ON-FARM LIME EXTRACTION GUIDELINES

SOUTHCOAST
NATURAL RESOURCE MANAGEMENT INC.

Practical guidelines for growers on WA's South Coast to assess the opportunity and potential impacts of developing on-farm lime sources.

www.southcoastnrm.com.au SEPTEMBER 2018

Acknowledgements

These guidelines have been developed as part of the South Coast Natural Resource Management Incorporated project, 'Optimising Lime for Agricultural Sustainability in the Shires of Esperance and Ravensthorpe', which has been funded by the Goldfields-Esperance Development Commission.

A 'Technical Advisory Group' guided development of the project. Membership included industry experts, growers and representatives of regulatory authorities. Key topics included discussing soil acidification, lime, the unique situation on the South Coast and opportunities and challenges associated with on-farm lime extraction. A list of Technical Advisory Group members and the guideline authors is included at the end of this document.

Project Funded by Goldfields - Esperance Development Commission

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Cover photo: Consulting Great Southern. A South Coast Lime pit. Note: Extraction is still occurring from this pit and final rehabilitation has not commenced.

Key Steps for the 'on-farm' lime extraction

1 Understand what is happening in your soil – managing soil acidity (SECTION 1)

Soil acidification is a natural process accelerated by agriculture through the movement of nitrates beyond the root zone and removal of food and fibre. It can impact on the productive capacity of the soil. Knowing your soil pH and the quality of lime you use is critical for an effective liming.

2 Understand the liming cost - lime requirements and supplies (SECTION 2)

Transport and spreading costs are related to the total volume of lime required. Carting high-quality lime over long distances may be as economic as using higher volumes of poorer quality lime from a nearby source.

If you identify sourcing lime from a nearby source as the most cost effective option, you may consider 'on-farm' lime extraction.

3 Identify an on-farm lime resource and site selection (SECTION 3)

If there is an on-farm lime source, testing the quality of the lime is the first step in determining if developing a pit will be feasible. If lime quality is suitable on your property, establish objectives for the pit and consider site selection.

4 Check your local government's requirement for extraction approvals (SECTION 4)

Talk to your local government as early as possible to acquire all necessary information in the applications. Local government applications are subject to local laws and policies as well as the Western Australian Planning Commissions state planning.

5 Establish a site and operation management plan (SECTION 4)

Environmental management, roads, infrastructure &mobile plant, cultural heritage and visual landscape and rehabilitation and restoration should be considered in the management plan. Master check list (**SECTION 5**) is designed to be useful when considering and planning on-farm extraction.

Esperance Coastline Photo: Consulting Great Southern

Introduction

Surface and subsurface soil acidity (measured as soil pH) is a significant economic and natural resource threat to the agricultural industry across the South Coast, and Western Australia at large. The results of soil assessment in 2005-2012 by Department of Agriculture and Food showed that 72% of topsoils and 45% of subsurface soil were below the targets of pH 5.5 and 4.8 respectively (Figure 1)(Gazey et al., 2013). Bulk lime in the form of lime sand, crushed limestone or dolomite is currently the most cost-effective way to address acid soils.

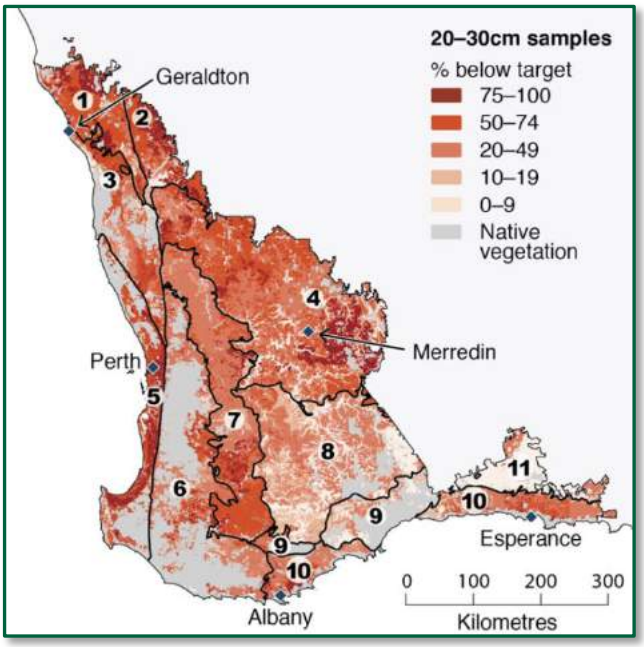


Figure 1: Percentage of sites sampled (2005-12) with soil pH at 20-30cm depth below the DAFWA target pH 4.8. Numbers 1-11 on map indicate 11 Ag Soil Zones. (Gazey et al., 2013)

This document provides an overview of the process for determining the most cost effective and efficient lime source for agricultural use on the South Coast, including the opportunity for on-farm lime extraction. Also provided is guidance in relation to planning for implementation of on-farm lime extraction and rehabilitation. This document addresses lime extraction on private land. Of significant importance to note is that where the lime is transported on a public road, between titles or is supplied to other growers (including neighbours), this is considered commercial use, which triggers additional approval processes. Thorough planning of a potential on-farm lime pit is required as aspects of the lime pit development may trigger other approval processes (i.e. clearing of remnant vegetation).

These guidelines should be used in conjunction with all relevant policies and requirements, as referenced herein. Raw material extraction on crown land or reserved land is not covered in this document and will be subject to other approval processes through the Department of Mines, Industry Regulation and Safety.

These guidelines are provided in six sections as follows:

Section 1	**Soils & Agricultural Lime**
Section 2	**Sourcing Lime in WA**
Section 3	**On-farm Extraction Planning**
Section 4	**Planning Resources**
Section 5	**Master Checklist**
Section 6	**References and Information Sources**

SECTION 1: SOILS & AGRICULTURAL LIME

This section outlines the need and importance of knowing the soil acidity levels on your property and then provides summary information on the science of soil acidification, managing soil acidity, and agricultural lime and lime quality.

> *"Soil acidification is an insidious process that develops slowly and, if not corrected, can continue until the soil is irreparably damaged"* (Moody et al. 2002 p19).

Soil acidification represents one of the greatest threats to production and natural resource management on the South Coast, with the application of lime being the most cost-effective broad scale management techniques available.

Know Your Soil pH

The only way to diagnose and make precise management decisions about soil acidity is to sample the soil and test the pH. Topsoil pH (0-10cm) can be quite different from the subsurface soil pH (10-30cm) and sampling only the topsoil may lead to inadequate lime applications. The Department of Primary Industries and Regional Development recommends sampling at 0–10cm, 10–20cm and 20–30cm in summer to determine a soil pH profile.

Further to soil sampling and analysis, monitoring changes in soil pH is an important part of soil acidity management. Re-sampling every three to four years will enable you to refine your liming program. Geo-location of sampling locations is highly recommended given the soil pH variances across paddocks. The Department of Primary Industries and Regional Development recommends sampling 25% of a farm each year enabling a four-year rotation to spread the costs of sampling.

On farm Lime crushing. Photo: Nathan Dovey

The Science of Soil Acidification

Soil acidification is a natural process that is accelerated by productive agriculture with the main causes being; the movement of nitrates beyond the root zone and the export of food and fibre from the farm. Soil acidifies because the concentration of hydrogen ions in the soil increases. Soils and agricultural production are not closed systems, so losses and gains impact on balances, in this case, soil acidity levels. The rate of soil acidification due to agriculture can be reduced but not eliminated – liming will always be needed to prevent soil from becoming too acidic.

Soil acidity is measured using soil pH in calcium chloride (pH_{Ca}). The Department of Primary Industries and Regional Development recommends soil pH_{Ca} values at or above 5.5 in the topsoil and 4.8 in the subsurface. The Department of Primary Industries and Regional Development website can provide further information on the science of soil acidification www.dpird.wa.gov.au.

The effects of soil acidity in the agricultural landscape centre around the impact of poor soil health on plant health, plant growth and the corresponding impacts on production and inadequate nutrient and water uptake. Specifically, acidic soils are directly related to:

- Aluminium toxicity through increased availability of aluminium affecting plant root health;
- Nutrient availability to plants being altered by soil pH with vital nutrients being less chemically available;
- Soil microbial activity being impaired, including nitrogen-fixing rhizobia bacteria; and
- Impaired plant nutrient and water uptake and corresponding issues that reduced plant growth have off-site impacts by contributing to salinization, sedimentation and eutrophication because of decreased water and nutrient uptake.

Acidic soils impact on rotation options for growers in the first instance and ultimately, can impact on enterprise and farm production and profitability.

Managing Soil Acidity

The Department of Primary Industries and Regional Development state that applying agricultural lime is the most cost-effective way of treating soil acidity. Liming programs are designed to recover acidic soils and/or maintain the recommended soil pH levels in the surface and subsurface as part of best practice soil health management and production. The amount of lime required will depend on the current soil pH profile, soil type, rainfall, farming system and lime quality.

The buffering capacity of a soil indicates the capacity of the soil to resist soil pH change. Soils differ in their buffering capacity. Soils with a high proportion of clay or organic matter have a larger number of surface sites able to accommodate hydrogen ions before they increase in the soil solution. Once acidic however, these soils are able to release hydrogen ions into the soil solution to maintain equilibrium and resist increase in soil pH. Clays are generally better buffered than loams, which are in turn better buffered than sands. Better buffered soils are slower to acidify but require more lime to lift soil pH when they do acidify.

Spring liming pasture Bodalin. Photo: Department of Primary Industries and Regional Development

The naturally acidic peaty sands of the south coast have a high buffering capacity and would require more lime to increase soil pH than other types of soils.

Managing soil acidity is part of overall soil health management, which requires a whole of farming system approach.

"It makes sense in terms of profitability, as well as environmentally, to recover and protect the soil resource," Chris Gazey, Department Primary Industries and Regional Development

Agricultural Lime and Quality

Agricultural lime is any product that is used to increase the pH of soil. In WA, the three main sources are: lime sand, limestone and dolomitic lime. The ability of lime to increase soil pH is termed its effective neutralising value. With a higher effective neutralising value lime, less lime can be used, or more area treated, for the same soil pH change. Two key indicators of agricultural lime quality are neutralising value and particle size regardless of source. Neutralising value is expressed as percentages relative to pure calcium carbonate. Lime with a higher proportion of finer particles will react quicker to neutralise acid in the soil because they have a greater surface area to react with the soil. Lime particles over 0.5mm are only 50% as effective as smaller lime particles in increasing soil pH in the short to medium term. Lime particles over 1mm have very little effect. Lime particles less than 0.25mm are considered to be 100% effective (Cregan 1989; Whitten 2002). Regarding processing, limestone and dolomite requires crushing and sieving whereas lime sand does not need much additional processing.

Lime is a non-renewable resource, and with the ongoing need to apply lime to Western Australian agricultural soils, the availability and cost of lime into the future is a major concern for growers and the wider agricultural industry. Lime sales have been steadily increasing since 2004, with a reduction noted

from 2015 linked to seasonal factors and commodity prices. While there is an increasing trend, estimates are that only 40-60% of the land area impacted by soil acidity in WA is currently being treated.

Barriers to liming have been identified as: cost (purchase, cart, and spread); benefits not immediately evident leaving growers to question return on investment compared to other investment opportunities; timing not suitable and time constraints, an adopted “wait and see approach” i.e. wait for acid tolerant varieties and difficulties associated with addressing subsurface soil acidification.

Lime supplies on the South Coast are limited and often of much lower efficiency compared to lime sources from the west coast. However, transport costs of accessing west coast lime are high, particularly for growers in the eastern parts of the South Coast region. It is crucial that growers assess the economics of their liming program as the efficiencies of this method of soil management vary with the quality of lime source and costs of such are greatly impacted by transport. With an increase in demand (from agricultural and other industries, including mining, power and construction) and loss of access through land use and tenure, additional lime pits on the South Coast will be required to provide lime to the agricultural industry into the future. A further option for consideration for South Coast growers may be on-farm lime extraction.

Having accurate measures of lime quality is critical for growers to determine lime sources and required rates. If quality is considered and rates are adjusted, then it is possible to get similar increase in soil pH with a lower quality lime with the real question being; does it pay to put more on of a lower quality or less on of a better quality, with transport costs a very important consideration.

Lime Trial Site: Left – control site. Right – post Liming. Photo: Department of Primary Industries

SECTION 2: SOURCING LIME IN WA

There are numerous considerations in sourcing lime on the South Coast, and across the growing region of WA, with strategies based on cost (impacted by quality and distance from source); convenience; effectiveness (lime quality varies according to neutralising value and particle size, rates and frequencies of lime application need to be considered); and budget and returns.

On the South Coast, the cost of transport and the differences in lime quality of South Coast lime sources compared to that of west coast sources, emphasises the need to consider lime supply sources carefully. Because of its geological history, the South Coast Region has much fewer and lesser quality lime supplies, than the west coast. The best quality lime supplies on the South Coast occur in coastal outcrops of Tamala and Tamala-like limestone, on coastal reserves and national parks. The cost of freight is a major constraint to growers purchasing high quality lime from west coast supplies. The transport cost issue is a greater problem for the eastern parts of the South Coast Region, particularly Esperance growers.

Lime Requirements

Liming is a key part of sustainable agriculture and sustainable natural resource management. A range of tools are available to assist in developing a liming program that meets the needs of soils, production methods and business (see Section 6 for further information). Importantly, growers need to be aware of the longer-term nature of investment in soil acidity management and the quality of the lime that is sourced. Further, other factors in how quickly lime will reduce acidity in a soil are independent of lime supply and relate to the buffering capacity of the soil. Therefore, soil quality analysis (surface and sub-surface), and ongoing monitoring, is critical. In determining lime requirements, key questions are:

Table 1: My Lime Requirements - Key Questions

My Lime Requirements - Key Questions	
1.	What is your starting soil pH?
2.	What is your target soil pH?
3.	Is your liming program for recovery and/or maintenance (this may be paddock specific)?
4.	Are there any another soil health issues that require addressing (i.e. non-wetting soils, soil compaction)?
5.	What is the quality of the lime source?
6.	What timeframe is your lime program working on?
7.	What application rate/s are required (linked to above)?
8.	What frequency of application are you looking at (linked to above)?
9.	What is your total lime tonnage required?
10.	Are there lime efficiency strategies to maximise return but limit annual requirement?
11.	What is your lime program budget per year (sampling, lime, transport and spreading)?
12.	Have you determined an investment strategy related to planned rotations?

Off-Farm Lime Supplies

There are more than 20 commercial lime pits operating in Western Australia. When accessing lime through commercial suppliers, growers are encouraged to request the most recent lime product analysis. Lime WA Inc. is an industry association providing information to users and producers about liming products available in WA. Many of the commercial pits in WA are members of this industry association whereby lime from these sources is independently audited annually and the members operate in accordance with the Western Australian Agricultural Lime Industry Code of Practice. The Lime WA Product Information Sheet provides a full breakdown of size distribution and associated neutralising values. Many pits do their own tests more regularly than the annual audit.

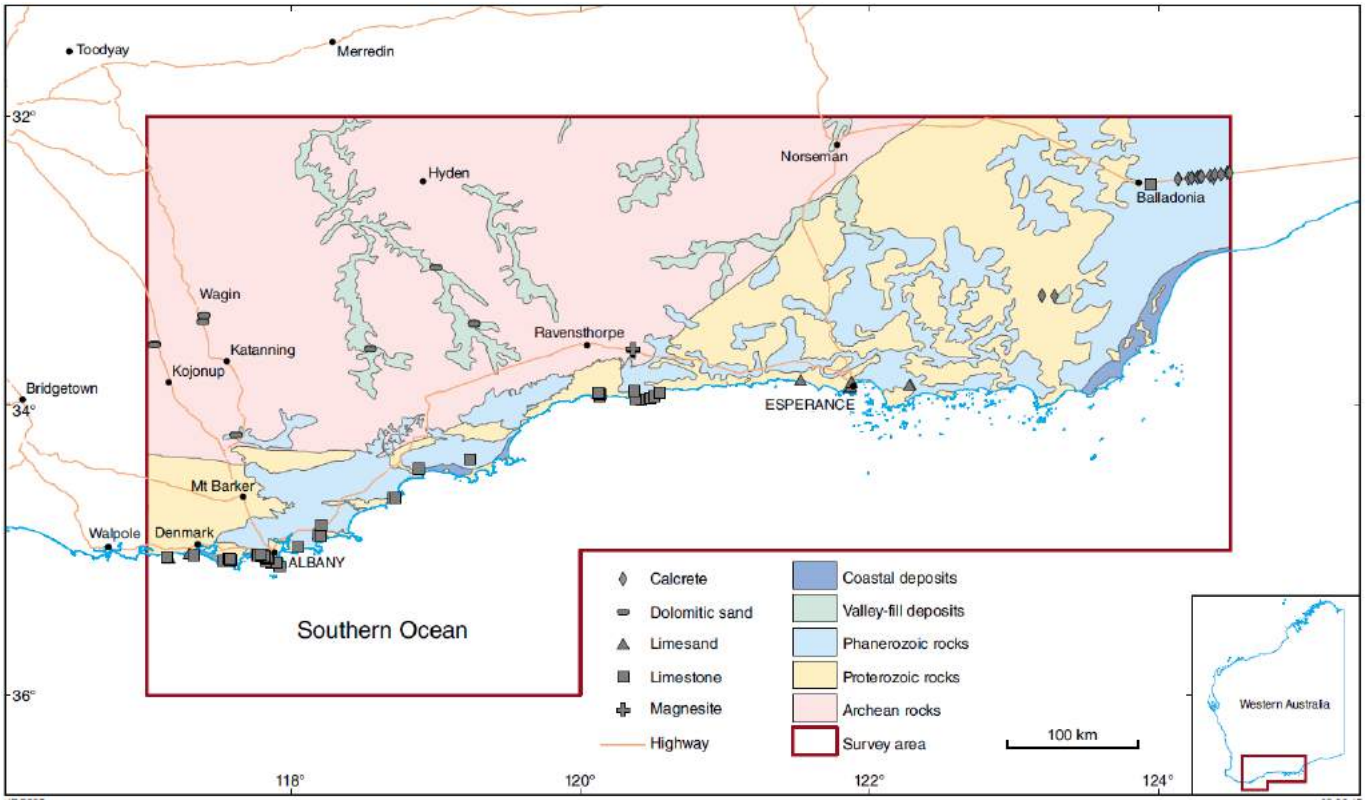


Figure 2: Limesand and limestone occurrences in southern Western Australia. Source: Geological Survey of Western Australia

A report produced for South Coast Natural Resource Management Inc by Dr Julia Fry in 2015 identified that in comparing South Coast (Figure 2) and west coast sources:

- For South Coast lime of higher quality than 50% efficiency, it may not be economical to transport lime from the west coast;
- For west coast lime of lower quality than 80% efficiency, it may not be economical to transport lime from the west coast if South Coast lime was 40-50% efficiency;
- For South Coast lime of very poor quality (< 30% efficiency) it would, in most cases, be more economical to transport high quality lime from the west coast;

- It would be better in terms of carbon emissions to use more of lesser quality south coast lime than to transport lime from the west coast (currently an environmental consideration, potentially this could be an economic rationale); and
- The economics of the comparison will vary from lime pit to lime pit and growers transporting lime from the west coast would need to be assured that the quality justified the extra cost of freight. For example, there may need to be certification that the lime transported from the west coast came from a pit with recent audit data. Therefore, it is important for growers to request lime quality data such as those available from Lime WA Inc. members.

Other factors identified in this report regarding effective cost of lime are:

- Lime product information is not available from all pits and lime quality can vary significantly within some pits;
- Lime can vary slightly in solubility, depending on the amount of aragonite, calcite or magnesium present (Morse and McKenzie 1990; Morse et al. 2006); and
- Freight costs are likely to increase more rapidly than lime costs.

In assessing and comparing off-farm sources, key questions are:

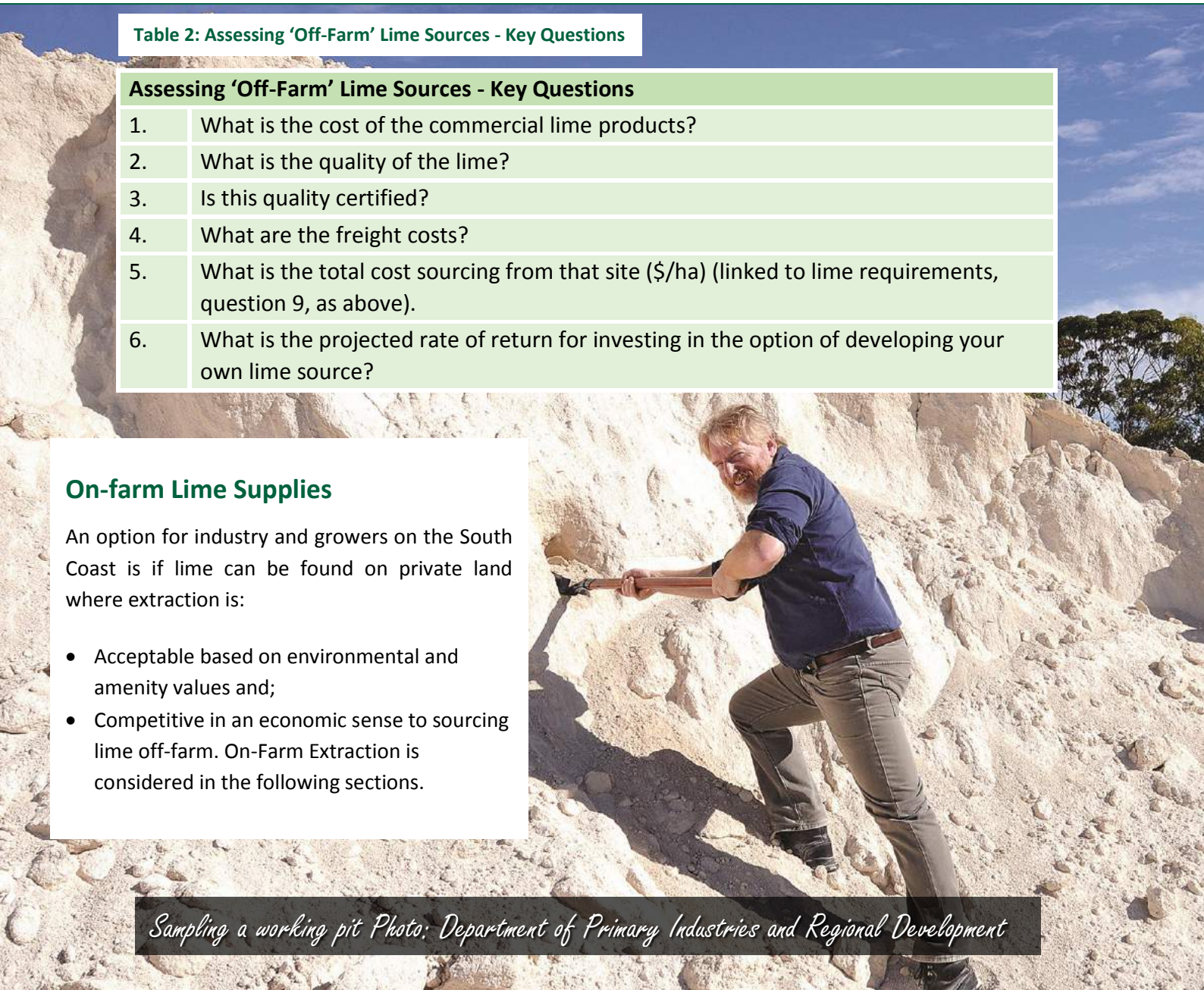
Table 2: Assessing 'Off-Farm' Lime Sources - Key Questions

Assessing 'Off-Farm' Lime Sources - Key Questions	
1.	What is the cost of the commercial lime products?
2.	What is the quality of the lime?
3.	Is this quality certified?
4.	What are the freight costs?
5.	What is the total cost sourcing from that site ($/ha) (linked to lime requirements, question 9, as above).
6.	What is the projected rate of return for investing in the option of developing your own lime source?

On-farm Lime Supplies

An option for industry and growers on the South Coast is if lime can be found on private land where extraction is:

- Acceptable based on environmental and amenity values and;
- Competitive in an economic sense to sourcing lime off-farm. On-Farm Extraction is considered in the following sections.



Sampling a working pit Photo: Department of Primary Industries and Regional Development

SECTION 3: ON-FARM LIME EXTRACTION PRELIMINARY PLANNING

This section sets out a staged approach to considering on-farm lime extraction. Comprehensive planning should enable the development, operation and final rehabilitation to run smoothly. It is strongly recommended that all on-farm lime extraction projects begin with identifying what you want to achieve during the life of the pit and the results you seek when the pit is expired. Considerations include successful approvals, extraction, sound financial management, sound natural resource management and successful site rehabilitation, restoration and also social consideration.

Stage 1: On-farm Lime Extraction Objectives

An important place to start, and often revisit, is what the on-farm lime extraction objectives are. These objectives will guide the development of your applications and determine if on-farm lime extraction is a viable option for sourcing your agricultural lime requirements. Some questions which may guide the development of your objectives are:

- Is the lime for on farm use, selling to neighbours or wider commercial distribution?
- What quality of lime is required to be financially better than lime sourced from elsewhere?
- What planning, development, operational and rehabilitation costs need including in financial planning?
- Is clearing of bush areas to be considered?
- What impacts on the arable areas of the farm are acceptable?
- What is special on your farm that you don't want to change?
- Is affecting neighbours and the wider community appropriate?
- What will the pit area be used for and look like when all the lime has been extracted?

Stage 2: On-farm Lime Source Prospecting and Site Selection

If you are considering extracting lime on your own property, it is likely you already have an idea that there is a lime source. Following are some of the methods that can be used for investigating, or confirming the presence of, quality and extent of lime sources.

- Sourcing airborne magnetic and radiometric surveys from the Department of Mines, Industry Regional and Safety. Visit http://www.dmp.wa.gov.au/Geological-Survey/Basic-Raw-Materials-1411.aspx for more information or contact the department directly;
- Ground truthing and local knowledge, current and potential sites of interest, which including landholder knowledge and prospecting;
- Initial investigation with hand tools (if promising, mark boundary with tape). In relation to testing, this should be done in a systematic manner during dry soil conditions, with due consideration of hygiene in sensitive environments;
- Identify potential sources of the lime whilst minimising the disturbance to vegetation;
- Drilling and sampling of potential sites;

- If machine exploration is required then a backhoe is the preferred machine, as this will enable the disturbed area to be minimised in comparison to using loaders or bulldozers;
- Analysis of samples for potential efficacy and economic value, comparisons are freight costs from commercial sources and quality of the on-farm lime source (SEPWA, 2017). Ensure that the need for crushing or other forms of processing is factored into the economic analysis; and
- Backfill and/or cap all sample holes once exploration is completed. Replace topsoil and debris last.

You may have already identified in your objectives there are certain areas of the farm you don't want to disturb which will focus the investigations to acceptable areas. Sites with low natural values should be utilised in preference to undisturbed ecosystems, e.g. power-line easements, cleared private property etc. Final site selection may need to be justified in these terms.

The Fizz Test

An in-the-field test to check if your sample is lime.

Gather a sample of the suspected lime in your hand, pour on a little household vinegar. If it fizzes, there is evidence of the sample containing lime. The speed of the reaction relates to particle size.

'Fizz test' – Some reaction evident in the foreground sample. Photos: South Coast NRM

Once a lime source is located that is suitable for on-farm extraction, there are various other aspects of site selection. These will depend on the scale and purpose of the proposed pit and surrounding landscapes and land uses. For example, the extraction site itself will need to allow adequate space for the pit, processing, operations and building, as well as overburden and topsoil management area.

Aspects of site selection that are important to consider are:

Table 3: Site Considerations

Site Location Considerations	
1.	The site has safe access to major roads, and existing roads are in good condition. The access roads proposed are suitable for the volume of traffic and type of heavy vehicles.
2.	The site is not in a visually significant location, such as on a ridge, or visible from major roads.
3.	The site is not situated within 500 metres to 1000 metres of any sensitive land uses, such as residential development, schools, and hospitals.
Environmental Attributes	
4.	The site is not considered priority agricultural land or other special designated local government area.
5.	The proposal will not involve major disturbance of acid sulphate soils.
6.	The proposal will not involve significant clearing of native vegetation, that is, the site is bare of vegetation from previous uses or does not contain good quality bushland of significant quantity.
7.	The site provides adequate setback to existing wetlands, water courses and drainage lines.
8.	The site is not listed as a Bush Forever area (Note: not relevant currently to South Coast landholders).
Planning Considerations	
9.	The site is not located in a local government special designated area.
10.	Land zoning in the local government scheme. Ensure the nature of the proposed activity is consistent with the current zoning, and any proposed zoning. Contact your local government to ensure the proposed site is in a zone where an extractive industry is permitted. It is recommended you also enquire about any other approvals at this stage.
11.	The timeframe for the proposed activity considers the long-term impact on the local community.

Dumping Lime – Wongan Hills. Photo: Department of Primary Industries and Regional Development

Site Selection Considerations	
12.	The proposed activity is compatible with surrounding land uses.
13.	The proposed activity will not cause disturbance to the amenity of the area.
14.	The site will not have a negative visual impact on major roads, scenic areas or adjoining properties.
15.	The site provides an adequate separation distance to any residential or special rural area, or existing dwelling in a rural area. Typically, separation distances should be 500 metres to 1000 metres – check with your local government.
16.	Operational issues such as hours of operation, noise and dust monitoring and site access are addressed with a view to minimising any potential noise or dust issues for surrounding sites.
17.	Other relevant state and local planning policies and strategies, including but not limited to the following have been addressed: • *State Planning Policy 2.4 Basic Raw Materials* • State Planning Policy 4.1 State Industrial Buffer Policy • Extractive Industry Local Laws • Local planning scheme provisions • Region scheme planning provisions
18.	Consider the potential for long term impacts on the values of the farm. Reduction in amenity or ongoing environmental issues may reduce the long-term value and attractiveness of the property.
19.	Consider staged development, provide for future expansion plans and ensure a rigorous rehabilitation plan which is fully implemented.
20.	Potential for impacts on cultural values. Checking the Department of Planning Lands and Heritage website for Aboriginal Heritage Sites or talking to members of the local Aboriginal community and/or local government is advised.

Depending on the outcomes of the assessment and analysis of the various values, there may be several pit locations to consider. Once the lime sources have been located on the property, potential extraction sites need to be identified, evaluated and compared, financially and quality wise, to other potential sites and to lime available from commercial pits.

Surface Liming South of Northam. Photo: Department of Primary Industries and Regional Development

Stage 3: Site and Pit Planning and Design

The process of selecting the site of the pit will likely have identified several factors to be incorporated into the site development phase. These considerations, operational requirements and pit closure (rehabilitation) plans, will all significantly influence the layout of the pit and associated infrastructure. Identification of extraction and processing techniques and associated infrastructure is required to produce the lime product in accordance with your objectives. Considerations that are particularly relevant at this stage of planning are listed below.

- Government planning requirements;
- Determine the preferred management arrangement such as landholder owned and operated or leased to a contractor;
- Access road location;
- Infrastructure location including building design;
- Services (power, water, telecommunications etc.);
- Extraction procedures;
- Occupational safety and health procedures;
- Drainage and run off management;
- Extraction planning and landform design over time;
- Vegetation management;
- Rehabilitation and restoration planning (including topsoil management); and
- Screening requirements.

Occasionally the pit design process may identify issues that can only be resolved with a new site for the pit, but this is unlikely if the pit location process has been thoroughly assessed and planned out.

Old Lime pit on a farm in Esperance. Photo: SEPWA

SECTION 4: PLANNING RESOURCES

The planning stages proposed in section three require knowledge and understanding of a range of issues, values and procedures. This section provides additional information on several aspects relating to lime pit planning and development. This information will likely be relevant for one or more steps of the planning process, dependent on the scale and scope of individual pits.

Relevant Legislation

There are numerous acts, along with related regulations, policies, codes, licence and approval processes relating to basic raw material extraction on private property. The triggering of many of these processes is dependent on the location of the proposed pit and the intended use for the lime (i.e. on-farm use or provision to neighbours or wider).

Table 4: Examples of relevant legislation – Planning process

Activity	Relevant Legislation	Relating Agency
Clearing permits	Environmental Protection Act 1986	Department of Water and Environment
Native title, Aboriginal heritage	Aboriginal Heritage Act 1972 Native Title Act 1993	Department of Planning, Lands and Heritage
Administration of planning approvals of WA Planning Commission, State planning policies	Planning and Development Act 2005	Department of Planning and Infrastructure and your local government
Land titles, easements and covenants	Land Administration Act 1997	Landgate
Safe working environments	Mine Safety and Inspection Act 1994 Occupation Safety and Health Act 1984	Department of Mines, Industry Regulation and Safety

Local Government & WA Planning Commission Approvals

Extractive industries on private land (freehold land) require approval under the Planning and Development Act 2005 with the approval authority for basic raw materials extraction being local government and/or the Western Australian Planning Commission. Anyone intending to extract any basic raw materials on-farm consults with their local government as early as possible.

It is important to note that the local government approvals and licence processes are triggered when a landholder:

a. Will be providing the basic raw material (i.e. lime) to a neighbour or other party, and/or;

b. The basic raw material leaves the original title from where it was taken, particularly if it will be transported on a public road.

The Western Australian Planning Commission has prepared a very detailed booklet: Basic Raw Materials Applicants' Manual (Western Australian Planning Commission, 2009). This document provides guidance on the basic raw materials extraction approvals process (Figure 3). Both the use of the land for this purpose and the extractive operations are subject to development approval.

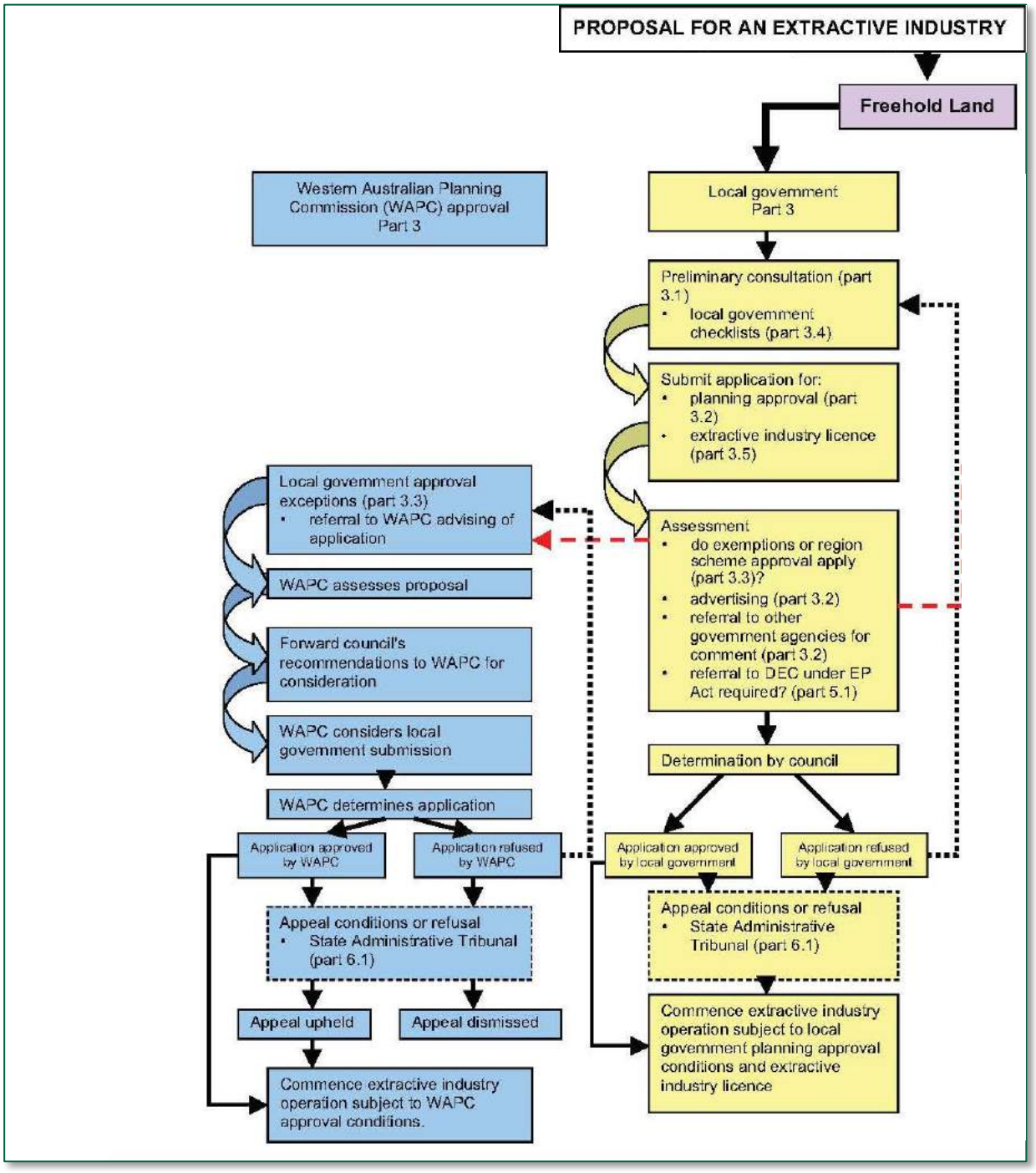


Figure 3: (Abridged) Proposal for an extractive industry process on private land (freehold land) (Source: Basic Raw Materials Applicant's Manual, Western Australian Planning Commission).

The Western Australian Planning Commission identifies seven key responsibilities for applicants proposing an extractive industry on private land (freehold land):

1. Be familiar with relevant legislation and guidelines,
2. Ensure site selection considers planning and environmental issues,
3. Consult with local government beforehand,
4. Consider a pre-application discussion with Department of Environment and Conservation,
5. Consider submitting applications simultaneously,
6. Allocate plenty of time for approvals, and
7. Be aware of your appeal rights and those of third parties.

Across the South Coast region, each local government has different requirements for establishing an extractive industry. Some local governments require an extractive industry licence only, some require both a development application and extractive industry licence, and others do not determine extractive industry applications but rather, refer them to the Western Australian Planning Commission for determination.

Applicants should familiarise themselves with the information contained in any relevant extractive industries Local Planning Scheme or policy, if applicable, to ensure they include all necessary information in their application. Local government applications are subject to local laws and policies as well as the Western Australian Planning Commissions state planning. A local planning scheme is the primary statutory tool for land use and development control at the local government level. Local governments must have due regard to the state planning policies when preparing and administering their local planning schemes.

Old Hammer Mill used for on-farm crushing. Photo: Nathan Dovey

Examples of South Coast Local Government Approvals Processes

Shire of Esperance

The Shire of Esperance utilises an "Extractive Industries Local Law" and licence application process whereby an annual licence is issued for a twelve-month period.

Shire of Ravensthorpe

The Shire of Ravensthorpe operates with a "Local Planning Policy: Extractive Industry" whereby a development application form is lodged, along with a detailed written submission and, detailed accurate and scaled plans. Council then considers the application and if successful, an extractive industry licence will be issued for a twelve-month period and may be renewed annually subject to no complaints being received.

City of Albany

The City of Albany operates with a Local Planning Policy and a local law. A Development application form is lodged, along with a detailed written submission and detailed, accurate and scaled plans and other information. The City then considers the application and if successful, an extractive industry licence will be issued for a twelve-month period and may be renewed annually subject to compliance with the conditions and no complaints being received.

TAKE HOME MESSAGE: TALK TO YOUR LOCAL GOVERNMENT AS EARLY AS POSSIBLE IN YOUR DECISION-MAKING PROCESS.

Your local government may require that an application be referred to neighbouring landowners for comment. Further, and depending on the nature of the application, the local government may refer the application to relevant government agencies during the assessment period for comment. These may include Main Roads WA, Department of Biodiversity Conservation and Attractions, and Department of Water and Environmental Regulation. The local government may also determine to advertise any application for extractive industry. It is also important to be aware if your proposed pit site is within a local government special designated area and you should discuss this with your local government very early in the planning phase. Once your pit is operational, your local government may not issue reminder notices for licence renewals, so the operator must ensure renewals are applied for in time.

Larger extractive industries may require registration or a license as a 'prescribed premise' from the Department of Water and Environmental Regulation.

Planning Checklist

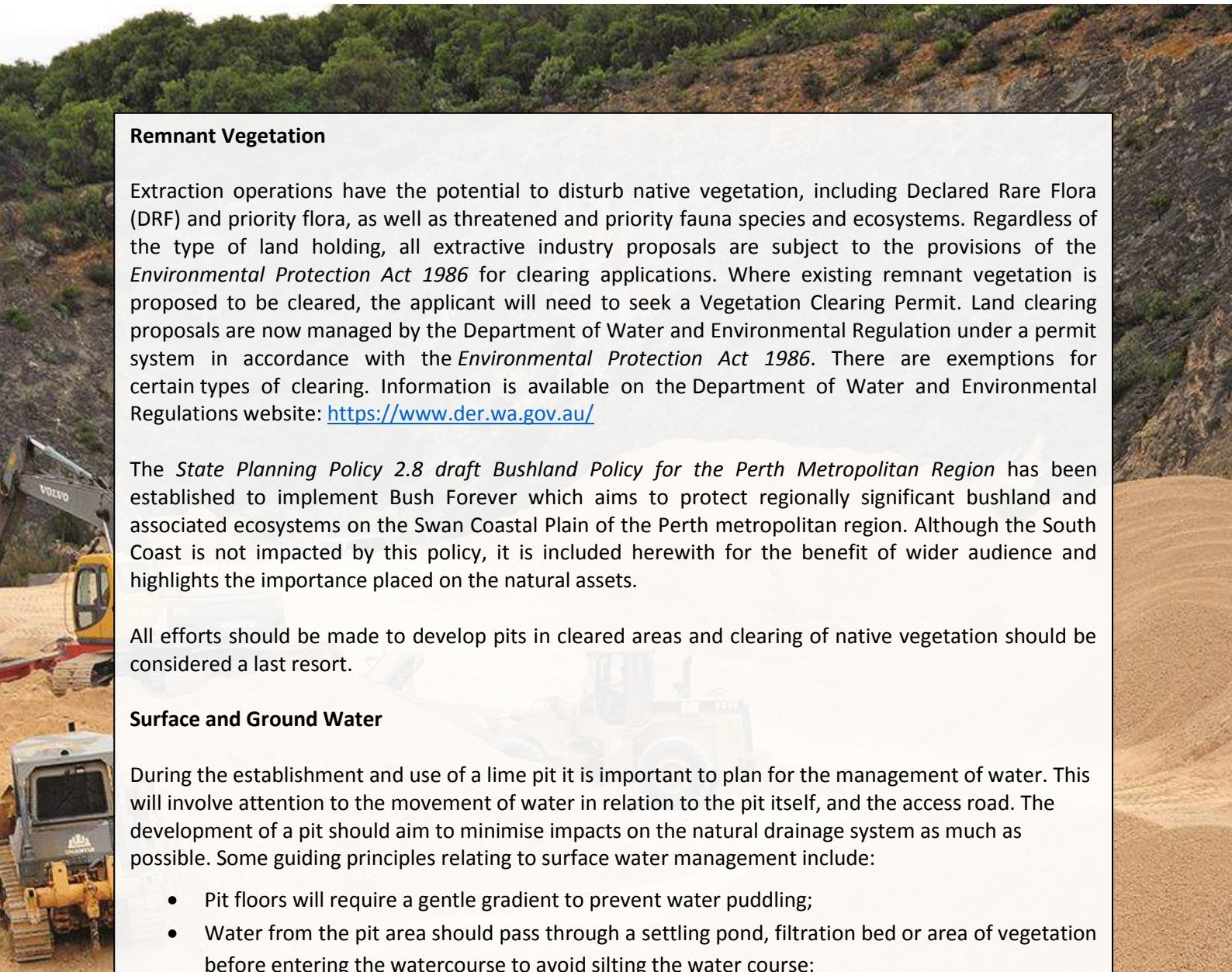
The following checklist may be useful when planning an extractive industry. Note: refer to the relevant local government's local law for more specific application requirements. (Adapted from: Basic Raw Materials Applicant's Manual, Western Australian Planning Commission).

Table 5: Planning checklist

Legal Considerations		**Tick?**
1.	Written consent from owners of site	
2.	Department of Water and Environmental Regulation approval – clearing permit (where applicable)	
3.	Extractive industry licence	
4.	Local government submission form and fees	
5.	WAPC submission form and fees (where applicable) – confirm with your local government	
6.	Certificate of title	
Site Details		**Tick?**
7.	Existing and proposed land contours	
8.	Description of land – roads, boundaries, fences, existing buildings, waterways, ridge lines, visibility, existing vegetation etc	
Proposed Extractive Industry Details		**Tick?**
9.	Location, total area, shaped, proposed angle of slope and depth of proposed excavation	
10.	Location, proposed angle of slope and proposed maximum height of stockpiles	
11.	How much material is proposed to be extracted (on an annual and total basis)	
12.	Method and route(s) of proposed vehicle access to and from the site	
13.	Location of proposed buildings, treatment plants, tanks etc	
Details of Management of Operation		**Tick?**
14.	Noise attenuation – hours of operation, types of vehicles to be used, maximum number of truck movements per day, earth bunding	
15.	Screening – location of screening and species to be planted, staging of operations	
16.	Dust management plan	
17.	Environmental management - measures to protect existing vegetation, acid sulphate soil management, dieback control, fire management, water quality management, drainage details, and treatment of wastes	
18.	Rehabilitation	

Environmental Considerations

As part of sustainable natural resource management, and in the event your pit requires a formal application process and subsequent Environmental Management Plan, all pit developers and operators are strongly encouraged to consider a range of environmental aspects.



Remnant Vegetation

Extraction operations have the potential to disturb native vegetation, including Declared Rare Flora (DRF) and priority flora, as well as threatened and priority fauna species and ecosystems. Regardless of the type of land holding, all extractive industry proposals are subject to the provisions of the *Environmental Protection Act 1986* for clearing applications. Where existing remnant vegetation is proposed to be cleared, the applicant will need to seek a Vegetation Clearing Permit. Land clearing proposals are now managed by the Department of Water and Environmental Regulation under a permit system in accordance with the *Environmental Protection Act 1986*. There are exemptions for certain types of clearing. Information is available on the Department of Water and Environmental Regulations website: https://www.der.wa.gov.au/

The *State Planning Policy 2.8 draft Bushland Policy for the Perth Metropolitan Region* has been established to implement Bush Forever which aims to protect regionally significant bushland and associated ecosystems on the Swan Coastal Plain of the Perth metropolitan region. Although the South Coast is not impacted by this policy, it is included herewith for the benefit of wider audience and highlights the importance placed on the natural assets.

All efforts should be made to develop pits in cleared areas and clearing of native vegetation should be considered a last resort.

Surface and Ground Water

During the establishment and use of a lime pit it is important to plan for the management of water. This will involve attention to the movement of water in relation to the pit itself, and the access road. The development of a pit should aim to minimise impacts on the natural drainage system as much as possible. Some guiding principles relating to surface water management include:

- Pit floors will require a gentle gradient to prevent water puddling;
- Water from the pit area should pass through a settling pond, filtration bed or area of vegetation before entering the watercourse to avoid silting the water course;
- Silt fences such as hay bales maybe required to trap sediment;
- Runoff from the pit can be harvested to support rehabilitation. The dieback status of the water course and the rehabilitation areas should be considered when directing water from the pit to areas of vegetation, unless the pit is being managed as a dieback free pit;
- Pits generally should be constructed along the contour to assist with drainage management;
- Surface water flow upslope of the pit should be redirected around the pit with a contour catch/cut off drain. If it is an extensive pit, a contour bund will likely be required within the pit with associated sill outlet and a sill outlet will be required at the lowest point of the excavation;
- Vehicle access to the pit should not be at the lowest point or that will act as a drain for the pit; the haul road should be constructed to the most elevated point of the pit so drainage from the pit can be effectively managed;

Limestone Mine. Photo: Department of Primary Industries and Regional Development

Relevant checks need to be conducted to ensure that important environmental values and sensitivities of the proposed site and surrounds are not threatened by the establishment of the pit. Formally, local governments or other agencies who are responsible for issuing approvals for an extractive licence must refer a proposal to the Environmental Protection Authority if the proposal is likely to have a significant effect on the environment.

The construction of manoeuvring areas, parking areas, building pads etc. will also need effective drainage if erosion is to be avoided;

- If a water supply (say for dust control) is required for the pit and a dam or water point is to be constructed, creating a naturally shaped dam, this will contribute to the naturalness of the area;
- While typically extraction of lime sources occurs in the drier months, it is prudent to consider access to the site in wet weather; and
- Orientation of drains so that water is directed outside the curve of any access road to reduce the likelihood of the effluent water being re-collected on the road. Pits should be inspected for potential ponding or erosion issues in winter to determine if the surface water management has been effective. Urgent remedial action to correct ineffective drainage and/or repair erosion must be completed immediately, and non-urgent remedial action completed as soon as hygiene or soil conditions permit.

Typically lime sources are identified in porous and free-draining landscapes. Landholders are encouraged to be aware of groundwater levels and the local groundwater hydrology. If the clearing of remnant vegetation is required, the impacts on the local groundwater hydrology will likely be assessed. Changes to local hydrology can impact on-site and off-site and have the potential to contribute to salinity and waterlogging.

Dieback Management

Phytophthora dieback is caused by the plant pathogen, Phytophthora cinnamomi, which kills susceptible plants, including many proteaceous species such as banksias and hakeas, by attacking their root systems. Dieback is a symptom of a Phytophthora infection and affects more than 40 per cent of the native plant species and half of the endangered species in the south-west of Western Australia. The plants die because they cannot take up the water and nutrients they need. There is no known cure for Phytophthora and the pathogen is very easily spread through the movement of wet soil and mud, especially vehicles and footwear.

It is important to consider dieback in terms of on-site management as well as the potential site/industry where the lime may be spread. Where native vegetation persists that contains plants that are susceptible to dieback (uninfected areas), proposed pits, roads and other infrastructure development should first aim to locate elsewhere and secondly aim to avoid introducing dieback. Ideally development should be located away from, or at least downslope of uninfected natural areas. Where impacting areas that are free of dieback is considered necessary, a dieback management plan is recommended (prepared by appropriately skilled consultants).

Southern Coastline Photo: Consulting Great Southern

Management practices to prevent the spread of Phytophthora dieback into uninfected areas include strict hygiene measures such as:

- Do not move soil or plant material (topsoil management is critical);
- Use clean-down stations and boot cleaning stations;
- Stay out of quarantined areas in bushland and forest;
- Plan works to avoid rain or predicted wet conditions;
- Cleaning stations to avoid transport of contaminated soil;
- Use of dieback free construction materials;
- Always stay on roads/tracks;
- Consideration of seasonal and permanent road and trail closures; and
- Information signs and education.

Air Pollution

Consider the potential for dust and gaseous emissions as pollutants in all phases of lime extraction, particularly pit development and operations. These aspects can trigger complaints in which case you will need to be prepared to deal with the situation.

Wind Erosion

Wind erosion can be a major issue in the South Coast region, particularly if there will be exposed sand surfaces for any length of time. Some strategies to mitigate wind erosion include:

- Locating the pit to avoid exposure to prevailing winds, particularly hot north-westerly and north-east winds and the cool south-west and south-east winds. Even wet sand will blow if the wind is strong enough as evidence by winter storm damage along coastal tracks. Creation of wind tunnels through the site should be avoided;
- Stabilising, even temporarily, any exposed banks, batters, mounds or slopes. Coir or jute matting can be effective;

- Installing shelter belt planting (which might also double as screen planting). Planting should be of a similar form and scale to the surrounding vegetation or it will draw attention to the pit; and
- Should wind erosion commence, wind fences can be installed to trap the moving sand/soil. Ideally these would be of materials that will break down long term to avoid them becoming hazards if the sand shifts over time and they re-emerge in a few years.

Weed Management

In operation, the pit should be regularly inspected and maintained free from introduced weeds both agricultural and environmental. It is important to identify the declared pests (plants and animals) and the classes and categories of declared plants present on the property. The weed management plan should be prepared taking the form of a summer and winter weed program within the defined zone (DAFWA, "Guidelines for weed control procedures for extractive industries"). Treatment of weed may include herbicide spraying (registered herbicide), mechanical removal and any other legal effective means. Equipment and trucks should be cleaned and inspected for potential sources of weeds, in conjunction with hygiene management prior to the commencement of clearing, carting or rehabilitation operations. Lime from weed infested pits should not be used where there is the potential to spread weeds along road verges and establish new infestations.

Waste Management

In planning for waste management some considerations include:

- No oil changes in the pit;
- Ensure advice to Department of Water and Environmental Regulation in the event of fuel or chemical spills;
- Remove soil contaminated by spilt oil and fuel; and
- Remove all rubbish to an authorised waste disposal site.

Fire Management

All landholders are encouraged to contact their local government and/or the Department of Fire and Emergency Services regarding local government laws, fire management notices and landholder requirements relating to fire.

Topsoil and Overburden Management

Topsoil is the upper, outermost layer of soil which can vary in thickness but is generally considered to be around 0-10cm. This is the zone where most plants, roots, earthworks, insects and micro-organisms are active. Effectively managing topsoil from the initial stages of pit development is the only effective means of re-establishing a diverse vegetation community on the site. Overburden refers to subsoil material, the material below the topsoil but above the raw material intended for extraction.

Management of topsoil and overburden is critical to the success of rehabilitation and restoration. Guidelines on best practice include:

- To allow enough area for stockpiling of vegetation (to be used and not burnt), topsoil and overburden and pit activities, the vegetation should be stockpiled within the pit boundary at a distance of at least 10 (preferably 20) times the proposed depth of the lime resource;
- A nominal 10-15cm of topsoil is to be immediately respread on pre-prepared pit or stockpiled;
- Topsoil stock piles should not exceed 2m in height;
- Topsoil should not be left standing for more than 12 months;
- Overburden or subsoil below 15cm should be removed if necessary and stored separately;
- Immediate topsoil use should be encouraged by sequential operations if the pit is ongoing;
- Topsoil from newly cleared area should be used for rehabilitation of the previously mined area; and
- Topsoil from road alignments may be used to assist with rehabilitation of basic raw material pits with relevant authority approval, providing that the soil has a suitable disease status, and is not required for rehabilitation of the road.

South Coast Commercial Lime Pit and Crushing Plant. Photo: Consulting Great Southern

Roads, Infrastructure & Mobile Plant

The development and operations of an on-farm lime pit require a range of access roads, infrastructure and mobile plant. Thorough planning to identify requirements and costs is essential to ensure accurate costing on the development of an on-farm lime resource.

If buildings are required as part of the pit development such as a site office, toilet or shelter for mining equipment, their form, colour and set out should be considered carefully. Some points to consider are:

- Buildings should be located to ensure pedestrians walking to and from the buildings and their vehicles will not be crossing vehicle access routes;
- Buildings grouped together look better than buildings scattered across the site;
- Using the same/similar colours for all the buildings and using a colour from the surrounding landscape, preferably a dark grey (galvanised iron is fine) will enable the buildings to blend into their background;
- Collecting water from rooves may give water for rehabilitation.

Plant required for the operation of the pit will include, but is not limited to: loader, bulldozer, excavator, crushing plant, screening plant, water tank (dust suppression), on-site fuel storage (if required), storage sheds and water. The purchase and ongoing costs, including maintenance, of this equipment must also be factored into the cost of developing your own lime source on-farm.

Road Access

The access road to the pit should be designed to cater for the safety of other road users and to minimise its environmental and visual impact. Input from an engineer should be sought to ensure it is of a standard suitable for the proposed traffic, particularly as this will likely include large, heavily loaded trucks. Principles to consider include:

- Ensure any roadwork complies with relevant legislation (Road Traffic Act (1974), Road Traffic Code);
- Position the access road junction on a straight section of road, and avoid junctions on crests or curves;
- Have the Main Roads Department/Local Government Authority approve the intersection or crossing configuration on public roads;
- Ensure that the sight distance either side is sufficient for the expected speed of the traffic; and
- Design a relatively level junction to enable quick merging of trucks with through traffic. Access off the public road should be at right angles for safety and visual reasons as this requires the truck to stop before entering the road and road users cannot easily look down the road to the pit;
- The alignment of the road should be curvilinear to reflect the surrounding landform;
- The surface of the road needs to be suitable for the proposed use, easy to maintain and if possible of a dark colour to blend into the landscape;
- The road should be effectively drained with likely either a cross fall, in slope or out slope surface with associated table and cut off drains (see surface water section for points to consider regarding management of stormwater); and

- Road signage should also be provided as necessary and the provision of a traffic management plan is a likely requirement of the approval process.

Cultural Heritage

All sites are to be checked by the landholder for Indigenous and non-indigenous heritage values. Field surveys may be required, and sufficient lead time should be available to allow these to be undertaken. Should material of heritage interest be found during clearing or basic raw materials extraction activities, then the work should cease, and the pit manager must advise the relevant authorities.

Check with Department of Planning, Lands and Heritage regarding the cultural heritage aspects of your planned site.

Occupation Safety and Health

The Department of Mines, Industry Regulation and Safety have a role under the *Mine Safety and Inspection Act 1994* to ensure the safety of extractive industries. Safety and health in the Western Australian workplace are regulated by the *Occupational Safety and Health Act 1984* and the Occupational Safety and Health Regulations 1996 which are supported by codes of practice and guidance notes. All landholders are encouraged to contact the relating departments for further information.

Considerations will include:

- Emergency and incident management procedures;
- Signage;
- Site and machinery inductions;
- Working in isolation procedures and processes;
- Occupation noise and dust; and
- Appropriate personal protective equipment.

Signage

The colour, style and scale of signage says a lot about the management of the area. Consider the impression you want to give visitors to the site when selecting and installing signage for the area. High impact signage can also draw attention to the mining operation and so less obvious but clear signage may be more appropriate. Clear signage from decision points such as the turnoff from main roads will assist those who don't know the area to find your pit.

Planning the Excavation & Pit Operations

The extraction process will be influenced by the profile and quantity of the resource, but the following should be considered when planning the excavation:

- How will the area be used when the extraction is complete (arable land, pasture, natural area, water catchment, dam, recreation area using exposed cliffs etc.);
- What is the life of the pit, will excavation be staged and involve several smaller pits over time rather than one very large pit? and
- Can the profile (forms and lines) of the surrounding landform be reflected in the final shape of the excavated area?
- Does the proposed excavation need engineering input to ensure it is structurally sound?
- Who operates the pit, the landholder or a contractor? It is recommended that the landholder operates the pit when it is for personal use.

It will also be very important to continually assess the quality of the lime that you are extracting from the pit. Analysis costs range from $100 to $300 per sample.

Complaints

Whether the pit is operating under a licence through the local government, or if the pit is simply providing lime on-farm within the title it is extracted from, complaints by neighbours and public could be received about the pit and its operations. It is suggested that a register of complaints be kept with templates available online for these. Complaints and your ability to address concerns, may impact on the future operation of the pit.

South Coast Lime Pit. Photo: Consulting Great Southern

Colour and position in the landscape of a limestone pit making it evident in the view from a tourist road. Photo: Vicki Winfield

Visual Landscape Management

Managing visual amenity (the visual landscape) is generally considered as important by landowners and other community members. All extraction activities will require some consideration, planning and remediation work relating to both the natural and cultural landscape visual amenity. While a grower may see it as their farm scape, the wider community see it as part of a wider landscape. The level of focus on this will depend on the scale of the proposed development, the attractiveness of the existing landscape and the visibility and/or importance of the site to the public. In the case of on-farm lime extraction, the activity will be part of a landscape that has already been modified and the aim is more likely to be to reduce the prominence of the site.

Local government, in assessing applications based on their planning policies and local laws, may give regard to whether the site is in a visually significant location, such as on a ridge, adjacent to the coast or an estuary, close to a national park or nature reserve, visible from a major road, tourist destination, scenic or tourist route. Considering the visual impacts of a proposed pit from the outset of the project may avoid time delays with the approval process and expensive screening and amelioration costs later. Planning in this area can ensure the attractiveness of your property can be maintained during and post extraction.

In some instances, where a potential site is in a visually significant area a landowner may be required to manage the appearance of the pit during operations and rehabilitate the pit to be in-evident after use or locate their pit in a less significant area.

The Visual Landscape Management Plan

A visual landscape management plan essentially documents the key features of the landscape prior to creation of a pit, how people view the area and the measures to be undertaken to retain visual amenity during operations and as part of rehabilitation. If the proposed site is visually significant or where detailed formal assessment is required as part of the approval process, it is recommended that a landscape consultant undertakes the visual assessment and prepares a visual landscape plan. Alternatively, if consultants are generally not being used to prepare the development application a landowner may conduct their own visual landscape planning.

These guidelines are not intended to provide the level of detail required to allow a landowner to prepare their own plan to the formal standard of a landscape architect. The information below is intended to inform landowners in relation to the key features so that they can consider relevant issues and have informed discussions as part of their decision-making process.

Where a landowner chooses to analyse the visual aspects of their proposals themselves and prepare their own informal visual landscape management plan, the minimum level of detail recommended for inclusion is:

- Photographs of the site taken from locations where people are likely to be viewing the site from (viewing points) prior to commencement of works. These viewing points should be marked on a map or air photo with an arrow showing which way the photo was taken;
- Dot points or notes on the map, describing how the views from these viewing points will be changed by the proposed pit;
- Photographs and dot points identifying and describing any visually significant features in the landscape around the pit, such as ridge lines and water courses; and
- Dot points describing the measures which will be implemented to ensure visual quality of the views and the significant landscape features will be maintained in the site location, site development, excavation and rehabilitation phases of the project.

The form and texture of these heaps contrasts with the background making them very evident in the landscape. Although the spoil heaps have revegetated to match the surrounding paddock they form. Photo: Vicki Winfield

Understanding Landscape Evaluation

A more detailed description of the various steps involved in analysing the visual impact of a proposed lime pit and preparing proposals to retain the visual amenity of the area is given below. For further information please refer to https://www.planning.wa.gov.au/publications/1205.aspx

Step 1. Define the scope of the evaluation and set the context;

Step 2. Describe the visual landscape character - the primary characteristic of a landscape may be its main land use such as natural, rural or built, but the landscape should also be described in terms of its landform, water form, land use and cultural features including built form;

Step 3. Identify how people interact with the landscape - consult stakeholders including neighbours and evaluate how people access, view and experience the landscape and what visual landscape is valued;

Step 4. Determine Visual Objectives - Once the significance of the visual qualities of the area has been established, visual management objectives for the proposed development can be identified;

Step 5. Describe the proposed development – identify components such as the depth and area of excavation, machinery and plant required, haulage routes to be used (etc);

Step 6: Identify and describe the potential visual impacts - this will include how the significant elements in the landscape such as ridgelines and shore lines will be impacted and the anticipated changes to views, particularly the popular views. The significance (regional, local or site level) of the view also needs acknowledging;

Step 7: Develop visual management recommendations - the recommendations should relate to achieving the objectives that were previously identified. They can be at the broad scale, site planning level, involve operational guidelines and relate to rehabilitation.

Recently shaped soil heaps alongside heaps to be shaped. Photo: Vicki Winfield

The overall objective for any lime pit will likely be that it is not evident at least in the long term. The general siting and design guidelines for minimising the visual impact of any land use should be applied to the planning and development of limestone pits. For further information please refer to https://www.planning.wa.gov.au/publications/1205.aspx

Some considerations include:

- Consider options for relocating the pit if it will be very prominent in the landscape;
- Size of footprint – if feasible propose a similar scale and shape to the surrounding landscape elements. Retain any special features such as outcrops or pinnacles;
- Depth – should relate to the surrounding landform; consider the final use of the pit (pasture, arable land, native bush, motocross or 4WD course etc.);
- Configuration of the outer boundary and fencing - should reflect natural lines in the landscape and fencing should blend in;
- Angle of faces – should reflect the surrounding landform;
- Length of time faces are exposed before being re-contoured and re-vegetated should be minimised and if staged carefully may be able to break up the scale of the pit during excavation;
- Time sequence for planting of exposed surfaces;
- Retain existing vegetation if feasible;
- Planting programs including screen planting. Use of local plants and reflect natural groupings and patterns avoiding regular lines and shapes;
- Construction of screen mounds/bunds – natural forms will make them less obvious as will setting them back from a road with some foreground planting. They should be removed/re-shaped/respread long term if natural forms cannot be achieved;
- Siting of access roads – preferably at right angles to the access road to minimise views into the site, better still have the access off a minor road;
- Design of entry statements and signs – consider keeping them unobtrusive;
- Siting or, design and maintenance of plant and buildings – to reduce visibility, consider scale and silhouette, group elements together, colours (dark is often less obtrusive, use colours frective materials, consider screening (even just their base) etc;
- Location of power lines, pipelines and other services – underground if feasible;
- Alignment and design of access roads and rail links;
- Changes to original landscape to be minimised especially landform and vegetation. Avoid significant areas such as ridgelines, drainage lines and silhouettes;
- Lighting – during production can impact on the character of the landscape; and
- Rehabilitation – reinstate original contours if feasible (plan for this from the outset) and create landforms similar to those adjacent. Provide surfaces suitable for planting.

Rehabilitation and Restoration

The rehabilitation and restoration plan of a pit is directly related to the pre-extraction land use, with the success of this rehabilitation and restoration being guided by the appropriate level of planning.

Rehabilitation

Rehabilitation emphasizes the reparation of ecosystem processes, productivity and ecosystem services. Rehabilitation of land back to natural vegetation usually requires the involvement of the rehabilitation experts as it is difficult and expensive. It is recommended that pits should be planned to locate in cleared areas or grassland cleared areas if possible where it is much easier to rehabilitate. Factors to consider in pit rehabilitation include:

- Pit management for completion;
- Initial earthworks; including the removal or destruction of timber (consider burning material for ash to be reused later if site is to be revegetated with local native species), re-shaping works are completed (shaped to natural contours), sides have been battered to 1:4 and pit floors have at least 1:100 fall;
- Initial soil preparation has been completed: ripping of pit floor is required in almost all cases due to compacted soils. Pit floor has been ripped and occurred specific to the land use to which the area will be returned (i.e. pasture of revegetated), clods of compacted soil less than 100mm in diameter and an 8mm rod can be pushed by hand to a depth of at least 80cm at 80 per cent of sample points on any ripped lines (particularly relating to ripping for revegetation);
- Soil preparation has been completed: topsoil and ash has been respread uniformly across the pit or access road. In the case of land back to pasture, it is only top soil to be spread and fertiliser if required. The topsoil is generally loose and friable. Topsoil should not be deep enough to ensure plant survival but to a minimum depth of 10cm, an 8mm rod can be pushed by hand to a depth of at least 10cm over 80 per cent of the pit or access roads. In the case of revegetation to pasture only top so ;
- Water management structures are installed: Upslope runoff and excessive water flow has been diverted away from the rehabilitated area, surface water management structures have been installed across the contour (0.5%), pit floors should have at least 1:100 fall, and effective water dispersal to prevent ponding and dieback intensification;
- Revegetation works: as described in next sub-section;

Ecological restoration of Remnant Vegetation

Ecological restoration of degraded landscapes is important because biodiversity provides stability and resilience to the landscape. However it is best left to the experts as it is difficult and expensive. It is recommended to avoid extraction in these areas unless the lime is of exceptional quality.

In agricultural landscapes, natural and semi-natural ecosystem patches become a resource for agro-ecosystems, and agro-ecosystems can assume a positive rather than negative role in preserving the integrity of natural ecosystems (Gleissman, 2007). The interface between different ecosystems is fundamentally important in an agricultural mosaic, helping prevent soil erosion, improving the

microclimate and in absorption of pollutants and nutrients needed across slopes and buffering watercourses (Farina, 1998).

Ecological restoration guided by revegetation aims to restore as much as practicable the pre-existing vegetation (i.e. the locally occurring historic or pre-existing native vegetation communities to match soil types, hydrological conditions and landscape positions). It aims to create or restore a self-replacing system that can evolve over time with changing hydrology and climate and maximises biodiversity benefits to the ecosystem and health of the broader landscape (e.g. maximising habitat and connectivity for threatened fauna species).

From fauna perspectives it is important to understand a habitat of invertebrates to maximise benefits of biodiverse revegetation (within context of structure and function of model or reference ecosystems/vegetation being restored). Organic matter is the major driver of invertebrate distributions and the invertebrate numbers determines the vertebrate numbers. To have a quality of organic matter, it is critical to consider heterogeneity (variety) of species and structure (i.e. upper storey, middle storey, lower storey), vertically (in height) and horizontally (across the landscape).

Once desired trajectory is reached, growers may be able to switch from restoration mode to environmental management mode using adaptive management principles. Rehabilitation, restoration and monitoring activities and factors to consider in biodiversity revegetation on land that was previously bushland include (Note: Vegetation Clearing Permit is required to clear existing remnant vegetation, see P24):

12 months prior to clearing for lime extraction

- Seed from local endemic species growing at the site from bush, especially targeting vegetation that is to be cleared needs to be collected and stored for use in the revegetation phase of rehabilitation;
- Investigate the possibility of propagation of Restionaceae species (dryland rush/sedge species) that are the dominant understorey vegetation but are unlikely to regenerate from the soil seed bank and don't produce viable seed;
- Ensure sufficient seed/vegetative material is collected for propagation and rehabilitation post-lime extraction to maintain as many pre-lime extraction conservation values as is practically possible after lime extraction has taken place;
- Seed from stands with large populations (more than 100-200 plants) of each species collected will provide the highest quality revegetation sites. (When this is not possible, seed from a number of smaller populations should be combined to ensure that the newly restored populations have high genetic diversity to limit inbreeding effects as plants become reproductive. As a general rule, source seed from stands as close as possible to the revegetation site.

Clearing for lime extraction

- Develop lime extraction policies that maximise maintenance of existing conservation values of the reserve and the land has the best chance of being rehabilitated effectively post extraction; and

- Clearing is managed to maximise the regeneration of native species richness of native vegetation to regenerate after the disturbance, within the capacity of available resources. (The target precent of species richness retention post rehabilitation at a certain point of time needs to be specified in restoration plan).

During lime extraction

- Throughout the life of the pit, topsoil, overburden and vegetation will be stockpiled separately ready for respreading in the rehabilitation process. The freshly removed topsoil should be spread as soon as possible after removal from site to maximise the viability of soil micro-organisms and soil seed bank.

Post lime extraction

- The general process of rehabilitation requires deep ripping at 1m intervals across the contour. Ripping is especial critical for the survival of natural vegetation especially trees. The pit needs to be shaped so that the surfaces are as smooth as possible, and the edges are battered down to blend in with the landscape. The batter slopes should be no steeper than 4H:1V (Shire of Broomehill-Tambellup, 2012);
- The overburden and then the topsoil should be returned to the pit. Weeds on the topsoil should be removed/sprayed out prior to replacing. The site then should be cross-ripped at 1m intervals on the contour to encourage plant growth;
- In late autumn or when with enough soil moisture and weed issues are dealt with, direct seed stored native plant seed using precision seeding machinery (e.g. CommVeg seeder). Finally, brush mulch with stock-piled vegetation that was removed prior to seeding on areas between direct seeded rows. Brush mulching should be undertaken as soon as possible after the harvesting of plant material to avoid most of the seed being lost.

Stacked rocks draw attention to an old pit. Photo: Vicki Winfield

Detailed site assessment informs revegetation design, including site preparation, species selection and quantities of seed and/or seedlings, planting techniques and design to maximise the survival of plants. These threats include water-logging/salinity, rabbits/kangaroos, weeds and disease pathogens such as phytophthora dieback.

For a successful seed/seedlings establishment, consider:

- Combination of direct seeding and seedlings. Seed has greater potential to restore habitat/diversity for less cost but direct seeding needs some expertise (in equipment, seed preparation, timing and sowing depth). Seeds of some species such as members of the Proteaceae family (e.g. banksia, hakea) are in short supply and better use of this valuable resource when planted as seedlings;
- Waterlogged/saline soils need to be mounded prior to planting;
- Rabbits and excessive kangaroo numbers need to be managed;
- Rutherglen bug can also be a problem that needs to be watched out for on newly establishing plants in late spring/early summer, particularly after a wet spring/summer; and
- Retain old and large trees, dead or alive as much as possible. These can be habitats for birds and small animals to help control pests.

Risk Management and Contingencies

In thoroughly planning and scoping an on-farm lime extraction pit, it will be important to consider risk management and contingencies at each step. Foresee issues with all aspects of the pit and have in your plans, and your budgets, the costs of either managing, or remediating these.

Monitoring and Evaluation

As with other on-farm enterprises and operations, it will be very important to monitor and evaluate:

- The lime source quality of your on-farm pit, in comparison to sourcing lime from a commercial operation;
- The financial performance of the venture, in comparison to sourcing lime from a commercial operation; and
- The success, performance and effectiveness of the various aspects of the development, operation and rehabilitation efforts.

It is strongly advised that the various question rose throughout this document are revisited at least annually to allow for this comparison. Thorough review could be scheduled in winter or spring, in preparation for summer when lime is typically excavated and spread. The ultimate question to be covered in the review would be: what was the cost of the actual on-farm extraction compared to commercially available, that is, what is the true cost of on-farm versus off-farm?

SECTION 5: MASTER CHECKLIST

This checklist is designed to be a useful reference to utilise as a 'Master checklist' when considering and planning on-farm extraction. This checklist summarises the main points from lists in other sections. It is not exclusive and all other sections of the document, as well as legislation and standards must be also referenced. It is assumed that growers referencing this master checklist are considering on farm-extraction as an option.

Table 6: Master Checklist

	Sourcing Lime	Answer
1.	Using available lime calculators and other information to evaluate commercial options (quality, cost, transport, tonnage at appropriate neutralising value etc), what would be the most cost-effective commercial source for your lime?	
2.	What tonnage would you require delivered each year from the most cost-effective commercial source you identified above?	
3.	What is the cost of the lime you require (each year) from the commercial source identified above - taking into account landed on-farm cost and spreading?	
4.	In the case of on-farm extraction – would the lime be transported on a public road, between titles, or supplied to other growers (including neighbours)? *Note: This is considered commercial use, which triggers additional approval processes.*	
5.	In the case of on-farm extraction – are other permits and approvals likely to be relevant? (i.e. clearing of native vegetation)	
6.	In the case of on-farm extraction – Have you spoken to your Local government to discuss your potential plans and the approval process?	
7.	Have you read all sections, considered all reasonably foreseeable factors and identified the total cost per tonne of lime sourced on-farm (i.e. taking into account planning, consultants fees, approvals, all elements of extraction and rehabilitation?	
8.	If yes to the above what tonnage would you require extracted each year from your own pit?	
9.	What is the total cost per year to extract (from your own land) and spread the required tonnage?	
10.	If supplying lime commercially what is the net profit you would reasonably expect per year, taking into account all relevant factors?	
11.	Taking into account all relevant factors, which is the most cost-effective source of lime for your needs – off-farm or on-farm?	

If you identified 'on-farm' as the most cost-effective option above:

	Site Location and Selection Considerations	Answer
12.	Have you considered site location consideration listed in section 3?	
13.	Have you considered environmental attributes listed in section 3?	
14.	Have you considered 'planning considerations' listed in section 3?	
15.	Have you considered site selection considerations listed in section 3?	
16.	Given the above what is the location of your pit?	
	Planning Considerations	**Answer**
17.	Have you identified legal considerations listed in section 4?	
18.	Have you documented site details as listed in section 4?	
19.	Have you documented proposed extractive industry details as listed in section 4?	
20.	Have you documented details of proposed management of operation as listed in section 4? (this will include all aspects, including but not limited to OHS and operational legislative compliance)	
21.	Have you documented an environmental management plan, including a visual landscape management plan and rehabilitation plan?	
	Monitoring and Evaluation Plan	**Answer**
22.	Have you considered and documented how you will monitor and evaluate whether your extraction operation meets all standards and aspects of your planning? How will you know your operation is a success?	
23.	Have you documented the steps you will take to bring performance back on track in the event you identify a future issue?	

SECTION 6: REFERENCES AND INFORMATION SOURCES

This section recognises that this document is a summary of the vast array of technical and procedural documentation available regarding extractive industries. The information sources below are provided in sections to allow for easy reference, followed by contact information.

Print and Online Publications

Section 1: Soil and Agricultural Lime

References

Cregan D., Hirth R. and Conyers K. (1989) *Amelioration of soil acidity by liming and other amendments.* In A.D. Robson (eds) *Soil Acidity and Plant Growth Academic Press, Marrickville* 206-264pp

Gazey C, Andrew J and Griffin E (2013). 'Soil acidity'. In: Report card on sustainable natural resource use in agriculture, Department of Agriculture and Food, Western Australia. https://www.agric.wa.gov.au/report-card-conditions-and-trends/report-card-sustainable-natural-resource-use-agriculture-western

Gazey C., Davis S. and Master R. (2014) *Soil acidity: a guide for WA growers and consultants,* Department of Agriculture and Food Western Australia, South Perth. https://researchlibrary.agric.wa.gov.au/bulletins/223/

Moody W., Merry H., Gazey C., Wilson R., Hughes B., Grose J., Dixon J. and McKenzie J (2002) *Soil Acidification* in McKenzie, N.J and Dixon, J (eds) *Monitoring soil condition across Australia. Recommendations from the Expert Panels Draft Document.*

Information source

Climate Action Farming website https://climateactionfarming.com.au/
This website has a host of information including "Why test my lime?"

Department of Environment and Conservation (2009) *Manual for the Management of Surface Water, Department of Environment and Conservation*. Sustainable Forest Management Series, SFM Manual No. 3. Department of Environment and Conservation, Perth

Fry J. (2015) *Lime Situation Report 2015: South Coast NRM Region*. South Coast Natural Resource Management Inc., Albany. https://climateactionfarming.com.au/soil-acidity/report-soil-acidity

Gazey C. and Gartner D. (2009) Survey of Western Australian agricultural lime sources. Bulletin 4760. Department of Agriculture and Food Western Australia, South Perth. https://researchlibrary.agric.wa.gov.au/bulletins/194/

Liebe Lime Profit Calculator
http://www.liebegroup.org.au/liebe-group-publications/lime-profit-calculator/

Optlime Mobile App
Ranking Options for Soil Amelioration (ROSA) Contact Jeremy Lemon at Department of Primary Industries and Regional Development, Albany.

Stuart-Street (1994). *Reading the Remote: Landscape Characters of Western Australia*. Department of Conservation and Land Management, Kensington.
Walden F. (1982) *Conservation and Regeneration Techniques*. Main Roads of Western Australia, Perth.

Section 2: Sourcing Lime in WA
References

Morse W. and Mackenzie T. (1990). *Geochemistry of Sedimentary Carbonates*. Elsevier, Amsterdam, 707pp.

Morse W., Andersson J. and Mackenzie T. (2006) Initial responses of carbonate-rich shelf sediments to rising atmospheric pCO2 and ‘‘ocean acidification’’: Role of high Mgcalcites. Geochimica et Cosmochimica Acta 70 5814–5830pp

Information source

For more information on your lime requirements and to develop a liming program, contact your agronomist, soil health advisor or business consultant.

The following on-line calculators may be of assistance:
Lime Benefit Calculator: http://www.soilquality.org.au/calculators/lime_benefit
Lime Comparison Calculator: http://www.soilquality.org.au/calculators/lime_comparison
Liebe Lime Profit Calculator: http://www.liebegroup.org.au/liebe-group-publications/lime-profit-calculator/

South Coast Lime Pit. Photo: Consulting

Section 3: On-farm Extraction Planning

References

SEPWA (2017) *Alternative Lime Sources*. SEPWA Newsletter 87. South East Premium Wheat Growers Association, Esperance

Information source

Australian Institute of Landscape Architects http://www.aila.org.au/
Bradshaw W. and Woodall G. (2014). *North Stirlings and Pallinup River Catchment Revegetation Guide: Restoring biodiversity values on farmland through direct seeding and seedling plantings.* http://www.gillamii.org.au/resources.aspx

Bradshaw W. and Woodall G. (2014). *Mid-Upper Frankland-Gordon River Catchment Revegetation Guide: Restoring biodiversity values on farmland through direct seeding and seedling plantings.* http://www.gillamii.org.au/resources.aspx

Department of Biodiversity, Conservation and Attractions. *Phytophthora dieback*. https://www.dpaw.wa.gov.au/management/pests-diseases/phytophthora-dieback

Department of Biodiversity, Conservation and Attractions. *Parks and Wildlife Service: Guidelines for the Management and Rehabilitation of Basic Raw Materials Pits* https://www.dpaw.wa.gov.au/images/documents/conservation-management/forests/FMP/preparing_FMP_2014-23/guideline_brm_rehabilitation.pdf

Department of Planning, Lands and Heritage. *Visual Landscape Planning in Western Australia a manual for evaluation, assessment siting and design.* https://www.planning.wa.gov.au/publications/1205.aspx

Western Australian Planning Commission (2009) *Basic Raw Materials Applicants' Manual*, Western Australian Planning Commission. https://www.planning.wa.gov.au/dop_pub_pdf/BRM_Text.pdf

Section 4: Planning Resources

References

Department of Agriculture and Food (DAFWA), *Department of Agriculture and Food WA guidelines for weed control procedures for extractive industries licence*

Farina A. (1998). '*Ecotones', in Principles and methods in landscape ecology.* Chapman & Hall, London, 93-108pp

Gliessman R. (2007). *Landscape Diversity and Agroecosystem Management' in Agroecology: The ecology of sustainable food systems.* 2nd Edition. CRC Press, Taylor & Francis Group, USA, 313-323pp

Shire of Broomehill-Tambellup (2012). *Shire of Broomehill-Tambellup Policy Manual*, 134-135pp

Western Australian Planning Commission (2009) *Basic Raw Materials Applicants' Manual*, Western Australian Planning Commission. https://www.planning.wa.gov.au/dop_pub_pdf/BRM_Text.pdf

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Bradshaw W. and Woodall G. (2014). *North Stirlings and Pallinup River Catchment Revegetation Guide: Restoring biodiversity values on farmland through direct seeding and seedling plantings.* http://www.gillamii.org.au/resources.aspx

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Department of Mines, Industry Regulation and Safety (2018) *Basic Raw Materials*. Accessed http://www.dmp.wa.gov.au/Geological-Survey/Basic-Raw-Materials-1411.aspx

Department of Water and Environmental Regulation. *Clearing permit application forms*. https://www.der.wa.gov.au/our-work/clearing-permits/46-clearing-permit-application-forms

Judd S. (2004) Presentation at Gondwana Link Workshop "Restoration – not Revegetation Workshop", Quaranup, Albany 13 December, 2004

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Western Australian Planning Commission (2009) *Basic Raw Materials Applicants' Manual*, Western Australian Planning Commission. https://www.planning.wa.gov.au/dop_pub_pdf/BRM_Text.pdf

Contacts

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Department of Water and Environmental Regulation P (08) 6364 7000 E info@dwer.wa.gov.au	**Department of Mines, Industry Regulation and Safety** www.dmp.wa.gov.au P (08) 9222 3333
Department for Planning and Infrastructure www.planning.wa.gov.au P (08) 6551 8002	**Shire of Esperance** P (08) 9071 0666 E shire@esperance.wa.gov.au
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Shire of Manjimup P (08) 9771 7777 E info@manjimup.wa.gov.au	**City of Albany** P (08) 6820 3000 E staff@albany.wa.gov.au
Shire of Denmark P (08) 9848 0300 E enquiries@denmark.wa.gov.au	**Department of Planning, Lands and Heritage** P (08) 6551 8002 E info@dplh.wa.gov.au
Landgate P (08) 9273 7373 E customerservice@landgate.wa.gov.au	

For more information relating to revegetation, suggested contacts are South Coast Natural Resource Management, your local Landcare Centre, or Greening Australia WA. Comprehensive revegetation guides for the Mid-upper Frankland-Gordon River Catchment and the North Stirling's and Pallinup Catchments from the Gillamii Centre and Pallinup Landcare Centre respectively.


Old Lime pit at Orleans Farm. Photo: SEPWA

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