any dense vegetation that cannot be walked through, fenced/restricted access areas, roads/tracks, inaccessible areas, etc. If a quadrat encompasses any of these areas but litter can still be identified (i.e. it is behind a fence) then it should be included, otherwise the area not surveyed should be noted. If the quadrat centrepoint falls within an excluded area, a replacement quadrat should be selected instead.
- The initial expectation is for 20-30 quadrats to be used at sites (noting that this is a relatively lower area of sampling than other AusLM sites). 30 quadrats (or more) should be the preference, though fewer quadrats might be used at smaller (e.g. <25 m long) or more heavily litter sites. Quadrat numbers should preferably only be reduced if litter is consistently being identified within quadrats – if many quadrats have no litter, more are needed.

Figure 18. Example of how the Generic Site approach could be used to sample a train station. Haphazardly placed orange dots indicate the location of circular quadrats for sampling litter.

Figure 19. Example of how the Generic Site approach could be used to sample a non-specific site type. Haphazardly placed orange dots indicate the location of circular quadrats for sampling litter.
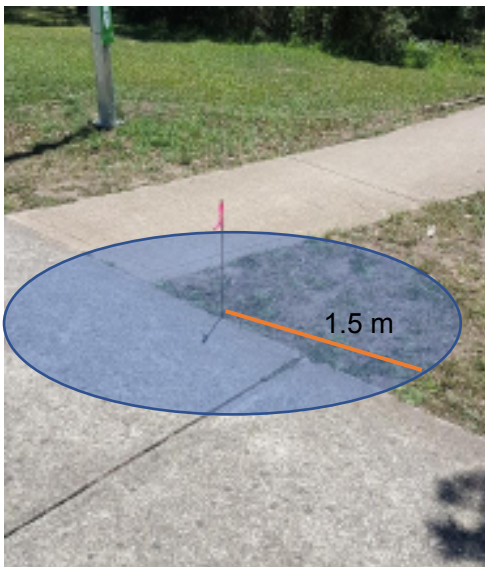

Figure 20. Example illustrating how a circular quadrat (radius 1.5 m) relates to a central marker. All litter within the blue shaded area would be counted.

Carparks

Carparks were not included in the original design of the AusLM because of concerns over:

- Safety – moving cars pose a risk to surveyors if they are identifying litter in the same areas as cars are located.
- Variability in sampling area – parked cars obscure the ground and make it difficult to reliably identify/count litter. Because car numbers fluctuate, they can create problems of consistency in the area being sampled.
- Variability in approach – carparks come in a diverse array of forms and so ensuring a standardised approach to sampling (mindful of the above two points) is difficult.

The approach outlined below could be used to sample carparks in a way that mitigates the issues above. The key aspect to note is that it would be **a survey of the gutter and area immediately bordering parked cars** (where people are likely to walk). It is not necessarily representative of the litter across the entire 'carpark area' as the middle of the road and the area where cars are parked is not sampled. However, it should provide a reasonably standardised and repeatable approach to sampling this type of environment.

Key steps are:

- **Note the location of the carpark** – this should be reasonably descriptive in the early stages before a more refined set of categories is developed (e.g. foreshore/beachfront carpark, shopping centre carpark, roadside, park, sporting facility, tourism attraction, etc.).
- **Define the boundaries of the carpark**:
    - Like AusLM Park sites, we suggest a rough limit to the site of no more than 200 m across. Thus, in Figure 21, there are multiple potential carparks to be sampled but the area has been defined as the area in the right of the image, which is roughly 200 m across with a clear entry/exit. Note that it is also a more formal carpark than others in the image (the others being on unsealed surfaces).
    - The site should not include frontages (e.g. retail, residential fronts) – the focus is on carpark infrastructure and the gutter/strip of land adjacent to cars where pedestrians can safely walk. If there is a retail frontage or similar, this would fall into the retail site type category.
- **Identify three transects to sample**. These can run along any non-road edge of the carpark that is adjacent to parked cars.
    - Figure 22 shows three haphazardly placed transects for the first site, Figure 23 shows a range of possible transects for a second site, as well as areas that should not be sampled.
    - Transects are expected to be up to 100 m long. Also note that, in small carparks, they may be quite short (10-20 m).
    - Transects are 2 m wide and extend from the pedestrian area into the gutter (in the same way as sampling happens for residential, retail and industrial sites). If there is no defined gutter, the back of marked parking spaces should be considered the gutter and thus the limit of sampling (or the equivalent estimate in non-marked carparks). The transect notes should clarify whether a gutter is part of the transect or not.
    - In some cases, 2 m may be too wide for the available area. If this is the case, the transect width can be reduced, but should be as wide as possible (and measured and recorded as such).

- **GIS should be used to estimate the size of the carpark**, including the # spaces. The proportion of carpark area surveyed should be included in the data (i.e. survey area/total carpark area) as this will differ for linear (Figure 22) versus square (Figure 23) carparks and could be a covariate in analyses.

Figure 21. Shows delineation of a carpark site in a case where there are multiple potential carparks. The site follows the natural boundaries of the carpark (i.e. there are marked bays, as compared to other carparks in the image). The sampling area follows the edge of the parked cars, as shown in Figure 22 below.

Figure 22. Potential layout of transects (orange lines) at a carpark site

Figure 23. Alternative carpark site showing multiple ways that transects could be surveyed as well as areas that would be excluded. Any combination of these transects could be sampled.

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