APPENDIX 4

Report on Quarry Resource Assessment Investigations

8.3.3 Volcanic Breccia

The single sample of volcanic breccia yielded a particle density of 2.64 t/m^3 and water absorption of 2.3 %.

8.3.4 Dolerite

The single sample of dolerite yielded a particle density of 2.76 t/m^3 and water absorption of 2.1 %.

8.3.5 Results Summary

All samples tested exceed the minimum article density thresholds for most quarry products. While the minimum particle density threshold for armourstone is 2.60 t/m3, it is unlikely that the particle densities of unfractured rock types within the project area will preclude their use as armourstone. Accordingly, particle density is not expected to represent a constraint on the production of quarry products from rocks within the Project Area.

Most samples tested produced water absorption results below the threshold of ≤ 3 % for sealing aggregates and below the threshold of ≤ 2.50 % for coarse concrete and asphalt aggregates.

Samples of competent rhyodacite and unaltered dacite also produced water absorption results below the threshold of ≤ 1.5 % for armourstone.

8.4 Wet Strength and Wet / Dry Strength Variation (WDSV)

Thirty-one (31) samples were submitted for wet strength and WDSV testing in accordance with AS1141.22. The relationship between wet strength and WDSV results for all test samples is illustrated on **Figure 16,** with relevant threshold limits for determining quarry product suitability.

8.4.1 Rhyodacite

Twenty-one (21) samples of competent rhyodacite produced wet strength results ranging from 161-275 kN, with a mean of 223 kN. Corresponding WDSV results ranged from 1-34 %, with a mean of 10%.

Five (5) samples of fractured and/or brecciated and laumontite veined rhyodacite associated with the Central Fault produced wet strength results ranging from 86-169 kN. WDSV results ranged from 21-47 %.

8.4.2 Dacite

The near surface sample of dacite from hole ARDG-DDH03 produced a wet strength result of 159 kN and WDSV of 34 %.

The underlying interval of competent dacite produced a wet strength result of 209 kN and a WDSV of 14 %.

The altered dacite sample from ARDG-DDH15 produced a wet strength result of 39 kN and a WDSV of 75 %.

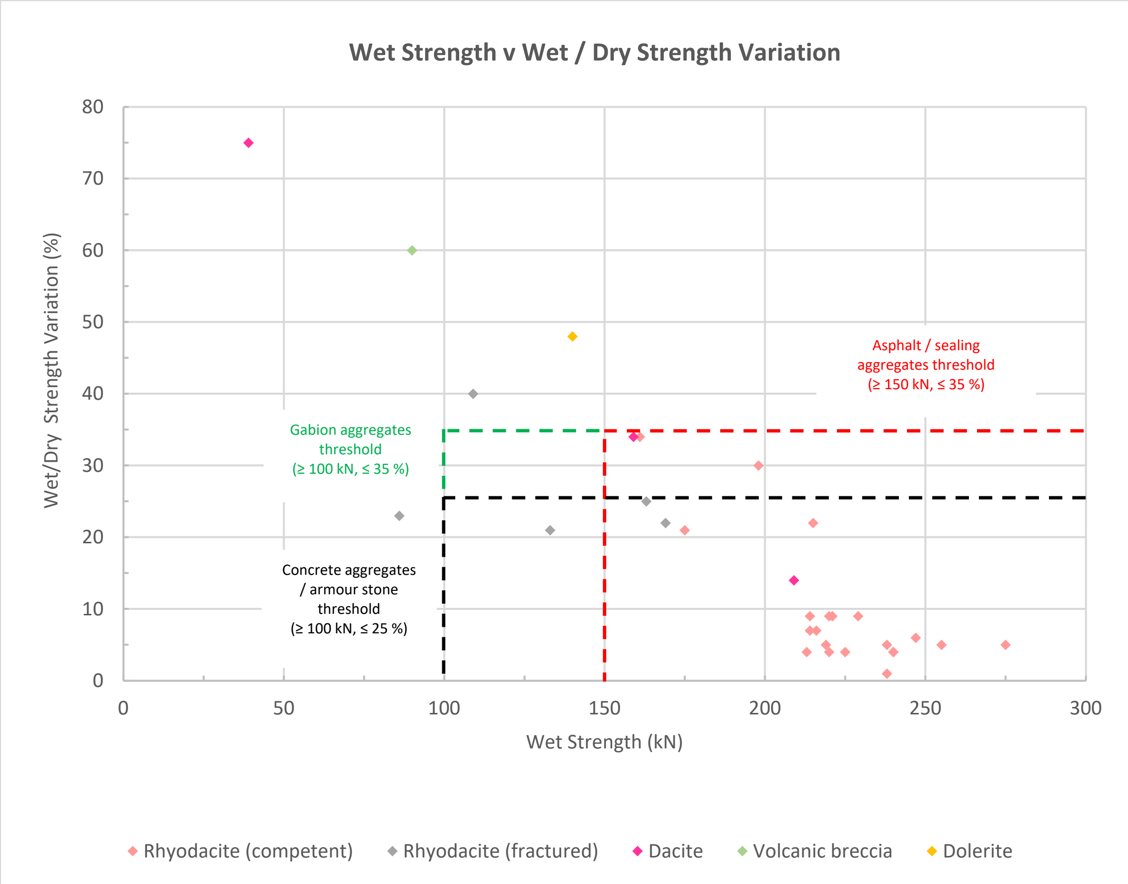

Figure 16 – Wet strength vs Wet / Dry Strength Variation (WDSV) test results for diamond core samples

8.4.3 Volcanic Breccia

The single sample of volcanic breccia produced a wet strength result of 90 kN and a WDSV of 50 %.

8.4.4 Dolerite

The single sample of dolerite produced a wet strength result of 140 kN and a WDSV of 48 %.

8.4.5 Results Summary

Of the 21 samples of competent rhyodacite tested, all consistently exceeded the minimum wet strength threshold (*i.e.* ≥ 100 kN) for coarse concrete aggregates, gabion and armourstone, as well as the minimum threshold (*i.e.* ≥ 150 kN) for asphalt and sealing aggregates. Only one of the rhyodacite samples failed to exceed the minimum wet strength threshold of 175 kN for railway ballast.

Nineteen (19) of the 21 samples achieved the minimum WDSV threshold (*i.e.* ≤ 25 %) for concrete aggregates, railway ballast and armourstone. All samples achieved the minimum WDSV threshold (*i.e.* ≤ 35 %) for gabion, asphalt and sealing aggregates.

Of the 5 samples tested of fractured and/or brecciated and laumontite veined rhyodacite associated with the Central Fault, none achieved the minimum wet strength threshold (*i.e.* 175 kN) for railway ballast. Three (3) of these samples also failed to achieve the minimum wet strength threshold of (*i.e.* ≥ 150 kN) for asphalt and sealing aggregate. However, 3 of the samples did comply with the wet strength threshold (*i.e.* ≥ 100 kN) and WDSV threshold (*i.e.* ≤ 25 %) for concrete aggregates, gabion and armourstone.

Of the 3 dacite samples tested, only 2 samples from hole ARDG-DDH03 exceeded the minimum wet strength thresholds for coarse concrete, asphalt and sealing aggregates, gabion and armourstone, although only the deeper sample achieved the WDSV threshold for all these product types.

The altered dacite sample from ARDG-DDH15 and samples of volcanic breccia and dolerite all failed to meet acceptable wet strength and WDSV thresholds for quarry products, and accordingly should be avoided.

8.5 Los Angeles (LA) Abrasion

Twenty-two (22) samples were submitted for coarse particle density and water absorption testing in accordance with AS1141.23. **Figure 17** and **Figure 18** illustrate the LA results against wet strength and Aggregate Crushing Value (ACV), along with relevant threshold limits for determining quarry product suitability.

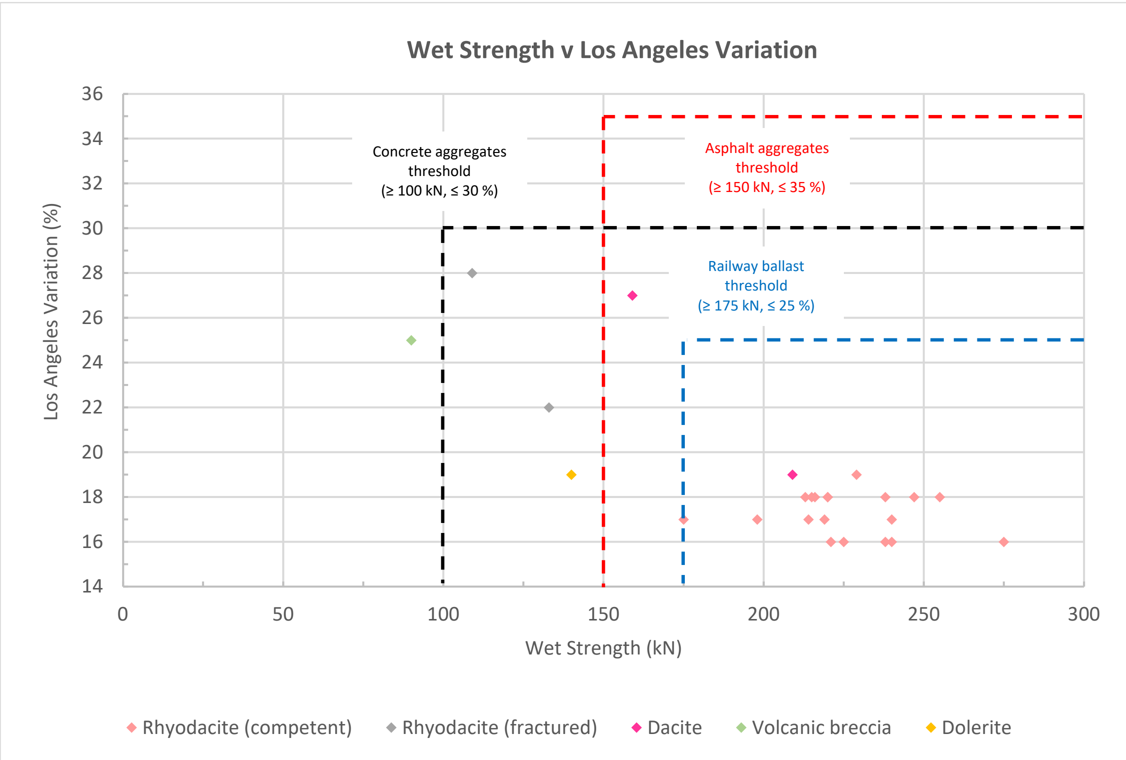

Figure 17 – Wet strength vs Los Angeles Abrasion (LA) test results for diamond core samples

8.5.1 Rhyodacite

Nineteen (19) samples of competent rhyodacite produced LA results ranging from 16-19 %, with a mean of 17 %.

Two (2) samples of fractured and/or brecciated and laumontite veined rhyodacite associated with the Central Fault produced LA results of 22 % and 28 %.

8.5.2 Dacite

The near surface sample of dacite from hole ARDG-DDH03 produced an LA result of 27 %. The underlying interval of competent dacite produced an LA result of 19 %.

The altered dacite sample from ARDG-DDH15 was not tested.

8.5.3 Volcanic Breccia

The single sample of volcanic breccia produced an LA result of 25 %.

8.5.4 Dolerite

The single sample of dolerite produced an LA result of 19 %.

8.5.5 Results Summary

Of the nineteen samples of rhyodacite tested, all produced LA results less than the maximum thresholds for the full range of quarry products types. Of the two samples of fractured rhyodacite that were tested, only one achieved the LA threshold (*i.e.* ≤ 25) for railway ballast.

Of the two tested samples of dacite, both produced LA results below the thresholds (*i.e.* ≤ 30) for concrete aggregates, but only the deeper sample achieved the LA threshold (*i.e.* ≤ 25) for railway ballast. Given the tenor of dacite results, it is reasonable to expect that blending as part of any future quarry operation is likely to produce more compliant results from a railway ballast perspective.

Notwithstanding the non-compliance of the volcanic breccia and dolerite samples with wet strength and WDSV thresholds, both samples also produced acceptable LA results.

While LA does not appear to represent a significant constraint on the use of the tested materials for various quarry products, it is not a useful indicator of rock durability (*i.e.* wet strength, WDSV).

8.6 Aggregate Crushing Value (ACV)

NSW Railcorp requires that AS2758.7 be used for assessing the suitability of source rock material for railway ballast. AS2758.7 specifies that durability testing of railway ballast can be undertaken by one of two methods – using either ACV and wet attrition value, or ACV and LA. Accordingly, the latter method was selected for assessment of the test samples.

ACV results for the twenty-one samples tested are plotted on **Figure 18** against LA results.

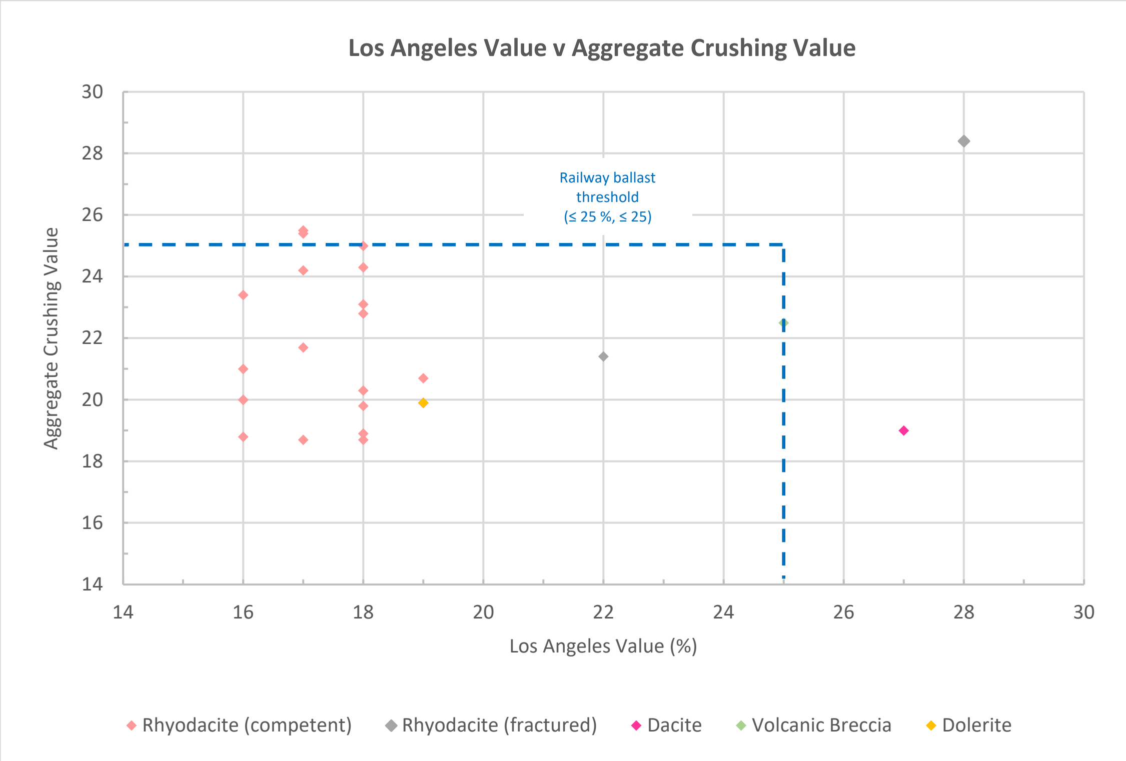

Figure 18 – Los Angeles Abrasion (LA) vs Aggregate Crushing Value (ACV) test results for diamond core samples

8.6.1 Rhyodacite

Nineteen samples of competent rhyodacite produced ACV results ranging from 18.7-25.5, with a mean of 21.7.

Two samples of fractured and/or brecciated and laumontite veined rhyodacite associated with the Central Fault produced ACVs of 21.4 and 28.4.

8.6.2 Dacite

The two samples of dacite from hole ARDG-DDH03 produced ACV results of 19.0 and 19.9.

8.6.3 Volcanic Breccia

The single sample of volcanic breccia produced an ACV result of 22.5.

8.6.4 Dolerite

The single sample of dolerite produced an ACV result of 19.9.

8.6.5 Results Summary

Of the samples tested, all but two of the competent rhyodacite samples produced results well under the maximum ACV threshold (*i.e.* ≤ 25); with counterpart LA results well below 25 %. The two rhyodacite samples that did not comply only just exceeded the maximum threshold. As the test samples were produced using a laboratory jaw crusher, improvement in aggregate shape achieved through a processing plant, would be expected to significantly improve (*i.e.* lower) all the ACV results.

Accordingly, the rhyodacite would be suitable for producing railway ballast.

8.7 Sodium Sulphate Soundness (SSS)

Two (2) samples of rhyodacite from drill hole ARDG-DDH04 (one of competent material and the other of fractured and brecciated material) were tested for SSS in accordance with AS1141.24, to determine whether this durability test was worth extending to all test samples. The sample of competent rhyodacite produced a result of 0.4 % loss, whereas the fractured sample produced a result of 0.8 % loss.

The SSS test is relevant for concrete aggregates (maximum 6 % loss), sealing aggregates (maximum 12 % loss) and asphalt aggregates (maximum 12 % loss). As the test results were well under these thresholds and given that the WDSV test was adopted as the main durability test, it was decided not to extend SSS to the other test intervals.

8.8 Chemical and Impurity Properties

8.8.1 Chlorides and Sulphates

Eleven (11) drill core samples were submitted for chloride and sulphate testing in accordance with AS1012.20. These samples covered rhyodacite, dacite, volcanic breccia and dolerite.

Chloride testing confirms that the chloride content is well below specified limits for reinforced and non-reinforced concrete applications. Of the samples tested, only one result triggered the 0.01% reporting limit, with the rest of the results < 0.01%.

Sulphate contents for rhyodacite and dacite samples (the materials that would be used in concrete) ranged from 0.004-0.025%, with a mean of 0.012%. AS2758.1 requires materials with a sulphate content greater than 0.01% to be reported. However, the critical requirement is that the sulphate content of the concrete mix does not exceed 5% by mass of Portland Cement. These test results would not result in this critical threshold being exceeded.

8.8.2 Sugar and Organic Impurities

Given the mode of formation of the *Eagleton Volcanics* and likely quarry extraction method, testing of sugar and organic impurities was not considered meaningful in this geological environment. Notwithstanding, the rocks within the Project Area are free of ‘sugar’ and below the base of weathering will be free of organic impurities.

8.9 Wet Weather Skid Resistance – Polished Aggregate Friction Value (PAFV)

Twenty-five (25) samples were submitted for PAFV testing in accordance with AS1141.41/42. The relationship between PAFV and wet strength results, and PAFV and WDSV results for all test samples is illustrated on **Figure 19** and **Figure 20**, respectively.

8.9.1 Rhyodacite

Twenty-three (23) samples of rhyodacite produced PAFV results ranging from 42-63 with a mean of 50.

8.9.2 Dacite

The two samples of dacite from hole ARDG-DDH03 produced PAFV results of 43 and 55.

8.9.3 Volcanic Breccia

The volcanic breccia was not submitted for PAFV testing.

8.9.4 Dolerite

The dolerite was not submitted for PAFV testing.

8.9.5 Results Summary

A minimum PAFV of ≥ 48 is required for wearing course asphalt aggregates and ≥ 44 for sealing aggregates. In addition, the respective wet-strength and WDSV targets of ≥ 150 kN and ≤ 35 % must also be achieved.

All samples submitted for PAFV testing achieved the wet-strength and WDSV targets for coarse asphalt aggregates and sealing aggregates. While three samples produced PAFVs less than 44, with blending, both the rhyodacite and dacite would readily achieve the PAFV targets for sealing aggregates.

Blending, supported by regular testing, should also enable the PAFV target of 48 for wearing course asphalt aggregates to be readily achieved from both the rhyodacite and dacite.

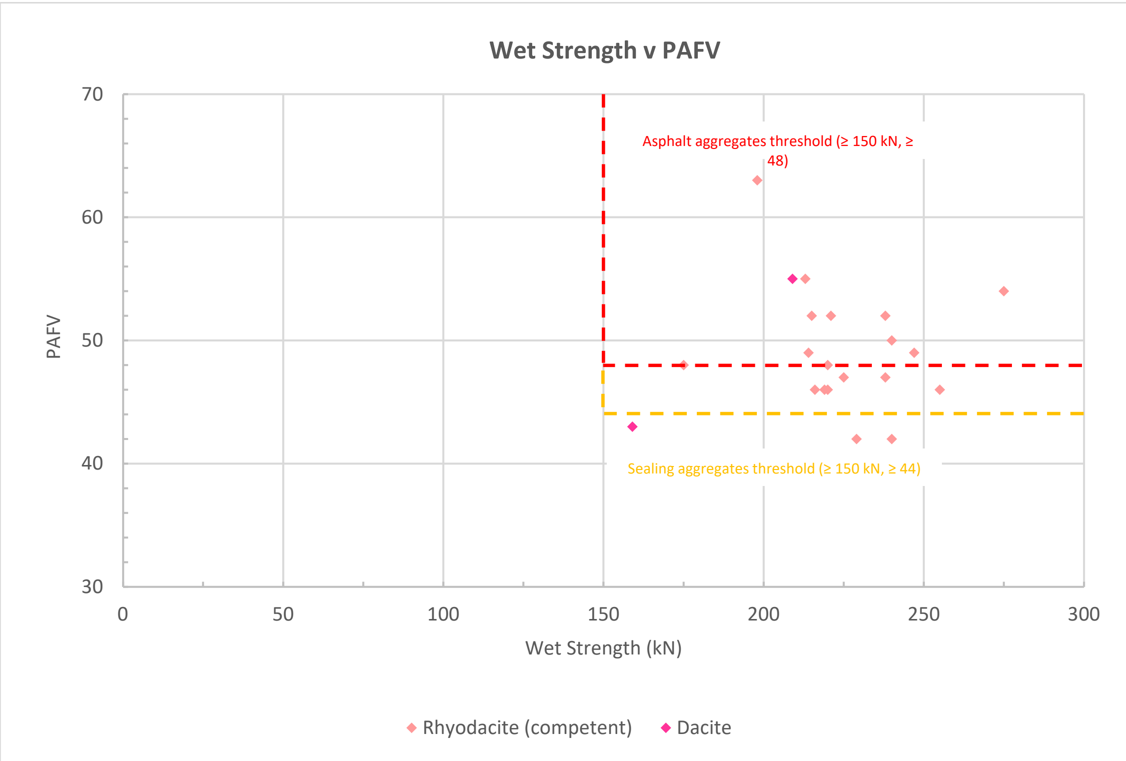

Figure 19 – Wet strength vs Polished Aggregate Friction Value (PAFV) test results for diamond core samples

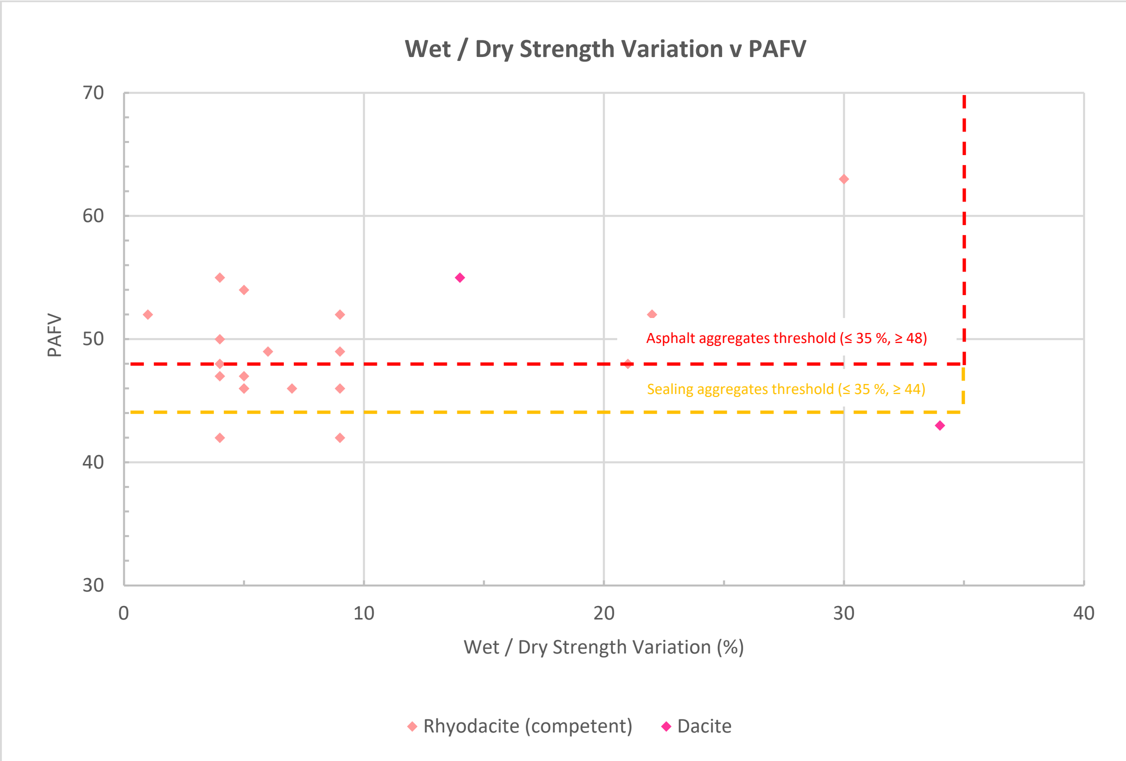

Figure 20 – Wet / Dry Strength Variation (WDSV) vs Polished Aggregate Friction Value (PAFV) test results for diamond core samples

8.10 Bitumen Adhesion and Stripping Resistance

8.10.1 Initial Adhesion of Cover Aggregates and Binders

Four samples of rhyodacite and a single sample of dacite were submitted for initial adhesion testing in accordance with RMS T238. Tests were undertaken using three different binding agents. All samples produced results of < 5 % stripping against a maximum stripping limit of 10 %.

8.10.2 Resistance to Stripping of Aggregates and Binders

The same four rhyodacite samples and single dacite sample were tested for resistance to stripping in accordance with RMS T230. Again, tests were undertaken using the same three binding agents. All samples produced results ranging from < 2 % to 4 % against a maximum stripping limit of 10 %.

8.11 Alkali Aggregate Reactivity (AAR)

The most common form of alkali aggregate reaction (AAR) in concrete in involves a reaction between alkali hydroxides in the pore solution of the concrete and non-crystalline forms of silica in the aggregate, to produce an alkali-silicate gel. This gel may absorb water, thereby causing disruption, expansion and weakening of the concrete.

The free silica (quartz) in the rhyodacite is considered to have potential to cause mild AAR given the nature of quartz mineralogy. Four samples of rhyodacite were submitted for accelerated mortar bar testing for AAR in accordance with RMS T363. The results of this testing are illustrated on **Figure 21.**

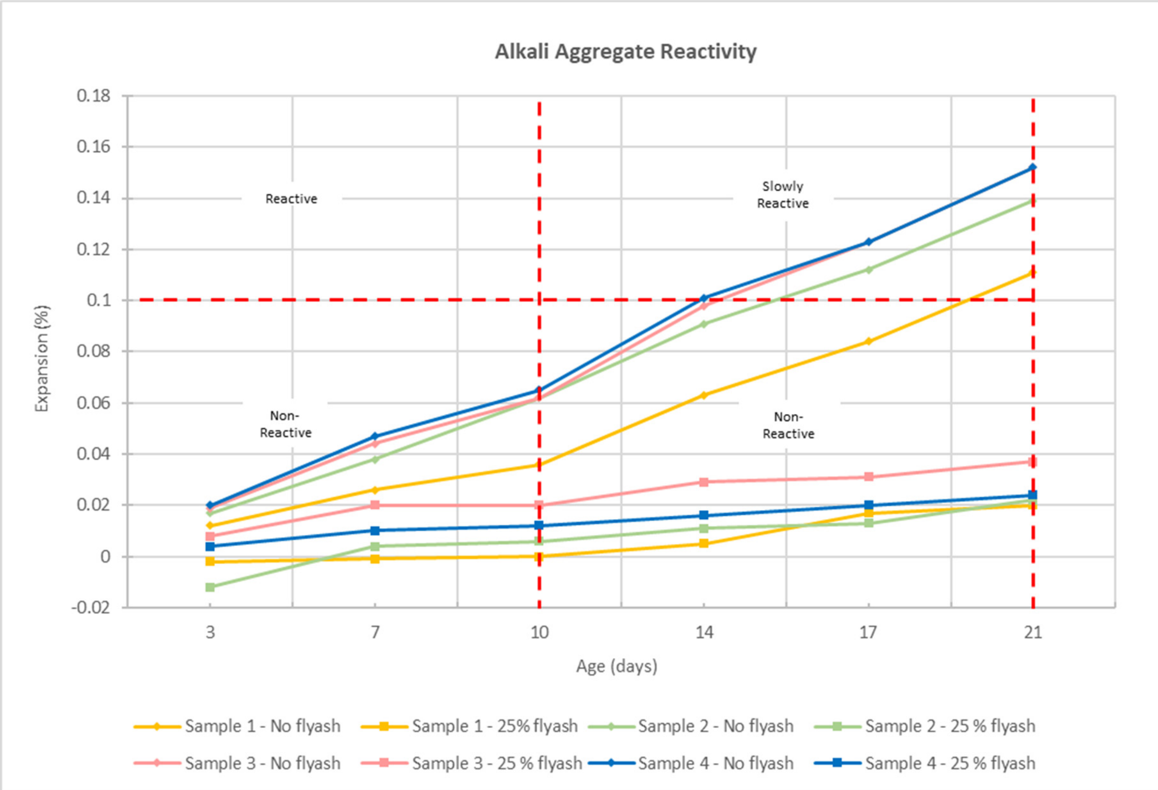

Figure 21 – Alkali Aggregate Reactivity (AAR) test results for mortar bars before and after the addition of 25 % flyash

The first round of testing involved the preparation of four separate mortar bars for each aggregate sample, along with Boral general purpose shrinkage-limited cement from Berrima, NSW. The results of initial testing revealed the mix to be "slowly reactive" from an AAR perspective.

The second round of testing involved the preparation of four separate mortar bars for each aggregate sample, along with a mix of 75 % Boral general purpose shrinkage-limited and 25 % flyash from Eraring. The results of this round of testing revealed produced a "non-reactive" result, indicating that the presence of flyash had neutralised potential for an AAR.

8.12 Methylene Blue Value ISSA (MBV ISSA) and Deleterious Fines Index (DFI)

The MBV ISSA test is performed on the passing 75 µm size fraction of the overall manufactured sand (-4.75 mm) size fraction. The test is designed to identify the presence of clay and similar minerals that can adversely impact the performance of the sand when used in concrete and asphalt manufacture.

From a manufactured asphalt sand perspective, the passing 75 µm size fraction of the sand when used in asphalt tends to be a significant component of what is termed "filler"– *i.e.* the combined fraction of aggregates and added fillers that pass 75 µm. When clay levels in the filler exceed an MBV ISSA of 10, they tend to reduce asphalt durability. As a result, the dense and open graded asphalt specification RMS DCM116 has a requirement that the filler has an MBV ISSA of ≤ 10. To achieve this target, it is recommended that the MBV ISSA of the manufactured asphalt sand be kept below 8, and preferably below 6, in order to offset any other contribution of clays from other sands (*e.g.* natural sand) and materials used in asphalt production.

From a manufactured concrete sand perspective, the Deleterious Fines Index (DFI) is used to determine whether the sand has clay levels that will impact on concrete water demand and in turn cement requirement. The DFI is the multiple of the MBV ISSA and the percentage of material passing the 75µm sieve in any manufactured sand. The revised Australian Standard for Concrete Aggregates AS2758.1 will apply a DFI of < 150 for the total sand fraction in concrete mixes. A best-practice maximum DFI of 60 should be targeted for manufactured sands when targeting replacement levels of up to 50 %. Assuming the percentage of manufactured sand passing 75µm falls within typical ranges of 10-14 % (say 13 %), MBV ISSA values < 5 are considered preferable.

Fifteen samples were submitted for MBV ISSA testing, comprising nine competent rhyodacite samples; two fractured and/or brecciated and laumontite veined rhyodacite samples from close to the Central Fault; two dacite samples; and single samples of volcanic breccia and dolerite. The results of MBV ISSA testing are plotted on **Figure 22** against the calculated DFI results.

MBV ISSA results for all rhyodacite samples ranged from 1 to 4, with a mean of 2. Counterpart DFI results ranged from 1 to 4, apart from a sample of sericite altered rhyodacite from hole ARDG-DDH06 that produced a DFI of 12. The two dacite samples produced MBV ISSA results of 3.5 and 10.5, with DFI results of 4.

The rhyodacite and dacite samples typically meet the target MBV ISSA of < 6 for the filler component of manufactured asphalt sand; the MBV ISSA target of < 5 and the DFI target of < 60 for manufactured concrete sand. Given the excellent results for most test samples, blending of source rock within a quarry would neutralise the effect of any occasional exceedance of these targets.

The volcanic breccia and dolerite samples produced MBV ISSA results of 5.5 and 3.0 respectively. The counterpart DFI results were 17.0 and 15.0. While the results for these samples are generally acceptable, it is unlikely that they will be targeted for extraction given their poor durability characteristics and limited occurrence.

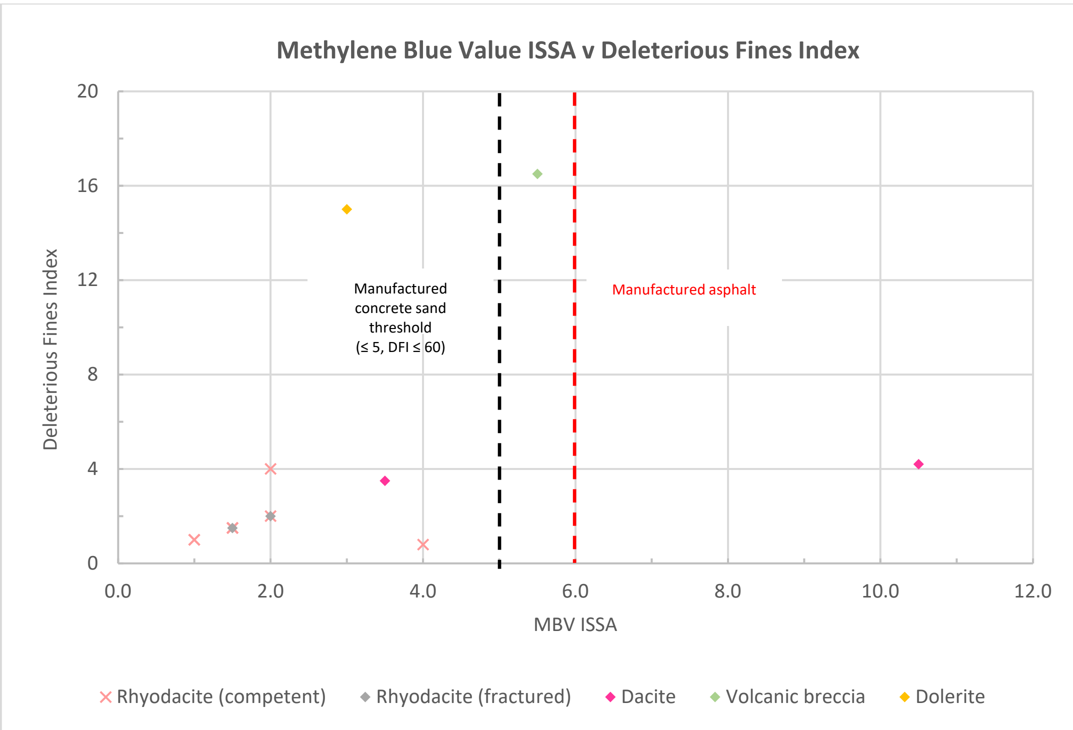

Figure 22 – Methylene Blue Value ISSA vs Deleterious Fines Index results for diamond core

8.13 Atterberg Testing / Plastic Properties

All unweathered / fresh rhyodacite and dacite from the Project Area would be classified as non-plastic if subjected to (AS1289.3.1.1, 3.2.1, 3.3.1). Accordingly, these rocks would meet the non-plastic requirement for manufactured asphalt sand under RMS 3152.

As roadbase products typically require a plastic index > 0, Atterberg testing was undertaken on nine (9) samples of weathered volcanic sedimentary rocks of the Upper Stratigraphic Sequence to confirm the availability of high plasticity material suited to blending.

Eight (8) of the weathered volcanic sedimentary rocks produced plastic index results ranging from 1 to 24, with an average of 13 and median of 13. The lowermost sample was non-plastic and is interpreted to reflect a lower level of weathering approaching the base of oxidation.

8.14 Weak and Light Particles

Five (5) samples were tested for light particles in accordance with AS1141.31. All samples produced results of 0 %.

Eleven samples were tested for weak particles in accordance with AS1141.32. Only one of the samples produced a weak particle result above 0 % (*i.e.* 0.1%); well below the maximum thresholds of 0.5 % for concrete aggregates and 1 % for asphalt and sealing aggregates.

8.15 Shape

8.15.1 Flakiness Index

Ten (10) samples of rhyodacite and two samples of dacite were tested for flakiness in accordance with AS1141.15. These samples produced flakiness index results between 18 and 44, with a mean of 32, against threshold limits of < 35 for concrete and sealing aggregates and < 25 for asphalt aggregates. Given that the diamond core samples were processed in a laboratory using a jaw crusher, the results would be significantly improved upon if a multi-stage crushing plant was used to produce a better shaped aggregate for testing.

8.15.2 Mishapen Particles

The same ten (10) samples of rhyodacite and two dacite samples were tested for misshapen particles at a 2:1 ratio in accordance with AS1141.14. These samples produced results between 13 % and 33 %, with a mean of 24 %, against threshold limits of ≤ 35 % for roadbase and sealing aggregates; ≤ 30 % for railway ballast; and ≤ 25 % for asphalt aggregates. Again, the results would significantly improve if a multi-stage crushing plant was used to produce a better shaped aggregate for testing.

8.16 Quarry Product Suitability

8.16.1 Coarse and Fine (Manufactured Sand) Concrete Aggregates to Australian Standard Requirements

Table 8-4 summarises the critical test parameters that apply to coarse and fine (manufactured sand) concrete aggregates under the relevant standards.

TABLE 8-4 **Critical Test Parameters for Coarse and Fine (Manufactured Sand) Concrete Aggregates**							
AS2758.1 – 2014: Aggregates and Rock for Engineering Purposes – Part 1 Concrete aggregates							
Test	**Standard**	**Target**	**Compliance of Major Rock Types**				
			Rhyodacite		**Dacite**	**Volcanic Breccia**	**Dolerite**
			competent	**fractured**	**unaltered**		
Particle Density	AS1141.6.1	≥ 2.1 %					
Flakiness Index	AS1141.15	≤ 35 %				NT	NT
Weak Particles	AS1141.32	≤ 0.5 %					
Wet Strength	AS1141.22	≥ 100					
Wet/Dry Strength Variation	AS1141.22	≤ 25 %					
Los Angeles Abrasion	AS1141.23	≤ 30 %					
Chlorides	AS1012.20	≤ 0.01 %					
Sulphates	AS1012.20	≤ 5 %					
% Passing 75µm by Washing	AS1141.12	< 14					
Methylene Blue Value (MBV) ISSA	AS1141.66	< 7					
Deleterious Fines Index		≤ 150					
Alkali Aggregate Reactivity (25 % flyash)	RMS T363					NT	NT
NT = Not Tested							

The **rhyodacite** meets all critical requirements for producing coarse concrete aggregates and manufactured concrete sand. Competent unweathered intervals of **dacite** also meet the requirements for producing coarse concrete aggregates. However, weathering and alteration can adversely impact the suitability of the dacite for producing coarse and fine concrete aggregates and would need to be closely monitored if production from this unit was to be considered.

The **volcanic breccia** and **dolerite** do not achieve the critical durability criteria and hence are unsuitable source rocks for producing coarse or fine concrete aggregate.

8.16.2 Coarse and Fine (Manufactured Sand) Asphalt Aggregates to RMS Requirements

Table 8-5 summarises the critical test parameters that apply to coarse and fine (manufactured sand) asphalt aggregates under the relevant standards, with the purpose of confirming compliance with RMS requirements.

TABLE 8-5 **Critical Test Parameters for Coarse and Fine (Manufactured Sand) Asphalt Aggregates**							
AS2758.5 – 2009: Aggregates and Rock for Engineering Purposes – Part 5 Course asphalt aggregates **RMS 3152 – Aggregates for Asphalt**							
Test	**Standard**	**Target**	**Compliance of Major Rock Types**				
			Rhyodacite		**Dacite**	**Volcanic Breccia**	**Dolerite**
			competent	**fractured**	**unaltered**		
Particle Density	AS1141.6.1	≥ 2.1 %					
Water Absorption	AS1141.6.1	≤ 2.5 %					
Particle Shape (% Mishapen Particles 2:1)	AS1141.14	≤ 25 %				NT	NT
Flakiness Index	AS1141.15	≤ 35 %				NT	NT
Weak Particles	AS1141.32	≤ 0.5 %				NT	NT
Wet Strength	AS1141.22	≥ 150					
Wet/Dry Strength Variation	AS1141.22	≤ 25 %					

Los Angeles Abrasion	AS1141.23	≤ 30 %					
Chlorides	AS1012.20	≤ 0.01 %					
Sulphates	AS1012.20	≤ 5 %					
Polished Aggregate Friction Value	AS1141.41/42	≥ 48				NT	NT
Initial Adhesion	RMS T238				NT	NT	NT
Resistance to Stripping	RMS T230				NT	NT	NT
NT = Not Tested. NT = Not Tested, Predicted Compliance							

The **rhyodacite** meets all critical requirements for producing coarse asphalt aggregates and manufactured asphalt sand. With blending, the rhyodacite would be able to consistently meet (and exceed) the ≥ 48 PAFV threshold applicable to wearing coarse asphalt aggregates. Competent unweathered intervals of **dacite** also meet the durability and PAFV requirements for wearing coarse asphalt aggregates, although the MBV ISSA would need to be monitored if fine asphalt sand was to be produced from this material, to determine the levels of natural sand replacement that could be achieved using this material.

The **volcanic breccia** and **dolerite** do not achieve the critical durability criteria and hence are unsuitable source rocks for producing coarse or fine asphalt aggregates.

8.16.3 Sealing or Cover Aggregates to RMS Requirements

Table 8-6 summarises the critical test parameters that apply to sealing or cover aggregates under the relevant standards, with the purpose of confirming compliance with RMS requirements.

TABLE 8-6
Critical Test Parameters for Sealing or Cover Aggregates

AS2758.2 – 2009: Aggregates and Rock for Engineering Purposes – Part 2 Aggregate for sprayed bituminous surfacing
RMS 3151 – Aggregate for Sprayed Bituminous Surfacing

Test	Standard	Target	Compliance of Major Rock Types				
			Rhyodacite		Dacite	Volcanic Breccia	Dolerite
			competent	fractured	unaltered		
Particle Density	AS1141.6.1	≥ 2.1 %					
Water Absorption	AS1141.6.1	≤ 2.5 %					
Particle Shape (% Mishapen Particles 2:1)	AS1141.14	≤ 35 %				NT	NT
Flakiness Index	AS1141.15	≤ 35 %				NT	NT
Weak Particles	AS1141.32	≤ 0.5 %				NT	NT
Wet Strength	AS1141.22	≥ 150					
Wet/Dry Strength Variation	AS1141.22	≤ 25 %					
Chlorides	AS1012.20	≤ 0.01 %					
Sulphates	AS1012.20	≤ 5 %					
Polished Aggregate Friction Value	AS1141.41/42	≥ 44				NT	NT
Initial Adhesion	RMS T238				NT	NT	NT
Resistance to Stripping	RMS T230				NT	NT	NT
NT = Not Tested. NT = Not Tested, Predicted Compliance							

The **rhyodacite** meets all critical requirements for producing sealing aggregates. The rhyodacite would be able to consistently meet (and exceed) the ≥ 44 PAFV threshold applicable to sealing aggregates. Competent unweathered intervals of **dacite** also meet the durability and PAFV requirements for sealing aggregates.

The **volcanic breccia** and **dolerite** do not achieve the critical durability criteria and hence are unsuitable source rocks for producing sealing or cover aggregates.

8.16.4 Railway Ballast to Australian Standard Requirements

Table 8-7 summarises the critical test parameters that apply to railway ballast under the relevant standards.

TABLE 8-7
Critical Test Parameters for Railway Ballast
AS2758.7 – 2015: Aggregates and Rock for Engineering Purposes – Part 7 Railway ballast

Test	Standard	Target	Compliance of Major Rock Types				
			Rhyodacite		Dacite	Volcanic Breccia	Dolerite
			competent	fractured	unaltered		
Particle Density	AS1141.6.1	≥ 2.5 %					
Particle Shape (% Mishapen Particles 2:1)	AS1141.14	≤ 30 %				NT	NT
Weak Particles	AS1141.32	≤ 5 %				NT	NT
Los Angeles Abrasion	AS1141.23	≤ 25 %					
Aggregate Crushing Value	AS1141.21	≤ 25 %					
Wet Strength *	AS1141.22	≥ 150					
Wet/Dry Strength Variation *	AS1141.22	≤ 25 %					

* Not specified under AS2758.7 – 2015. *NT = Not Tested*

Unweathered / fresh and unfractured **rhyodacite** and **dacite** meet all critical requirements for producing railway ballast.

While the **volcanic breccia** and **dolerite** achieve the target LA and ACV requirements, their durability confirmed by wet strength and WDSV testing indicates that they will be unsuitable source rocks for producing railway ballast.

8.16.5 Armourstone to Australian Standard Requirements

Table 8-8 summarises the critical test parameters that apply to armourstone under the relevant standards.

TABLE 8-8
Critical Test Parameters for Armourstone
AS2758.6 – 2008: Aggregates and Rock for Engineering Purposes – Part 6 Guidelines for specification of armourstone

Test	Standard	Target	Compliance of Major Rock Types				
			Rhyodacite		Dacite	Volcanic Breccia	Dolerite
			competent	fractured	unaltered		
Particle Density	AS1141.6.1	≥ 2.6 %					
Water Absorption	AS1141.6.1	≤ 1.5 %					
Wet Strength	AS1141.22	≥ 150					
Wet/Dry Strength Variation	AS1141.22	≤ 25 %					
Los Angeles Abrasion	AS1141.23	≤ 30 %					
Sodium Sulphate Soundness	AS1141.24	≤ 6 %			NT	NT	NT

NT = Not Tested. NT = Not Tested, Predicted Compliance

Unweathered / fresh and unfractured **rhyodacite** and **dacite** meet all critical requirements for producing armour stone.

The **volcanic breccia** and **dolerite** do not achieve the critical requirements and hence are unsuitable source rocks for armour stone.

8.16.6 Gabion to Australian Standard Requirements

Table 8-9 summarises the critical test parameters that apply to gabion under the relevant standards.

TABLE 8-9 Critical Test Parameters for Gabion								
AS2758.4 – 2017: Aggregates and Rock for Engineering Purposes – Part 4 Aggregate for gabion baskets and wire mattresses								
Test	Standard	Target	Compliance of Major Rock Types					
			Rhyodacite		Dacite	Volcanic Breccia	Dolerite
			competent	fractured	unaltered		
Weak Particles	AS1141.32	≤ 1 %					
Wet Strength	AS1141.22	≥ 100					
Wet/Dry Strength Variation	AS1141.22	≤ 35 %					

Unweathered / fresh and unfractured **rhyodacite** and **dacite** meet all critical requirements for producing gabion.

The **volcanic breccia** and **dolerite** do not achieve the critical requirements and hence are unsuitable source rocks for gabion.

8.16.7 Roadbase Materials to RMS Requirements

Rhyodacite and dacite meets the RMS durability requirements for production of the coarse aggregate component of roadbase. The fines component of aggregate generated from these rock types is non-plastic and further investigation into a suitable source of fines that could achieve the plasticity target is required.

TABLE 8-10 Critical Test Parameters for Roadbase							
RMS 3051 – Granular Pavement Base and Subbase Materials							
Test	Standard #	Target	Compliance of Major Rock Types				
			Rhyodacite		Dacite	Volcanic Breccia	Dolerite
			competent	fractured			
Particle Shape (% Mishapen Particles 2:1)	AS1141.14	≤ 35 %				NT	NT
Wet Strength	AS1141.22	≥ 100					
Wet/Dry Strength Variation	AS1141.22	≤ 35 %					
NT = Not Tested							

9. CONCEPTUAL QUARRY DESIGN

9.1 Conceptual Quarry Development Sequence

A set of conceptual staged quarry development plans (**Figures 23-32**) have been prepared for the Project Area to illustrate the proposed progression of quarry overburden stripping extraction activities to support the production and sale of up to 1.5 Mtpa of quarry products over a 30-year operational period, from a hard rock resource of approximately 49.5 Mt.

The conceptual plans comprise ten extraction stages that cover initial site establishment (Stage 0), followed by development of the main rhyodacite resource associated with Stone Ridge (the Main Pit), as well as development of a satellite pit (North Pit) on the northern side of Stone Ridge to access the upper dacite unit of the Lower Stratigraphic Sequence (Stages 1-9). The conceptual development sequence integrates with quarry processing and stockpiling activities located on the southern side of Stone Ridge.

The quarry face design parameters reflected in the conceptual plans are summarised in **Table 9-1,** along with other design parameters that would be adopted relating to terminal berm widths and haul roads.

TABLE 9-1
Design Parameters – Conceptual Staged Quarry Development Sequence

Bench Height	15m
Face Angle	-80°
Active Berm Width (optimal)	30m
Terminal Berm Width (minimum)	10m
Haul Road Width	25m
Haul Road Gradient	1V:10H (-5.7°)

The retention of 30-metre-wide benches at the completion of each stage of quarry development (vs development of narrow terminal width benches) reflects ARDG's intention to maintain operational width benches at all stages of quarry development to facilitate:

(i) maximum operational flexibility across multiple quarry faces and at different levels within the quarry by maintaining access to all bench levels;

(ii) safe and stable quarry face conditions at all stages of development – achieved by the design parameters considered highly conservative as they retain an overall face slope angle of between 24˚ and 25˚; and

(iii) use of the lower level of quarry when required for surface water storage to meet the requirements of the quarry's surface water management system.