NATSPEC// Construction Information

TECHreport TR 08

October 2024

Management of Council gravel pits in country areas – A case study

This TECHreport can be used by Councils who operate licensed gravel pits to comply with their duty of care and be compliant with the legal framework required by the State Governments. Councils can build and maintain better sealed and unsealed roads using a system of materials extraction and blending from different pits to meet the required performance standards. This report shows how Councils can achieve better whole of life costs and reduce budget expenditures for both sealed and unsealed roads.

MANAGEMENT OF COUNCIL GRAVEL PITS IN COUNTRY AREAS

MANAGEMENT OF COUNCIL GRAVEL PITS IN COUNTRY AREAS

1 INTRODUCTION

1.1 General

This TECHreport can be used by Councils that operate licensed mine gravel pits to more effectively comply with their duty of care and ensure compliance with the legal framework required by State Governments. The report provides guidance on how Councils can better manage their licensed gravel pits.

The report shows how to build and maintain better sealed and unsealed roads using a system of materials extraction and blending from different pits to meet the required performance standards.

Each State will have different test specifications for selected materials to use for unsealed and sealed roads.

1.2 Problems with maintaining rural local roads

- Country Councils have both sealed and unsealed roads. Recent legislation changes such as, the state Civil Liability Acts, create obligations for Councils to be responsible for road asset management and to be accountable for design and construction of roads to meet the requirements of the road user.
- The road authorities have permitted the trucking industry to use heavier, wider and longer trucks on public roads.
- Road Authorities own 878,000 km of the total road network in Australia of which 678,000 km (77 % of the total) are local and regional roads. Of this 77% of Council roads 413,000 km are unsealed and 265,000 km are sealed and accounts for over 50% of road accidents.
- Revenue collected from road users is not returned to local government commensurate with the damage done to the local Council roads due to trucks and heavy vehicles.
- The increase in the number of trucking axle loads is causing increased damage to roads built with marginal Council pit gravels.
- Due to the lack of funds Councils are persevering with gravels that are not meeting life cycle demands. The materials used are redundant without stabilisation options, geotechnical testing, gravel blending, and quality construction control.
- For many local Councils, particularly in country areas, obtaining suitable materials for the effective construction and maintenance of road pavements is a continual challenge. The options of using locally sourced and readily available marginal materials are often required as quality materials become scarce or inaccessible.
- Professional laboratory testing is needed to achieve the best use of local materials. ARRB has also developed a spreadsheet with macros Road Base Test Kit to allow essential testing and evaluation on site, for local materials. The preferred option is an off-site lab testing when immediate answers are not essential.
- A good, unsealed road wearing course is influenced significantly by particle size distribution. Achieving low permeability (impermeable), blending pit mix selections can create materials with resistance to ravelling and corrugations, and resistance to potholing.
- Sieve gradings and linear shrinkage percentage testings are required for each input material characteristics for the ARRB spreadsheet and associated unsealed wearing coarse selection chart.

1.3 Purpose of this TECHreport

- The purpose of this report is to examine how Councils can meet the challenge with local gravels so that sealed roads are built with the whole-of-life target of 60 years, and unsealed roads with the target of 20 years, with fewer maintenance interventions. The aim is to build and maintain the roads for lower whole-of-life costs rather than focus on immediate material costs.
- This report references an ARRB spreadsheet to analyse blending of different materials for longer lasting unsealed roads requiring less resheeting interventions. It provides proven examples from different Councils, a detailed case study from Lachlan Shire Council and a survey response from the Central NSW Joint Organisation of Councils in NSW.

1.4 Proven examples from Councils

- Cassowary Coast Regional Council in Queensland for example, extended their maintenance intervention from three months to three years using the ARRB model (GHD modified). Furthermore, potholes were reduced from hundreds in number down to one single pothole after a cyclonic rain event. The road was immediately usable after the rain without intervention.

- The Shire of Albany in Western Australia is home to some of the most highly used unsealed roads in Australia. Almost 40% of its 1,100 km unsealed network has over 50 vehicles per day, with up to 350 vehicles per day in some sections. As gravels found in the region are predominantly sandy with little to no plasticity, when used on unsealed roads, they require a high degree of maintenance grading to maintain acceptable serviceability. As a trial, one of the busiest roads were resheeted with a 20% clay stabilised gravel, and the results found that:
    - Maintenance grading consequently reduced from weekly to twice per year.
    - There was no potholing along the crown of the road after the new mix was applied.
    - Dust was reduced by 20-25%.
    - Water did not penetrate due to the creation of impermeable pavement and dried more quickly after wet weather.
    - The surface did not become slippery when wet, or ravel or corrugate in hot weather.
    - Resheeting intervention increased from 3-5 years to 10-15 years.

1.5 Management of unsealed roads

Councils' pit materials have remained static in strength, and plasticity. Singular gravel sources properties cannot improve without stabilisation or cross-pit blending, including blending with commercial by-products from hard rock quarries. The average natural pit gravels are CBR% 25 or less unsoaked, with plasticity index 15 with variations. The desirable target for an unsealed wearing course is over CBR% 40 unsoaked, plasticity index between 9 and 13, and Maximum Dry Density (MDD) of over 2.2. The MDD needs to be high in order to create an impermeable gravel blend which assists reduction in potholes.

1.6 Importance of gravel pits

The management of public road assets requires ready access to road building and maintenance gravel materials. The location of natural gravel pits close to the road job site reduces the damage to the roads caused by haulage trucks. Short haulage distances also reduce maintenance costs for roads and in particular, for unsealed roads. Councils over the years have developed local gravel quarries by:

- Directly owning the land and the connecting access track easement to the public road; or
- Agreement with the landowner and paying royalties per cubic metre loose.

1.7 Insurance liability

Clear pit and easement ownership responsibility reduces likelihood of liability disputes in case of accidents. Accidents where death or serious injury occurs the Council General Manager and/or Quarry Manager may be culpable if negligence is proven.

In NSW the Resources Regulator (RR) regards the access road as part of the mine license. In very few cases do Councils ensure that the access road is marked on the plan included with the Landowner agreement and the Safety Management System (SMS). To avoid negligence or culpability actions, Councils need to significantly improve their management of mine licences. The *Work Health and Safety (Mines and Petroleum Sites) Act 2013 (NSW)* and the *Work Health and Safety (Mines and Petroleum Sites) Regulation (2022) (NSW)* places more emphasis on safety risk for licensees.

1.8 Abbreviations

- ARRB: Australian Road Research Board.
- LiDAR: Light detection and ranging.
- MSMS: Mines Safety Management System.
- PI: Plasticity Index.
- QM: Quarry Manager.
- QO: Quarry Operator.
- RR: NSW Resources Regulator
- SMS: Safety Management System.

1.9 Definitions

Reference: Austroads.

- Gravel pit: A site for the extraction and/or crushing of gravel.
- Pit-run gravel: Material obtained from a natural deposit of gravel without crushing or addition of other materials.
- Reference Roads Act: Road work includes any kind of work, building or structure (such as a roadway, footway, bridge, tunnel, road-ferry, rest area, transit way station or service centre or rail infrastructure) that is constructed,

installed or relocated on or in the vicinity of a road for the purpose of facilitating the use of the road as a road, the regulation of traffic on the road or the carriage of utility services across the road, but does not include a traffic control facility, and carry out road work includes carry out any activity in connection with the construction, erection, installation, maintenance, repair, removal or replacement of a road work.

2 WORK HEALTH AND SAFETY (MINES AND PETROLEUM SITES) ACT 2013 (NSW) AND WORK HEALTH AND SAFETY (MINES AND PETROLEUM SITES) REGULATION (2022) (NSW)

2.1 Regulatory requirements

Councils are required to register and license their quarries as mines with the Resources Regulator in NSW, or other States equivalent. This requirement exists whether the Council owns the land or uses the land by agreement with private landowners.

Work Health and Safety (Mines and Petroleum Sites) Regulations 2022 (NSW) requires Councils to identify all risks associated with activities at the quarry pits, for each pit, as part of the SMS.

2.2 Council requirements in NSW

- The Council is required to arrange training for any nominated QM with the NSW RR. The NSW RR is required to approve and appoint the selected QM for competency testing based on training, work experience, examination and site interview audit of knowledge of all pits under the nominated person's control. A document is then provided to the Council approving and issuing a practising certificate to the person as QM for the nominated licensed pits.
- The Council can arrange for SMS certified contractors to provide drilling, blasting, dozer winning, crushing, screening, loading and gravel transport for all pits. The QM will need to induct the contractor and contract the works under the Council's SMS. The contractor's Safety Management System needs to comply with Council's SMS.
- A unique SMS is required for each pit due to variations in each pit's geography and access road. These can be incorporated into one SMS document if required. Any differences in some pits can be added to the one document.
- The QM needs to train each property owner in their responsibilities under the MSMS. Further training may apply if the property owner changes. A written safety contract is required prior to each use of the pit with a QM diary reference.
- The Council needs a plan of each pit and the access road as part of the SMS.
- The pit needs to be properly defined to prevent accidental access by the landowner or approved persons. A fence and a locked gate are the preferred option for safety restraint. Mounding of earth is another barrier approved. The Landowner will be notified each time the pit is accessed, as outlined in the Landowner/QO agreement.

2.3 NSW Work Health and Safety Regulation Enquiry 2014

Following is an extract of the submission made by Carrathool Shire Council (NSW) to the NSW Work Health and Safety Regulation Enquiry 2014:

"Carrathool Shire Council has recently (2014) completed a review of all gravel pits (including retired pits) to determine the future procedures required in the rehabilitation of these pits should this become necessary. This has been done as part of Council's Gravel Pits Management Plan which identifies the current and future requirements of each of the pits under Carrathool Shire Councils jurisdiction. Most of Council's gravel pits are located on private land with Council signing agreements for operation of the gravel pits. Council contracts specialist mining operators to complete drilling, blasting and crushing operations usually a couple of times each year but this may vary depending upon demand and workload. No Council employee enters the pits while this is being conducted. Stockpiles are generally not located within the gravel pit itself and Council operations are limited to loading and hauling of material."

Councils generally have Safe Work Method Statements developed for all operations that are carried out including those associated with gravel pits and these are part of Local Governments focus on WHS as whole. Council believes that with 38 active gravel pits under the new regulation if gravel pits were to be treated as mines there would be a requirement for Council to have the same structure and procedures in place as are required in major mining operations which would place a greater burden on Council resources. Council's currently have Mines General Manager and Mine Production Manager (Carrathool Shire Council has 4 Production Managers) which we believe adequately covers our gravel pit operations."

Note: The NSW RR in Feb 2018 issued further explanatory guidelines in a bid to explain the requirements of the NSW Mines Act 2013 and the Regulations 2014 (this Act and regulation has been updated since 2018 as per **Clause 2**) as it will affect Council gravel pits.

Councils in NSW like Carrathool are having difficulties with the onerous nature of legal responsibilities focus and interpretation by NSW RR. Hopefully this will be further clarified in training for Quarry Managers for the new application to NSW RR for the Practising Certificate for Council's in NSW.

2.4 Safety of pit gravels across Australia – airborne and skin risks

Gravel pit operators need to test each licensed pit for the existence of toxic crystalline silica which is found in rocks containing silica (RCS), which is known cause:

- Lung cancer due to silicosis, for RCS particle sizes less than 10 micrometres and a concentration in air above 0.1 mg/m^3.
- Skin problems, caused by RCS particles greater than 5 mm in size.

Workers in the open pit should wear P2 respirators, safety glasses, overalls and gloves, where testing shows crystalline silica exists in the gravel. Amorphous silica is not a problem. This will be defined by testing laboratories.

Similar Airborne Crystalline Silica Exposure Groups - Level of dust exposure for workers:

- Driller (high).
- Crusher operator (high).
- Loader operator in quarry (in a/c cabin) (moderate).
- Truck driver (in a/c cabin) (moderate).
- Quarry supervisor intermittent exposure (moderate to high).
- Excavator (in a/c cabin) (moderate).
- Pugmill operator on the job mixing gravels (high).
- On road job labourer measuring load spacings / site foreman (high).
- Water truck operator on road job (in a/c cabin) (moderate).
- Loader operator at the pugmill (in a/c cabin) (moderate).
- Grader operator on the road job (in a/c cabin) (moderate).

2.5 Regulatory requirements in other states

In Western Australia's dry climate, the gravel material needs to withstand excessive degradation during construction and service. When subject to weathering processes, rocks can deteriorate over time (sometimes as little as 2 years). In the basecourse, shear failure can occur, leading to rutting, crocodile cracking and potholing. Disintegration can form excessive fines and loss of adhesion to the surface seal. The most common disintegrating rocks are quartzites, quartz gravels, sandstones, mud rocks and shales.

Main Roads WA *Operational guideline 96* is a generic document for gravel pit development that can be used in all states in Australia. It gives guidance for:

- Contracts with landowners.
- Field investigations.
- Equipment.
- Testing recommendations for different usages.
- Evaluating deposits in detail.
- Sampling for the different materials used for base course, subbase etc.
- Land ownership agreements with the landowner, including access easements.
- Stormwater drainage, provision for local drainage outlet rather than ponding.

In Queensland they have legislation *"Queensland Government, Model Operating Conditions: ERA 16 – Extractive and screening activities."* Gravel extraction and screening is listed as an Environmentally Relevant Activity (ERA) in the Environmental Protection Regulation 2008 – ERA 16 Extractive and screening activities. Most Councils will be a 2 (a) threshold activity 5000 to 100,000 tonnes. Other legislative requirements are in the *Environmental Protection Act 1994 (Qld)*, the *Planning Act 2016 (Qld)*, the *Mining and Quarrying Safety and Health Act 1999 (Qld) and the Mining and Quarrying Safety and health regulation 2017.*

3 QUARRY GRAVEL EXTRACTION FOR COUNCILS (NSW CASE)

3.1 Existing legal situation in NSW Councils

In NSW Councils, the existing Mines Production Managers (MPM) are usually operational employees of the Council, nominated by the Council to NSW RR. The MPM reports to the NSW RR Inspectors for Safety Management within the pit and on the access road.

In the *Work Health and Safety (Mines and Petroleum Sites) Act (2013) (NSW)* and in the *Work Health and Safety (Mines and Petroleum Sites) Regulation (2022) (NSW)* the MPM is now called the Quarry Manager (QM) and the nominating Council is now called the Mine Operator (MO).

As an example, in amalgamating Councils' the old Council entities are redundant and thus the only legal entity remaining is the MPM. The new amalgamated Council needs to nominate itself as the MO and to nominate the QM's to NSW RR. The MO needs to upgrade the gravel pit Mines Safety Management Plan to the new required Safety Management System (SMS) as described in the previous Mines Regulations 2014.

3.2 Landowners

As an example, some newly amalgamated Councils have a public relations problem when the royalty payments paid in one Council area are much higher than in other Council areas. This can be solved in one of two ways, either:

- The royalties are increased to the level of the better paying Council or
- The higher payment pits are acquired by compulsory land resumption, or by negotiation.

In one amalgamation situation, one Council paid royalties 3 times to that of the other Council.

In acquisition situations the Council should, before landowners are approached, complete any drilling investigations to determine possible future pit expansion to enable the size of any land resumption to be planned.

4 TESTING OF GRAVEL PITS

4.1 General

Many Councils single gravel pits (farmer pits) are described as providers of marginal road building materials. By collectively blending 2 or more adjacent pit gravels, the quality of the combined gravel may be improved to achieve better outcomes for sealed and unsealed roads.

- Testing of gravels permits selections of materials for road building by comparison with the desired use of the road pavement. Modelling can be used with test results for mixing of materials both local and commercial to achieve improved structure, density and impervious, waterproofing with dry powdered polymers and foam bitumen, and a stronger road pavement. Not all pit gravel blending will be successful. Therefore, it requires a lot of trial and error with different mix testing to achieve high density and impervious gravels with higher CBR and improved PI.
- Properties which are known to exert a major control on the performance of gravel are moisture content, maximum dry density, strength and stiffness (a materials capacity to resist deformation under load). Testing methods include:
  - The CBR test, for compressive strength.
  - Maximum Dry Density.
  - Plasticity Index.
  - Repeated load triaxial tests (RLTT), for characterisation.
  - Falling Weight Deflectometer test, for stiffness.
  - The Clegg Impact Test, for strength and stiffness.

5 FINANCIAL ARRANGEMENTS WITH GRAVEL EXTRACTION

5.1 Gravel as a stock item

It is ideal for gravel to be a stock item, subsidised by working funds. This arrangement allows for more gravel to be available for shorter haulage to the worksites, and for the blending of gravels from different pits. This reduces costs associated with unsealed roads and for construction of better sealed roads with close haul gravels. This cost saving is offset by reduced stockpile holding cost, however more differing material stockpiles are more cost efficient in an overall net cost.

Theft of stockpiled gravel and diesel fuel is an increasing problem. Access to use the gravel for farm tracks should be tightly controlled by the Council Quarry Manager. CCTV monitoring may also be utilised at the gate entrance and stockpile, to minimise theft.

6 UNSEALED ROADS READY RECKONER EVALUATION

6.1 Paige and Green study and the ARRB Spreadsheet model[i]

Paige and Green carried out a field study in 1989 to determine the performance of wearing course gravels in relation to material properties. The study found that the engineering geological classification of a material was insufficient for acute prediction of its performance in unsealed roads. Shrinkage product and grading coefficient are more appropriate for classification purposes. Blending wearing course materials known as mechanical stabilization is an effective method to utilize and enhance available materials while reducing road user operating costs and improve their properties and performance.

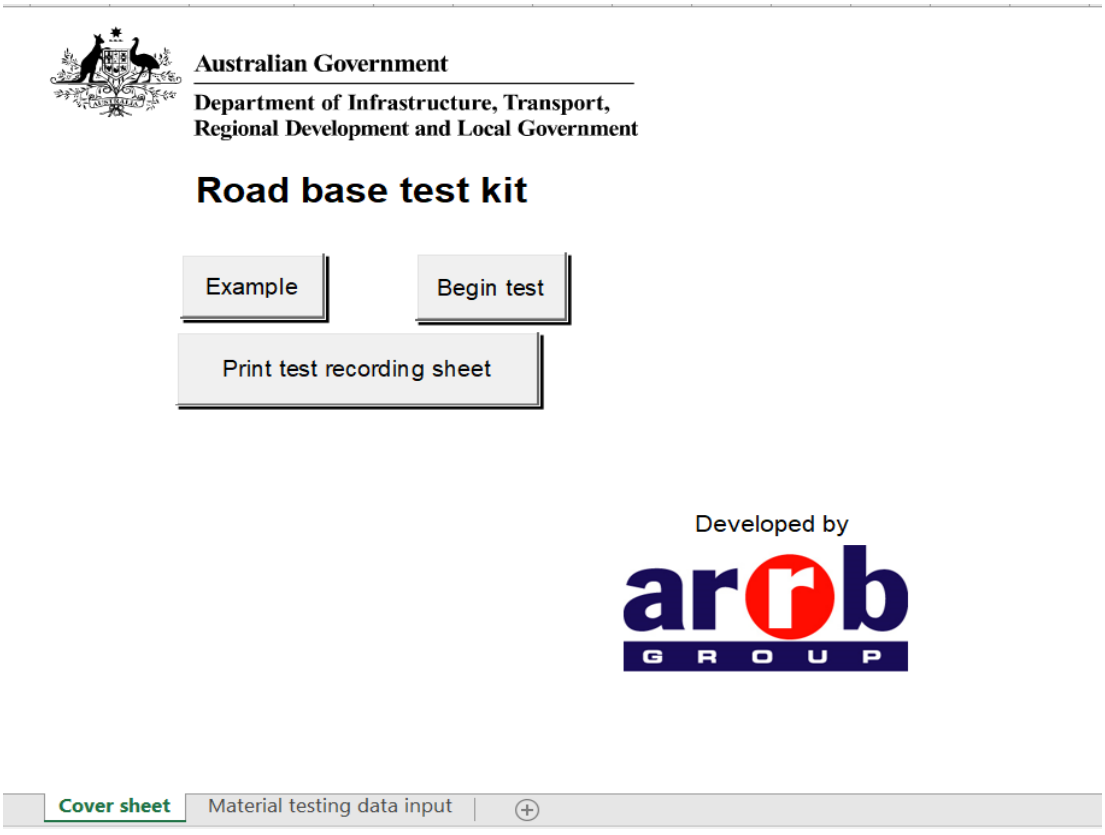
To assist local road practitioners, particularly in isolated areas, the Council can make better use of their local materials by using an ARRB road base kit. The kit provides a practical and low-cost method for assessing the suitability of natural gravels for pavements and requires the Council to conduct six separate tests to measure soil and water properties. The results are then entered into the spreadsheet to derive material properties and assess against given specifications. The spreadsheet has the capability to undertake mix design enabling blending of up to three marginal materials.

Each local Council gravel pit has different grading and shrinkage characteristics. Any given pit rarely has the exact requirements for an unsealed road wearing course requiring increased impermeability. Modifications by blending may be desirable to achieve better whole-of-life cost savings and extend resheeting intervention timing.

From the geotechnical laboratory report or the ARRB Road base kit, identify each gravel for suitability for wearing course gravel to minimise defects and extend the life of the unsealed roads between resheeting of the wearing course. If the gravel has particular defects, use the ARRB model for blending of different gravels to rectify the defects, as well as for granular blending, stabilisation and increasing time between grading interventions.

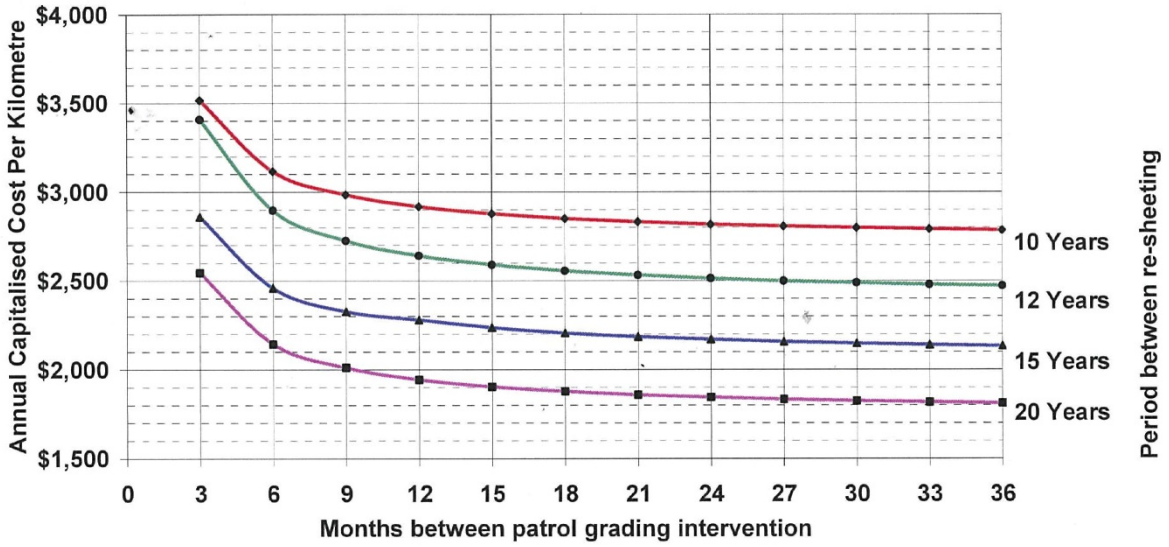
For more information, see NATSPEC TECHnote *DES 035 Improvement and Stabilisation of Unsealed Roads*.

The ARRB spreadsheet model is freely available by directly contacting the ARRB office.



7 GRADING INTERVENTION FREQUENCY AND GRAVEL RESHEETING LIFE

According to Austroads AGPT06 Clause 9.2.3, increasing grading intervention beyond 12 months has little impact on life cycle costs, increasing resheeting life reduces lifecycle costs significantly. Processes such as blending gravel materials or stabilisation that increases resheeting life can have a drastic whole-of-life cost benefit, even though the initial set-up costs are greater.



Life cycle analysis of sheeting life and grading interventions

8 BLENDING OF MATERIALS

8.1 Step by Step process

Councils can improve their gravel pits by examining the geotechnical test results from all pits in the local government area and examine those pits close to the required construction job by using the following steps:

- Step 1: Undertake a comprehensive geotechnical testing audit of all Council pits for both sealed and unsealed roads. See “Sample Gravel Testing” spreadsheet in the **Annexures** where the sample results are for sealed construction.
- Step 2: Obtain test results of nearest commercial quarry for lower cost product materials such as DGS20 or crusher dust. Tests required include sieve gradings, soaked and unsoaked CBR%, Atterberg Limits, Linear Shrinkage, Unconfined Compressive Strength (UCS), Maximum Dry Density (t/m^3), Los Angeles value, Permeability Coefficient and Optimum Moisture Content.
- Step 2a: Examine the mix testing results for the highest MDD to assess the impermeability of the gravel mix.
- Step 3: Use the free ARRB Spreadsheet Mix model for unsealed roads to draw grading graphs of mix combinations in various percentages totalling 100%. Try to use gravels with high CBR and opposite plasticity for both gravels. Consider screening one of the gravels for all plastic gradings below 0.425 mm to achieve a Plasticity of 7 or less and a CBR above 70.
- Step 4: Laboratory test the blending use of the closest pit gravel 80% by weight with say 20% commercial DGS20 gravel with all the gradings below 0.425 mm removed from the commercial DGS20 at the quarry before delivery.
- Step 5: Carry out comprehensive lab testing of all % trial and error variations to determine whether the complying CBR% and Plasticity Index can be created, and other bitumen seal complying testing can produce a gravel suitable for long life basecourse pavement layers.

Assuming suitable base gravel is available, ensure that the materials are delivered on the construction site in heaped areas for blending with a pugmill with the two gravels and water at 2% below optimum and possibly some lime stabilent if required.

Blended base gravel from a pugmill is capable to triple the daily production and achieve better quality of compaction due to better moisture control and thus higher compaction densities. The extra costs of material inputs and double handling at the pugmill is financially offset with substantially lower construction costs per tonne.

The creation of impermeable gravel is particularly important for unsealed roads, unsealed road shoulders for sealed roads, and the possible penetration of rainwater through microcracking of the bitumen seal. This results in the reduction of edge breaks and potholing, saving Councils considerable maintenance costs.

This use of better materials science and better construction management will lead to longer pavement life and lower amortised whole of life costs per annum.

9 BLENDING OF DIFFERENT GRAVELS AND STABILENTS

9.1 Pugmills

Pugmills are increasingly used by commercial quarries to create higher performing compliant gravels. Quarries have to discount non-complying gravels thus there is considerable financial benefit from blending.

A pugmill generally costs about $260,000 and can be used for blending gravel for both unsealed and sealed roads. A pugmill should be a standard item of maintenance equipment in single Councils or shared by groups of Councils.

A pugmill can be used at a job site for mixing different gravels with water and lime stabilent, up to 400 tonnes per hour.

An average daily production with grader, watercart and rollers is 500 tonnes per day. Production with a pugmill can reach up to 2000 tonnes per day on the job spread and compaction. Selection of a high output pugmill is more efficient than a lesser output pugmill when the cost of all the plant items is incorporated in the job cost.

When the water is controlled to 2% below optimum, it can be supplied mixed and ready for immediate placement and compaction. Stabilent can also be added in the pugmill if required. A Speedy moisture tester can achieve moisture control within 0.5%, with regular sampling at the pugmill. Moisture control is critical for achievement of maximum density and longer pavement life.

Typical pugmill

Blending of compatible gravels, especially with crushed hard rock stone, creates a dense and impervious gravel with lower plasticity and higher CBR%. The dense pavements reduce water percolating down to the weaker subgrade material, limiting the opportunity for potholing defects. Maximum Dry Density (MDD) can increase from 1.9 to 2.3 due to the filling of voids. Higher density improves pavement strengths and creates impervious pavements particularly for weather exposed unsealed roads. The increased speed of construction can offset the extra costs of importing materials and the double handling of materials with the loader and pugmill. This process can extend pavement life and lower annual whole-of-life costs.

The blending with a pugmill ideally could occur on a prepared roadside surface close to the construction site, allowing trucking materials import to occur from the various material sources prior to construction. This removes the delay of mixing material on site while the grader waits for the trucks to arrive, and substantially reduces grader and roller construction cost per tonne placed on the job, by increasing the daily tonnage productivity.

9.2 Standard grader gang

Mixing with conventional maintenance equipment can take extra time and with less quality control depending on the experience of the grader operator. Cassowary Coast Regional Council use the standard grader gang with the mix designed by the ARRB model ready reckoner with macros. They blended 3 materials which is difficult with just a grader gang. Using this method of blending Cassowary Coast Council (refer NATSPEC TECHnote DES 035) was rewarded with extended pavement life, less defects such as potholes and reduced interventions with maintenance resheeting.

9.3 Mixing with stabiliser machine

Productivity is dependent on delivery of gravels on site, with an extra task of mixing and incorporation of water and lime. Mixing with a stabiliser machine is less productive and lesser quality control than a pugmill. More variation occurs with control of water and stabilent by this method.

The stabiliser machine allows improvement of subgrade by incorporation of some of the clay subgrade material into a stabilent/gravel subbase mix to achieve a high density impervious base pavement.

9.4 Long term/whole-of-life target

Many Councils are resisting stabilisation and blending because it is an additional cost per tonne when added with other materials, transport, and purchase costs. These Councils do not properly consider reduced construction costs using high output mixing, reduced maintenance costs with longer maintenance intervention intervals, which results in reduced whole-of-life costs, per annum for Councils' annual maintenance budget due to longer pavement life.

9.5 Crushed hard rock filler

A screened crushed hard rock gravel (under 0.425 mm removed) when added 20% to the local pit gravel using a pugmill can increase the CBR% by up to 300% as compared with adding local ingredient gravels. Mixing water on site with the pugmill can triple the daily trimmed and compacted tonnage on the job. Mixed material can be provided from a roadside pugmill mixing area with a short haul to the road job.

9.6 Mixing trials

A local pit gravel of CBR% 30 when blended with another local pit gravel of CBR% 20 and1.5% lime could achieve a CBR% of more than 70. This is due to grading compatibilities and plasticity stabilising characteristics of lime. This requires testing in the laboratory. Some gravels may mix better than others. Refer to the sample test spreadsheet in Annexures.

9.7 ARRB sample modelling for blending

At Cassowary Regional Council (QLD), the mixture of three different local pit gravels using the ARRB spreadsheet-modelled design mix reduced potholing and other defects and extended the intervention maintenance time from three months to three years.

Mixing was done using a grader; however, a pugmill would have been more efficient and effective.

For more information, see NATSPEC TECHnote *DES 035 Improvement and stabilisation of unsealed roads*.

The ARRB spreadsheet model could be used to achieve the right blended percentage mix for unsealed roads, as well as to get longer wearing course sheeting life, reduced whole-of-life costs and better unsealed road usability performance satisfaction. ARRB Best Practice Guide 1: Road Materials and ARRB Best Practice Guide 2 Unsealed roads provide further guidance on the use of marginal materials for pavements.

9.8 Austroads Marginal Materials Report

Austroads have released AP-T335 *Appropriate use of marginal and non-standard materials in road construction and maintenance* which discusses the use of marginal road gravels in road construction and maintenance. Austroads AP-T352 addresses the use of marginal materials in both sealed and unsealed road pavements and Austroads AP-T353 provides guidance on fit-for-purpose use of locally available materials for sealed and unsealed road construction.

10 CASE STUDY: LACHLAN SHIRE COUNCIL, NSW

10.1 Introduction

The Lachlan Shire is a local government area in the Central West region of New South Wales. The entire shire area encompasses 14,973 km^2 with a population of 6,372 (2021). Its largest town is Condobolin with a population of 3500 (2021).

Lachlan Shire Council has 31 natural working gravel pits and 40 disused pits in its local government area. It has access to three blue metal quarries at West Wyalong, 110 km south of Condobolin; Forbes, 90 km to the east; and Roache, 48 km to the north.

The breakdown of Lachlan Shire's roads in kilometres is as follows:

	Sealed	**Unsealed**	**Total**
Regional	600	100	700
Local	400	3300	3700
Total km	1000	3400	4400

10.2 Gravel pits

Of the 31 working pits and 40 disused pits, 21 have stored gravel stocks.

For this stored gravel, is a sunk investment. The Council has created close access from the quarries to the job sites.

Interest holding costs on the gravel stocks are offset by savings from shorter truck hauls and reduced damage costs to the existing local road when the gravel stocks are transported to the job site.

The large number of pits allows more defect rectification opportunities by proportional blending of gravels from different pits, aided by the ARRB spreadsheet model.

Most of the pits require drilling and blasting, so there is a lead time needed to procure gravel with drilling and blasting contractors. Larger purchase quantities reduce the cost per tonne in establishment costs for crushing and screening.

Contractors usually prefer contract job lots of 5,000 m^3 loose, with minimum quantity 3,000 m^3. The larger the job lot quantity, the cheaper the total cost per cubic metre, due to establishment and disestablishment costs.

10.3 Geologist's report

Lachlan Council commissioned a geologist to do an assessment review of the 31 current Council-operated gravel pits. The report is comprehensive and documents basic geological interpretation. It also provides an operational overview that includes site access, pit sizes, historic volumes extracted, current mining methods, and the amount of gravel observed as stockpiles.

The geologist report includes a table of pit rankings based on observed geology and material hardness. Geotechnical testing of crushed material samples is yet to be completed, as testing of crushed and screened gravel can produce very different results in comparison with the geologist's interpretations.

Locations for drilling investigations for best pit expansion have also been recommended. These should be included in pit mapping in the landowner's agreement and gravel pit license with the State mining authority.

Five of the pits were identified with vertical walls slope stability safety risks and will require further drilling and blasting to create a 45-degree slope batter.

10.4 Future options

For the spreadsheet that tabulates information from the geologist's report, see SPREADSHEET- Lachlan Shire gravel pits.

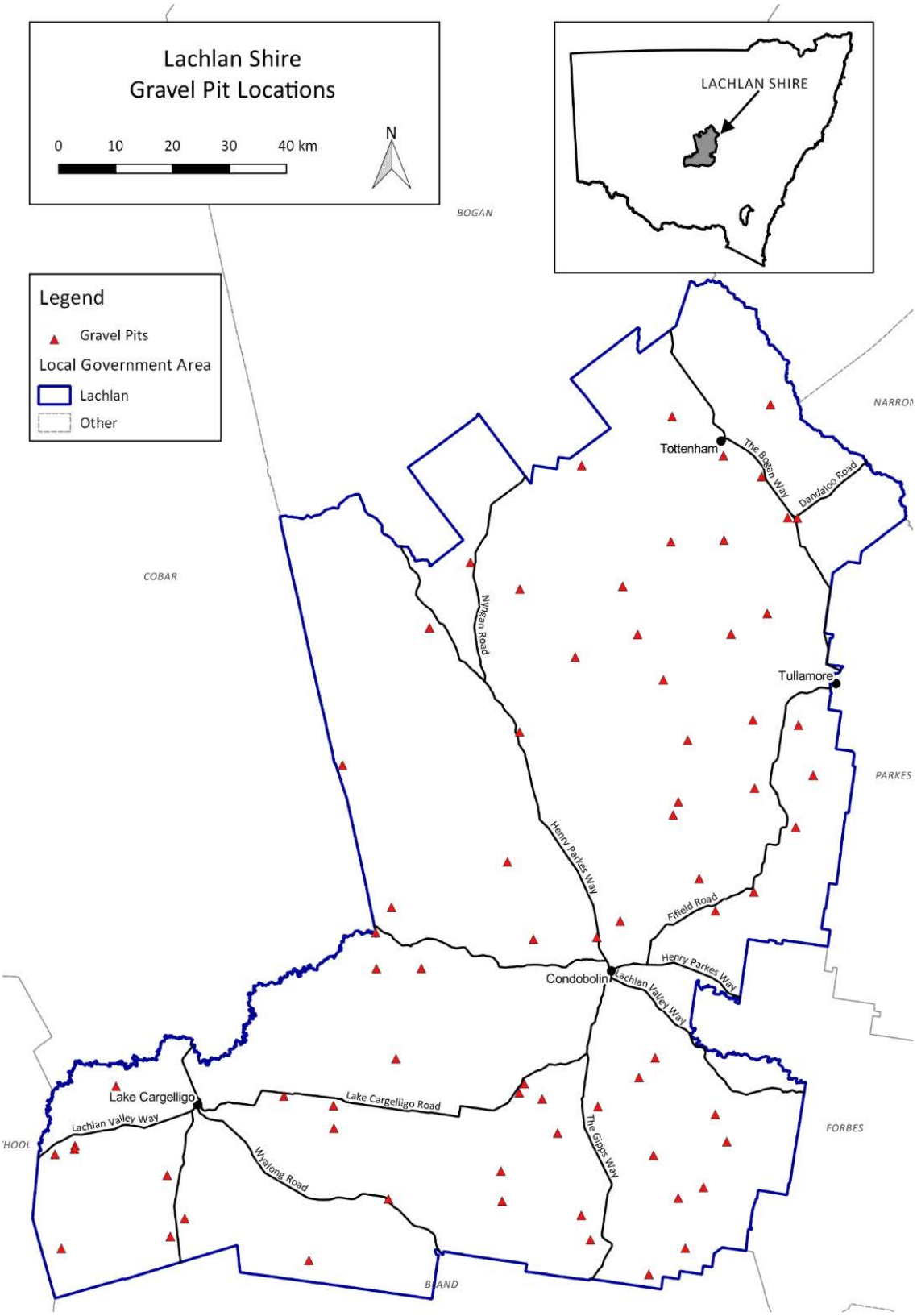
Lachlan Shire Geotechnical testing results for crushed and screened gravel only exist for seven of Lachlan Shire's pits. The tests need redoing to include linear shrinkage percentage for use on the ARRB unsealed roads blending spreadsheet.

The first step to assess the material quality from the gravel pits is to comprehensively test each of the 31 used pits, 40 disused pits, and non DGB20 by-product materials from any local commercial quarry. Tests required include sieve gradings, Atterberg limits, plasticity index, soaked and unsoaked CBR%, linear shrinkage percentage, optimum moisture content, unconfined compressive strength, aggregate durability, repeated load triaxial tests, Clegg impact factor, and maximum dry density. See worksheet in Annexures.

The consultant geologist's suggestions should be utilised by developing a drilling investigation plan for all 31 pits for future pit expansion. Drilling and blasting soil samples for geotechnical testing could be undertaken, for example, to create safety barriers in the suspect pits. Further consultation with another geologist may be required.

The geotechnical drilling and testing results may be used to determine an extent for future pit expansion. It is important to be aware of the potential of each pit by planning for future extension. The alternative is cancelling the pit licence which triggers pit rehabilitation requirements to comply with environmental legislation.

MANAGEMENT OF COUNCIL GRAVEL PITS IN COUNTRY AREAS



10.5 Mix design trial – Pit A and Pit B gravels

The *Road Base Test Kit – Mix Design* graph is the final selection trials of different blends of Pit A and Pit B pit gravels located in Lachlan Shire.

Single pit gravel graphs for each individual gravel were produced that allowed assessment of the best percentage mix blend with the aim of getting the red triangle in the centre of the "good" portion of the graph. The mix 30% Pit B and 70% Pit A was selected by the trial and error design process.

Road Base Test Kit - Mix Design

File name Pit A

Sample number: Trial 1

Material use: Base (unsealed and wearing co

Material B source: Pit B — Material B number: 14 180

Material C source: — Material C number:

Material Grading

Sieve Size (mm)	Target grading upper limit %	Target grading lower limit %	Test Material A %	USER INPUT Material B %	USER INPUT Material C %	Resultant mix design %
37.5	100	100	100	100		100
19	100	100	88	92		88
9.5	90	60	72	73		72
4.75	75	40	61	57		61
2.36	65	25	53	46		53
0.425	45	10	43	32		43
0.075	30	6	28	17		28
Liquid Limit	30	1	35	27		29
Plasticity Index	18	8	14	9		11

Calculate mix design

Out of range

% passing 25mm 91.9

% passing 2mm 51.8

Mix design proportions

A	B	C	Total
0.30	0.70	0.00	1.0

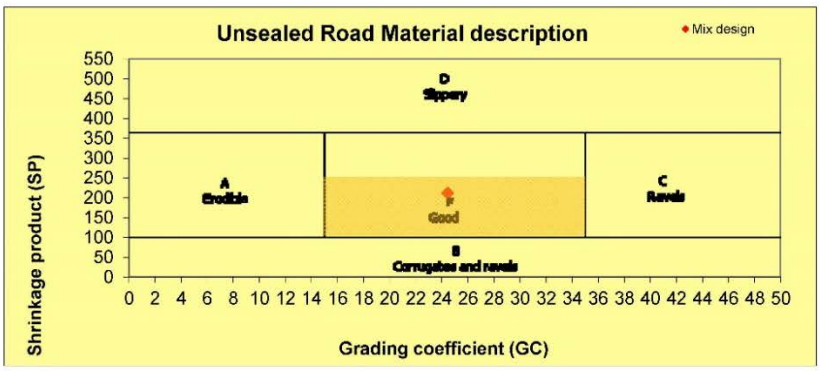
Note: Proportions are by weight

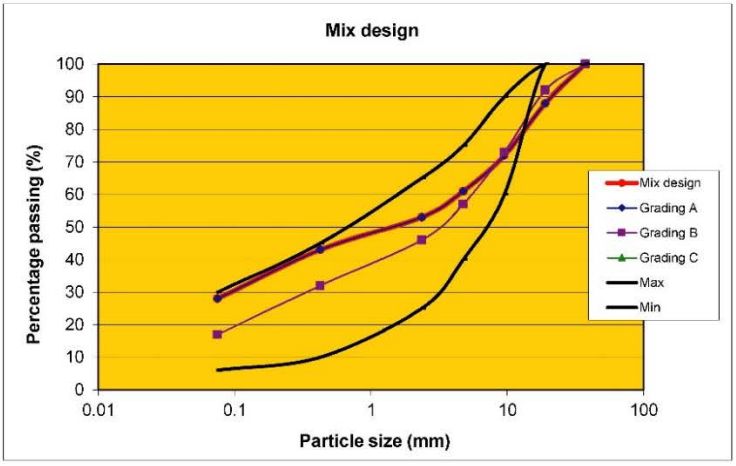
Material description	Brown silty gravel
Possible density range (t/m^3)	2.1
Estimated MDD (t/m^3)	1.83
Estimated OMC (%)	9.30
Possible CBR range (%)	

OMC Not applicable - conduct test - refer to

Minimum amount of material A to use: 30 %

This should only be used if the mix design result does not use material A and it is required that the mix use some proportion of material A





10.6 Better Construction Methods with blended materials for Lachlan Shire

Current pits

- Presently, Lachlan's natural gravels are approximately CBR% 30 with plasticity 12, subject to more geotechnical testing.
- Blending with small percentages of screened DGS20 (e.g. 20%) and lime at 1%, should produce minimum CBR% 70 and plasticity 6 or 7, which is suitable for sealing. A further option to assist achieving a lower Plasticity Index is to remove, by screening, less than 0.425 mm fines at the commercial pit before transporting the remnant larger gradings DGS20 gravel to the job site.
- Blending for Pit A in the laboratory with 1.5% lime increased from CBR 30 to CBR 60.
- Prepare pit plans and build fence surround.

Better pit management

- Prepare a pit site plan with aerial photo overlay for each of the 31 current pits and 40 disused. Include the access road to the closest Council public road as a map base for the MSMS for each pit. Include contours if LIDAR is available to extract contour information. Otherwise, drones can be used to survey the quarries and surrounds. Use the plan to construct new boundary fencing as a safety item.
- Identify new cadastral plans for each pit, to create new boundaries based on future expansion evaluations.
- If resumption is selected due to failed landowner negotiations, arrange purchase of land and access easements, by compulsory acquisition resumption and gazettal.
- Arrange construction of boundary fencing to the new pit boundaries, including a gate with only a Council gravel pits master lock and a lock interconnected with the farmers lock when farmer access is permitted by the landowner/Council agreement. Arrange suitable signs at the public road access identifying the name of the pit and ownership.

Mine risk management plan

There are 3 reports:

- Geologist report, geotechnical report, and a safety report.

Actions required:

- Reference the geologist report with slope stability risks on about five pits.
- Prepare a new safety pit batter plan for all the identified unsafe pits for submission to the NSW RR and inclusion in the MSMP.

Sealed road base pavement

There is a need to increase the quality of the local pit gravels using a blending of crushed and screened hard rock gravel with the local pit material. Asphalt sealed roads may require more strength and stiffness in the base gravel.

Try laboratory test blending using a by-product blue metal DGS20 from Millers West Wyalong pit or Millers Forbes pit or Roaches Pangee Road pit 47 km southwest of Nyngan. From test results do a blending model for selected local pits to create a qualifying road base for bitumen sealing. Use AUS-SPEC worksections *0042 Pavement Design* and *1141 Flexible pavement base and subbase*.

Select local pits in close proximity to programmed new sealed roads identified in works programmes by the Asset Manager for sealed reconstruction and rehabilitation.

Disused pits

Some of the 40 disused pits can be identified and selectively tested (should it be required) near roads that have wearing course defects. Information is not available as to exactly why these pits became disused. Potential causes include the gravel being too plastic or drilling and blasting being required and more accessible materials being available elsewhere. If the material is clayey and plastic, the clay pit could be used to improve other nearby pit gravels that have low plasticity. Low plasticity can cause ravelling and corrugation problems for unsealed roads.

Estimated cost for geotechnical testing of 31 gravel pits at Lachlan

The estimate of $46,000 for one comprehensive suite of tests per pit, assuming tender work is done with provisional items for extra testing if required with unused pits and blue metal quarries. Extras also may include trialling 20% screened West Wyalong DGS20 (remove/screen material sieve material below 0.425mm) mixed with 80% Council pit gravel.

11 SURVEY RESPONSES

Quarry management forms the basis of the provision of quality roads services. Quarries are a key part of this service however they are inherently a high risk for Councils. Control of quality and risk in quarries should be key performance control targets for Councils' day-to-day management.

A number of Councils in central NSW were invited to respond to a questionnaire conducted by AUS-SPEC, regarding methods of quarry pit management in their local government area. AUS-SPEC was prompted by the introduction of NSW Mines Act 2013 and Mines Regulations 2014 this Act and regulation has been updated since 2018 as per **Clause 2**) that affected NSW Councils regarding the management of their gravel supply for roads maintenance and construction.

Councils that responded to the questionnaire included the members and a few other Councils is a voluntary regional collaboration of councils in Central NSW and is now known as the Central NSW Joint organisation (2018).

Responses were received from Councils in Wagga Wagga, Cowra, Gilgandra, Parkes, Bathurst, Lachlan, Weddin, Forbes, Cabonne, Blayney, Bogan, Wellington, Midcoast and Dubbo.

11.1 Summary of the survey responses

Question	Responses	Notes
No. of gravel pits controlled by Council	Ranging from 0 km at Bathurst to 31 km at Lachlan.	
Length of unsealed Council roads	Ranging from 166 km at Bogan to 3000 km at Lachlan.	
Length of sealed Council roads	Ranging from 370 km at Blayney to 1000 km at Lachlan.	
Gravel stocks funded by stock item or direct allocated annual budget job costs?	5 Councils fund as a stock item, and 6 Councils produce gravel with direct budgets.	Stock items create consistent production funding from working funds, producing efficiency savings on haulage distances from closer pit stocks.
How much total gravel in stock (m^3 loose)?	Ranging from 3500 m^3 at Bogan to 222,000 m^3 at Lachlan.	Interest costs on stock reserves are offset from savings in haulage to the needy sites.
Do you have full geotechnical tests for each pit?	Yes – 5 Councils; no – 4 Councils.	
Do you have linear shrinkage tests for each pit?	Yes – 2 Councils; no – 9 Councils.	Linear shrinkage is needed for unsealed roads.
Do you have sieve gradings for each pit?	Yes – 3 Councils; no – 6 Councils.	Sieve gradings are needed for both sealed and unsealed road design.
Do you have soaked and unsoaked CBR% for each pit?	Yes – 2 Councils; no – 8 Councils.	Soaked CBR% is needed for suitability for roads that are subject to occasional flood inundation. Unsoaked CBR% for other roads.
Do you have Plasticity Index for each pit?	Yes – 3 Councils; no – 8 Councils.	Plasticity Index and CBR% are key road gravel design indicators.
Do you use closest pit principle for maintenance of unsealed roads?	All Councils said yes.	Wagga stipulated "unless quality is a problem."
Do you blend or stabilise gravels for improving unsealed roads?	Yes – 7 Councils; no – 4 Councils.	It is unclear whether it is a mixing of different gravels or chemical stabilising. The largest cost item for unsealed roads is resheeting. Gravel blending can extend wearing course life, improve defects and ratepayer satisfaction, and reduce unsealed roads maintenance expenditure.
Do you use ARRB test kit for designing unsealed roads wearing course?	All Councils said no.	
Do you blend or stabilise gravels for improving sealed roads?	All Councils said yes.	Councils have an opportunity to blend different gravels to achieve a longer life for their sealed roads, and compliance for base course selection.

Question	Responses	Notes
Do you have blue metal quarries in your Council area or nearby?	Yes – 8 Councils; no – 3 Councils.	There is considerable opportunity to create high density and strength base course materials by blending small percentage blue metal with products with local pit gravels. A key benefit of blending is the increase in dry density, creating impervious base and subbase gravels to reduce potholing. See relevant AUS-SPEC worksections and TECHnotes for more information.
Do you own all the pits in your Council area?	Cowra owns all three of their pits. Other Councils, except Bathurst, lease pits by royalty agreement with the landowner and mines license with NSW RR.	Bathurst is the only Council that totally purchases all gravel from contract pits without owning or operating any pits. Cowra now has long hauls, up to 85 km for gravel. The closing of high PI farmer pits has been detrimental to unsealed roads maintenance.
If no, how many pits from total of pits do you own?	Very few pits where the Council is the landowner.	Comprehensive agreements between the Councils and landowners are needed. A selection of reference landowner agreements from various Councils are available in **Annexures**.
How many pits do you have a DPI quarry license for?	Ranging from 3 at Cowra to 31 at Lachlan.	
How much royalty to the landowner do you pay per m^3 loose?	Ranging from \$0.60 at Lachlan to \$3.00 at Wellington.	Some Councils, such as Wagga, pay an additional annual fee of up to \$2000 per annum. Other Councils allow the landowner to obtain a limited amount of free gravel for their farm roads. This is not recommended where the farmer uses their own loader and trucks unsupervised. Council is the Quarry operator and is directly responsible to DPIM for any unsafe actions by the landowner.
How much do you pay for crushing and screening per m^3 loose?	Ranging from \$6.60 to \$10 per m^3 loose in heap.	Lachlan Council has a contractor doing drilling, blasting, winning, crushing and screening for extra costs.
What is the minimum crushing and screening quantity required by your contractor?	Ranging from 2000 to 6450 m^3.	Lower quantities are priced higher to reflect establishment and disestablishment costs.
Do you do drilling and blasting?	Yes – 5 Councils; no – 6 Councils.	
What is your mobilisation cost for drilling and blasting by your contractor if known?	Two councils responded: \$1200 and \$1693 per site.	
What is the cost per m^3 loose for material sourced by drilling and blasting, excluding establishment or disestablishment costs?	One response: \$4.79 per m^3 loose, blasted and uncrushed compared with \$4.31 per m^3 loose ripped and won by dozer only.	This is dependent on the remnant size of rocks that may need further work with a rock hammer to get rocks down to an acceptable size for the crusher jaws.
Have you had a geological safety inspection of your pit walls for slope stability?	Lachlan, Weddin and Cabonne said yes.	

12 DISCUSSION OF THE SURVEY SUBMISSIONS FROM THE QUESTIONAIRE

12.1 Discussion on survey submissions

- Councils in most cases need to upgrade their legal agreements for access to private land for quarry and quarry access track. Alternatively, with the permission of the Councils, use the Blayney, Wagga (new) Lockhart generic or Upper Lachlan Council policies and templates.
- Councils use Local Government procurement AS 2124 contracts for drilling, blasting, winning, crushing and screening and stockpiling for payment measurement. This requires the appointment of a Contract Superintendent as a separate position to Quarry Manager.

- The position of Mines Production Manager or the new position of Quarry Manager in the new Mines Act does not recognise the authority of a Contract Superintendent within the boundaries of the pit and access road license. The solution is to make the Quarry Manager the Contract Superintendent for any contract within the Quarry license area including quarry access road.
- The position of Quarry Manager is a statutory position for each pit or all of Councils licensed pits and is a position appointed only by NSW RR based on only a nomination from Council.
- Councils should ensure that any person nominated and appointed as extra Quarry managers/ decision makers within the pits Safety Management System are appointed and approved persons by NSW RR in writing by a formal instrument from NSW RR.
- All the activities and procedures such as drilling, blasting, winning, crushing, screening, loading, and trucking should be documented within the Mines Safety Management System.
- Councils operational staff or contractors should gain approval from Councils Quarry Manager before entering any quarry. Entry Permit Documentation should be created as a proforma, or a Quarry Diary be used to document all access and site inductions. It may be best to nominate an operational supervisor as the Quarry Manager rather than an office-based person.
- In some Councils it is best practice to appoint multiple Quarry Managers where multiple works depots are used for operational control. This is required in Councils where former Council works depots are retained by amalgamation requirements. Amalgamated Councils need to reapply to NSW RR as a single Mines Operator and to renominate Mines Production Managers as Quarry Managers if applicable.
- All pits should be evaluated for future expansion and quality and quantity surveyed. This will require drilling and testing of samples by geotechnical laboratories. This should be followed up with a revised pit map from GIS maps for the enlarged area plus the access road. Alternatively use a stand-alone drone survey of all pits and access road. These actions are essential to guard against any future disputes that may occur between Council and the landowners with change of land ownership.
- When the expansion mapping is completed for all pits, it is recommended that all landowners be sent the new upgraded legal agreement.
- Council should be aware that if the Council and Landowner cannot reach agreement and Council elects to withdraw from the pit license then Council will be liable for pit rehabilitation as defined by State legislation.
- An alternative is compulsory acquisition under the Local Government Act. An alternative to rehabilitation expenditure is a combination strategy of pit expansion and land resumption.
- Cowra Council operates and owns 3 licensed pits that are low PI and high CBR pits. They abandoned the use of “farmers pits” for use on unsealed roads more than 15 years ago due to onerous environmental regulations and fear of the cost of environmental reports and the Council Development Application process. These farmers pits provided a good source of plastic gravel however low CBR%. The farmer pits were closer to the worksites thus reducing haulage costs. They have problems with their existing 3 low plasticity pits with some of their unsealed roads displaying defects such as ravelling, corrugations and potholes thus Cowra may need to revisit farmers pits to enable use of blending to improve the quality and plasticity (PI) and lower the whole of life operating costs of their unsealed roads. Blending of high CBR / low PI gravels with low CBR / high PI gravels farmer pits is an option to be considered to achieve a target PI between 9 and 13. Higher MDD and accordingly improved impermeability (and reduced potholes) is a further bonus for blending.
- Amalgamated Councils may have gravel royalty problems. The constituent Councils may have substantially different history of royalty amounts per cubic metre loose in heaps. If this becomes a problem in particular sites, then the Council may need to acquire the land and access road to regain royalty control.
- Landowner Access Agreements, Wagga Wagga City Council. See Annexures of this report. This can be used as a sample by other councils.

12.2 Summary and conclusion of survey questionnaire from Councils

- All Councils should do comprehensive geotechnical and slope stability testing of each gravel pit.
- Quarry Manager should be appointed by Contract Superintendent (AS 2124) for contractors working in the licensed gravel pits.
- Quarry Manager is a RR appointed position under the NSW Mines Act 2013 and needs to be notified of all movements in and out of any licensed pit.
- All pits should be surveyed, tested and mapped for future expansion including access track and the gravel pit information template should be prepared for each pit as per Section 15.2 of this report.

MANAGEMENT OF COUNCIL GRAVEL PITS IN COUNTRY AREAS

- Revised landowner agreements (select better agreement wordings) should be prepared with proper mapping that includes access road and new expanded pit areas for future pit growth.
- Disused pits should be re-evaluated for blending opportunities to achieve improved gravel performance. These may require new DAs to reactivate pits if required.
- Use of gravels from commercial hard rock quarries may be tested and considered for blending with Council pits or disused pit gravels.
- Contractor activities such as drilling, blasting, winning, crushing, screening, loading and trucking should be controlled for safety and risk in the quarries, by matching Councils Mines Safety Management Systems (MSMS) within the Contractors Safety Management Plans.

13 ANNEXURES

13.1 SPREADSHEET- Lachlan Shire gravel pits (July 2017)

Working gravel pits (31)

Gravel pits	Amount extracted (m^3)	Existing loose gravel stockpile (m^3)	Comments
1. Good quality			
Davis	21,000	200	Hard rock, sandstone, unstable walls.
Glencoe	40,000	11,000	Pit walls unstable, requires land resumption.
L'Estrange	63,000	200	Remnant stockpiles require testing.
May	24,000	10,500	
Todd	0	0	Needs short drill program, good prospect.
2. Moderate quality			
29 Mile	54,000	2429	Close to road, good pit expansion prospect.
Beatie	62,700	25,000	Testing and samples needed, no limits.
Bolam	145,000	10,000	Unstable pit wall, good expansion prospect.
Bryant	50,000	0	Silt stone clays, CBR with 1% lime increases to 50.
Dwyer	46,000	8500	Relocated road, hard rock.
Elwin	116,000	17,000	Variable material.
Fair	20,000	15,000	One of two pits abandoned due to water.
Medcalf	44,000	200	Requires testing.
Mooney	27,500	2300	Requires testing.
Quade	10,000	0	Requires drilling and geotech testing.
Reid	15,000	0	Won by dozer, near LG boundary.
Rigney	88,000	12,700	Increase to CBR 60 with 1% lime, alternative trial testing with 20% by-product blue metal DGS20 fines screened out ex pit then cart reduced DGS20 for onsite granular blending for sealing road base material.
Stanley	11,000	0	Softer material won by dozer, near LG boundary.
Wilson	0	0	Requires drilling and geotech testing
Worthington (north end)	45,000	0	Southeast corner of pit is promising.
3. Poor quality			
Fox- Ashwin	62,000	3600	Unstable walls, soft rock, good prospect for expansion.
Glenlee	47,000	20,000	Needs testing.
Harding	68,500	10,400	Not used for a number of years. Needs testing. Large stockpile needs using.
Hope	0	2,100	Not required due to Glencore pit nearby.
Martin	14,000	23,000	High clay content needs access track upgrade.

MANAGEMENT OF COUNCIL GRAVEL PITS IN COUNTRY AREAS

Gravel pits	Amount extracted (m^3)	Existing loose gravel stockpile (m^3)	Comments
North Condo	72,000	23,000	Unsafe walls require EIS for expansion 50 CBR unsoaked and 19 CBR soaked. Needs stabilisation or granular blending to reduce effects of moisture.
Sanson	85,000	14,000	Clay and siltstone, requires testing and drilling to assess extent and depth.
SR103	10,000	200	Small piles of uncrushed material need lab crushing and testing.
Turner	35,000	2,500	Recent mining, unstable pit walls, different rock types require testing, angled drill program on walls for safety.
Webb	28,000	9,100	High clay content requires shot drilling, walls unstable.
Winter	31,000	0	High clay content, requires test drilling, requires EIS.
Total	**1,334,700**	**222,929**	**Future pit expansion capacity needs determining for each pit**

13.2 Gravel pit information template

<table>
<tr><td colspan="3">Sample PIT INFORMATION FORM</td><td colspan="2">Council</td><td>ABC Council</td></tr>
<tr><td>Pit Number</td><td>Pit Name</td><td colspan="4">Pit Location</td></tr>
<tr><td rowspan="8"></td><td rowspan="8"></td><td colspan="4"></td></tr>
<tr><td colspan="2">Longitude</td><td colspan="2">Latitude</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Nearest crossroad and distance</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">Owner and Postal Address</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Has Council and the Landowner signed an access agreement?</td><td></td><td colspan="2">Has Council completed a Safety Management Plan for this pit?</td><td colspan="2"></td></tr>
<tr><td>Area of pit</td><td>Depth of gravel</td><td colspan="2">Estimated quantity (m³)</td><td>Life expectancy</td><td>Average yearly removal by Council (m³)</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="3">Sale to outside sources (m³ per year)</td><td colspan="3">Price external loose per m³ ex bin</td></tr>
<tr><td colspan="3"></td><td>Crushed and Screened 20 mm</td><td>$</td><td>Crushed and Screened 40 mm</td><td>$</td></tr>
<tr><td>Gravel Type</td><td colspan="6">20 or 40 mm</td></tr>
<tr><td>Comment</td><td colspan="6"></td></tr>
<tr><td>Plastic Limit</td><td>Linear shrinkage %</td><td>Plasticity index</td><td>Maximum Dry Density</td><td>Optimum moisture content</td><td colspan="2">Soaked CBR% (unsoaked CBR%)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Date tested</td><td>Date tested</td><td>Date tested</td><td>Date tested</td><td>Date tested</td><td colspan="2">Date tested</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
</table>

% Passing sieve size mm	Target 20 mm nominal for unsealed road wearing course	Target 20 mm nominal for base course under wearing coarse unsealed roads	% passing this sample pit dated ……
53			
37.5			
26.5	100%	100%	
19.0	100	95 -100	
9.5	60 - 90	70 - 92	
4.75	40 - 75	50 -76	
2.36	25 - 65	35 - 63	
0.425	10 - 45	15 - 40	
0.075	5 - 30	4 - 25	

13.3 Quarry layout and locations

"[Insert quarry layout]"

"[Insert shire map and quarry locations]"

13.4 Owner and location pit information

Pit No.	Pit Name	Pit Address	Owner	Postal Address	Longitude	Latitude	Area
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

13.5 Wagga Wagga City Council

Landowner agreements

The following quote is an example from Wagga Wagga City Council regarding their Landowner agreements:

A 10-year agreement has been almost unsaleable. Shorter terms such as 3 years are much easier but less desirable operationally. The negotiation process and agreement terms seem to be influenced by the prevailing seasonal conditions and the general current farming outlook.

At Wagga the setting of royalties is not in staff delegation control. It requires a resolution of Council to adjust them (indexing is allowed), hence a consistent rate across council operations. Not all pit sites are fenced, nor gates locked due to location and land holder wishes. Maintaining a low-profile operation in the rural area assists with site security and landholder concerns re trespass. This conflicts with the mines requirements for signage at entrances. Where possible the signs are set back from the roads if possible and or have them at the pit gate if the site is in a paddock a bit removed from the public road.

Rehabilitation liability: Wagga use the mines "bond calculator" for accounting purposes. Domain areas are determined from google earth/ aerial imagery. It's a reasonable first step for assessing the expenses involved in rehabilitating a site in the event of an unplanned closure. The government is enforcing rehabilitation in commercial mining activities, and it is highly probable that Councils will need to pay rehabilitation costs where landowner agreements cannot be negotiated. The NSW RR advised us to conduct our own risk assessment in regard to type of fencing provided on site as a deterrent to trespass. A rural site is usually less concern than one closer to an urban area. Locally sourced gravel result in savings of about 50% on material supply relative to more remote commercial suppliers based closer to the urban area."

13.6 Sample gravel testing spreadsheet

Worksection 1602 Maintenance Schedules- road reserve

Sample Only Incomplete Example -Councils Gravel Pits and Geotechnical Test Results for Evaluation of Qualities of each pit and mechanical stabilisation for use as a sealed or unsealed pavemen

Gravel Pits - Geotechnical testing					Particle size distribution % passing																	
Pit No.	Pit Name	Material Description	Base or Unsealed wearing course usage target?	Test sample number	37.5mm	19 mm	9.5 mm	4.75 mm	2.36 mm	0.425mm	0.075 mm	CBR% soaked	CBR% unsoaked	Liquid Limit	Plasticity Index (PI)	linear shrinkage %	Maximum Dry Density (MDD)	Permeability Coefficient	Los Angeles value to AS 1141.23	Unconfined Compressive Strength Note: 5	ARRB spreadsheet model Defect Analysis- Good, slippery,dusty, corrugates, ravels erodible, low density is pervious not good results in potholes?	
1	Hansons/ Class 4/ DGB20	DGB20	Base or Unsealed wearing course usage target?	ABC	100	99	81	55	36	18	7	380		24	12	5	1.99				High structural strength , however Maximum Dry Density (MDD) is too low and too porous for use in unsealed roads. Porous gravels = subgrade failure and potholes.	
2	Mawsons	DGB20	Base or Unsealed wearing course usage target?	123	100	95	75	63	51	40	20	70		18	2	0	2.21				Needs blending with clay material to get higher plasticity. Try 30% of this Mawsons with 70% Western Red Ridge Gravel. Need higher MDD to qualify for unsealed wearing course.	
Mix 1	35% Hansons Class 4 with 65% Mawsons DGB 20	DGB20	Base or Unsealed wearing course usage target?	def	100	96	72	60	47	29	16			NP	NP	0.5					Will pothole , ravel and corrugate.	
Mix 2	25% Hansons Class 4 with 75% Mawsons DGB 20	DGB20	Base or Unsealed wearing course usage target?	456	100	97	74	63	51	32	16	200		NP	NP	0	2.38				High MDD qualifys as impervious gravel and high CBR gives good structural strength. Needs addition of clay western red ridge gravel to increase PI to over 9 for use as an unsealed wearing course.	
Mix 3	35% Hansons Class 3 with 65% Mawsons DGB 20	DGB20	Base or Unsealed wearing course usage target?	ghi	80	72	59	50	44	48	14	240					2.4				Ditto Mix2.	
Mix 4	25% Hansons Class 3 with 75% Mawsons DGB 20	DGB20	Base or Unsealed wearing course usage target?	789	100	97	74	62	51	29	16	240		NP	NP	2	2.4				This Mix 3 requires clay material. Density is good for unsealed and sealed roads. Good structural strength for sealed roads	
Mix 5	35%mawsons Class 2 with 65%Forsters	DGB20	Base or Unsealed wearing course usage target?	jkl	100	95	74	58	51	35	21	110		19	6	2	1.98				Requires clay gravel addition to get higher density (1.98 is too low) and higher plasticity over 9 PI for unsealed roads(existing only 2)	
Mix 6	25% Mawsons Class 2 with 75% Forsters Gravel	DGB20	Base or Unsealed wearing course usage target?	989	96	91	73	64	55	46	28	60		24	14	5	1.92				Forsters is not a good gravel and gives poor results with blending when tested with other local gravels.	
	Western Ridge Gravel	DGS20	Base in western roads or Unsealed wearing course usage target?	mno	80	72	59	50	44	36	14	25		25	15	5	2				Low density, high plasticity, has natural limestone stabilents. Downside is low structural strength due to low CBR. This material is used as sealed base course in dry western shires however it suffers loss of structural strength when moisture content exceeds 9%. Should blend well with Hansons to get higher density and impermeabilty which is good for unsealed roads.	

Note 1: The orange column is the key indicator for both sealed and unsealed roads. Require high Maximum Dry Density or low permeability coefficient.

Note 2: The yellow column is the CBR% which identifies structural strength of the gravel

Note 3: Reference Worksection *1141 ru Wearing Course, base and subbase unsealed* roads and *1141rs Flexible pavement base and subbase* for sealed roads:The blue column is the plasticity index. For sealed roads require between 2 and 6 or for dry climates up to 8. For unsealed roads wearing course require PI greater than 9 and up to 13 in wet areas and maximum 15 in dry areas.

Note 4: This is an incomplete testing report. Each single gravel pit needs comprehensive testing to select a suitable mix which also considers geographic location proximity of pits to each other. Then test the mix % of the blended gravels again comprehensively. Determine by reference to worksections *1141rs Flexible pavements base and subbase* and *1141ru Wearing course, base and subbase* whether the mix gravel is suitable for a sealed or unsealed pavement.

Note 5: Reference Worksection *1141rs Flexible pavement base and subbase* sealed construction: Base For sealed pavements maximum UCS should be less than 1.0 Mpa for base unbound, 1.0 to 2.0 Mpa for lightly bound, and greater than 2.0 Mpa for bound material.

Note 6 : Linear Shrinkage % is needed for the ARRB spreadsheet model and calculating the Shrinkage Product. Maximum 4.5% for sealed, and for unsealed wearing course wet areas maximum 3.0% and dry areas maximum 5.0%

14 REFERENCE DOCUMENTS

Styles, M, 2017 *Unsealed Roads – Make Marginal Materials Matter (Trialing by Central Goldfields)*, paper presented at IPWEA International Public Works Conference 2017.

Austroads AGPT06 Guide to Pavement Technology - Unsealed Pavements

Australian Road Research Board, *Road Base Testing Kit*, accessed November 2017, supplied by ARRB.

ARRB Best Practice Guide 1 – Road Materials 2020

ARRB Best Practice Guide 2 – Unsealed roads 2020

Austroads report AP-T335-18 Appropriate Use of Marginal and Non-standard Materials in Road Construction and Maintenance. 2018

Austroads AP-T352-20 Sustainable Roads Through Fit-for-purpose Use of Available Materials: Technical Basis

Austroads AP-T353-20 Sustainable Roads Through fit-for-purpose Use of Available materials: Evaluation Tool and User Guide

Extractive Activities for local government (QLD) Paper by John Davoren and Shoshanna Grounds

Marsdens Law Group, 2018, *Pit Extraction Licence Agreement Wagga Wagga City Council*, March 2018 draft supplied by Marsdens Law Group.

Main Roads Western Australia, 2017, *Operational Guideline 96 Searching for Gravel* www.mainroads.wa.gov.au

Main Roads Western Australia, 2024, *Operational Guideline 95 Extracting Road Building Materials from Land in WA* www.mainroads.wa.gov.au

Department of Environment & Climate Control NSW, 2008, *Managing Urban Stormwater – Soils and Construction Volume 2E Mines and quarries* www.environment.nsw.gov.au

Upper Lachlan Shire Council, 2016, *Gravel Quarries Policy*, upperlachlan.nsw.gov.au.

Main Roads Western Australia, 2003, *A Guide to the Selection and Use of Naturally Occurring Materials as Base and Subbase in Roads in Western Australia*, accessed date link.

Blayney Shire Council, 2013, *Memorandum of Understanding* template, date supplied by Blayney Shire Council

Gravel Pit Information Form, 2012, date supplied by source.

Agreement to Quarry Road Construction Materials from Mine template, date supplied by source.

NSW Resources Regulator https://www.resourcesregulator.nsw.gov.au/safety-and-health/topics/small-mines-and-quarries and Health and safety at quarries

Queensland Government, 2024 Model Operating Conditions: ERA 16 – Extractive and screening activities Version 4.06.