

ACS510 Earthworks

Contents

ACS510	Earthworks	1
ACS510.1	Scope.....	2
ACS510.2	Site management	3
ACS510.2.1	Dust control.....	3
ACS510.2.2	Erosion and sediment control.....	3
ACS510.2.3	Ground and surface water management	3
ACS510.2.4	Stockpiling and handling.....	4
ACS510.3	Classification of materials being excavated.....	5
ACS510.3.1	Topsoil material.....	5
ACS510.3.2	Type A1 material.....	5
ACS510.3.3	Type A2 material	5
ACS510.3.4	Type R1 material.....	6
ACS510.3.5	Type R2 material	6
ACS510.3.6	Type W material	6
ACS510.3.7	Type U1 material.....	6
ACS510.3.8	Type U2 material.....	7
ACS510.4	Excavation.....	8
ACS510.4.1	Safe practices.....	8
ACS510.4.2	Topsoil stripping	8
ACS510.4.3	Excavation level and overbreak	8
ACS510.4.4	Weather and trafficking protection	9
ACS510.4.5	Trenches.....	9
ACS510.4.6	Temporary trench support	9
ACS510.4.7	Obstructions and existing utilities.....	10
ACS510.4.8	Excavation by hydrovac	10
ACS510.5	Chemical acceptability of materials being used as fill.....	11

ACS510.5.1	Imported fill/soil material: acceptance without contamination testing.....	11
ACS510.5.2	Imported fill/soil material: pre-approval contamination testing.....	11
ACS510.5.3	Pre-approval chemical testing for backfill to structures.....	11
ACS510.5.4	Frequency of imported fill material: Pre-approval chemical testing.....	12
ACS510.6	Classification of materials being used as fill.....	12
ACS510.6.1	Acceptability and classification	12
ACS510.6.2	Basecourse, sub-base, and bituminous sealing materials	21
ACS510.7	Filling.....	22
ACS510.7.1	Subgrade preparation	22
ACS510.7.2	Materials.....	22
ACS510.7.3	Placement and compaction	22
ACS510.7.4	Backfill to retaining walls.....	22
ACS510.7.5	Backfill against sloping ground	22
ACS510.7.6	Backfill to other structures.....	23
ACS510.7.7	Placing of topsoil.....	23
ACS510.7.8	Surplus material.....	23

ACS510.1 Scope

This Specification covers excavation, removal, and stockpiling of materials and backfilling for construction works.

For trench backfill, pipe bedding and pipe encasement (haunch/side support and overlay), this section of the Specification shall be read in conjunction with *ACS710: Pipeline Construction*.

Where excavations are in the road corridor, the relevant Corridor Manager's requirements, the requirements of Auckland Transport Code of Practice (ATCOP) or NZ Transport Agency (NZTA) requirements, as appropriate, shall take precedence over this specification.

ACS510.2 Site management

ACS510.2.1 Dust control

Works shall be carried out and maintained to minimise the raising of dust. If there is a risk of dust being blown over the working area or neighbouring properties, works will be halted if required, and dust suppression measures implemented.

ACS510.2.2 Erosion and sediment control

At any location within the Contract Works where there is the risk of surface erosion or silt laden runoff occurring, the Contractor shall undertake measures to eliminate or mitigate the effects in accordance with the requirements of *GD05 Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region*. The Contractor shall allow, where necessary, to:

- Obtain the necessary local authority consents for excavation and the control of erosion and silt
- Liaise and cooperate with officers or representatives of the Auckland Council in respect of any consent requirements.

ACS510.2.3 Ground and surface water management

Excavations shall be kept free of water during construction and practicable steps shall be undertaken to prevent water from entering the excavation. Pipework, sub-drains, and sumps shall be installed, and the pumping plant operated and maintained at all times, as is necessary to deliver and maintain the excavation free from water.

Temporary sub-drains or sumps will only be allowed under any permanent works where they are essential to keep the excavation clear of water. When no longer required, temporary sub-drains and sumps shall be blocked off and filled up with concrete until watertight.

The Contractor shall perform work in an appropriate way to avoid damage to the structures, pipelines, etc. including but not limited to, lifting due to the hydrostatic uplift exceeding the weight of the structure.

Any flowing water shall be kept clear of the work area. The Contractor shall, at all times, maintain the continuity of stormwater flows in the site to a condition equivalent to, or better

than, the pre-contract conditions. The Contractor shall submit a Flow Diversion Plan for the Contract Administrator's acceptance.

Discharged water shall be disposed of in a manner that complies with all Consent conditions or, where there are no such conditions, in accordance with the RMA permitted activity rules.

No water shall be disposed of into a sewer without approval of the sewer owner. If the Contractor wishes to dispose of water into a sewer, the Contractor shall make the necessary arrangements. In such case, the Contractor shall provide the Contract Administrator with evidence that any approvals required from the sewer owner have been obtained.

Groundwater management measures shall be managed by the Contractor to ensure that settlement does not occur which might affect nearby structures, roads or buried services.

Groundwater management measures shall be managed by the Contractor to ensure that there is no heave in the base of the excavation.

ACS510.2.3.1 Contaminated groundwater

If signs of contamination are encountered, disposal of water shall cease unless this would create a risk to health and safety. The Contract Administrator shall be notified immediately. The Contract Administrator shall consider the option of engaging the services of a Contaminated Land Specialist Advisor to assess the type and extent of contamination with the aim of providing a site-specific Remedial Action Plan and treatment/disposal options.

ACS510.2.4 Stockpiling and handling

The Contractor shall control all stockpiling and temporary material storage operations to ensure the safe utilisation of the site without interfering with the passage of traffic and/or pedestrians or influencing the stability of slopes, structures, or excavations.

Unless required by the conditions of consent or project specific requirements, stockpiles of site-won material shall be held at the site.

Wherever possible, material shall be handled and stockpiled in such a way as to maintain or improve the quality of material for future re-use on site.

Separate stockpiles will be used for each material type.

Stockpiles shall be safe and stable with sloped faces that prevent any ponding.

Silt barriers with suitable drainage shall be installed around all stockpiles.

Stockpiles which are to be in place for more than 14 days, or when heavy rain is forecast, shall be covered with a suitable geotextile to prevent erosion. Where stockpiles are very large, a covering of grass (with grass of minimum 90% coverage from a suitable seed mix) may be used as an alternative to a geotextile, where agreed with the Contract Administrator.

Material inappropriately stockpiled that has, in the opinion of the Contract Administrator, become unsuitable for reuse, shall be removed and replaced.

Topsoil shall not be:

- a) Stockpiled for more than two years
- b) Compacted other than light tracking
- c) Unnecessarily trafficked either before stripping or when in a stockpile
- d) Surcharged or otherwise loaded.

ACS510.3 Classification of materials being excavated

Excavation will be classified as follows:

ACS510.3.1 Topsoil material

Topsoil is the layer of material immediately below the ground surface, which includes vegetation, turf and humus or other organic matter. This material is capable of supporting growth of vegetation, excluding peat.

ACS510.3.2 Type A1 material

Type A1 material is all material which does not fall within categories Topsoil, A2, R1, R2, W, or U1 and U2.

ACS510.3.3 Type A2 material

This is soil or rock which cannot be productively excavated by a 20-tonne hydraulic excavator with a toothless bucket in good condition but is easier to excavate than R1 or R2 material.

ACS510.3.4 Type R1 material

This is rock which cannot be productively ripped unless equipment is used which is more powerful than a crawler tractor having net engine (or flywheel) power in the range 100-115 kW and fitted with a twin shanked hydraulic ripper. If a tractor meeting the above specification is not readily available, then a 30-tonne hydraulic excavator using a bucket may be used to determine R1 materials. Alternatively, a smaller excavator with a single tyne ripper may be used providing its performance has been compared with a crawler tractor in similar materials.

ACS510.3.5 Type R2 material

This is rock which cannot be productively ripped unless equipment is used which is more powerful than a crawler tractor having net engine (or flywheel) power in the range 270-310 kW and fitted with a single shanked hydraulic ripper. If a tractor meeting the above specification is not readily available, then a 30-tonne hydraulic excavator with a single ripper on the boom may be used to determine R2 materials. Alternatively, a smaller excavator with a single tyne ripper may be used providing its performance has been compared with a crawler tractor in similar materials.

ACS510.3.6 Type W material

Type W is a secondary classification applied in addition to A1 or A2 (e.g. A2-W).

This is material which is too wet for immediate use but is suitable for use in construction fill after drying. This material may be cut to waste if the Contract Administrator considers the drying operation to be uneconomic.

Material with a water content (NZS 4407 Test 3.1 or NZS 4402 Test 2.1) more than 4% above the Optimum Moisture Content (NZS4402 Test 4.1.1) shall be classified Type W.

ACS510.3.7 Type U1 material

Type U1 is a secondary classification applied in addition to A1 or A2 (e.g. A2-U1).

This is material which should not be used in construction fill due to one or more of its following inherent properties making it unsuitable:

- Grain size
- Moisture sensitivity

- Organic content.

The following materials shall be classified Type U1:

- Peat, materials from swamps, marshes, and bogs
- Logs, stumps, significant quantities of topsoil or perishable material
- Clay having a liquid limit exceeding 50% or plasticity index determined exceeding 35%.

Type U1 material may be processed by mechanical, chemical, or other means to render the material suitable for use, if agreed with the Contract Administrator. If such processing is successful, the material may then be reclassified.

ACS510.3.8 Type U2 material

Type U2 is a secondary classification applied in addition to Topsoil, A1, A2, R1 or R2 (e.g. A2-U2).

This is material which should not normally be suitable for use as fill due to the presence of contaminants. All soil or rock shall be classified U2 if it contains levels of contamination above that given in the Ministry for the Environment Environmental Guideline Value Database for Soil Acceptance or in the Auckland Unitary Plan.

Signs of contamination may include, but are not limited to:

- a) Hydrocarbon staining and odours
- b) Fibrous material, for example, asbestos containing materials (ACM)
- c) Soil mounds or excavations that do not match the natural contour of the land
- d) Deposited inorganic wastes (e.g. car bodies, construction debris, drums, etc.)
- e) Deposited organic wastes (e.g. some vegetation, household wastes)
- f) Underground storage tanks
- g) Unnatural staining of soil or pooled water
- h) Unusual odours
- i) Unstable ground
- j) Gas bubbles in pooled water
- k) General refuse.

ACS510.4 Excavation

ACS510.4.1 Safe practices

Safe excavation practices shall be followed in accordance with the *WorkSafe NZ: Excavation Safety – Good Practice Guidelines 2016*.

Current service location plans shall be obtained by the Contractor and compared with visible indicators (such as manhole lids) on site. All known buried services shall have their position confirmed, and this position shall be physically marked at the surface. The method used to locate the services (typically by geophysical or physical excavation) shall be agreed between the Contractor and Contract Administrator.

ACS510.4.2 Topsoil stripping

Topsoil shall be removed within the limits of the earthworks. Care shall be taken during the removal to avoid contamination of the topsoil.

The depth of topsoil stripped shall be:

- a) At least 300 mm in farmland, residential property, or other cultivated areas, or
- b) At least 150 mm elsewhere, or
- c) The full depth of topsoil when less than the above depths exist.

Topsoil shall, wherever practicable, be used immediately after its stripping. If immediate use is not practicable it shall be stored in stockpiles separate from other materials.

ACS510.4.3 Excavation level and overbreak

Excavation shall be to the formation levels required by the specification and drawings. Soft soil, loose rocks and other unsuitable material shall be removed if found at the foundation or formation depths specified. The extra excavation ('overbreak') shall be filled with concrete or suitable compacted materials as directed by the Contract Administrator.

ACS510.4.4 Weather and trafficking protection

Where excavations are in soil and bad weather is expected, the formation shall only be exposed immediately before placing of concrete or fill with a minimum of 50 mm remaining for structures and road sub-base and 200 mm for pipe bedding.

Where excavations are in soil and bad weather is not expected, the formation shall not be exposed until the time defined below:

- For foundations for structures, the last 50 mm shall only be removed within 24 hours of laying concrete or hardfill
- For road sub-base, the last 50 mm shall only be removed within 24 hours of laying of the sub-base
- For trenches, the last 200 mm shall only be removed within 48 hours of laying the pipe bedding.

ACS510.4.5 Trenches

The trench shall be sufficient to accommodate construction of the pipe, bedding and/or encasement as required by Stormwater Standard Specification *ACS710 Pipeline Construction*.

The trench shall not be opened up for more than 10 m ahead of the completely backfilled of pipeline unless otherwise accepted by the Contract Administrator.

Where trenches are constructed in an embankment, the stability and integrity of the embankment shall be maintained.

ACS510.4.6 Temporary trench support

The walls of pits and trenches shall not be battered beyond the vertical without the prior acceptance of the Contract Administrator.

Trench support shall (where possible) be drawn up and removed as the concreting or backfilling progresses so as to ensure that all voids at the side, or in other places, are filled as the Contract Works advance.

All trench supports shall be removed on completion, unless otherwise accepted by the Contract Administrator. All trench support left in place shall be kept clear of the permanent Contract Works.

ACS510.4.7 Obstructions and existing utilities

Any voids, underground chambers, vaults, wells, etc. shall be immediately reported to the Contract Administrator. Do not enter or disturb them until checks have been completed and instructions given by the Contract Administrator.

Any obsolete structures, pipes, foundations etc encountered during excavation are to be reported to the Contract Administrator for further instructions.

ACS510.4.8 Excavation by hydrovac

Hydrovac excavation:

- May only be used as an alternative to hand excavation of small, localised areas.
- The excavation shall be directed away from bearing surfaces of existing structures that may compromise the structural purpose or integrity.
- The excavation shall be to a level above the lines and levels of the design.
- Hand excavation or mechanical plant shall be used to complete to the required dimensions.

Hydrojet or wand:

- Shall never remain motionless and may not advance ahead of the vacuum unit so as to cause flooding of the excavation area or washout of adjacent service bedding.
- The maximum water pressure for straight nozzles shall be 100 bar and for spinning nozzles shall be 200 bar.
- Pressure shall be monitored, and the water supply fitted with an emergency shut-off at the wand as well as the connection at the truck.
- Hydrovac equipment and operators shall be protected by equipotential bonding.
- Hydro excavation in the vicinity of energized plant, suspect or damaged cables shall be excavated with the infrastructure isolated and where practical de-energised.
- The excavation shall be screened to prevent any flying debris causing harm or damage.

ACS510.5 Chemical acceptability of materials being used as fill

ACS510.5.1 Imported fill/soil material: acceptance without contamination testing

Imported fill material may be accepted without contamination testing if there is prior written evidence to the Contract Administrator that:

- a) The source of the fill material is from a known cleanfill site such as a licensed quarry; or
- b) The source of the fill material is from a site not listed on the latest version of the Hazardous Activities and Industries List (HAIL), produced by the Ministry for the Environment (MfE) and there is no other evidence of potential contamination.

The Contract Administrator may require contamination testing at any time if they have any concerns about the quality of the material.

ACS510.5.2 Imported fill/soil material: pre-approval contamination testing

If there is any doubt about the source of the fill material, in particular if the source of the fill originates from a property identified on the HAIL or is likely to come from a property identified on the HAIL, the fill material shall be tested, as a minimum, for the contaminants listed in Table 3.

If there is reason to suspect that the imported fill material may contain volatile organic compounds, for example, visual or olfactory/smell evidence of odorous contamination, the imported fill testing criteria shall be extended to include the contaminants listed in Table 4.

Imported fill material containing detectable organic constituents not including those listed in Table 3 or Table 4 shall not be used unless accepted by the Contract Administrator.

ACS510.5.3 Pre-approval chemical testing for backfill to structures

All fill (including imported and site-won fill) for use within 2 m of any buried structure shall comply with the limits given in Table 3 unless agreed otherwise by the Contract Administrator.

ACS510.5.4 Frequency of imported fill material: Pre-approval chemical testing

The frequency of Imported Fill Material: Pre-Approval Chemical Testing shall be based on the volume of the source of the fill as follows:

- a) For $>250 \text{ m}^3$ from a single source: test at least one sample per 500 m^3 for the parameters listed in Section 6.2. A minimum one sample shall be provided in all cases.
- b) For $<250 \text{ m}^3$ from a single source: test at least one sample per 250 m^3 for the parameters listed in Section 6.2.

Testing must be completed by an accredited laboratory or other approved methodology accepted by Council.

ACS510.6 Classification of materials being used as fill

ACS510.6.1 Acceptability and classification

The tests in Table 1 shall be undertaken to assess the acceptability of excavated, stockpiled or imported material intended for re-use as backfill. Any materials failing these tests will not be used in the works unless accepted by the Contract Administrator, who may elect to accept the material for the whole works, part of the works, or request improvement of the material.

Fill obtained from the demolition of concrete or other structures shall not be used unless accepted by the accepted in the works unless approved.

With the exception of bulk fill, no material shall be sourced from argillaceous rock (e.g. shale or mudstone).

Table 1: Classification criteria for fill

Material type	Typical use	Test (Standard)	Minimum test frequency	Acceptance criteria
Riprap	Erosion / scour protection at outfalls	Refer Stormwater Standard Specification, ACS1340 Gabions and Reno Mattresses		
Rock fill		Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1) *	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
GAP 150		Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1) *	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
GAP 100		Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1) *	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
GAP 65 (‘Hardfill’)	Hardfill may include run of pit scoria, concrete washings, rejected basecourse, natural gravel etc.	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
GAP 40		Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA

Material type	Typical use	Test (Standard)	Minimum test frequency	Acceptance criteria
GAP 20		Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
Bulk fill	Bulk fill is selected material excavated on site (or imported if unavailable on site) for general earthworks	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Compaction (NZS4402:1986 Test 4.1.1)	1 per 500 m ³ and 1 for each change in material	N/A – used to set OMC
		Water content (NZS 4402:1988 Test 2.1)	1 per 500 m ³ and 1 for each change in material	Within ±2% of OMC
		NZS4402:1988 Tests 2.2-2.4	1 per 500 m ³ and 1 for each change in material	Plasticity index < 35% Liquid limit <50%
General granular fill		Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
		Compaction (NZS4402:1986 Test 4.1.1)	1 per 500 m ³ and 1 for each change in material	N/A – used to set OMC
		Water content (NZS 4402:1988 Test 2.1)	1 per 500 m ³ and 1 for each change in material	Within ±2% of OMC

Material type	Typical use	Test (Standard)	Minimum test frequency	Acceptance criteria
Clean sand	Drainage blankets, blinding.	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Compaction (NZS4402:1986 Test 4.1.1)	1 per 500 m ³ and 1 for each change in material	N/A – used to set OMC
		Water content (NZS 4407:2015 Test 3.1)	1 per 500 m ³ and 1 for each change in material	Within ±2% of OMC
Fine pipe bedding	Embedment (bedding, haunch support and overlay) for small diameter pipes	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 250 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
		Compaction (NZS4402:1986 Test 4.2.1 and 4.4.2)	1 for each change in material	N/A – used to set density target
Coarse pipe bedding	Embedment (bedding, haunch support and overlay) for large diameter pipes	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 250 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
		Compaction (NZS4402:1986 Test 4.2.1 and 4.4.2)	1 for each change in material	N/A – used to set density target

Material type	Typical use	Test (Standard)	Minimum test frequency	Acceptance criteria
Gabion rock	Placed fill in gabion baskets.	NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1 *	1 per 500 m ³ and 1 for each change in material	>mesh opening <60% gabion width <200 mm
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
		Abrasion resistance (NZS 4407:2015 Test 3.12)	1 per 500 m ³ and 1 for each change in material	<50%
Crib wall rock	Placed in crib retaining walls.	NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1 *	1 per 500 m ³ and 1 for each change in material	>mesh/face opening <60% crib width <200 mm
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
		Abrasion resistance (NZS 4407:2015 Test 3.12)	1 per 500 m ³ and 1 for each change in material	<50%
		NZGS Field Description of Soil and Rock 2005, Table 2.4	All loads delivered	Subangular or angular
Retaining wall drainage	Layer to reduce water loading on reinforced soil and retaining wall structures.	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Weathering quality index (NZS 4407:2015 Test 3.11)	1 per source	AA, AB, AC, BA, BB or CA
		Compaction (NZS4402:1986 Test 4.1.1)	1 per 500 m ³ and 1 for each	N/A – used to set OMC
		NZS 4407:1991 Test 3.1	1 per 500 m ³ and 1 for each change in material	Within ±2% of OMC

Material type	Typical use	Test (Standard)	Minimum test frequency	Acceptance criteria
Clay core	Central portion of bund for retention of water	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Compaction (NZS4402:1986 Test 4.1.1)	1 per 500 m ³ and 1 for each change in material	N/A – used to set OMC
		Water content (NZS 4402:1988 Test 2.1)	1 per 500 m ³ and 1 for each change in material	>1.3 times plastic limit
		Atterburg limits (NZS4402:1988 Tests 2.2-2.4)	1 per 500 m ³ and 1 for each change in material	Plasticity index >10% Liquid limit >35%
		Emerson Crumb test (ASTM D6572)	1 per 500 m ³ and 1 for each change in material	Non-dispersive (ND1)
Imported topsoil	Finishing landscaping	Grading (NZS 4407:2015 Test 3.8.1 or NZS 4402:1986 Test 2.8.1)	1 per 500 m ³ and 1 for each change in material	See Table 2
		Chemical acceptability	1 per 1000 m ³	See Table 3 and Table 4

Notes:

* = may be replaced with visual observation with the agreement of the Contract Administrator

Abbreviations:

OMC = Optimum Moisture Content

Table 2: Grading requirements

Sieve aperture size (mm)			150	100	75	65 or 63	40 or 37.5	20 or 19	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075 or 0.063	Uniformity coefficient
Acceptable range for percentage passing sieve	Rock fill	Min	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		Max	-	-	-	-	41	-	-	21	-	-	-	-	-	-	5	
	GAP 150	Min	100	79	64	58	41	28	-	21	15	9	6	4	3	1	-	
		Max	-	95	89	85	73	54	-	40	30	23	18	14	10	8	5	
	GAP 100	Min	-	100	80	70	54	39	32	27	20	15	10	6	3	1	-	
		Max	-	-	92	85	75	60	52	46	34	25	18	13	10	7.5	5	
	GAP 65 (source: ATCOP)	Min	-	-	-	100	80	50	-	30	20	15	10	6	4	2	-	
		Max	-	-	-	-	90	70	-	55	40	30	22	18	14	10	7	
	AP 40 (source: ATCOP)	Min	-	-	-	-	100	61	-	38	23	14	7	2	0	0	-	
		Max	-	-	-	-	-	80	-	57	43	33	25	19	14	10	7	
	AP 20 (source: TNZ M/4)	Min	-	-	-	-	-	100	-	55	33	22	14	8	5	-	-	
		Max	-	-	-	-	-	-	-	75	55	42	31	23	16	12	8	
	Bulk fill	Min	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	
		Max	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Clean sand	Min	-	-	-	-	-	-	-	-	100	95	-	-	-	-	-	
		Max	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	

Sieve aperture size (mm)		150	100	75	65 or 63	40 or 37.5	20 or 19	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075 or 0.063	Uniformity coefficient
	Fine pipe bedding (SAP7 or similar)	Min							100								10
		Max											5				
	Coarse pipe bedding	Min					100		75								10
		Max											5				
	Retaining wall drainage	Min	-	-	-	-	100	-	-	-	60	-	15	-	-	-	
		Max	-	-	-	-	-	-	-	100	-	45	25	-	5	-	
	Clay core	Min	-	-	-	-	-	-	-	-	-	-	-	-	65	40	
		Max	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Imported topsoil	Min	-	-	-	-	100	-	-	-	-	30	-	-	-	5	
		Max	-	-	-	-	-	-	-	-	-	80	-	-	-	50	

Table 3: Chemical acceptability

Contaminant of Concern	Unit (total recoverable)	Fill/Soil maximum allowable concentration
Organic content	%	Backfill within 2 m of structure or pipe <1 All other fill <5
pH		Backfill within 2 m of structure or pipe 6-8 All other fill 5-8.5
Oxidisable sulphides	% as SO ₄	<0.06
Water soluble sulphate	mg/litre as SO ₄	Backfill within 2 m of structure or pipe <1500 All other fill <2000
Arsenic	mg/kg	12
Cadmium	mg/kg	0.65
Chromium	mg/kg	55
Copper	mg/kg	45
Cyanide (total)	Mg/kg	1
Lead	mg/kg	65
Mercury	mg/kg	0.45
Nickel	mg/kg	35
Zinc	mg/kg	180
Total Petroleum Hydrocarbons (TPH) C7-C9	mg/kg	120 (note 2)
TPH C10-C14	mg/kg	58 (note 2)
Benzo(a)pyrene (equivalent)- note 1)	mg/kg	2 (note 3)
Total DDT	mg/kg	0.7 (note 4)

Notes:

- 1) For benzo(a)pyrene, the equivalent BaP concentration is calculated as the sum of each of the detected concentrations of nine carcinogenic PaHs (benzo(a)anthracene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene and indeno(1,2,3-cd) pyrene), multiplied by their respective potency equivalency factors.

- 2) Derived from Ministry for the Environment Guidelines for Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand 1999, revised 2011. Table 4.15 Tier 1 soil acceptance criteria for TPH, residential use, 'all pathways' agricultural use.
- 3) Based on the available information, an interim value in the absence of national soil background values of 2 mg/kg BAPTE is proposed as a background level for urban soils where a region's specific value is not available (page 55 of Appendix C of *Technical Guidelines for Disposal to Land*, Waste Management Institute New Zealand (WasteMINZ), April 2016).
- 4) US EPA (2006) ecological receptors.

Table 4: Chemical acceptability (volatile organic compounds)

Contaminant of Concern	Unit (total recoverable)	Fill/Soil maximum allowable concentration
Benzene	mg/kg	0.0054- 0.66 (note 1)
Ethylbenzene	mg/kg	1.1 (note 1)
Toluene	mg/kg	1.0 (note 1)
Total Xylene	mg/kg	0.61 (note 1)

Notes:

- 1) Derived from Ministry for the Environment Guidelines for Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand 1999, revised 2011. Table 4.20 Soil acceptance criteria for protection of groundwater quality (clay). We note the 0.66 mg/kg value in Table 4.20- assumes that depth of contamination is <1 m and groundwater table is 4 m. The criteria for Benzene of 0.0057 mg/kg is for depth of contamination < 1m and groundwater table at 2 m and assumes that "contaminated soil layer is in direct contact with groundwater and hence no attenuation associated with vertical migration through the soil column occurs."

ACS510.6.2 Basecourse, sub-base, and bituminous sealing materials

Basecourse, sub-base and bituminous sealing materials shall be in accordance with the ATCOP or NZTA specifications as appropriate.

ACS510.7 Filling

ACS510.7.1 Subgrade preparation

Any loose material and topsoil at the base of the excavation shall be trimmed before fill operations are commenced.

No work of any kind shall be carried out upon the prepared excavation surfaces or backfilling commence until the Contract Administrator has given acceptance. Backfilling shall be undertaken immediately after the required operations preceding it have been completed.

ACS510.7.2 Materials

Filling shall consist of material classified according to Table 1 and accepted by the Contract Administrator and which allow the requirements of these specifications to be complied with. Accepted excavated material ('bulk fill') shall be used for filling unless otherwise specified or agreed to by the Contract Administrator. Any portion of the excavated material, which the Contract Administrator considers unsuitable for filling, shall be disposed of as surplus material.

ACS510.7.3 Placement and compaction

Unless otherwise specified, filling shall be in accordance with Table 5.

ACS510.7.4 Backfill to retaining walls

Tanking membranes shall be protected with polystyrene sheets glue-fixed in place and with joints taped.

Over-compaction shall be avoided by using nothing heavier than plate compactors for any compaction within 1 m of the wall unless otherwise agreed by the Contract Administrator.

ACS510.7.5 Backfill against sloping ground

Where fill is to be placed on or against sloping ground (steeper than 4H:1V), the natural ground shall be benched prior to fill placement. Bench heights shall be no less than 0.5 m and no more than 1.5 m.

ACS510.7.6 Backfill to other structures

Care must be exercised during placing and compacting near pipelines or structures to prevent displacement or damage. Where the risk of displacement or damage exists, hand rammers weighing not less than 5 kg may be used but in all other cases mechanical compaction using suitable rammers, vibrators or rollers shall be used. Backfill should be raised equally around all sides of pipes and structures.

ACS510.7.7 Placing of topsoil

Prior to placing topsoil, the surface shall be scarified to avoid creating an impermeable surface.

Topsoil shall be placed in a single layer 300 mm thick (loose thickness) and lightly compacted.

Where topsoil is placed on slopes of 3H:1V or steeper, the compaction shall be with a tracked excavator running up and down the slope to give ridges in the topsoil following the contour lines to reduce run-off.

ACS510.7.8 Surplus material

Surplus material is deemed to be defined as excavated or other material remaining after the Contract Works have been properly backfilled and restored. Surplus material may include material displaced by pipes, bedding, cushion material, hardfill, manholes, structures concrete encasement etc. and surplus excavated spoil.

Table 5: Filling requirements and acceptance criteria

Material	Usage scenario (as shown on drawings)	Placement requirements	Test (Standard)	Frequency	Acceptance criteria
Riprap	Stormwater outfall	Hand placed	N/A	N/A	N/A
GAP150, GAP100, GAP65	Bulk earthworks	Loose layer thickness <350 mm	Impact Test - 20kg Clegg Hammer (ASTM D 5874)	1 per 250 m ² on each compacted layer (min 2 for each layer of fill)	CIV >4
GAP40, GAP20, General granular fill, Retaining wall drainage	Bulk earthworks in non-trafficked open ground	Loose layer thickness <250 mm	Relative density (NZS 4407:2015)	1 per 250 m ³	>90% MDD <10% air voids
			Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 250 m ² on each compacted layer (min 2 for each layer of fill)	CIV >5
	Structural fill (beneath foundations)	Loose layer thickness <250 mm	Relative density (NZS 4407:2015)	1 per 100 m ³	>95% MDD <8% air voids
			Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 50 m ² on each compacted layer (min 2 for each layer of fill)	CIV >10
	Structural fill (alongside walls, chambers etc)	Loose layer thickness <250 mm	Relative density (NZS 4407:2015)	1 per 100 m ³	>90% MDD <97% MDD <10% air voids
			Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 50 m ² on each compacted layer (min 2 for each layer of fill)	CIV >10

Material	Usage scenario (as shown on drawings)	Placement requirements	Test (Standard)	Frequency	Acceptance criteria
Fine pipe bedding, coarse pipe bedding	Pipe bedding or surround	Loose layer thickness <150mm	In-situ density (NZS 4402:1986 Test 5.1. or NZS4407: 1991 Test 4.2)	1 per 500 m of trench	Density Index (I _D) >50%
Bulk fill	Bulk landscaping	Loose layer thickness <300 mm	Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 250 m ² on each compacted layer	CIV >3
	Bulk earthworks in non-trafficked open ground	Loose layer thickness <250 mm	Relative density (NZS 4407:2015)	1 per 250 m ³	>90% MDD <10% air voids
			Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 250 m ² on each compacted layer (min 2 for each layer of fill)	CIV >5
	Structural fill (beneath foundations)	Loose layer thickness <250 mm	Relative density (NZS 4407:2015)	1 per 100 m ³	>95% MDD <8% air voids
			Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 50 m ² on each compacted layer (min 2 for each layer of fill)	CIV >10
			Shear strength (NZGS Shear Vane Guidelines) – <i>clay soils only</i>	1 per 50 m ²	Cu > 120 kPa
	Structural fill (alongside walls, chambers etc)	Loose layer thickness <250 mm	Relative density (NZS 4407:2015)	1 per 100 m ³	>90% MDD <97% MDD <10% air voids
			Impact Test - 4.5kg Clegg Hammer (ASTM D 5874)	1 per 50 m ² on each compacted layer (min 2 for each load of fill)	CIV >10

Material	Usage scenario (as shown on drawings)	Placement requirements	Test (Standard)	Frequency	Acceptance criteria
Clay core	Bunds for temporary water retention	Loose layer thickness <150 mm Compact with sheepsfoot roller.	Relative density (NZS 4407:2015)	1 per 100 m ³	<5% air voids
			Shear strength (NZGS Shear Vane Guidelines)	1 per 50 m ² on each compacted layer (min 2 for each load of fill)	Cu > 40 kPa
			Permeability	1 test per 100 m finished bund	Coefficient of permeability <10 ⁻⁹ m/s