ACS740 Recycled aggregates

Contents

ACS740.1 Scope

This specification sets out the material requirements for Recycled Aggregate (RAg) comprising Recycled Concrete Aggregate (RCAg) and Recycled Natural Aggregate (RNAg) for the following purposes in Auckland Council-Family projects (see ACS740.4 Definitions):

- Installation of buried concrete pipe in accordance with AS/NZS 3725
- Installation of buried flexible pipelines in accordance with AS/NZS 2566 Parts 1 and 2, excluding metal pipe that could be in contact with the bedding or backfill
- Installation of pipeline infrastructure associated with construction and maintenance of buried concrete and flexible pipelines, excluding items with unprotected metal surfaces[1] that would be in contact with bedding or backfill
- Reinstatement of trenches and other openings following maintenance of existing pipelines and pipeline infrastructure in accordance with the above, and
- Low-risk Auckland Council-Family applications not covered by existing specifications when approved by Auckland Council on a case-by-case basis.

This specification also includes requirements and guidance for designers on selected aspects of RAg usage that could differ from those of natural aggregates used in the same applications and that is necessary to ensure the RAg is used appropriately[2]

This specification applies to RAg supplied by any producer or contractor for any of the above purposes unless otherwise approved in advance by Auckland Council on a case-by-case basis.

This specification specifically excludes:

- Use of Recycled Crushed Glass, Recycled Crushed Brick, Reclaimed/Recycled Asphalt Pavement, and any other type of recycled aggregate (see ACS740.4 Definitions)
- RAg for use in buildings and structures other than pipeline infrastructure described herein

[1] To minimise the risk of corrosion, RAg shall not be used in association with metal pipe (whether coated or uncoated) or un-coated metal *structures*, elements, or items, unless otherwise approved in advance by Auckland Council on a case-by-case basis.

[2] *Appendix A presents further requirements and guidance on selected topics for designers.*

- Applications for which the use of RAg is specifically covered by other Auckland Council-Family specifications
- Methods of producing, storing, transporting, and handling RAg, other than aspects described herein
- Requirements for the design and construction of buried pipelines in which RAg may be used other than the selected aspects described herein[2]
- Requirements for the evaluation of the economic and embodied carbon benefits and costs of RAg and natural aggregates used in any application[3]
- Background information about the specified requirements other than comments on selected clauses presented herein[4].

Any physical Contract Works Specification, which may amend this specification where necessary, takes precedence over this specification.

ACS740.2 Interpretation

For the purposes of this specification, the word 'shall' refers to requirements that are essential for compliance with this specification and the word 'should' indicates a recommended practice.

Where other standards, specifications and guidelines are referenced herein (see ACS740.3) the current edition shall always be used.

ACS740.3 Referenced standards / specifications / guidelines

The following Standards and Specifications are referenced by this specification:

- ANZG 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.
- AS 1012.20.1-2016 *Methods of Testing Concrete.* Method 20.1, Determination of Chloride and Sulphate in Hardened Concrete and Aggregates – Nitric Acid Method.
- AS 1142.22- 2019 *Methods for Sampling and Testing Aggregates:* Wet/Dry Strength Variation.
- AS 4964-2004 *Method for the Qualitative Identification of Asbestos in Bulk Samples.*

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[3] *Appendix B lists factors that such evaluations should consider.*

[4] *Appendix C presents comments on selected clauses.*

- AS/NZS 2566.1:1998 *Buried Flexible Pipelines – Part 1: Structural Design.*
- AS/NZS 2566.2:2002 *Buried Flexible Pipelines – Part 2: Installation.*
- AS/NZS 3725:2007 *Design for Installation of Buried Concrete Pipes.*
- AS/NZS 4058: 2007. *Precast Concrete Pipes (Pressure and Non-pressure).*
- Auckland Council *Code of Practice for Land Development and Subdivision*, Chapter 2: Earthworks and Geotechnical, Version 2, May 2023.
- Auckland Council Standard Specification ACS510 *Earthworks. Version 2.0,* Rev 2, March 2023.
- Auckland Council Standard Specification ACS710 *Pipeline Construction.* Version 2.0, Rev 3, March 2023.
- Auckland Council *Unitary Plan Operative in part* (2023) Clause E30 Contaminated Land.
- BS 1377-3:2018+A1:2021. *Methods of Test for Soils for Civil Engineering Purposes, Chemical and Electro-chemical Testing.*
- BS EN1744-1:2009+A1:2012. *Test for Chemical Properties of Aggregates – Chemical Analysis.*
- EN 13577:2007 *Chemical Attack on Concrete - Determination of Aggressive Carbon Dioxide Content in Water.*
- Concrete Institute of Australia. Recommended Practice: *Durability Exposure Classifications.* Concrete Durability Series Z7/02, September 2018.
- DIN 4030-2:1991 *Assessment of Water, Soil and Gases for their Aggressiveness to Concrete; Collection and Examination of Water and Soil Samples.*
- Ministry for the Environment (MfE). *Hazardous Activities and Industries List* (HAIL). New Zealand, October 2011.
- Ministry for the Environment (MfE). *National Environment Standard for Managing Contaminants in Soil to Protect Human Health* (NES CS). New Zealand 2011.
- NSW Transport RMS Test Method T276:2012 *Foreign Materials Content of Recycled Crushed Concrete.*
- NZ Geotechnical Society (NZGS). *Field Description of Soil and Rock* – Guideline of the Field Classification and Description of Soil and Rock for Engineering Purposes, December 2005.
- NZS 3101:2006. *Concrete Structures Standard.*
- NZS 4402:1986 *Methods of Testing Soil for Civil Engineering Purposes.*
- NZS 4407:2015 *Methods of Sampling and Testing Road Aggregates.*
- TNZ M/4 Specification of *Basecourse Aggregates*, Transit New Zealand, 2006.

- USEPA SW-846 test method 1312: 1994 *Synthetic Precipitation Leaching Procedure.* Part of Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. United States Environmental Protection Agency, September 1994.
- Watercare Material Supply Standard, version 1.11, 30 July 2021.

ACS740.4 Definitions

For the purposes of this specification the following definitions apply:

ACS740.4.1 Recycled materials

Recycled Aggregate (RAg)	• Aggregate produced from the crushing and processing of inorganic or mineral materials from construction and demolition waste for subsequent use in civil engineering works. • RAg shall be classified based on the origin and the composition of source materials. • In this specification RAg is limited to recycled concrete aggregate (RCAg) and recycled natural aggregate (RNAg).
Recycled Concrete Aggregate (RCAg)	• Recycled aggregates in which crushed concrete is the main component. • RCAg is commonly sourced from buildings (vertical concrete structures) and roads or hardstands (horizontal concrete structures). • Depending on the origin, the source demolition material usually contains foreign materials including but not limited to soil, crushed glass, brick, wood, steel, and road surfacing materials, which for most applications needs to be removed before or during processing into RCAg. • In the context of this specification, RCAg is subangular or angular Sandy GRAVEL (NZ Geotechnical Society (NZGS) 2005) with a rough, porous surface, little or no plastic or other fines and limits on the maximum particle size.
Recycled Natural Aggregate (RNAg)	• Recycled aggregates comprising material from natural geological deposits that has been excavated during demolition and/or construction. • RNAg includes hardfill from previous construction works, materials excavated from undisturbed natural ground during the current works, or combinations of both. • In the context of this specification, RNAg is rounded, subrounded, subangular or angular SAND or Sandy GRAVEL (NZGS, 2005), with limits on the plastic or other fines content and on the maximum particle size.

Other definitions:

Abrasion Resistance	• The abrasion resistance of aggregates shall be determined using the test method in NZS 4407 Test 3.12.
Buried Pipeline Embedment	• Material used for support under and around the pipe, described as bed, haunch, and side zones in ACS710. • The extent of embedment is specified in the corresponding standards for buried flexible and concrete pipelines, AS/NZS 2566.1 and AS/NZS 3725. • Note: for flexible pipes (as per AS/NZS 2566), the pipe overlay is considered part embedment.
Buried Pipeline Backfill	• Material used above the pipeline bedding up to the underside of any pavement, hardstand, or other surfacing. In the context of this specification, this includes the additional ordinary fill layer above the bedding that is specified in AS/NZS 3725
Clay Index (CI)	• The clay index shall be determined using the test method of NZS 4407 Test 3.5.
Crushing Resistance, Wet and Dry Strength Variation	• The crushing resistance of coarse aggregate under specified load shall be determined using the test method in NZS4407 Test 3.10. • In addition, the wet and dry strength variation shall be determined using the test method in AS 1142.22.
Foreign Material Content (FMC)	• FMC refers to any extraneous physical material existing in recycled aggregates with different inherent properties. • FMC shall be determined using the NSW Transport RMS T276 test method.
Heavy Compaction Test	• The density/water content relationship shall be determined using the test method in NZS 4402 Test 4.1.2.
Leachate	• Leachate is defined as in Chapter J1 of the Auckland Unitary Plan.
Particle Size Distribution (PSD)	• The particle size distribution shall be determined using the wet sieve test method in NZS 4407 Test 3.8.1.
Plasticity Index (PI)	• The plasticity index shall be determined using the test method in NZS 4407: 2015, Test 3.4.
Standard Compaction Test	• The density/water content relationship shall be determined using the test method in NZS 4402 Test 4.1.1.

ACS740.5 Source materials

This specification covers RAg to be supplied as RCAg or RNAg only.

The nominated source materials shall comprise natural aggregate of sedimentary, igneous, or metamorphic rock origin including but not limited to waterworn alluvial gravel, quarried sedimentary or volcanic rock; or recycled concrete, recycled footpath, road, or hardstand pavement materials containing such natural aggregate material.

The nominated source material/s shall be sound, of uniform consistency and quality, free from soft or disintegrated stone, foreign material (see ACS740.9.2) or other deleterious contaminants.

RAg shall not be sourced from sites or structures listed on the MfE Hazardous Activities and Industries List (MfE 2011) unless approved in advance by Auckland Council on a case-by-case basis.

Specific source material properties are specified in ACS740.9.

ACS740.6 Stockpiles

All stockpiles shall be managed to prevent material segregation or breakdown, with clear separation from water courses to mitigate risks of alkaline leachate and clay/silt contamination, in accordance with Auckland Council specification ACS510.

The contractor shall detail specific requirements for RAg stockpiling, including but not limited to routine testing of the pH of stockpile runoff, in the project-specific Construction Environmental Management Plan (CEMP) for Auckland Council's approval.

RCAg shall not be used until the pH of the runoff is less than 8.5.

RAg sourced from different sites or comprising materials of different quality shall either be maintained in separate stockpiles or blended to ensure consistent material properties.

ACS740.7 Sampling and testing

Representative samples of aggregate shall be taken from conveyor belt, bin, stockpile, or truck, in accordance with NZS 4407, Parts 2 and 3, unless otherwise approved in advance by Auckland Council.

All testing shall be performed by a laboratory with current IANZ accreditation for the specified tests, unless otherwise approved in advance by Auckland Council.

ACS740.8 Compliance

RAg that does not comply with this specification shall be rejected, or be tested and approved in advance by Auckland Council as a variation under a contract works specification.

ACS740.9 Source property tests

ACS740.9.1 General

The suitability of the nominated source material/s for use in RAg production shall first be demonstrated by the criteria specified in Clauses ACS740.9.2 and ACS740.9.3.

The source property testing shall be completed on samples of the nominated source material/s to be extracted and used for subsequent RAg production.

For RAg comprising materials from more than one source, the requirements of ACS740.9 shall apply to each individual source material.

If a nominated source material changes, extraction and production with the affected RAg shall stop and the source properties shall be re-tested.

Extraction and production of the RAg can only proceed again when the re-tested source material properties are shown to comply with this specification.

ACS740.9.2 Determination of foreign materials content

The percentages of foreign materials in each source material shall be determined as the mass retained on a 4.75 mm sieve by the NSW Transport RMS T276 test method and shall not exceed the limits shown below:

- Type I Materials: Metal, Glass, Asphalt, Stone, Ceramics and Slag (other than blast furnace slag): < 3%
- Type II Materials: Plaster, Clay lumps and other friable material: < 1%
- Type III Materials: Rubber, Plastic, Bitumen, Paper, Cloth, Paint, Wood, and other vegetable or decomposable matter: < 0.5%

In addition, source material shall contain no visible steel fibre reinforcement or synthetic fibre reinforcement materials as determined by visual examination when testing for foreign materials by the NSW Transport RMS T276 test method.

Source material shall contain no asbestos or asbestos fibre as determined in accordance with

AS 4964-2004.

ACS740.9.3 Crushing resistance and abrasion resistance

The crushing resistance with wet and dry strength variation (see ACS740.9.3.1) or the abrasion resistance (see ACS740.9.3.2) of the source materials shall be confirmed prior to production of the RAg.

ACS740.9.3.1 Crushing resistance with wet and dry strength variation

The crushing resistance with wet and dry strength variation of the nominated source(s) shall be determined as described below.

When tested in accordance with NZS 4407: 2015, Test 3.10, modified to meet the procedures and reporting requirements for dry and wet tests and the wet/dry ratio specified in AS 1142.22: 2008, the minimum loads (dry) for 10% fines and the maximum wet/dry ratio shall be as given in Table 1.

Table 1: Crushing Resistance and Wet/Dry Ratio for Nominated Source Materials

Material	Minimum Load (dry) for 10% Fines (kN)	Maximum Wet/Dry Ratio ((D-W)/D) (%)
Buried pipeline bedding aggregate	130	35
Buried pipeline backfill aggregate	130	30

ACS740.9.3.2 Abrasion resistance

When tested in accordance with NZS 4407: 2015, Test 3.12, the maximum abrasion resistance rate (LAA) shall be as given in Table 2.

Table 2: Los Angles Abrasion Rate for Nominated Source Materials

Material	Maximum LAA Rate at 500 Revolution
Buried pipeline bedding aggregate	40
Buried pipeline backfill aggregate	40

ACS740.9.4 Compliance

If the requirements of ACS740.9.2 and ACS740.9.3 cannot be met, the nominated source material(s) shall be rejected, unless otherwise approved by the Auckland Council.

ACS740.10 Production property tests

ACS740.10.1 General

The suitability of the RAg product shall be demonstrated by the sampling and testing specified in ACS740.10.2 to ACS740.10.6 before the RAg is used.

ACS740.10.2 Production property sampling

All samples shall represent the current source material/s and production techniques.

Representative samples of aggregate shall be taken from conveyor belt, bin, stockpile, or truck, in accordance with NZS 4407, Part 2.

The minimum sampling rates from Lots of RAg large enough to complete all production testing are given in Table 3.

Table 3: Minimum Sampling Rate for Production Property Tests

Lot Size (measured stockpile volume)		Number of Samples
Minimum	**Maximum**	
1 m^3	400 m^3	2
400 m^3	1500 m^3	3
1500 m^3	4000 m^3	4
Greater than 4000 m^3		1 per additional 1000 m^3 or part thereof

Sampling for and completion of the necessary production acceptance testing to demonstrate compliance with this specification shall be carried out not more than three months before delivery for construction, from and to nominated stockpiles.

The above period for testing may with prior approval from Auckland Council be waived if traceability of complying production testing and stockpile management is documented by an independently audited plant quality assurance system.

ACS740.10.3 Particle size distribution (PSD)

ACS740.10.3.1 PSD of buried pipeline bedding aggregate

The PSD of bedding aggregates for both concrete and flexible pipelines shall conform with the distributions given in Table 4 when the aggregate is tested according to NZS 4402: 1986, Test 2.8 Wet Sieving Test.

Table 4: Particle Size Distributions for RCAg and RNAg Bedding Aggregates

Sieve Size (mm)	Weight Passing (%)	
	RCAg	RNAg
19	100	100
9.5	83 - 20	100 - 20
4.75	66 - 5	100 - 5
2.36	50 - 2	100 - 2
1.18	36 - 2	100 - 2
0.600	25 - 2	90 - 2
0.300	18 - 2	66 - 2
0.150	12 - 0	38 - 2
0.075	5 - 0	10 - 2

ACS740.10.3.2 PSD of buried pipeline backfill aggregate

The PSD of the RCAg and RNAG backfill aggregates for both concrete and flexible pipelines shall conform with the distribution given in Table 5 when the aggregate is tested according to NZS 4402: 1986, Test 2.8 Wet Sieving Test.

Table 5: Particle Size Distribution Envelopes for Buried Pipeline Backfill Aggregate

Sieve Size (mm)	Weight Passing (%)
63	100
26.5	80 - 60
9.5	60 - 30
2.36	35 - 12
0.6	20 - 5

Sieve Size (mm)	Weight Passing (%)
0.075	10 - 0

ACS740.10.4 Quality of Fines

ACS740.10.4.1 Introduction

The fines in RCAg shall be non-plastic when tested according to NZS 4407: 2015, Test 3.3. Testing for RNAg shall be in accordance with ACS740.10.4.2 and ACS740.10.4.3.

ACS740.10.4.2 Plasticity index

The Plasticity Index (PI) of RNAg shall not be greater than 5 when tested according to NZS 4407: 2015, Test 3.4.

ACS740.10.4.3 Clay Index

The Clay Index (CI) of RNAg shall not be greater than 3 when tested according to NZS 4407: 2015, Test 3.5.

ACS740.10.5 Chloride and sulfate content

ACS740.10.5.1 Chloride ion content

The acid soluble chloride ion content of RAg shall not exceed 0.80 kg/m^3 of aggregate when tested to AS 1012.20.1 or equivalent method.

ACS740.10.5.2 Sulfate content

The maximum acid soluble sulfate content of RAg shall either not exceed 0.5% (as SO4) by mass of the aggregate when tested to AS 1012.20.1 or equivalent method; or the maximum water-soluble sulfate content of RAg shall not exceed 0.2% (as SO4) by mass of the aggregate when tested to BS EN 1744-1 part 10 or equivalent method.

No soluble oxidisable sulfides shall be present when the aggregate is tested qualitatively to AS 1012.20.1.

ACS740.10.6 Mobility of potential environmental contaminants

The mobility (leachability) of potential contaminants within the RAg shall be determined on the RAg product fraction finer than 4.75 mm using the synthetic precipitation leaching procedure (SPLP) of USEPA SW-846 Test Method 1312 using extraction fluid #3. The resulting leachate (‘extract’) shall then be analysed for the contaminants listed in Table 6.

The concentration of contaminants in the RAg extract shall conform with the limits given in Table 6 unless agreed otherwise by the Contract Administrator.

If there is reason to suspect that the RAg may contain additional contaminants, for example if visual or olfactory evidence or results from the measurement of total petroleum hydrocarbons indicate the presence of volatile organic compounds, then additional testing should be undertaken at the direction of a suitably qualified and experienced practitioner. Such RAg shall not be accepted unless approved by the Contract Administrator.

Table 6: Acceptance criteria for potential leachable chemical contaminants

Contaminant	Maximum allowable concentration in RAg extract (µg/L) (notes 1 and 2)
Arsenic	24
Cadmium	0.2
Chromium	3.3
Copper	1.4
Lead	3.4
Mercury	0.6
Nickel	11
Zinc	8
Benzo(α)pyrene	0.2
DDT	0.1
Total petroleum hydrocarbons (TPH)	(note 3)

Notes to Table 6:

1) The limits in Table 6 are based on the freshwater concentration limits for 95% species protection cited in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

2) The concentration of the contaminant determined in accordance with USEPA 1312 as described herein and expressed as the concentration in the RAg extract.

3) Measurement of TPH is a screening test for the presence of volatile organic compounds. If the results indicate elevated concentrations of volatile organic compounds, then further testing should be undertaken at the direction of a suitably qualified and experienced practitioner.

ACS740.11 Additional reporting

ACS740.11.1 Introduction

Prior to using RAg in construction on site, for each approved stockpile of RAg up to a maximum of 2000 m^3 measured stockpile volume, the contractor shall, for compliance with this specification, report the following IANZ Accredited test information together with the prerequisite Source and Production Property tests (see ACS740.9 and ACS740.10).

ACS740.11.2 RAg bedding

For Sandy GRAVEL bedding report the determination of the dry density/water content relationship under NZ Standard compaction, in accordance with NZS 4402: Test 4.1.1, for a minimum of three samples obtained in accordance with NZS 4407: Part 2.

For SAND bedding, report the relative density in accordance with NZS 4402: Tests 4.2.1, 4.2.2 and 4.2.3, for a minimum of three samples obtained in accordance with NZS 4407: Part 2.

ACS740.11.3 RAg backfill and other low risk applications

Report the determination of the dry density/water content relationship under NZ Heavy compaction, in accordance with NZS 4402: Test 4.1.2, for a minimum of three samples obtained in accordance with NZS 4407: Part 2.

Appendix A1.0 Further requirements and guidance for pipeline designers

In addition to the requirements for RAg properties set out in this specification, the following guidance is provided for designers to ensure the use of RAg does not compromise the performance of drainage systems or the durability of other construction components and that RCAg remains durable for the life of the installation.

Appendix A1.1 and Appendix A1.2 are normative. RAg complying with this specification shall not be used in the applications described in Appendix A1.1 and Appendix A1.2 unless otherwise approved on a case-by-case basis by Auckland Council.

For sites potentially contaminated by industry or agricultural activities, different evaluation criteria may need to be considered.

Appendix A1.3 is informative. It recommends procedures for reducing the likelihood of subdrains becoming clogged with precipitates from cementitious materials.

Appendix A1.1 RCAg and RNAg use in contact with metal items (normative)

RAg shall not be used in contact with or at 500 mm distance from unprotected metals, including steel, galvanised steel, stainless steel, and aluminium unless the metal items are protected by a membrane or barrier coating specifically designed for this purpose such as those specified in Watercare Materials Supply Standard, and the protective treatment has been applied in accordance with the manufacturer's requirements and is undamaged at the time the RAg is placed.

Appendix A1.2 RCAg durability (normative)

RCAg shall not be used in the following applications unless a detailed geotechnical evaluation concludes that the risk of acid or sulfate attack on the RCAg is not significant or can be managed satisfactorily by geotechnical control:

- In areas of acid sulphate soils or potential acid sulphate soils (Auckland Council's Code of Practice for Land Development and Subdivision, Version 2, May 2023 and references cited therein).
- Where concentrations of water-soluble sulfates exceed 300ppm in groundwater or in 2:1 water to soil extract (test method BS 1377-3 or equivalent).
- Where pH is more acidic than 6.0 in groundwater or in 2:1 water to soil extract (test method BS 1377-3 or equivalent).

- Where soil acidity exceeds 200 ml/kg of air-dry soil (test method DIN 4030-2).
- Where aggressive CO2 in groundwater exceeds 5ppm (test method BS-EN 13577 or equivalent)

Comment:

The durability provisions in AS/NZS 4058 and NZS 3101 enable new concrete products and structures to be cast from concrete mix designs of sufficient quality to provide a 50 to 100 year specified intended life in accordance with the durability provisions of the NZ Building Code. In contrast, RCAg comprises a wide range of concrete mix designs, therefore it may be less durable than concrete pipe or structural concrete designed for specific ground conditions. To ensure that RCAg will be sufficiently durable in service even if made from lower quality concrete than concrete pipe or structural concrete designed for specific ground conditions, the limits specified above for sulfates, pH, and aggressive CO2 are the most conservative limits for non-aggressive exposure classes defined by Concrete Institute of Australia's Recommended Practice Z7/02 (2018), and the limit for soil acidity is the lower limit for exposure classification XA1 defined by NZS 3101:2006.

Appendix A1.3 Drainage systems (informative)

Where RCAg is used in conjunction with sub drains, the following procedures from TNZ M/4 (2006) are recommended to reduce the likelihood of drainage systems becoming clogged by leachate precipitates including calcium hydroxide and calcium carbonate from Portland cement in the aggregate or in other materials:

- Wash the processed RAg to remove dust from the coarse particles (washing during wet-screening and other wet production processes may suffice).
- Ensure that any geotextile fabric surrounding the drainage trenches (containing the sub drains) does not intersect the drainage path (to avoid potential plugging with fines)

Appendix B1.0 Factors to consider when evaluating benefit/cost and environmental consequences of using recycled aggregate in individual projects

The economic and environmental impacts of the extraction, processing, and use of RAg materials from vertical or horizontal sources can be compared with those of alternative rock products extracted and processed from "greenfield" sources, which in the Auckland region are usually fixed hard rock quarry locations.

Auckland Council expects that the following factors shall at least be considered when evaluating the benefits or otherwise of using RAg.

The extraction of RAg source materials from vertical or horizontal locations within the urban and peri-urban environment will likely impact neighbours (dust and noise and vehicle movements) and local environment conditions in more reactive ways, requiring case-by-case interventions.

The availability and economic cost of disposal of waste to cleanfill or landfill needs to be assessed on a case-by-case basis.

Fixed hard rock quarry locations operate under agreed consent conditions, the effects of which can be assessed on a case-by-case basis.

Detailed comparisons of the mechanical efforts needed to extract RAg source material using mobile operations with those needed to extract natural rock from fixed hard rock quarry locations (e.g., blasting and excavation) may not yield significant differentials because the plant and operations needed are likely of similar scale. In both cases fixed costs are high, and environmental consequences (e.g. embodied carbon / global warming potential) can be significant, particularly with traditional plant and processes.

Once the source rock material has been extracted and is ready for use, evaluation of the economic and environmental impacts of the next steps could include the efforts needed to:

- Sort and clean source materials, remove deleterious materials and contaminants to safe disposal
- Uplift and transport source materials to production facility
- Stockpile and test source materials at production facility before production
- Crushing and screening at production facility
- Stockpile and test the aggregate products at production facility after production
- Uplift and transport the aggregate products to construction site.

Appendix C1.0 Supporting Comments on Selected Clauses

Clauses prefixed ‘C’ provide additional information on the corresponding clauses. They are not to be taken as the only or complete interpretation of these clauses and are not requirements for conformance with this specification.

Appendix C1.1 Scope

Auckland Council supports the recycling and re-use of aggregate and building materials where this can be shown to reduce the environmental footprint of civil engineering works and support the design and construction of resilient infrastructure.

Future revisions of this specification will be based on evidence from ongoing material production, civil engineering construction activity, and industry feedback.

Very localised corrosion is enough to cause failure of a metal pipe, therefore this specification specifically excludes RAg for use in association with metal pipe. Future revisions of this specification could extend its scope to include metal pipe if appropriate means can be specified to ensure metal pipe materials and coatings will be durable in contact with the RAgs being produced, and that pipe coatings are undamaged before RAg installation and remain undamaged during the RAg installation. Limiting the scope of this version to more durable pipe materials will enable RAg production and use to be successfully established before RAg is used on inherently more vulnerable pipeline materials.

Similarly, this specification excludes RAg used in association with unprotected metal pipeline infrastructure items. The term “pipeline infrastructure” covers:

Unspecified major buried items such as access chambers, well liners, or other items not covered by AS/NZS 2566 or AS/NZS 3725, but which are likely to be an integral part of the buried pipeline system and therefore in contact with the RAg pipeline bedding or backfill.

Unspecified fittings (non-metal) that are an integral part of the buried pipeline’s operating and maintenance system.

The term does not cover items installed at or near ground level, such as catchpits.

Footnote 1 acknowledges that pipelines and ‘low-risk applications will probably include metal fixtures and fittings. Addressing the specific needs of every metal item in all such applications is beyond the scope of this specification. In practice, corrosion of some metal items might not present a significant risk. Therefore Footnote 1 provides for Council to approve the use of RAg on a case-by-case basis and Appendix A1.1 enables designers to take appropriate precautions for at least some items/applications.

Appendix C1.2 Crushing Resistance and Abrasion Resistance

The confirmation of either crushing resistance with wet and dry strength variation or abrasion resistance is intended to confirm that the source material(s) can adequately resist the future production and construction processes without unforeseen breakdown.

The control of fines in RAg will support compaction control during construction and help mitigate against excessive re-cementation post construction and in service.

Appendix C1.3 Particle Size Distribution (PSD)

All RAg materials are expected to be processed, crushed aggregates manufactured from rock crushing and screening plants operating under independently audited quality assurance systems.

The performance of pipeline bedding and backfill is strongly influenced by the quality of compaction in situ. Specifying generic PSDs designed to facilitate good compaction, and controls on fines quality (ACS740.10.4), was considered a simpler and more reliable approach than specifying laboratory tests for compactibility for the wide range of RAg materials and applications covered by this specification.

Appendix C1.3.1 Particle Size Distribution (PSD) of Buried Pipeline Bedding Aggregate

The PSDs in Table 4 will supply RCAg as Sandy GRAVEL and RNAg as either SAND or Sandy GRAVEL. These materials should be straightforward to transport, place and compact, and thereby provide stable foundation support, provided that adequate compaction is consistently applied.

Where being used in applications where greater pipeline support is necessary (HS3 or with soil modulus more than 7 MPa), specific testing may be required to confirm the modulus requirements of AS/NZS 3725 and AS/NZS 2566 can be met in service.

The PSD limits for RCAg bedding aggregates are intended to:

- Align with the coarse-grained limits for single size AP20 aggregate in AS/NZS 2566 and for RNAg in this specification.
- Mitigate against excessive post construction re-cementation by limiting the fine fractions (SAND, SILT and CLAY), and align with an AP20 RCAg already on the market.

Whilst the grading envelopes are wide and allow for a significant range of acceptable gradings, the supplier should aim to provide RCAg in a similar grading to those commonly produced from natural aggregate in accordance with AS/NZS 3725 and AS/NZS 2566 and which are likely to have been used by designers. This will ensure substitution with RAg is more feasible.

The PSD limits for RNAg bedding aggregates are intended to:

- Align with the coarse-grained limits for single size AP20 aggregate in AS/NZS 2566 and for RCAg in this specification.
- Expand the fine-grained limits to include largely SAND materials that align with the fine-grained limits in AS/NZS 3725.

The material grading given in this specification may be selected for low-risk Auckland Council-Family applications at the discretion of the Contract Administrator on a case-by-case basis.

Appendix C1.3.2 Particle Size Distribution (PSD) of Buried Pipeline Backfill Aggregate

The PSD in Table 5 will supply RAg that is uniformly or well graded. These materials should be straightforward to transport, place and compact, and thereby provide stable foundation support, provided that adequate compaction is consistently applied.

The PSD limits for both RCAg and RNAg backfill aggregates are intended to:

Generally align with the PSD limits for well-graded aggregate in the CCPA Guidelines and an AP65 RCAg already on the market.

Mitigate against excessive post construction re-cementation by limiting the fine fractions (SAND, SILT and CLAY) and support construction and in-service stability.

The material grading given in this specification may be selected for low-risk Auckland Council-Family applications at the discretion of the Contract Administrator on a case-by-case basis.

Appendix C1.4 Quality of Fines

The control of fines content and composition in RAg will support compaction control during construction and help mitigate against excessive re-cementation post construction and when in service.

Appendix C1.5 Chloride Ion Content

RAg contaminated with chloride ions can lead to premature corrosion of reinforcing steel in concrete pipe, other steel-reinforced concrete items, and unprotected or inadequately protected metals in contact with or downstream from the RAg (see also Appendix A1.1).

Appendix C1.5.1 Sulfate Content

RAg contaminated with sulfates or oxidisable sulfur compounds can lead to premature degradation of concrete materials containing Portland cement. Oxidisable sulfides can lead to

corrosion of unprotected or inadequately protected metals in contact with or downstream from the RAg (see also Appendix A1.1).

Appendix C1.6 Mobility of Potential Environmental Contaminants

The environmental risk associated with contaminated soils is assessed by comparison with Auckland Unitary Plan (AUP) clause E30 requirements for contaminated land and National Environmental Standards for Assessing and Managing Contaminants in soil for the protection of human health (NESCS). RAg is not a natural soil, fill, or aggregate but a manufactured construction material. Construction materials are not assessed through AUP or NES provisions, however it was important to design a testing regime to reduce the likelihood of environmental degradation as a result of use of this material.

Even if not sourced from a recognised HAIL site, RAg may contain contaminants that were present at its source location. Therefore it is important that some testing is undertaken to ensure the environmental performance of this material is acceptable.

The principle behind the testing specified herein is that the concentration of contaminants leached from the RAg in service must not exceed toxicity limits for the freshwater system into which they could discharge.

The SPLP test method recommended in this specification provides an appropriate methodology for measuring contaminants that could be leached from the aggregate. The most likely source of such contaminants is the finer fraction of the aggregate, therefore only the fraction finer than 4.75mm is tested. This provides a conservative assessment of leaching risk. To simulate in-service conditions, it is tested without being crushed. The concentrations of contaminants in the extract prepared from the sample are then compared directly to the ANZG 2018 requirements.

This methodology provides appropriate level of control to assess and manage potential impacts of the RAg on the environment.