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BEFORE AN INDEPENDENT HEARINGS COMMISSIONER
AT NELSON

COUNCIL REF: RM200488,
RM200489 AND RM220578

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replacement version
Received by email
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included in error - para 28, fig 2 & 3

UNDER THE	Resource Management Act 1991
IN THE MATTER OF	Land use consent applications by CJ Industries Limited to extract gravel from 134 Peach Island Road, Motueka from the berm of the Motueka River and on the landward side of the stopbank at Peach Island with vehicle access via a right of way over 493 Motueka River West Bank Road, Crown land and unformed legal road (RM200488 and RM200489); and discharge permit application by CJ Industries Limited to discharge contaminants to land from backfill material associate with the proposed gravel extraction (RM220578)

STATEMENT OF EVIDENCE OF IAIN CAMPBELL ON BEHALF OF VALLEY RESIDENTS AGAINST GRAVEL EXTRACTION (PRODUCTIVE SOILS)

Dated: 11 November 2022

QUALIFICATIONS AND EXPERIENCE

1. My name is Iain Campbell. I am a Soil Scientist and a Fellow of the New Zealand Society of Soil Science.

2. I hold the qualifications of B Sc. And M Sc. With Honours in geology and also the degree of D Sc. (Doctor of Science, [soil]) from Canterbury University.

3. I have worked as a Soil Scientist for 60 years, initially for 27 years as a Soil Scientist with the Department of Scientific & Industrial Research, New Zealand Soil Bureau Division and latterly as a Soil Scientist and a consultant for 33 years.

4. A large part of my work has concerned the mapping and identification of soils, with over 4,500 km^2 surveyed and mapped throughout New Zealand and elsewhere, and more particularly in the Nelson and Marlborough regions over the past 45 years. This survey work has been reported in 35 published reports and numerous unpublished reports.

5. I have also conducted extensive scientific research into various aspects of soils which in the 1990's included environmental impacts and assessments.

6. I have been involved with soil restoration and land rehabilitation issues in the Tasman and Marlborough districts for more than 40 years.

CODE OF CONDUCT

7. I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note (updated 1 December 2014) and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in the statement of evidence below are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

8. My evidence is presented on behalf of objectors to the proposed gravel extraction at Peach Island.

9. My evidence in this submission addresses the identification and nature of the soils In the Peach Island area and their potential productivity.

10. My evidence provides an overview of the issues around soil restoration following gravel extraction, from two case studies located on the Waimea Plains near Nelson. It also outlines the problems and difficulties involved in regaining the productive capacity of soils prior to their disturbance and will include observations related to the present application. In addition, I comment on the draft Soil Management Plan proposed by the Applicant as part of its volunteered condition set.

11. My evidence will also address some broader issues around the management of soil and land resources and the need for aggregate materials.

12. In preparing my evidence I have read the evidence of:

    12.1 Mr Timothy Corrie-Johnston (15 July 2022 and 4 November 2022)

    12.2 Dr Reece Hill (15 July 2022 and 4 November 2022)

    12.3 Mr Michael Nelson (15 July 2022).

13. I have also read:

    13.1 the draft Soil Management Plan attached to Mr Hill’s evidence

    13.2 the s42A reports as they relate to soil productivity and soil management issues

    13.3 submissions relating to soil management and loss of soil productivity concerns.

EXECUTIVE SUMMARY

14. I have reviewed the s42A Addendum and agree with the conclusions of council staff Ms Bernsdorf Solly and Ms Langford that the application site is highly productive land as defined under the National Policy Statement for Highly Productive Land (NPS-HPL).

15. I have assessed the soil productivity potential of Riwaka soils (which are the type of soils found on Peach Island). The soils are of high to moderate soil versatility class and can produce a wide variety of crops.

16. The 2021 Landvision Peach island LUC and Soil Survey (the Landvision report) claims that the productive potential of the land in Stages 1-3 of the proposal is limited. In my view the Landvision Report lacks soil science substance.

17. From my years of work with Riwaka soils, I am confident the soils have moderate to high productive potential and this is consistent with the highly productive classification of the land in the NPS-HPL. To allow extractive activities within pockets of the land will result in the fragmentation that has occurred for many decades and which the NPS-HPL is aiming to halt.

18. I have examined soils on numerous other gravel extraction sites on the Waimea Plains and I discuss two specific case studies below. Various best practice methods have been used aiming to minimise soil physical impairment, compaction, drainage impairment and promote soil restoration. In one case study I discuss, no foreign materials were allowed as backfill. Despite these measures, there has always been deterioration in soil properties as a result of the disturbance from removal and replacement and through the cultivation needed for seed bed preparation and sowing. Therefore, even using best practice methods, there was distinct soil productivity loss.

19. In my view, the disturbed soils on Peach Island will not be able to be restored to their high potential productive status. I am particularly sceptical about the measures proposed regarding backfilling at the site because foreign materials will be brought to

site with no independent third party checks before the backfill is placed in the pits. In the Staplegrove Farm case study I discuss in my evidence, it was clear that resource Consent Condition Clauses, including extraction and backfill replacements reasonably similar to those proposed for Peach Island, had not been adhered to. With a quarry project of this size, scale and duration, it will be very difficult to ensure no operational errors and therefore protection of the soil properties. Dr Hill talks in his evidence about the need for careful management, pre-planning and adherence to the Soil Management Plan. In my experience, this is very difficult if not impossible to achieve in practice.

20. The removal and replacement of the soils on low terrace surfaces cannot successfully maintain their physical characteristics and productivity potential. The natural network of pores and fissures and soil structure within the soil material, which are essential for moisture movement, moisture storage, root penetration and biological and chemical processes are destroyed during the removal, stock-piling and replacement, irrespective of whether or not excessive compaction occurs. Relying on there being no human error in operational practices over a 15 year timeframe for a project of this size is not realistic.

21. Alluvial aggregate is available from other nearby sources that will not impact on highly productive land. These sources should be preferred over extraction from the productive soils at Peach Island.

SOILS OF THE PEACH ISLAND AREA

22. The soils of Peach Island belong to the Riwaka soil type family, as identified in *NZ Soil Bureau Bulletin 30 (1966)* and the Landcare Research S-Map system. They are formed from recent alluvium of the Motueka River and are derived from a variety of rocks, of which greywacke, quartzite, limestone, granite and basic igneous rocks are the most common. I am familiar with this soil type from farm-scale soil surveys for various purposes that I have undertaken in the Motueka district over the years.

23. As with most soils of the low terraces and floodplains, soil mapping and examinations of the alluvial soils of the Motueka Plain have shown that the Riwaka soils are varied in

their properties and range from deep to shallow silt loams, sandy loams and sands with gravel sometimes at the surface and at variable depths. They are usually well drained except in small lower lying areas. Being of youthful age these river plain soils have weakly developed soil structure and a high to moderate natural nutrient status. Because they occur on a geologically recent river terrace system, lower surfaces have been subject to flooding in the historic past, as is evidenced by flood layers and buried topsoils observed within some soil profiles.

24. During the 1950's soil mapping of the Motueka Plain was undertaken by the Cawthron Institute at a semi-detailed scale of 1:15,840 (Figure 1 Appendix). This unpublished map is the compilation from the field work that was carried out in the 1950's and was used as the basis for the subsequently published soil report and map (Chittenden, Dodson & Hodgson Soil Bureau Bulletin 30, 1966). It is widely used by horticulturalists on the Motueka Plain.

25. For the Peach Island area, 11 differing Riwaka soil units are shown on the unpublished soil map and they differ in their depths and texture. This variable soil pattern at Peach Island is similar to other parts of the Motueka Plain where Riwaka soils occur and where they are intensively used for a range of horticultural crops, more particularly apples and kiwifruit.

26. Detailed soil mapping on the Waimea Plain, which I have undertaken for the Tasman District Council (*TDC Waimea Plain Soil Reports 2012-2017)* has likewise shown similar soil depth and texture variation patterns on the low terrace/floodplain Waimea river system. For example, at the western end of Bartlett Road, where Waimea soils occur, the area is intensively used for market garden crops with the depth of fine material over gravel varying from 15 cm to > 100 cm and with surface stones present in many places.

27. Notwithstanding the variable depths, textures, stoniness and drainage differences over small distances, most of the Waimea Plain is under intensive horticulture and or market gardening *(Tasman District Council Land Use cover map, Waimea Plains).*

28. Paragraph redacted at request of submitter.
Done by Alastair Jewell, Principal Planner 16/11/2022.

[redacted]

SOIL PRODUCTIVE CAPACITY

29. Various systems have been used in the past to categorise the productive capacity of land in New Zealand. In many earlier New Zealand Soil Bureau reports, productive capacity was assessed using non empirical data, which were considered to be the limiting soil factors that formed the basis for determining various classes for broad land use groupings, such as cropping, pastoral and forestry uses.

30. The Tasman District Council land classification system (*Classification for Productive Land in the Tasman District; Agriculture New Zealand 1994)* is a hybrid system that incorporated some soil climatic data, but it lacks objective definitions for the class limits. In that classification, Riwaka soils were grouped within class A.

31. The Land Use Capability system has been widely used, but along with the earlier NZ Bureau and TDC systems, it lacks objective definitions for the class limits and has poorly defined criteria. It has no clear relationship between factors used for the classification and crop production or management. The system is designed to assess general capability of land for cropping, pastoral, forestry use and soil conservation on a broad scale rather

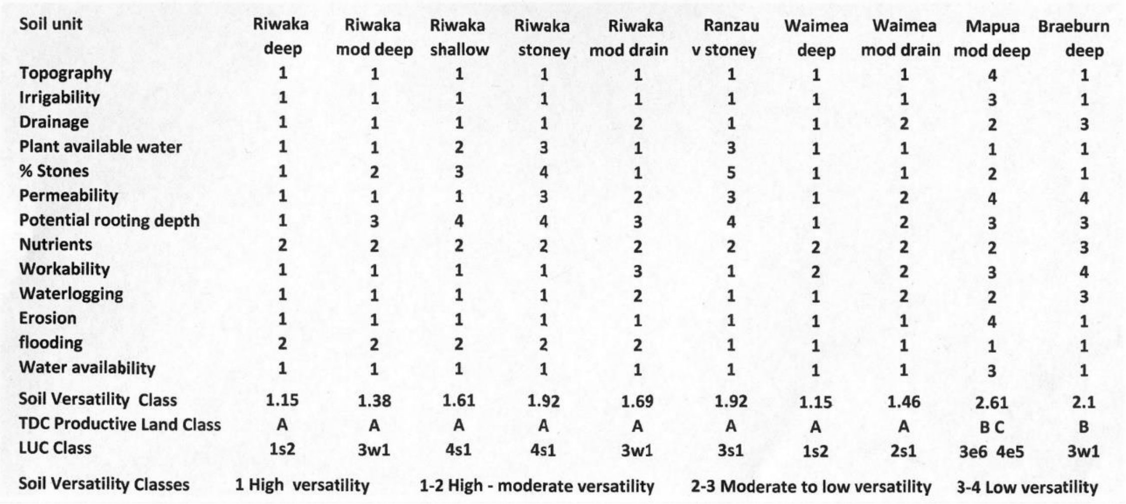
than soil suitability and productive capacity for particular intensive land uses. It is inappropriate in some instances, for example with sandy textured and stony soils downgraded under dryland farming but highly productive under irrigation. It also emphasises the possibility of wind erosion which under many intensive horticultural uses is negligible or zero.

32. Webb and Wilson (1995) discussed the deficiencies of the LUC system, as outlined above. They provided details for a comprehensive system for evaluating the productive capacity of rural land *(Webb and Wilson 1995. A manual of land characteristics for the evaluation of rural land. Landcare Research Science Series No. 10).*

33. The central concept of the Webb and Wilson system is that numerical ratings for a range of soil and land attributes are based on measurable values which directly influence crop growth or management. The attributes used include key soil physical properties (for example, effective rooting depth, soil penetration resistance and density, profile available water, soil wetness, permeability, and stoniness) and also soil chemical properties and environmental and climatic characteristics. In this system, a range of measurable values are assigned to each attribute which thus provide a quantitative basis for land use assessments. It gives a measure of *soil versatility* and the relative value of a soil for productive use.

34. When the assigned attribute values for particular a soil are summed and averaged, the average value gives a measure of the *soil versatility* and the *productive potential* for that soil. The empirical basis of this land evaluation system results in reliable and reproducible soil versatility assessments that are seen to match with existing land uses.

35. In the table below, using the assigned values for each soil property assessed, the Soil Versatility Class and potential productivity for five Riwaka soil variants are given, along with 5 other soils from elsewhere in the Tasman district. The TDC Productive Land Class and the LUC Land Class assessments are given for comparison.



Soil unit	Riwaka deep	Riwaka mod deep	Riwaka shallow	Riwaka stoney	Riwaka mod drain	Ranzau v stoney	Waimea deep	Waimea mod drain	Mapua mod deep	Braeburn deep
Topography	1	1	1	1	1	1	1	1	4	1
Irrigability	1	1	1	1	1	1	1	1	3	1
Drainage	1	1	1	1	2	1	1	2	2	3
Plant available water	1	1	2	3	1	3	1	1	1	1
% Stones	1	2	3	4	1	5	1	1	2	1
Permeability	1	1	1	3	2	3	1	2	4	4
Potential rooting depth	1	3	4	4	3	4	1	2	3	3
Nutrients	2	2	2	2	2	2	2	2	2	3
Workability	1	1	1	1	3	1	2	2	3	4
Waterlogging	1	1	1	1	2	1	1	2	2	3
Erosion	1	1	1	1	1	1	1	1	4	1
flooding	2	2	2	2	2	1	1	1	1	1
Water availability	1	1	1	1	1	1	1	1	3	1
Soil Versatility Class	1.15	1.38	1.61	1.92	1.69	1.92	1.15	1.46	2.61	2.1
TDC Productive Land Class	A	A	A	A	A	A	A	A	B C	B
LUC Class	1s2	3w1	4s1	4s1	3w1	3s1	1s2	2s1	3e6 4e5	3w1

Soil Versatility Classes 1 High versatility 1-2 High - moderate versatility 2-3 Moderate to low versatility 3-4 Low versatility

36. The five Riwaka soils fall within the high to moderate soil versatility class.The two Waimea soils (similar to the Riwaka soils) likewise are within the high to moderate soil versatility class. The very stony Ranzau soils on the Waimea Plain are at the lower end of the high to moderate versatility class but are classed as 3s1 under the LUC system. The Ranzau soils and the Waimea soils are extensively used for horticultural and market gardens on the Waimea Plains *(Tasman District Council Land Use cover map, Waimea Plain).* The Mapua soils from the Tasman district are within the moderate to low versatility class (3e6 & 4e5 in the LUC system), yet they are used extensively for a variety of horticultural crops including apples, pears, cherries, grapes and olives. They are not suitable for crops requiring cultivation because of multiple soil factors, hence their lower soil suitability ranking. The Braeburn soils, also within the moderate to low versatility class, (LUC class 3w1) are heavy textured soils that are imperfectly drained and occur in the Lower Moutere area where they are extensively used for horticulture and other crops.

37. To summarize, the Peach Island soils are Riwaka soils and in respect of their physical properties and variability, they are similar to other soils of the Motueka and Waimea Plains and the Takaka Valley river system, which, over most of the Motueka and Waimea

Plains areas, are under intensive horticulture and or market garden uses producing a wide range of crops.

38. The Nelson region has the smallest area of high value versatile soils compared with all other New Zealand regions (*Environment Ministry and Stats NZ Report 2021)*, and these soils are confined to narrow river valleys and three small valley plain areas. A significant portion of the most versatile soils on this land is already lost to urban development and is continuing to be diminished by inappropriate uses. For example gravel extractions alone on the Waimea Plain have taken place over around 1.5% of the area while > 20% of the 3,500 ha. Motueka Plain area is lost to urban uses.

THE SOIL MANAGEMENT PLAN AND PROPOSAL TO RESTORE THE QUARRIED LAND ON PEACH ISLAND

39. I have reviewed the draft Soil Management Plan (SMP) attached to Dr Reece Hill's evidence.

40. The proposal is not small-scale or temporary. Approximately 7.4ha of the site is proposed to be quarried (some 55% of the site area). Around 181,000 to 250,000m3 of aggregate is intended to be quarried over 15 years and I am informed that the applicant owns adjoining land at 493 Motueka River Westbank Road. If this land is also quarried this will be a very substantial operation with long-lasting impacts on the soil. I agree with Ms Bernsdorf Solly's view that the proposal is not small-scale or temporary in nature.

41. The aim of the draft SMP attached to Dr Hill's evidence is to ensure that the removal, management and placement of soil avoids or minimises impacts on the soil properties prior to and following placement, and that the re-established soil retains or exceeds the soil versatility of the original soil on the site while also minimising the potential for soil loss to water.

42. I have the same concerns as Ms Bernsdorf Solly and Ms Langford regarding the implementation of the SMP. In my view the SMP is unlikely to adequately restore the soil etc.. *Among other things, I note that the backfill will not be checked by a third party ie seems quite a high trust approach!]*

43. In numerous places in his evidence, Dr Hill emphasises the need for adherence to the SMP. For example, in paragraph 3.38 of his evidence of 15 July 2022 he states: "Provided the extracted gravels are replaced with a fine soil subsoil and topsoil in a way that the soil physical properties are not compromised by compaction, the reinstated soil profile will retain the same productive potential or improve to a similar level as the neighbouring land areas with deeper fine soil matrix soils. The recommendations in the Soil Management Plan provide for the soils to be managed in this way". Again at paragraphs 4.6 to 4.8 Dr Reece emphasises that "careful soil management throughout the operation and following reinstatement of the soil will reduce impacts on soil properties" and that "Key to the effective re-establishment of the soil on the gravel extraction site are careful pre-planning, adherence to the guidance provided in the Soil Management Plan".

44. I have experience with similar soil restoration projects. Even where similar management approaches to that proposed by Dr Hill have been followed, there has been a marked loss in soil productivity and physical impairment of various soil properties. Irrespective of directive wording and specific mitigation measures in the draft SMP, the likelihood of human error over the project's 15 year timeframe is high.

45. I discuss two case studies below. These studies show that once productive soil is disturbed through quarry activities, it is exceptionally difficult to restore it to its original productive capacity.

CASE STUDIES OF GRAVEL EXTRACTION-LAND RESTORATION IN THE NELSON REGION

Case Study 1

46. In 1974 a proposal was advanced to extract gravel from the stony Ranzau soils at a site in Waimea East (Ranzau Road). This was objected to by the Ministry of Works Town and Country Planning Division because in terms of the Town and Country Planning Act, the very stony Ranzau soils (Class A, TDC Classification system, Class 3s1 LUC system) were rightly judged to be of high, actual or potential value for food production as shown by the wide range of horticultural and market garden crops that are grown.

47. After a hearing before the Town and Country Planning Appeal Board at which technical evidence was presented, approval was given in July 1976 for gravel extraction and soil restoration to proceed on an experimental basis. The method of extraction was prescribed to minimise the destruction of the soils physical properties. *(Land Reclamation after Gravel Extraction on Ranzau Soils, Nelson, New Zealand. D J McQueen; New Zealand Soil Bureau scientific report 58. Department of Scientific and Industrial Research Wellington, New Zealand 1983).*

48. Narrow strips of land were to be worked from the upper surface to minimise compaction. The topsoil (A horizon) and the subsoil (B Horizons) were to be separately removed followed by the underlying gravel, with the subsoil then being replaced on top of the new surface by the excavator, working from the surface above. All this was to take place without the use of wheeled machinery. Following levelling of the mounds of replaced subsoil, the stockpiled A horizon topsoil was replaced.

49. No foreign soil materials were allowed as backfilling at this site.

50. The consent ordered that agricultural trials be carried out to assess the productive capacity of the replaced soil as against the original undisturbed soil and the consent conditions were strictly adhered to.

51. Extensive scientific investigation of soil properties of both the original soil and the replaced soil were also undertaken. The agricultural trials (carried out by MAF) showed a marked loss in soil productivity as assessed through various crops, while physical impairment of various soil properties was also recorded, including soil drainage impedance.

52. This exercise provided probably the best conditions for gravel extraction and soil restoration likely to be found anywhere on alluvial soils. The Ranzau soil is older than other alluvial soils on the Waimea Plain, has more stable topsoil structure, has a high topsoil stone content (commonly in excess of 30%) a very stony subsoil that should render it less prone to compaction, and has a deep subsoil. The combined topsoil (A horizon) and subsoil (B horizons) weathering depth are around 1.2 m. This meant that the replaced soil (about 1.2 m in total) provided a good medium for deeper rooting plant requirements.

53. Changes in certain soil physical conditions including soil structure breakdown, could not however be avoided.

54. The scientific report on the operation *(D.J McQueen, 1983. NZ Soil Bureau Scientific Report 58.)* suggested that a deterioration in the soil physical properties may have resulted from movement of soil materials when soil moisture levels were above the optimum desirable level. This conclusion however is regarded as equivocal for the following reasons:

    54.1 Subsoil materials (gravelly textured) were not stockpiled and were only placed in low mounds that were simply levelled in one operation, hence the amount of compaction from tracked machinery was minimal.

    54.2 No measurements of the soil moisture levels were taken at the time of re-spreading and have only been inferred from rainfall/evaporation record assessments. The soil materials were <u>not</u> handled under wet conditions.

54.3 Given the methods being employed (low ground pressure tracked machinery), it is unlikely that compaction would have occurred everywhere, yet ponding, indicative of impeded drainage was and is still present at various times.

54.4 The major sampling for the soil physical properties took place on September 27th which was after the field trial had been sown, so it might also be concluded that deterioration observed in soil properties was cumulative, as a result of the disturbance from removal and replacement, as well as the cultivation required for seed bed preparation and sewing.

55. So, under the best possible methods used for the gravel extraction and soil replacement, soil physical impairment, drainage impairment and productivity loss in these stony soils still occurred.

56. I have examined soils on numerous other gravel extraction sites that cover more than 100 ha on the Waimea Plains and at none of the earlier sites has the land been restored to its original intensive high potential productive status.

Case study 2

57. Gravel extraction began at Staplegrove Farm, Waimea West in the 1980's but the extraction and restoration process was not subject to the same level of scrutiny as the Ranzau soils exercise. A consent order granted following a hearing in February 1992 covered issues related to the expectation of an acceptable level of soil remediation following gravel extraction, notably, working methods, drainage and ground levels as summarised below.55. *Working Methods*

(a) Operation progress to be a strip by strip fashion.

(b) Topsoil and subsoil to be stripped and stored separately with stockpiles not more than 600 mm high

(c) No topsoil or subsoil to be removed if above 25% moisture content.

(d) No vehicle movement on top of topsoil or subsoil before stripping or while being stockpiled.

(e) The surface of the ground level after stripping to be contoured and ripped to ensure adequate subsurface drainage.

(f) A minimum thickness of 500 mm of replaced topsoil and subsoil over subsurface material and no compaction of topsoil or subsoil which would prevent adequate soil drainage.

(g) Topsoil and subsoil introduced into the extraction area to be compatible with existing materials and no toxic or foreign materials to be introduced.

(h) The land to be returned to at least an equivalent land capability that existed prior to disturbance.

(i) Appropriate drainage to be installed.

(j) A finished land surface with fall to take surface water to drainage channels.

(k) The level of the excavated ground to be not less than 0.3m above the normal winter water table.

(l) Wells be installed to determine the normal winter water table.

(m) Additional clauses required that gravel extracted be only used for high quality aggregate products.

AN INVESTIGATION OF SOIL RESTORATION AT STAPLEGROVE FARM

58. Prompted by complaints from members of the public about inappropriate proceedings at the extraction site, Tasman District Council ordered the operator to obtain a soil report for the Staplegrove gravel extraction site *(Client Report: Report on Soil Restoration at Staplegrove Farm Gravel Extraction site, Waimea West, May 2017. I Campbell).* I attach a copy of this report to my evidence statement.

59. From the examination requested by the contractor, ten very large (10 m length) randomly chosen pits were excavated to 2 m depth on land that was restored over several years prior to the latest phase of gravel extraction and the soils were described and sampled. In addition, observations and samplings were made at the current gravel extraction and backfill site. Observations of gravel extraction and backfilling operations had also been made in earlier years while undertaking detailed soil survey work on the Waimea Plain.

60. The soil examinations revealed:

    60.1 The subsoil heavier-textured backfill material was severely compacted in each examination pit, but with no evidence that this was due to replacement under wet conditions. The backfill materials were not compatible with the existing alluvial materials.

    60.2 Soil drainage was poor with reducing conditions (blue colours in the report) present in dense subsoil in many places;

    60.3 Extensive surface ponding of water occurred after some rainfalls;

    60.4 The replaced ‘topsoil’ thickness was not consistent, sometimes being very shallow and had a very high permeability. A recognisable A horizon (true topsoil) was virtually non-existent.

    60.5 There was a considerable variety of foreign materials present in the backfill including treated timber, metals, plastics, concrete slabs, bricks, ash, and asphalt materials;

    60.6 Similar materials were being dumped in the current excavation site;

    60.7 Trucks driving over the backfill (early March, dry conditions) to unload more backfill were unavoidably compacting the fill materials;

60.8 Stock-piled surface soil materials were not separated into the soil A horizon (true topsoil) and subsurface soil horizons (B horizons) and were mixed;

60.9 Stock-piled material was stored in large mounds more than 3 m high and trucks had driven up and over the weakly structured soil material to form these mounds;

60.10 Excavation at the current site was taking place within the water table zone;

60.11 Chemical analyses of samples showed elevated levels of some heavy metals including cadmium, chromium and arsenic, many times above baseline levels in undisturbed soils.

60.12 Polyaromatic hydrocarbons were also found, probably a product of the asphaltic materials that were present.

60.13 It was clear that Resource Consent Condition Clauses had not been adhered to from the time that the resource consent for gravel extraction was granted.

60.14 The gravel extraction and backfill replacement method used at Staplegrove Farm was fairly similar to that proposed for Peach Island with a relatively small pit area exposed and back filling taking place at the same time, however the pit depth was not as great as that expected at Peach Island.

THE PROBLEM

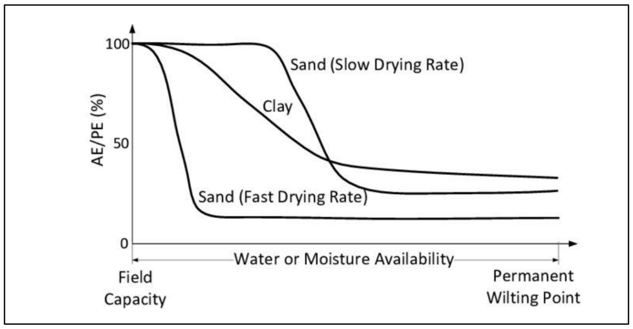
61. Most of the gravel extractions on the Waimea Plain have taken place on Wai-iti soils, which, like the Riwaka soils, are young soils with weakly developed soil profiles formed on the present flood plain or slightly older surfaces. Key features of these soils are:

61.1 A variable thickness (20 cm-100 cm+) of silty, sandy or sometimes gravelly textured soil over un-weathered coarser sandy gravel, sometimes stony at the surface;

61.2 Weakly developed soil structures because of their youthful age;

61.3 A close proximity to the groundwater table (3-5m) because of their low lying position.

62. There is an extensive world-wide scientific literature relating to the reinstatement of disturbed land and compaction is seen as a universal problem. Soil materials with clayey textures are especially vulnerable to compaction because it is very difficult to achieve a moisture content that is low enough to avoid compaction when the soil is compressed during backfilling. The figure below illustrates a drying curve for a clay textured soil, with less than 35% moisture content becoming difficult to achieve (a moisture content of 15% is acceptable for earth bricks made from clay).



(Source: Canadian Geotechnical Journal 1997 34: 144-155

63. The removal and replacement of the soils on low terrace surfaces can never be expected to be a successful operation in respect of maintaining their physical characteristics and primary production potential. The natural network of pores and fissures and soil structure within the soil material, which are essential for moisture movement, moisture storage, root penetration and biological and chemical processes are destroyed during the removal, stock-piling and replacement, irrespective of whether or not excessive compaction place.

64. Handling these weakly structured soils under dry conditions is more likely to lead to physical breakdown than when the soil is moist, as under dry conditions there is little

soil cohesion in these weakly structured soils, and more especially when the soils have sandy textures.

65. The destruction of pore spaces and soil structural aggregates inevitably leads to changes in the soil density, infiltration rates and moisture holding capacity, regardless of the soil moisture state at the time of disturbance.

66. In addition, soil biological processes and macro fauna populations which are essential for soil nutrient relationships are curtailed. The micro-pores present in undisturbed soil allow plant root hairs to grow into the network of pore spaces where the microbiological interactions associated with plant moisture extraction and nutrient uptake take place. This highly complex system is largely destroyed during soil removal and replacement when pore space, soil structure and soil moisture holding capacity are disrupted.

67. Also destroyed are the natural progressive chemical and physical changes that occur through the soil profile with increasing depth. These physical and chemical gradients are important for plant root adaptation and soil moisture movement within the soil profile and constitute one reason why some plants perform better on different soils.

68. The substitution of foreign subsurface materials with inferior qualities at close proximity to the surface inevitably creates a soil chemical and physical hiatus within the soil profile.

69. The back fill materials at Peach Island will come from a variety of sources (i.e. clay and quarry rubble, slip debris, excavations) differing soil types and various rock types. Across the reclaimed area they will not be consistent in their physical properties or conducive for consistency in deeper rooting crop production.

70. The introduction of foreign earth material at Staplegrove Farm occurred at the commencement of gravel extraction, but the justification for this has never been subject to any objective questioning or rigorous scientific examination. Inevitably, replacement

material will have heavier textures than the gravels that they are replacing as these are the materials that contractors want to dispose of.

71. The substitution of inferior heavier textured earth material into the subsurface at Peach Island is likely to lead to impeded downward water movement and soil drainage restriction within the soil profile, as was clearly evident at Staplegrove Farm where widespread surface water ponding occurred and blue colours (in the attached report), indicative of reducing conditions were present. The juxtaposition of the re-spread soil with many macropores over heavier textured fill materials with fewer macropores constitutes a barrier to water movement. What is a well-drained subsurface material at Peach Island would be replaced with a non-uniform medium that would be less well drained owing to the presence of heavier textured, and structure-less subsurface materials.

72. At Staplegrove farm, the absence of soil structure in the respreads soils was evident, while soil drainage, soil permeability, workability and waterlogging were soil properties that were all adversely affected. The lack of uniformity in thickness of the replaced soil horizons was not unexpected as attempting to re-spread various soil layers to a uniform thickness with heavy machinery is at best a difficult operation.

73. One of the most common causes of soil drainage impedance within a soil profile is the presence of a textural unconformity, as even a very thin textural contrast layer in gravelly subsoil soil material can cause drainage (and root penetration) to be impeded because of the adhesive properties of water. Periodic inundation of a pit at the proposed Peach Island gravel extraction site can be expected to leave a fine silt layer over the whole surface that will later act as an additional barrier to the downward movement of soil profile water.

74. Introduced foreign subsoil materials at Peach Island are also likely to be a problem for the management of deeper rooting horticultural crops. Significant variation over small distances in the texture, soil density, hydraulic conductivity, plant available water and

soil nutrient levels of the subsoil material can be expected as it is unlikely that the physical or chemical properties of the backfill material in each extraction area will be the same. This is likely to result in making crop management for consistent yield over an area difficult due to a lack of uniformity in the soil profiles.

75. It is indicated that the extraction areas at Peach Island would vary between 3 and >4 metres deep. Assuming that the backfill materials were able to be replaced without compaction as envisaged, there would be natural settlement within the loose soil materials when they later became saturated with fluctuating groundwater, which will rise to 1.2m from the soil surface. The amount of settlement that would follow will differ across the restored ground surface depending on the thickness and nature of the backfill. It would be expected that over time, the finished ground surface would develop uneven hollowing due to the differential subsurface settlement which would be exacerbated by the periodic saturations by the ongoing fluctuating watertable changes.

76. Dr Hill says that there will be reduced productivity in the short term (0-3 years) only, and then the site will be fully remediated after that, and probably better than before.

77. I do not agree with this statement for the reasons I have discussed above drawing on my experience on similar extraction projects over many years. Soil materials such as those at Peach Island are vulnerable to compaction, and their removal and replacement, backfilling with foreign materials is likely to lead to physical breakdown, loss of productivity characteristics and potential and destruction of the natural network or pores, fissures and soil structure which are essential for moisture movement, moisture storage, root penetration and biological and chemical processes.

78. This in turn curtails macro fauna populations which are essential for soil nutrient relationships. Highly complex soil biological and chemical processes which are important for plant root adaptation and soil moisture movement will be destroyed during the extraction and replacement operations proposed in this application. The substitution of foreign subsurface materials with inferior qualities at close proximity to

the surface will inevitably create a soil chemical and physical hiatus within the soil profile and lead to impeded downward water movement and soil drainage restriction as evident at Staplegrove Farm.

79. The well-drained subsurface material at Peach Island should not be replaced with a non-uniform, drainage impeded medium. This will cause significant effects on deeper rooting horticultural crops in particular.

PROPOSED EXTRACTION IN STAGE 1

80. The soils outside the stopbank will differ from those inside depending on the flooding history. Typically frequently flooded soils are downgraded for potential productive use because of flooding, but this does not preclude their use for very productive purposes. They can be used for market gardens growing root crops but not tree crops etc, so their versatility is lower. Lettuces are one of the most profitable crops to grow. It is just that the grower has to accept the risk of intermittent wipe out. This can be acceptable if the capital investment is low (ie no land cost as it is leased from the local authority at a reasonable rate and no infrastructure, apart from irrigation). There are many delta areas throughout the world which are flooded annually but still used intensively and annually. It is just that we are not accustomed to doing this in NZ. I do not think that factors such as an inherent seasonally high watertable, flood risk and variable or shallow soil depth necessarily preclude the land from being used for productive purposes.

MANAGEMENT OF EARTH RESOURCES AND THE NEED FOR AGGREGATE MATERIALS

81. A frequently advanced reason for continuing a gravel extraction operation in a local area, as opposed to going to some other source of less agricultural significance is the cost. This argument was raised at the 1975 hearing related to the Ranzau soils but was promptly dismissed by Judge Treadwell, who pointed out that in other parts of the country, as is the case for much of the North Island where no alluvial gravels are present, aggregate had to be transported large distances and or acquired from hard rock quarries.

82. Alternative sites for gravel mining exist, for example, in the upper reaches of the Motueka River, between Motupiko and Golden Downs. Here, the valley system is narrow, often heavily frosted in winter and the soils are Tapawera soils (Chittenden, Dodson & Hodgson Soil Bureau Bulletin 30, 1966) which are included in Class C of the Tasman District Council land Classification system and classes 4s3, 5s4 and 6s4 of the LUC system.

83. Cost cannot be a compelling reason in deciding for a less environmentally suitable activity or course of action, since this inevitably leads to a continuation of the multiple and compounding ongoing environmental problems being experienced throughout the world today. The National Policy Statement on Highly Productive Land aims to stop the fragmentation of productive land and protect it for use in land-based primary production.

84. Maintaining an ongoing supply of aggregate materials for the district would be better served if the Tasman District Council undertook a survey to find suitable sites for rock quarries within the Motueka area. This survey should also include finding suitable sites for the disposal of excavated hard fill materials, so that the convenient but unsuitable practice of dumping hard fill waste beneath replaced high value terrace and floodplain soils is not continued.

85. Hardfill materials should be considered as a resource, because with rising sea levels and a necessity in future to raise the heights of roads and stop banks, large quantities of fill materials will be required.

86. In his evidence statement Mr Corrie-Johnston says that river aggregate is essential for high end concrete products and sealing chip. I am aware that Hhrd rock quarries at Dunedin, Wellington, Tauranga and Auckland produce a range of aggregates which are used for concrete products and sealing chip with the rock types having a higher rating than some rock types in the Motueka River.

87. Sealing chip for a large part of the Nelson area comes from the Marsden Valley quarry at Stoke where the rock is Mesozoic sandstone with a high class weight rating. The Mapua bypass road which was constructed several years ago used Marsden Valley chip for the sealing with a transport distance of up to 25 km.

88. On their website, CJ Industries state they charge over $48 per ton for builders' aggregate. Horikiwi Quarries (hard rock) at Wellington charge $42.50/ton for builders' aggregate. Hard rock quarries at several other locations also charge around $48/ton. I note that gravel requires less processing compared with hard rock materials which need to be blasted out and crushed.

____

Iain Campbell

APPENDIX

Figure 1. The unpublished original soil map of part of the Motueka Plain area is a compilation from the field work that was undertaken by the Cawthron Institute in the 1950's.

The published map (Chittenden, Dodson & Hodgson Soil Bureau Bulletin 30, 1966) that shows the Riwaka soils on the Motueka Plain was derived from this early compilation sheet.

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REPORT ON SOIL RESTORATION AT STAPLEGROVE FARM

GRAVEL EXTRACTION SITE, WAIMEA WEST, NELSON

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June 2017

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Original filename as received - "11 Nov 22 Attachment to Evidence of Iain Campbell on behalf of Valley Rage (Productive Soils) Staplegrove Farm Report.pdf"

CONTENTS

REPORT ON SOIL RESTORATION AT STAPLEGROVE FARM GRAVEL EXTRACTION SITE, WAIMEA WEST, NELSON

Dr Iain Campbell
Land & Soil Consultancy Services
Nelson

INTRODUCTION

Staplegrove Farm in the Waimea West district Nelson, has been a site for gravel extraction since the 1980's. At the time of examination, gravel was being extracted to a depth of approximately 4m below the existing ground surface (Figure 14) with a thickness of about 3.5m of earth materials back filled. At a request from *Downer* (e-mail 27/2/2017), an examination of the soils and soil materials was undertaken for the purpose of preparing a report to ascertain if conditions of the Resource Consent issued by The Planning Tribunal Hearing 10/2/1992 were being fulfilled. The examination focussed on the conditions of the resource consent given as per the brief below. Other conditions of the Resource Consent are not addressed in this report.

- *a) Fill used in areas previously restored contains no materials prohibited by the consent including toxic substances, concrete or other demolition-type materials;*
- *b) That materials within the clean fill will not have significant adverse effect on the short term and long term productive capacity of the land;*
- *c) That measures in respect of drainage as required in condition 18 are being complied with;*
- *d) That there is adequate drainage through the restored ground including fill material which has replaced the extracted gravel;*
- *e) That the subsoil and topsoil that has been restored is of a nature that does not have a detrimental effect on the productive potential of the land.*

Site visits were made on seven occasions, (15/3; 17/3; 24/4 and 14/4) for familiarisation and site observations and three (21/3; 22/3 2/4) for detailed examinations and soil material sampling. The examinations were restricted to the area that had been most recently restored and to the present fill site.

EXAMINATION PROCEEDURE

Ground that had been restored after earlier gravel extractions between 2008 and 2013 was examined at 10 randomly chosen sites (Figure 1 sites 1-10), with pit excavations which were 12m long and 2.5m in depth being exposed to assess the nature of the restoration materials. When carrying out the excavations, the soil between depths of 0-50cm, between 0.5-1m and from 1-2.5m from the ground surface was sequentially removed, kept separate, then backfilled in the same order to avoid undue mixing of the materials and to ensure that reinstatement conformed as far as possible with the existing conditions. At each pit (sites 1-10) a sample of the subsurface materials (12 samples) and restored soil from 2 sites (2 samples) were collected for chemical analyses.

Additional samples (11 samples from site 11) were collected from the adjacent partly restored area (figures 15-23) and where waste materials at the time of inspections were being deposited. The earth materials in this area were examined because when the restoration is completed, the soil conditions will be analogous to those observed from former replacement and restoration area.

The samples that were collected for analysis represent a limited range of the differing earth materials that were observed in order to determine whether contaminants might be present due to the presence of foreign materials. In the pits, for example where multiple layers of earth fill material were observed, a single sample only was collected.

Undisturbed subsoil, seen in cutting exposures on the western boundary of the present gravel extraction area (Figure 1 site 12) was examined and sampled (1 sample) to provide a benchmark for comparison with all of the samples taken from the excavation pits and the site where fill materials were currently being deposited.

A total of 26 samples was collected for analyses, 7 in glass containers because of the presence of bitumen-like substances and the remainder in plastic bags. The samples were forwarded to R J Hill Laboratories for a range of chemical analyses.

Figure 1 location of sample sites

PHYSICAL DESCRIPTION OF RESTORATION MATERIALS

A) Pits

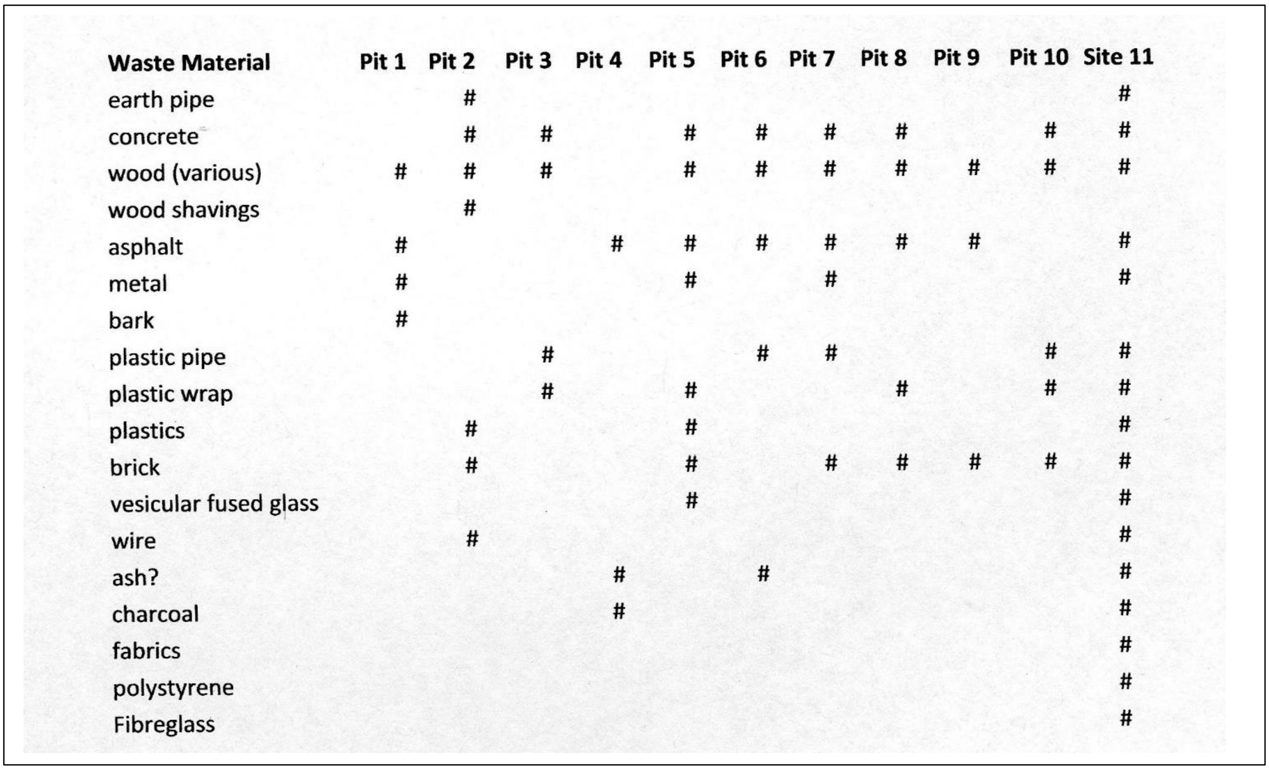
Each of the pits had a surface layer of replaced soil which was without any soil structure, was predominantly light olive brown coloured (2.5Y 5/4) and which varied in thickness from 20 to 70cm but with an average thickness of 39cm. This surface layer lacked an identifiable A horizon (topsoil*) and the stone content was in excess of 35% (gravimetric) and within the *very stony class* of soils. In deeper parts of the surface layer (e.g. Pits 6, 8), the replaced material is very dense and compacted. The upper 20cm of the surface layer is fragmented due to recent tillage. No foreign materials were observed within the surface layer of original soil. Permeability was measured at >300mm per hour (very rapid) and the soil was noted to be saturated after rainfalls, with extensive surface water ponding 2 days after rainfall (Figure 14). There is no overburden present and the transition from replaced soil to underlying fill is abrupt.

The subsurface material in all of the pits consisted of imported earth matter (waste fill) with no clearly identifiable origin. The predominant colour is dark grey (10YR 4/1), suggestive of a high organic matter content (although there is little resemblance to what might have been former topsoil). There is a general absence of brown earthy materials or what might be described as *'common oxidised subsurface soil.'* The texture of the subsurface material is predominantly clayey-silty, with a variable stone content, while its appearance is mostly massive, compacted and layered to varying degrees. In all of the pits, foreign debris was present (Table 1) including, concrete, wood remnants (posts and other) plastic pieces, brick, metals, plastic and metal pipe and asphalt like substances. In several of the pits, the upper layer of the waste fill had a grey or bluish grey colour. This and the overall grey colour of the subsurface materials is suggestive of strong reducing conditions. This may be due to the absence of aeration and restricted movement of water due to compaction during the placement and movement of the fill materials. Groundwater fluctuation within this subsurface zone may also be contributing to anoxic conditions within this earth material. Table 1 below summarizes the range of foreign materials found in the ten pits and the latest backfill area.

***In soil science, earth science, or in an agricultural sense, the correct definition of a soil is as follows: A horizon (topsoil) B horizon (subsoil) and C horizon (parent material, regolith or overburden). In general usage, 'soil' has no specific meaning other than unspecified earth material and is ambiguous.**

Table 1

Foreign materials identified within earth fill materials



Waste Material	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6	Pit 7	Pit 8	Pit 9	Pit 10	Site 11
earth pipe		#									#
concrete		#	#		#	#	#	#		#	#
wood (various)	#	#	#		#	#	#	#	#	#	#
wood shavings		#									
asphalt	#			#	#	#	#	#	#		#
metal	#				#		#				#
bark	#										
plastic pipe			#			#	#			#	#
plastic wrap			#		#			#		#	#
plastics		#			#						#
brick		#			#		#	#	#	#	#
vesicular fused glass					#						#
wire		#									#
ash?				#		#					#
charcoal				#							#
fabrics											#
polystyrene											#
Fibreglass											#

b) Current waste materials site

The area in which earth materials were being dumped at the time of the inspection was examined since this is the fill for the current phase of gravel extraction and the base for the soil when restoration is completed. The nature of the materials being disposed of is shown in Figures 14-20 and some of the materials that were noted are given in Table 1.

Following are observations with respect to the current waste fill area:

1) There are a wide variety of earth materials being disposed of, much with no clear origin. A typical excavation for a Nelson house site or subdivision would produce clean overburden, usually brown in colour, but there appears to be little of this type of earth matter present. Some very light coloured material appears to be ‘chalky.’ Some of the very dark or black material may be ‘ashy’ as charcoal was noted to be present and burning was observed to be taking place at the Downer site in Bartlett Road. The texture of the materials range from clay to gravelly. Dark coloured material does not resemble normal topsoil. Because of the diversity of earth materials, available plant nutrients will be variable but probably mostly low.
2) Foreign substances are widespread and of a similar nature to those seen in the pit sites. The presence of some fused, vesicular glassy material suggests an origin from a high temperature process and some baked earth material and charred wood is indicative of burning processes. The presence of asphalt (figures 1A, 19) suggests an origin from road materials.
3) The process of distributing and spreading the dumped materials is causing severe compaction (Figures 24).
4) Foreign objects present in the dumped materials are not being removed but buried with the spreading process (figures 20, 21).
5) Water ponding points to poor drainage within the fill materials, probably resulting from compaction and the introduction of clayey textured materials (Figures 22).

THE UNDISTURBED ORIGINAL SOIL

The undisturbed or original soil (Wai-iti family) as exposed in sections on the western edge of the site (site 12 Figure 12) has a shallow to moderately deep soil profile (between 45-100cm thick) overlying unconsolidated gravel. The topsoil*****(A horizon) has a dark yellowish brown colour, it averages about 20cm thick and it has well-developed soil structure. The subsoil***** (B horizon) colour is yellowish brown to olive brown and the soil structure is weakly developed. The subsoil passes into unconsolidated gravel (C horizon/overburden*****) that is sometimes weakly oxidised with reddish iron oxide staining due to water table movement within the gravel. Wai-iti soils (formerly Waimea soils on the Waimea Plains) were included in Class 1 of the Tasman District Council Classification System for Productive Land. In recent surveys of the soils of the Waimea Plains, they are classed as of moderate to high versatility, with slight limitations for intensive use. Wai-iti soils have a medium to high plant available water, have moderate permeability, have a deep to moderately deep effective rooting depth, have good drainage and are capable of cultivation throughout the year. These are essential elements for a potentially high producing soil.

RESULTS OF CHEMICAL ANALYSES

The heavy metals and polycyclic aromatic hydrocarbon analysis were chosen because of the observable presence of foreign substances likely to be producing contaminants related to these materials. The possible presence of other contaminants such as agrochemicals was not investigated.

The chemical analyses (Appendix 1 and Appendix 2) indicate the presence of contaminants including heavy metals, some at concentrations appreciably above background values, and also the presence of polycyclic aromatic hydrocarbons. These are associated with the foreign materials that have been brought in with the earth fill. (See Appendix 2 Report on contaminants).

SUMMARY OF ATTRIBUTES RELATED TO RESOURCE CONSENT ISSUES

a) Fill

1) The fill materials include a wide range of foreign substances at various concentrations and cannot be described as clean fill.
2) A range of contaminants are present in the form of heavy metals and petroleum products at values sometimes appreciably above ‘background’ levels measured in the original soil materials. (Appendix 1, & 2).

b) Effect of fill on productivity capacity

The deposited fill materials are detrimental to the short and long term productive capacity of the land.

1) They are of a contrasting textural nature to the upper layer of replaced original soil material. Textural contrasts within a soil profile are inhibiting to plant rooting and downward soil moisture movement.
2) The bluish grey subsurface colours indicate lack of aeration and is a sign of impeded water movement and possible waterlogging, which is restrictive for deep rooting. This may be due to impeded downward movement of water, or to the influence of groundwater when the water table is higher or both.
3) The compaction and consequent increase in soil density provides poor physical conditions for root penetration, soil moisture storage and soil drainage and has lowered the soil production potential.
4) There is a high degree of spatial variability in physical conditions of the subsurface earth material, due to the diversity of dump material and also unevenness of the spreading process (i.e. compaction, earth materials are not uniform). The fertility of the subsurface materials is also likely to be highly variable. This would make intensive crop management difficult, (i.e. irrigation, fertiliser management and nutrient loss, crop yield consistency) due to unpredictable soil variability.
5) What was a well-drained soil has now been replaced with earth material that has inferior physical and drainage properties and which impact on land management and potential crop use.

c & d) Drainage

1) As shown in Figures 13 and 21, there is significant surface and subsurface drainage impairment resulting from compaction and possibly also insufficient land surface gradient.
2) The summer groundwater table at the gravel extraction site (17/3/2017, 14/4/2017 Figures 14, 15) is at a level that will advance into the deposited fill material when the water table rises and will impede subsurface soil drainage.

e) Productive potential

1) The potential productive capacity of the restored soil at Staplegrove Farm, as evaluated by the soil criteria listed in Table 2 below, is assessed as being significantly diminished. The absence of an A horizon (topsoil), shallow and variable thickness of replaced original soil material, absence of soil structure and dense nature of subsurface materials have resulted in diminished water holding capacity, diminished effective soil rooting depth and reduced soil permeability. Properties of the deeper subsurface materials, including heavier soil textures and compaction have restricted the soil profile drainage. Together, all of the above, including an increased degree of soil variability, impose significant limitations for intensive use soil and crop management.

Table 2. Summary of key soil properties in Wai-iti soils and the Replaced Anthropic soils

Soil properties	**Undisturbed-Wai-iti**	**Replaced-Anthropic**
Profile drainage	well drained	imperfect
Profile available water	medium-very high	low
Permeability	moderate	rapid-slow
Trafficability	slight limitations	restricted
Workability	unrestricted	restricted
Waterlogging	negligible	severe
Aeration	unrestricted	restricted
Effective rooting depth	moderately deep-very deep	shallow
Soil horizon definition	distinct	nil
A horizon	distinct	nil
Horizon contrasts	transitional	abrupt
Pan	nil	compaction
Soil structure	moderate	nil/massive
Stoniness	non-very stony	very stony
Clay content	low	medium
Plant nutrients	moderate	low
Soil versatility class	high to moderate	low
Land class suitability (TDC)	A	D

CONCLUDING COMMENTS

a) Fill materials

As noted above, a variety of earth materials are used for back filling and include some foreign materials. It would be difficult to quantify the amount of foreign substances that are present but a guess would be somewhere within the range of 1-5% in some loads. Because of the variety of earth materials imported, not all dump loads contain foreign substances, some being free or with little foreign matter while other loads have higher amounts (for example where asphalt is present). This results in uneven distribution of foreign matter throughout the work site. The variation no doubt reflects the various sources from which the earth materials are derived. Since foreign materials are the likely source of the soil contaminants found in the chemical analyses, the inclusion of such material in the back fill should be avoided.

Removal of foreign materials that are within the already restored Staplegrove land area is probably impractical. It is suggested however, that consideration be given to screening the backfill materials before being brought to the site, in order to avoid this problem.

b) Soil contaminants

The results of the chemical analyses and the appended reports by Dr D Sheppard noted the presence of some contaminating substances. However, a number of the fill material samples that were analysed showed no evidence of the presence of contaminants above what is present in the undisturbed or original soil materials. Samples that did show elevated contaminant were related to the presence of foreign materials and are localised rather than being disseminated throughout the whole site.

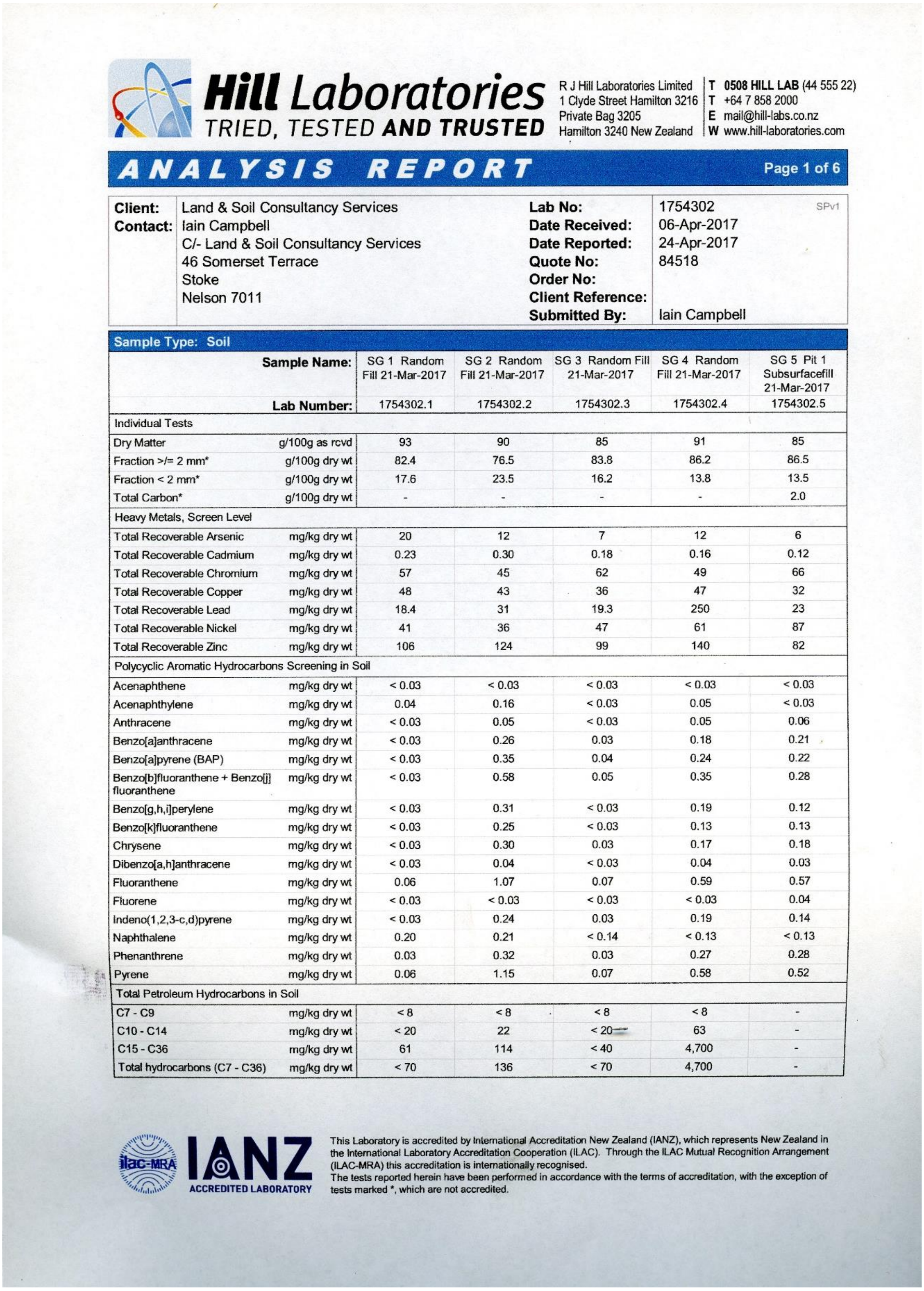
c) Drainage

The impeded drainage conditions in the restored land is attributable to compaction of earth materials during the process of backfilling and returning the original soil onto the new land surface, while the introduction of heavier textured, less freely draining earth materials that now form the soil subsurface is a contributory factor. Avoidance of compaction during soil stripping, gravel extraction and land restoration is essential to minimise soil drainage problems. For the most part, this can be achieved by using a strip-extraction method rather than an open cast technique. Deep ripping within the restored land area should be considered as a way of lessening the present drainage impediment.

d) Land productivity

Wai-iti soils, because of their intrinsic properties related to their youthful age, present great difficulty in retaining their productive capacity throughout any process of removal then replacement. Key attributes including soil structural integrity, soil hydrological characteristics, soil biological signature and soil rooting depth are inevitably compromised. Avoidance of soil compaction, restoring separate soil horizons and maintaining a minimum thickness of 75cm above underlying fill would go some way towards minimising potential productivity loss.

APPENDIX 1. RESULTS OF LABORATORY ANALYSES



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ANALYSIS REPORT

Page 1 of 6

SPv1

Client:	Land & Soil Consultancy Services	**Lab No:**	1754302
Contact:	Iain Campbell C/- Land & Soil Consultancy Services 46 Somerset Terrace Stoke Nelson 7011	**Date Received:**	06-Apr-2017
		Date Reported:	24-Apr-2017
		Quote No:	84518
		Order No:	
		Client Reference:	
		Submitted By:	Iain Campbell

Sample Type: Soil

Sample Name:		SG 1 Random Fill 21-Mar-2017	SG 2 Random Fill 21-Mar-2017	SG 3 Random Fill 21-Mar-2017	SG 4 Random Fill 21-Mar-2017	SG 5 Pit 1 Subsurfacefill 21-Mar-2017
Lab Number:		1754302.1	1754302.2	1754302.3	1754302.4	1754302.5
Individual Tests						
Dry Matter	g/100g as rcvd	93	90	85	91	85
Fraction >/= 2 mm*	g/100g dry wt	82.4	76.5	83.8	86.2	86.5
Fraction < 2 mm*	g/100g dry wt	17.6	23.5	16.2	13.8	13.5
Total Carbon*	g/100g dry wt	-	-	-	-	2.0
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	20	12	7	12	6
Total Recoverable Cadmium	mg/kg dry wt	0.23	0.30	0.18	0.16	0.12
Total Recoverable Chromium	mg/kg dry wt	57	45	62	49	66
Total Recoverable Copper	mg/kg dry wt	48	43	36	47	32
Total Recoverable Lead	mg/kg dry wt	18.4	31	19.3	250	23
Total Recoverable Nickel	mg/kg dry wt	41	36	47	61	87
Total Recoverable Zinc	mg/kg dry wt	106	124	99	140	82
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Acenaphthylene	mg/kg dry wt	0.04	0.16	< 0.03	0.05	< 0.03
Anthracene	mg/kg dry wt	< 0.03	0.05	< 0.03	0.05	0.06
Benzo[a]anthracene	mg/kg dry wt	< 0.03	0.26	0.03	0.18	0.21
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.03	0.35	0.04	0.24	0.22
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.03	0.58	0.05	0.35	0.28
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.03	0.31	< 0.03	0.19	0.12
Benzo[k]fluoranthene	mg/kg dry wt	< 0.03	0.25	< 0.03	0.13	0.13
Chrysene	mg/kg dry wt	< 0.03	0.30	0.03	0.17	0.18
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.03	0.04	< 0.03	0.04	0.03
Fluoranthene	mg/kg dry wt	0.06	1.07	0.07	0.59	0.57
Fluorene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	< 0.03	0.04
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.03	0.24	0.03	0.19	0.14
Naphthalene	mg/kg dry wt	0.20	0.21	< 0.14	< 0.13	< 0.13
Phenanthrene	mg/kg dry wt	0.03	0.32	0.03	0.27	0.28
Pyrene	mg/kg dry wt	0.06	1.15	0.07	0.58	0.52
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 8	< 8	< 8	< 8	-
C10 - C14	mg/kg dry wt	< 20	22	< 20	63	-
C15 - C36	mg/kg dry wt	61	114	< 40	4,700	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	< 70	136	< 70	4,700	-

ilac-MRA IANZ ACCREDITED LABORATORY

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The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Soil

Sample Name: Lab Number:		SG 6 Pit 2 Subsurfacefill 21-Mar-2017 1754302.6	SG 7 Pit 2 Topsoil 0-35cm 21-Mar-2017 1754302.7	SG 8 Pit 3 Subsurfacefill 21-Mar-2017 1754302.8	SG 9 Pit 4 Subsurfacefill 21-Mar-2017 1754302.9	SG 10 Pit 5 Subsurfacefill 21-Mar-2017 1754302.10
Individual Tests						
Fraction >/= 2 mm*	g/100g dry wt	81.1	87.3	94.2	87.8	86.9
Fraction < 2 mm*	g/100g dry wt	18.9	12.7	5.8	12.2	13.1
Total Carbon*	g/100g dry wt	3.6	0.92	4.1	2.6	3.2
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	4	5	7	5	18
Total Recoverable Cadmium	mg/kg dry wt	0.12	0.10	0.30	0.12	0.20
Total Recoverable Chromium	mg/kg dry wt	76	63	71	93	113
Total Recoverable Copper	mg/kg dry wt	28	24	39	37	58
Total Recoverable Lead	mg/kg dry wt	10.6	9.2	42	19.7	25
Total Recoverable Nickel	mg/kg dry wt	113	81	92	125	86
Total Recoverable Zinc	mg/kg dry wt	68	55	111	80	125

Sample Name: Lab Number:		SG 11 Pit 6 Subsurfacefill 22-Mar-2017 1754302.11	SG 12 Pit 7 Subsurfacefill 22-Mar-2017 1754302.12	SG 13 Pit 8 Subsurfacefill 22-Mar-2017 1754302.13	SG 14 Pit 8 Topsoil 0-35cm 22-Mar-2017 1754302.14	SG 15 Pit 9 Subsurfacefill 22-Mar-2017 1754302.15
Individual Tests						
Dry Matter	g/100g as rcvd	84	78	82	-	84
Fraction >/= 2 mm*	g/100g dry wt	83.8	80.9	93.4	81.4	95.0
Fraction < 2 mm*	g/100g dry wt	16.2	19.1	6.6	18.6	5.0
Total Carbon*	g/100g dry wt	3.1	6.4	2.4	0.84	2.3
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	7	10	8	3	16
Total Recoverable Cadmium	mg/kg dry wt	0.23	0.25	0.16	< 0.10	0.16
Total Recoverable Chromium	mg/kg dry wt	40	41	220	63	45
Total Recoverable Copper	mg/kg dry wt	42	69	38	23	38
Total Recoverable Lead	mg/kg dry wt	22	31	25	9.1	26
Total Recoverable Nickel	mg/kg dry wt	46	37	187	87	53
Total Recoverable Zinc	mg/kg dry wt	130	114	90	56	96
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	-	< 0.03
Acenaphthylene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	-	< 0.03
Anthracene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	-	< 0.03
Benzo[a]anthracene	mg/kg dry wt	0.07	< 0.03	0.04	-	0.18
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.09	< 0.03	0.06	-	0.20
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.11	< 0.03	0.08	-	0.23
Benzo[g,h,i]perylene	mg/kg dry wt	0.06	< 0.03	0.04	-	0.10
Benzo[k]fluoranthene	mg/kg dry wt	0.05	< 0.03	0.04	-	0.08
Chrysene	mg/kg dry wt	0.07	< 0.03	0.05	-	0.16
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	-	< 0.03
Fluoranthene	mg/kg dry wt	0.17	0.06	0.13	-	0.36
Fluorene	mg/kg dry wt	< 0.03	< 0.03	< 0.03	-	< 0.03
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.07	< 0.03	0.05	-	0.12
Naphthalene	mg/kg dry wt	< 0.13	< 0.15	< 0.13	-	< 0.13
Phenanthrene	mg/kg dry wt	0.07	< 0.03	0.06	-	0.07
Pyrene	mg/kg dry wt	0.16	0.05	0.11	-	0.35

Sample Name: Lab Number:		SG 16 Pit 9 Subsurfacefill 22-Mar-2017 1754302.16	SG 17 Pit 10 Subsurfacefill 22-Mar-2017 1754302.17	SG 18 Pit 10 Subsurfacefill 22-Mar-2017 1754302.18	SG 19 Pit 11 Undisturbed Soil 0-50cm 22-Mar-2017 1754302.19	SG 20 Random Surfacefill 22-Mar-2017 1754302.20
Individual Tests						
Dry Matter	g/100g as rcvd	85	-	86	-	92
Fraction >/= 2 mm*	g/100g dry wt	88.4	90.5	88.3	70.0	87.3
Fraction < 2 mm*	g/100g dry wt	11.6	9.5	11.7	30.0	12.7

Sample Type: Soil

Sample Name:		SG 16 Pit 9 Subsurfacefill 22-Mar-2017	SG 17 Pit 10 Subsurfacefill 22-Mar-2017	SG 18 Pit 10 Subsurfacefill 22-Mar-2017	SG 19 Pit 11 Undisturbed Soil 0-50cm 22-Mar-2017	SG 20 Random Surfacefill 22-Mar-2017
Lab Number:		1754302.16	1754302.17	1754302.18	1754302.19	1754302.20
Individual Tests						
Total Carbon*	g/100g dry wt	2.6	2.2	4.1	0.95	6.1
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	17	7	6	3	48
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	0.13	0.13	< 0.10	0.31
Total Recoverable Chromium	mg/kg dry wt	53	41	44	47	66
Total Recoverable Copper	mg/kg dry wt	46	38	31	22	85
Total Recoverable Lead	mg/kg dry wt	24	18.0	34	10.2	65
Total Recoverable Nickel	mg/kg dry wt	59	50	45	59	43
Total Recoverable Zinc	mg/kg dry wt	114	79	91	55	220
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.03	-	< 0.03	-	< 0.03
Acenaphthylene	mg/kg dry wt	0.03	-	< 0.03	-	0.05
Anthracene	mg/kg dry wt	< 0.03	-	< 0.03	-	0.07
Benzo[a]anthracene	mg/kg dry wt	0.11	-	0.07	-	0.09
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.17	-	0.09	-	0.09
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.22	-	0.12	-	0.17
Benzo[g,h,i]perylene	mg/kg dry wt	0.12	-	0.05	-	0.05
Benzo[k]fluoranthene	mg/kg dry wt	0.08	-	0.05	-	0.05
Chrysene	mg/kg dry wt	0.11	-	0.07	-	0.09
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.03	-	< 0.03	-	< 0.03
Fluoranthene	mg/kg dry wt	0.29	-	0.17	-	0.34
Fluorene	mg/kg dry wt	< 0.03	-	< 0.03	-	0.09
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.12	-	0.06	-	0.08
Naphthalene	mg/kg dry wt	< 0.13	-	< 0.13	-	0.18
Phenanthrene	mg/kg dry wt	0.09	-	0.06	-	0.42
Pyrene	mg/kg dry wt	0.27	-	0.17	-	0.32

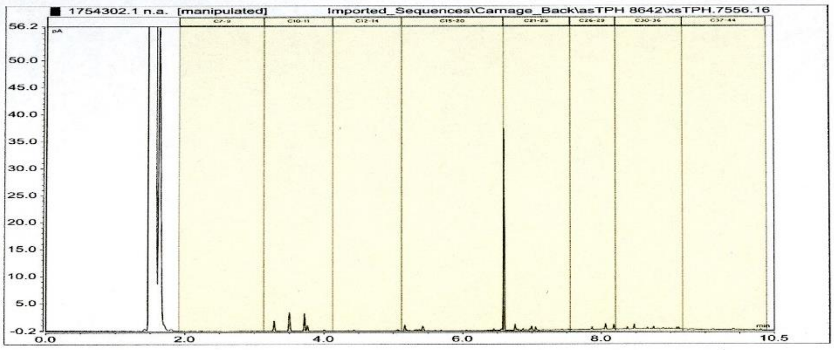
Sample Name:		SG 21 Random Fill 22-Mar-2017	SG 22 Random Fill 22-Mar-2017	SG 23 Random Fill 22-Mar-2017	SG 24 Random Fill 22-Mar-2017	SG 25 Random Fill 22-Mar-2017
Lab Number:		1754302.21	1754302.22	1754302.23	1754302.24	1754302.25
Individual Tests						
Dry Matter	g/100g as rcvd	-	-	-	96	95
Fraction >/= 2 mm*	g/100g dry wt	75.2	78.1	71.9	73.5	86.2
Fraction < 2 mm*	g/100g dry wt	24.8	21.9	28.1	26.5	13.8
Total Carbon*	g/100g dry wt	5.6	2.1	0.50	1.40	2.0
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	12	6	3	6	7
Total Recoverable Cadmium	mg/kg dry wt	0.46	0.14	< 0.10	0.11	0.16
Total Recoverable Chromium	mg/kg dry wt	66	49	20	38	45
Total Recoverable Copper	mg/kg dry wt	52	28	19	40	37
Total Recoverable Lead	mg/kg dry wt	17.9	10.5	14.3	18.3	23
Total Recoverable Nickel	mg/kg dry wt	57	71	15	25	41
Total Recoverable Zinc	mg/kg dry wt	131	65	54	96	109
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	-	-	-	< 0.03	< 0.03
Acenaphthylene	mg/kg dry wt	-	-	-	< 0.03	0.26
Anthracene	mg/kg dry wt	-	-	-	< 0.03	0.21
Benzo[a]anthracene	mg/kg dry wt	-	-	-	0.05	1.07
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	-	-	0.07	1.37
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	-	-	-	0.09	1.85
Benzo[g,h,i]perylene	mg/kg dry wt	-	-	-	0.05	0.96
Benzo[k]fluoranthene	mg/kg dry wt	-	-	-	0.04	0.68
Chrysene	mg/kg dry wt	-	-	-	0.05	0.86

Sample Type: Soil

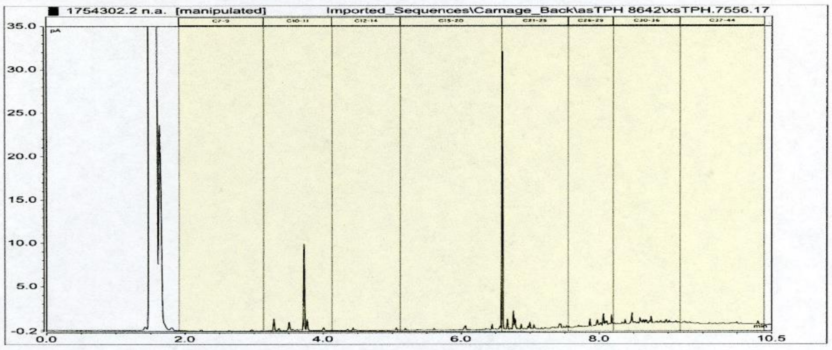
Sample Name:		SG 21 Random Fill 22-Mar-2017	SG 22 Random Fill 22-Mar-2017	SG 23 Random Fill 22-Mar-2017	SG 24 Random Fill 22-Mar-2017	SG 25 Random Fill 22-Mar-2017
Lab Number:		1754302.21	1754302.22	1754302.23	1754302.24	1754302.25
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Dibenzo[a,h]anthracene	mg/kg dry wt	-	-	-	< 0.03	0.28
Fluoranthene	mg/kg dry wt	-	-	-	0.13	2.3
Fluorene	mg/kg dry wt	-	-	-	< 0.03	0.05
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	-	-	0.05	1.43
Naphthalene	mg/kg dry wt	-	-	-	< 0.12	< 0.12
Phenanthrene	mg/kg dry wt	-	-	-	0.04	0.83
Pyrene	mg/kg dry wt	-	-	-	0.13	2.2

Sample Name:		SG 26 Random Fill 22-Mar-2017				
Lab Number:		1754302.26				
Individual Tests						
Fraction >/= 2 mm*	g/100g dry wt	66.3	-	-	-	-
Fraction < 2 mm*	g/100g dry wt	33.7	-	-	-	-
Total Carbon*	g/100g dry wt	4.3	-	-	-	-
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	6	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.21	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	32	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	32	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	49	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	37	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	89	-	-	-	-

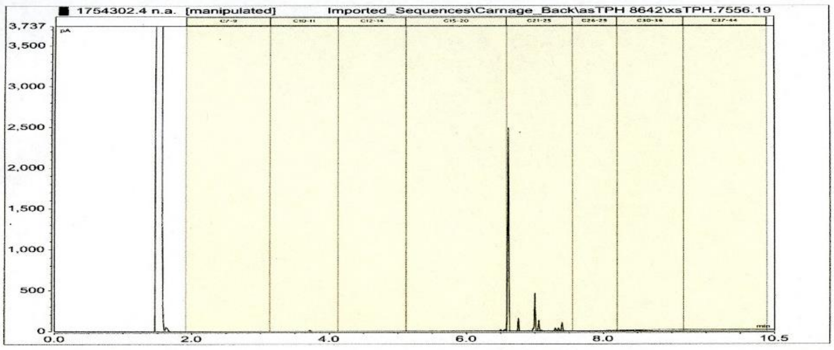
1754302.1
SG 1 Random Fill 21-Mar-2017
Client Chromatogram for TPH by FID



1754302.2
SG 2 Random Fill 21-Mar-2017
Client Chromatogram for TPH by FID



1754302.4
SG 4 Random Fill 21-Mar-2017
Client Chromatogram for TPH by FID



Analyst's Comments

Carbon particulates were observed in the matrix of sample 1754302.1 and .2 and this has absorbed some of the System Monitoring Compounds in the PAH, e.g. the recovery of Anthracene-d10 was 7% and 32% respectively. Therefore the results presented for these analytes may not represent the actual concentration in the sample.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
TPH Oil Industry Profile + PAHscreen	Sonication in DCM extraction, SPE cleanup, GC-FID & GC-MS analysis. Tested on as received sample. US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:5786,2805,10734;2695]	0.010 - 60 mg/kg dry wt	1-4
Heavy Metals, Screen Level	Dried sample, < 2mm fraction. Nitric/Hydrochloric acid digestion US EPA 200.2. Complies with NES Regulations. ICP-MS screen level, interference removal by Kinetic Energy Discrimination if required.	0.10 - 4 mg/kg dry wt	1-26
Polycyclic Aromatic Hydrocarbons Screening in Soil	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis (modified US EPA 8270). Tested on as received sample. [KBIs:5786,2805,2695]	0.010 - 0.05 mg/kg dry wt	5, 11-13, 15-16, 18, 20, 24-25

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-5, 11-13, 15-16, 18, 20, 24-25
Environmental Solids Sample Preparation	Air dried at 35°C.	-	1-26
Fraction >/= 2 mm*	Calculation: 100% - % < 2.00 mm sieve fraction.	0.1 g/100g dry wt	1-26
Fraction < 2 mm*	2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-26
Total Carbon*	Catalytic Combustion (900°C, O_2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	5-26

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental

APPENDIX 2. GEOCHEMICAL REPORTS

Geochemical Solution

Dr Doug Sheppard (Geochemist)

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Report 1

I have examined the chemical analyses of soils and fill material carried out by Hill Laboratories on samples from the Staplegrove Farm Gravel extraction Site, Waimea West, Tasman, as provided by Dr Iain Campbell of Land and Soil Consultancy Services. I have also been supplied with a draft of his report.

I have divided the sample set into three types of sample:

1. Undisturbed soil from 0 to 15 cm depth in Pit 11 (SG19) and clean, original topsoil Pit 2 (SG7) at 0 to 35 cm depth and Pit 8 (SG14) also at 0 to 35 cm depth.
2. "Random fill" samples collected on 21 March 2017 (SG1 to SG4) and "Random Surface fill" samples collected on 22 March 2017.
3. Subsurface fill samples taken at various depths within pits of up to 2.5m depth (SG5, 6, 8 to 13, 15 to 18).

The undisturbed soils are here used to provide baseline chemical compositions against which to compare the fill sample compositions.

Heavy Metals

Metal	Type 1 average mg/kg	Type 2 average mg/kg	Type 3 average mg/kg
(Total Recoverable fraction)	Baseline soils (3 samples)	Fresh fill (11 samples)	Subsurface fill (12 samples)
As	4	13 (48 max.)	10 (18 max.)
Cd	<0.10	0.19 (0.46 max.)	0.16 (0.30 max.)
Cr	57	48 (66 max.)	75 (220 max.)
Cu	23	42 (85 max.)	41 (69 max.)
Pb	9.5	47 (250 max.)	25 (42 max.)
Ni	76	43 (71 max.)	85 (187 max.)
Zn	55	112 (140 max.)	98 (130 max.)

The analytical method for the metals involves analysing the solution that results from crushing a sample and exposing to an acid mixture. This method does not indicate total amounts of the metals in the sample, but what may be regarded as being potentially easily mobilised or available to organisms.

As can be seen from this table, the fill materials (Types 2 and 3) have, on average, significantly more of five of the extractable metals, when compared to the relatively undisturbed, baseline sample soils (Type 1). The averages of the extractable chromium and nickel concentrations are lower in the fresh fill samples than the baseline samples and only slightly higher in the subsurface fill samples.

While most arsenic concentrations are less than 10 mg/kg in the fill materials it is at 48 mg/kg in sample SG20.

Cadmium is high in three samples (SG21 0.46 mg/kg, 0.31 mg/kg in SG20 and 0.30 mg/kg SG2, compared to less than 0.10 average for undisturbed soils). These samples also have relatively high zinc concentrations and cadmium is a normal contaminant of zinc metal as they have similar chemical properties in geochemical and metal refining environments.

Chromium is in remarkably high concentration in one sample (220 mg/kg in SG13 compared to the 57 mg/kg average in the baseline samples) and also elevated concentration in another (113 mg/kg in SG10). Copper is at its highest concentration in SG20 at 85 mg/kg, at about 3 times the baseline concentration but is generally about double the baseline, quite consistently.

Lead shows a very high level in the fill material sampled as SG4, at 250 mg/kg which is more than 25 times the baseline average concentration of 9.5 mg/kg. This is very much an outlier as most samples have about twice the baseline concentrations.

Zinc has been detected at two to three times the baseline concentrations in several samples with a maximum of 140 mg/kg in SG4. Zinc is generally twice the baseline concentration in the fill materials.

The fill material is, or is intended to be, buried below soil in an agricultural environment. However, Dr Campbell considers that there is evidence that the water table is high in this area and has observed that rainwater ponds on the surface due to poor drainage through the site. Anaerobic conditions are likely in such conditions and are suggested from his observations. Under these conditions, and particularly if the groundwater level fluctuates and hence transitory oxidizing conditions can exist, then concentration of these metals into zones is possible, particularly for arsenic, and mercury if present. Such reactions depend on the nature of the compounds in which the metals exist as well as the chemical and physical conditions present.

In general, the levels of most of the metals in some of the fill material is near to, or exceeds, levels which some guidelines consider should trigger further investigation for agricultural soils.

Polycyclic Aromatic Hydrocarbons

PAHs are organic molecules derived from coal deposits and they are also produced by the incomplete combustion of petroleum oils and fuels and of other organic matter in engines and incinerators, or when biomass burns in fires. They are commonly found in soils and sediments which drain industrial and busy roaded areas, gas works, coal processing facilities etc. Some levels of some components in the analysed fill materials are of concern when compared to ANZECC guidelines – e.g. pyrene at 1.15 mg/kg in SG2, the benzo- compounds and pyrene and fluoranthene in SG25. These measurements would indicate that further sampling and analysis is required of the types of fill from which these samples were obtained.

The fill from SG2 and SG4 had elevated petroleum hydrocarbon levels, particularly the latter sample. Only four samples were analysed for these and three of them showed evidence of longer chain oils. This suggests that fill materials contain oil or asphalt.

Concluding comments

It is evident from the chemical analyses that the fill materials, when compared to original, clean soils, are contaminated with heavy metals and organic materials.

I consider that there is sufficient indication of contaminated fill being, and having been, deposited. One implication of this is that there is a strong possibility of other chemicals of concern being present, such as agricultural chemicals. I consider that it would be wise to screen for these, particularly as there are indications that the fill material is exposed to groundwater movement and so has the potential to carry contamination beyond the immediate site.

Geochemical Solutions

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Report 2: comparison of analytical results with accepted environmental guidelines

I have examined the chemical analyses of soils and fill material carried out by Hill Laboratories on samples from the Staplegrove Farm Gravel extraction Site, Waimea West, Tasman, as provided by Dr Iain Campbell of Land and Soil Consultancy Services. In my first report to Iain I analysed the results of the chemical analyses that he had had carried out. I divided the sample set into three types of sample:

1. Undisturbed soil
2. “Random fill” samples and “Random Surface fill” samples
3. Subsurface fill samples

The undisturbed soils were used to provide baseline chemical compositions against which to compare the fill sample compositions. The results of that ordering of the data were summarised on the following table for the Heavy Metals**.**

Metal	Type 1 average mg/kg	Type 2 average mg/kg	Type 3 average mg/kg
(Total Recoverable fraction)	Baseline soils (3 samples)	Fresh fill (11 samples)	Subsurface fill (12 samples)
As	4	13 (48 max.)	10 (18 max.)
Cd	<0.10	0.19 (0.46 max.)	0.16 (0.30 max.)
Cr	57	48 (66 max.)	75 (220 max.)
Cu	23	42 (85 max.)	41 (69 max.)
Pb	9.5	47 (250 max.)	25 (42 max.)
Ni	76	43 (71 max.)	85 (187 max.)
Zn	55	112 (220* max.)	98 (130 max.)

**Reported incorrectly in my first report*

Table 1 Average heavy metal concentrations and maximum concentrations from soils and fill from the Staplegrove Farm site

Samples taken were not random. Dr Campbell targeted samples which contained materials which contained materials which were not normal rock and soil, i.e. were visibly contaminated, as well as the three clean samples for baseline comparison purposes. The purpose of this report is to illustrate, from the data available, what some of the chemical contaminants are, at what sort of concentration and how these compare with some relevant guidelines which are likely to be used by consenting authorities.

The analytical data can be compared with guideline values accepted by New Zealand authorities to assess the seriousness of any contamination found, in terms of expected land-use. I have used the Canadian CCME guidelines as these are recommended by MoE in their document *Contaminated Land Management Guidelines No.2: Hierarchy and Application in New Zealand of Environmental Guideline Values (Revised 2011). Ministry for the Environment, 2011.* I have formulated the following table to more easily allow assessments to be made. The following table shows the guideline limits in mg/kg dry weight.

Metal	Agriculture mg/kg	Residential mg/kg	Commercial mg/kg	Industrial mg/kg	% at or above agricultural limit	Range mg/kg
Arsenic	12	12	12	12	35	4 to 48
Cadmium	1.4	10	22	22	0	<0.10 to 0.46
Chromium	64	64	87	87	35	20 to 220
Copper	63	63	91	91	9	19 to 85
Lead	70	140	260	600	4	9.1 to 250
Nickel	45	45	89	89	70	15 to 187
Zinc	200	200	360	360	4	54 to 220

Table 2: Analytical results for heavy metals compared with CCME guideline values for use in areas with different land-use.

It is evident that a large fraction of the samples exceed the guideline values for Arsenic, Chromium and especially for Nickel. However, the Nickel results may need to be disregarded except for the highest as the baseline samples themselves all exceed the guideline limits, and may indicate a source which is in the local gravels and soils themselves. The outliers (e.g. the 250 mg/kg Lead result) indicate that there are some components in specific areas and layers of the fill which are significantly contaminated.

Polycyclic Aromatic Hydrocarbons

The guidelines that I have used to compare the analytical results with are the Canadian CCME 2008 (revised 2010) guidelines for Polyaromatic Hydrocarbons (PAH), and are in the set of such guidelines listed as suitable for use by our Ministry for the Environment.

The use of these guidelines for PAHs are complicated by the need to separately assess carcinogenic and non-carcinogenic effects on human health from contact with both contaminated soil and potable water resources, and those for the non-carcinogenic effects for the protection of environmental health. Given the nature of the site and its likely future use, I have evaluated the analytical results only for the last of these i.e. the non-carcinogenic effects for the protection of environmental health. If the land-use (and any derived groundwater) is to be used where human contact with them is possible, then the situation will need to be re-evaluated for carcinogenic risk.

PAH compound	Agriculture mg/kg	Residential mg/kg	Commercial mg/kg	Industrial mg/kg	% at or above agricultural limit	Range mg/kg
Anthracene	2.5	2.5	32	32	0	<0.03 to 0.21
Benzo[a]pyrene	20	20	72	72	0	<0.03 to 1.37
Fluoranthene	50	50	180	180	0	0.06 to 2.3
Naphthalene	0.013	0.013	0.013	0.013	>23*	<0.12 to 0.21
Phenanthrene	0.046	0.046	0.046	0.046	77	0.03 to 0.83
Benz[a]anthracene	0.1	1	10	10	46	<0.03 to 1.07
Benzo[b] fluoranthene	0.1	1	10	10		Not resolved**
Benzo[k] fluoranthene	0.1	1	10	10	31	<0.03 to 0.68
Benzo[b+j+k] fluoranthene	0.1	1	10	10	77	<0.06 to 2.53
Dibenz[a,h] anthracene	0.1	1	10	10	15	<0.03 to 0.28
Indeno[1,2,3-c,d] pyrene	0.1	1	10	10	39	<0.03 to 1.43
Pyrene	0.1	10	100	100	92	0.05 to 2.2

*The detection limits for Naphthalene analysis are high compared to the guideline limit. It is possible that all of the samples are above this limit: the sensitivity of the analysis compared with the guideline value does not allow any other conclusion.

** Benzo[b]fluoranthene was not analysed separately by Hill Laboratories; it is included in the Benzo[b+j+k]fluoranthene line.

It is evident from this analysis that the fill samples are significantly in excess of the guideline values for a number of PAH compounds when compared to the guidelines for agricultural use; to some extent for residential or parkland use; and slightly for industrial or commercial use. However, the samples analysed for PAH were those which contained observable asphalt-like materials.

This analysis shows that some of the material in the fill materials has concentrations of several components in excess of one relevant set of guideline values for agricultural use in soils. The extent to which this is an issue needs to be evaluated in view of the risk of buried contaminants becoming available to plants, animals and humans, through physical or chemical mobilisation in the soils themselves or through the medium of ground- and surface waters.

31 May 2017

Figure 1 A

Figure 1B

Figure 1C

Pit 1. top left, soil profile;
top right, trench cross section;
right, asphalt waste material.

Figure 2A

Figure 2B

Figure 2C

Pit 2. above left, soil profile;
above right, trench cross section;
right, waste materials.

Figure 3A

Figure 3B

Figure 3C

Pit 3. Top left, soil profile;
top right, trench cross section;
right, waste material.

Figure 4A

Figure 4B

Figure 4C

Pit 4. Above left, soil profile;
above right, trench cross section;
right, black material including asphalt
and charcoal.

Figure 5A

Figure 5B

Figure 5C

Pit 5. Top left, soil profile
top right, trench cross section;
right, waste materials.

Figure 6A

Figure 6B

Figure 6C

Pit 6, above left, soil profile;
above right, trench cross section;
right, concrete & plastic waste
materials.

Figure 7 A

Figure 7B

Figure 7C

Pit 7. top left, soil profile
top right, trench cross section
right, metal and concrete waste materials

Figure 8A

Figure 8B

Figure 8C

Pit 8. above left, soil profile
above right, trench cross section
right, plastic, concrete & asphalt waste

Figure 9A

Figure 9B

Figure 9C

Pit 9. top left soil profile,
top right, trench cross section
right, concrete waste material

Figure 10A

Figure 10B

Figure 10C

Pit 10. above left soil profile,
above right, trench cross section,
right plastic, brick, concrete & wood
waste material.

Figure 12. Undisturbed original soil

Figure 13. Water ponding on restored land.

Figure 14. Excavation and backfilling.

Figure 15. Backfill showing the variety of materials being deposited.

Figure 16. Backfill showing materials being deposited.

Figure 17. Foreign material.

Figure 18. Foreign material.

Figure 19. Foreign material, asphalt

Figure 20. Earth spreading and compaction.

Figure 21. Spreading compaction and drainage impairment.