GREATER TAREE CITY COUNCIL REZONING OF PITT ST WATERFRONT CHATHAM

Acid Sulphate Soil and Contamination Assessment and Review

Sinclair Knight Merz

GEOTTUNC01736AA-AD
7 November 2007

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
1/4 Douglas Avenue Tuncurry NSW 2428 Australia

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Sinclair Knight Merz
710 Hunter Street
Newcastle West NSW 2302

Attention: Brian Watson

Dear Brian,

RE: Acid Sulphate Soils and Contamination Assessment

Pitt Street Waterfront, Chatham (Taree)

We are pleased to provide our report on the assessment of contamination and acid sulfate soil conditions over the area of the proposed Pitt Street Waterfront redevelopment at Chatham.

Please do not hesitate to contact the undersigned if you have any questions in relation to this project.

For and on behalf of Coffey Geotechnics Pty Ltd

Steven Morton

Principal

EXECUTIVE SUMMARY

Coffey Geotechnics have undertaken a preliminary assessment of site contamination and acid sulfate soils in the area of the propose Pitt Street Precinct, Taree. It is located approximately 2km north of Taree city centre, on the Manning River and occupies an area of approximately 20ha. Current land zoning is a mixture of rural, residential, industrial, open space, and special uses. The site has been used for a mixture of industrial, commercial, residential, and agricultural purposes in the past. Much of the site is currently disused. Several previous investigations have been undertaken to assess contamination at specific sites within the study area.

The aim of this study was to identify any discrepancies or deficiencies in the previous works, update or rectify these where required, and draw conclusions regarding future site development and rezoning with recommendations to Council on the extent and nature of contamination present, an outline of additional assessment requirements, and management options for any ASS or potential contamination that may be present.

Based on a site walkover, several areas of environmental concern were identified as potentially containing contamination. A review was then undertaken of past information and documentation relating to these areas. Following this review, a nominal amount of sampling and analysis was undertaken to check on remaining contamination.

On the basis of the site walkover, review of past reports, and limited sampling and analysis undertaken as part of this assessment, the following points are noted:

- The fuel depot at the southwestern end of the site is a significant area of concern from a contamination perspective;
- The facility has been decommissioned and is undergoing demolition;
- Groundwater beneath the fuel depot contains contamination by petroleum hydrocarbons that from the test results obtained appear to be related to the presence of diesel;
- This area should be subjected to a detailed site contamination assessment;
- Remediation will be required within and adjacent to the fuel depot area;
- The extent of contamination downslope of the fuel depot should be investigated further. In particular, further wells should be installed and monitoring undertaken, to assess the extent and degree of groundwater contamination.
- The majority of the site on the southern, or river side of Pitt Street has been used for a variety of industrial purposes;
- Several phases of site investigation have been conducted over this area, resulting in identification of areas of contamination that were subsequently remediated;
- On the basis of the above the majority of the site would be considered suitable for landuses including residential, recreational, or commercial uses;

- The previous assessment and remediation work, although comprehensive, were not exhaustive, and therefore there may be some areas of contamination present within the study area. In particular, areas containing ash fill or visible surface staining should be further assessed;
- The Big Oyster site was formerly used as a service station. Underground tanks and associated lines were removed in 1999. The area was remediated and validated following the removal of the tanks.

Additional sampling and analysis will be required to comply with DEC Guidelines porior to rezoning the land to a more sensitive landuse.

The work also included a desk top study and limited sampling and analysis to characterise the site in terms of the presence of acid sulfate soils. Reference to the Taree 1:25,000 Acid Sulfate Soils Risk map published by the NSW Department of Land and Water Conservation indicates the site contains no known occurrence of ASS in elevated areas of residual soils.

Adjacent to the Manning River, particularly in the low lying area at the northeastern end of the agistment paddocks, an alluvial plain with a high probability of ASS between 1m and 3m from ground surface is marked. The low-lying drainage depression surrounding the creek that flows through the eastern end of the site is identified as an alluvial channel with a high probability of ASS between 1m and 3m below the ground surface.

Sampling and analysis indicated the presence of potential acid sulfate soils in low lying areas adjacent to the Manning River. Development in this part of the site, particularly elements requiring deep bulk excavation, will require further more detailed investigation and preparation of an acid sulfate soil management plan.

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1 INTRODUCTION

This report describes work undertaken by Coffey Geotechnics Pty Ltd (Coffey) for the review and assessment of acid sulphate soil (ASS) and site contamination conditions within the Pitt St Waterfront Precinct (The Precinct) at Chatham. It is understood the area is under consideration for rezoning and this study is required to assist in assessing the ability of the area to support residential, tourist, industrial, and marina landuses.

The site has been used for a mixture of industrial, commercial, residential, and agricultural purposes in the past. Much of the site is currently disused. Several previous investigations have been undertaken to assess contamination at specific sites within the study area.

The aim of this study was to identify any discrepancies or deficiencies in the previous works, update or rectify these where required, and draw conclusions regarding future site development and rezoning with recommendations to Council on the extent and nature of contamination present, an outline of additional assessment requirements, and management options for any ASS or potential contamination that may be present.

2 SCOPE OF WORK

To achieve the aims of the study outlined in Section 1, the following work was undertaken:

- An initial meeting with Council at project inception;
- Review of previous contamination assessment reports including the Big Oyster Contamination Assessment from 1999, and reports detailing assessments undertaken for a former dairy factory on the site;
- Review of Council-held documents pertaining to the area including DCP No 45 – Contaminated Land, Copies of Council Correspondence records regarding contamination within the precinct, DLWC ASS risk maps and associated documentation, and relevant GIS data layers;
- A site walkover to identify any visible evidence of contamination or ASS, identify evidence of any current or previous potentially contaminating activities, and identify locations for limited soil and groundwater sampling;
- A limited program of soil and groundwater sampling and analysis to further characterise the site and assess areas of potential contamination and ASS identified by previous phases of the study.

At the initial inception meeting, information was provided to Coffey including the documents outlined above. The above scope of work was then discussed and agreed.

3 GUIDELINES AND ASSESSMENT CRITERIA

To evaluate contaminant concentrations in soil the following references were adopted:

- NSW DEC (2006) Guidelines for the NSW Auditor Scheme, 2nd Edition;
- NSW EPA (1994) Guidelines for Assessing Service Station Sites;

Other references were used to supplement the above references where appropriate.

The NSW DEC(2006) *Guidelines for the NSW Site Auditor Scheme* present health based investigation levels for different land uses (e.g. industrial/commercial, residential, recreational etc.) as well as provisional phytotoxicity based investigation levels.

The future land use on the site is intended to be mixed residential, recreational and commercial. Therefore the investigation levels for these landuses as outlined in Appendix II in NSW EPA (2006) have been adopted as the primary investigation criteria.

The NSW EPA (1994) *Guidelines for Assessing Service Station Sites* provides acceptable threshold concentrations for petroleum hydrocarbons compounds at service station sites to be reused for sensitive land uses such as residential. The DEC has advised that these should also be used as investigation criteria for sites to be used for less sensitive land uses, including commercial / industrial. These guidelines were also used by previous consultants involved in investigation and remediation of a large part of the site.

4 THE SITE

4.1 Location and landuse

The extent of the study area is shown on Figure 1. It is located approximately 2km north of Taree city centre, on the Manning River and occupies an area of approximately 20ha. Current land zoning is a mixture of rural, residential, industrial, open space, and special uses. The following development and landuse was noted during the study:

- Former Manning Valley dairy Co-operative buildings (both used and unused). Current uses include a concrete plant and an agricultural machinery business;
- Disused rail spur associated with the above co-operative;
- Residential development on the west side of Pitt Street;
- Agricultural land occupying much of the northern part of the precinct, including remnant former piggery buildings;
- Car dealership on the former “Big Oyster” service station site;
- Creek and drainage channel;
- Disused wharves on the river front;
- Fishermans co-operative;
- Caltex fuel depot.

4.2 Topography

The site is located on a low-lying flood plain adjacent to the northern passage of the Manning River. The majority of the site is located on an elevated alluvial terrace, some 3m to 5m above river level. The area has an overall slope towards the east and south. Drainage is directed towards an easterly trending drainage depression that meanders through the site to the low-lying grassed eastern area, before discharging to the Manning River. This low lying area contains abandoned drainage channels and other low, poorly drained boggy features. Surface water ponding occurred in this area during the fieldwork which was undertaken at a time of prolonged heavy rainfall.

The riverbank that defines the southern edge of the site is incised and varies in height from 2m to approximately 4m at the western end. The western half of the riverbank is modified by filling and by the construction of wharf structures to service some of the former industrial facilities that occupied the riverbank. The river adjacent to the site is tidal.

As shown on Figure 1, industrial development occupies much of the western half of the site, while there is a narrow strip of residential land development in the site centre. The northeastern end of the site is occupied by a car retailer, which was formerly a service station site. The remainder of the site is occupied by grazing land, vegetated by well-established grass cover with some scattered trees.

4.3 Geology

Reference to the Hastings 1:250,000 Geological Series Sheet SH 56-14 indicates the site is underlain by the Byabbara Beds, which consists of lithic sandstones, siltstones, tuffs, shales and limestone and by Quaternary sediments adjacent to the Manning River.

Reference to the Taree 1:25,000 Acid Sulfate Soils Risk map published by the NSW Department of Land and Water Conservsation indicates the site contains no known occurrence of ASS in elevated areas of residual soils. Adjacent to the Manning River an alluvial plain with a high probability of ASS between 1m and 3m from ground surface is located in the area between the east flowing Creek and the existing industrial buildings. The low-lying drainage depression is identified as an alluvial channel with a high probability of ASS between 1m and 3m below the ground surface.

5 AREAS OF ENVIRONMENTAL CONCERN

5.1 Areas of Concern and Chemicals of Concern

A site walkover was undertaken to observe site conditions and in particular to note any visible surface features indicative of potential past or present contaminating activities and any visible evidence of contamination. On the basis of features observed during the site walkover, seven Areas of Environmental Concern were identified. These are summarised in Table 2.

Table 2. Areas of Environmental Concern Identified by Site Walkover

AREA OF CONCERN	ACTIVITIES	SITE OBSERVATION / ADDITIONAL INFORMATION	CHEMICALS OF CONCERN	POTENTIAL FOR CONTAMINATION
AEC1: Former fuel depot	Fuel storage	Known past spillage	TPH, BTEX, PAH, VOC's, Metals	Significant risk based on past usage.
AEC2: Rail siding	Spillage of fuels, oils, pesticide spraying	Some visible staining	TPH, BTEX, PAH, Metals, Pesticides	Significant risk based on past usage, especially adjacent to the fuel depot
AEC3:Vacant Fill area	Spillage of fuels, oils, pesticide spraying, importation of unknown fill	Some visible oil staining	TPH, BTEX, PAH, Metals, Pesticides	
AEC4: Concrete plant	Spillage of fuels, oils, pesticide spraying, importation of unknown fill	Truck maintenance Pit area with waste oil storage	TPH	Low risk of contamination given site observations and site usage.
AEC5: Dairy Factory	Processing of milk products, storage and usage of diesel, petrol, paints, solvents and oils, use of a coal fired boiler and deposition of ash in areas of fill		TPH, BTEX, PAH, Metals, Pesticides Asbestos	Potential for contamination from numerous sources.
AEC6: Rural store	Storage of fuels and chemicals		TPH, BTEX, PAH, Metals, Pesticides Asbestos	Low risk based on site usage and observations

AREA OF CONCERN	ACTIVITIES	SITE OBSERVATION / ADDITIONAL INFORMATION	CHEMICALS OF CONCERN	POTENTIAL FOR CONTAMINATION
AEC 7: Big Oyster	Fuel storage	Remediation report	TPH, BTEX, PAH	Low risk based on site usage and observations, and remediation report
AEC 8: Filled gully adjacent to Fishermans Co-operative	Past filling and usage of area for boat repairs and maintenance	Investigation and partial remediation report	TPH, BTEX, PAH, Metals, Tributyl tin Asbestos	Moderate risk based on unknown fill history and boat repair usage

Specific observations in relation to each of these areas are outlined below in the following sections.

5.2 AEC1: Former Fuel Depot

The site had been recently decommissioned and dismantling of plant and equipment was underway. The facility contained fuel storage and bulk distribution facilities as well as a retail fuel outlet. The bulk distribution facilities contained above ground fuel storage tanks were observed in a bunded area at the eastern end of the site. A second above ground tank farm was located at the western end, adjacent to a road tanker filling facility. Earth bunds, grass covered, were observed around the main above ground tank farm. No evidence of staining was visible from the road, and closer access was restricted by a recently erected security fence. An oil-water separator pit was observed that appeared to accept stormwater drainage from within the bunded area.

At the western end of the site a drum storage area was observed, containing packaged oil and lubricant products in drums of various sizes.

The former retail fuel outlet part of the site contained a concrete apron in front of a single storey building. Bowsers had been removed but former bowser stands were visible and underground storage tank filling points and breather tubes were also observed. The concrete apron around the bowsers and UST's did not contain visible evidence of boreholes or monitoring points that would normally be associated with a detailed environmental site assessment.

5.3 AEC2: Rail siding

The extent of the former rail siding is illustrated on Figure 2. Where the rail line passes into the former dairy factory the lines and sleepers have been removed. Over the remainder of the site the lines are still in place. Ballast and sleepers contain some oil staining. Most of the railway line easement is largely unvegetated, which might reflect the past common practice of using herbicide sprays in railway easements for the purposes of weed control.

At the western end of the site the rail line passes adjacent to the rear boundary of the fuel depot and a remnant concrete structure might indicate past usage of the rail line to either supply the depot or load rail tankers from the depot. There is visible oil staining in this area.

5.4 AEC:3 Vacant Fill Area

The western end of the site contained a filled area, with fill of unknown origin, and a disused storage shed with concrete slab floor. There was minor visible oil staining on the concrete slab floor and on the ground adjacent to the shed. Where fill of unknown origin exists there is always a risk that some contamination may be present within the fill.

5.5 AEC4: Concrete plant

The concrete plant contained storage facilities, silos and bins for concrete related materials. There was no evidence of fuel or oil storage on the site.

Stormwater appeared to be directed to a holding pond where fines are settled out before the water discharges to the river.

No visible evidence of contamination, or potentially contaminating activities was observed on this part of the site other than the minor oil staining outlined above, truck and vehicle usage, and unknowns within the fill.

5.6 AEC5: Dairy Factory

This is a complex containing numerous buildings slabs, loading bays, refrigeration equipment, items of disused plant, and a wharf structure. There is evidence in the concrete slabs of some former boreholes and further investigation revealed that a comprehensive site contamination assessment has been carried out for the site, which is discussed in Section 5.2 of this report.

Some visible oil staining was observed on the ground surface behind a shed in the southwest corner of the site and it appeared that this had been sprayed on the surface as a dust and weed suppressant.

The existing buildings contained visibly large quantities of asbestos-cement building products, including corrugated roof sheeting, guttering and wall cladding. The inside of the buildings was not accessed during the site walkover.

The rail siding in this area had been stripped to remove tracks, sleepers and ballast and was vegetated by grass.

5.7 AEC6: Rural store

This is essentially a large disused metal clad structure with concrete slab internal floors that appears to have been used mainly for the storage and sale of bulk rural products. There were some metal grain silos at the rear of the building adjacent to the railway line, and some large hoppers located inside the building. There was no evidence of above ground or underground fuel storage.

Internally there were some abandoned drums of “Teat Shield” an iodine based teat spray used in dairy farming. No other stored chemicals were observed.

Given the past usage of the building it appears that past activities predominantly consisted of the bulk storage of rural feeds and products. Chemicals are likely to have been brought into, stored, and taken from the site in drums, and are likely to have included some pesticide and weed sprays, as well as minor fuels and oils.

The internal and external walls did not appear to contain asbestos, although a detailed asbestos survey was not undertaken.

5.8 AEC 7: Big Oyster

This site is currently occupied by a car retailer. Current site activities include vehicle maintenance and servicing as well as preparing vehicles for sale. There are no fuel storage tanks on the site, and only minor storage of oils and degreasers for use in the servicing workshops.

Past usage of the site included a service station, with underground fuel storage tanks and bowsers. These have since been removed and the site validated by a previous assessment, which is discussed further in section 5.3.

5.9 AEC 8: Filled Gully at Fishermans Co-operative

The gully on the eastern side of the Fishermans Co-operative is known to have been filled using fill from an unknown source and based on the surrounding industrial landuse history there is a potential for this fill to contain contamination. No visible contamination was observed at the surface at the time of the site visit, however, there was visible evidence of a former small boat slipway. The likelihood of this having been used for boat repairs in the past is a further potential source of contamination.

6 PREVIOUS INVESTIGATIONS

6.1 Available Reports

The following reports were provided to Coffey for review as part of this assessment:

- Synnot & Wilkinson Pty Ltd. August 2004, “Report to Dairy Farmers, Initial Environmental Site Assessment, Taree Site Pitt Street Taree”;
- Envirosafe Australia Pty Ltd. October 2004 “Sampling & Site Contamination Results, Dairy Farmers, Pitt Street Taree NSW’ Reference ESAM-04.084;
- HLA Envirosciences Pty Ltd. November 2004 “Piezometer installation, Taree NSW.” Ref. S4034901_RPT_29NOV04
- Synnot & Wilkinson Pty Ltd. November 2004, “Report to Dairy Farmers, Remediation Action Plan, Taree site, Pitt Street Taree.”
- Synnot & Wilkinson Pty Ltd. February 2006, “Site Investigation Report. Dairy Farmers site, Pitt Street Taree.”
- Robert Carr & Associates Pty Ltd. September 1999, “Environmental Site Assessment/Validation, Former Ampol Service Station, Taree (Big Oyster).”

6.2 Synnot & Wilkinson Pty Ltd. August 2004

6.2.1 Scope

This report was an initial look at the portion of the current study area then owned by Dairy farmers and applied to an 800m long and 100m wide area along the southern side of Pitt Street which included land referred to as:

- Lot 6 and Lot D
- Lots 8, 11 and C
- Lot B and E
- Lot F
- Lot 21
- Lots 27, 28 and 29
- The railway Line (Lot 15)

6.2.2 Lot 6 and Lot D – The former fuel depot

These lots are located at the western end of the site and include the Caltex fuel depot (Lot D). The adjacent Lot 6 was formerly the Golden Fleece fuel depot. Information in the report indicates these sites to have operated as fuel depots for more than 40 years. Fuel was delivered to the sites in rail tankers and then pumped into holding tanks on the depot sites for transfer into road tankers and drums. The concrete structure observed at the rear of the Caltex depot is nominated as one of the railway unloading points.

Caltex operated a retail service station at the Pitt Street frontage of the site, which ceased operation in 2007.

The report includes discussions with some employees that note significant past spillages on the site, particularly in the vicinity of the rail siding. It also notes some bores within the bunded area that contained a significant hydrocarbon odour.

The report concludes that these facilities need a detailed site assessment.

6.2.3 Lot 8 and C – The Concrete Plant

This area has been used for maintenance and storage of concrete mix trucks since the 1960's, originally by a company called Hammonds and more recently by Readymix.

The report indicates an underground waste oil collection tank which collects waste oil from the servicing of trucks which is then pumped out and removed by a contractor. The report notes there is a potential for leakage of fuel or oil spills through cracks in the concrete from the vehicle maintenance pit.

6.2.4 Lot 11 – The Vacant Filled Area

The report indicates this area contained one of the first sawmills in the Taree area. This area was also vacant at the time of the 2004 assessment and contained no evidence of contamination although the report indicates that given its past usage as a sawmill it may have involved storage and spillage of some oils or fuels.

6.2.5 Lot B and E – The former Rural Store

The report indicates that the rural store formerly contained an above-ground diesel tank to fuel a heater used to heat molasses.

The report notes no visible contamination from the diesel tank or other sources, but does note the presence of potentially asbestos-containing linoleum tiles on he office floors. (Note: These appeared to have been predominantly removed at the time of the current assessment.)

6.2.6 Lot F – The Fishermans Co-operative

It is noted in the report that the current usage as a fishermans co-operative does not appear to involve any potentially contaminating activities. It is further noted that a slipway that formerly existed adjacent to the co-operative building was used for boat maintenance and repair.

6.2.7 Lot 15 – the Former Dairy Factory

This lot contains the majority of the former dairy factory buildings, including the railway line. The site was developed for dairy processing in the 1940's. It also includes agistment paddocks at the northeastern end of Pitt Street which contain some filling. The following points of potential contamination are noted within the dairy factory site:

- A trailer dock with 2,300L above ground diesel tank at the northern side of the former milk building
- Storage of hydraulic oil drums adjacent to the milk building
- Fill of unknown origin
- Area between milk building and the Manning River, which contained 2 above ground diesel storage tanks (which have been removed);
- Former underground diesel storage tank and bowser adjacent to the Manning River for servicing boats at the wharf. The tanks and bowser were noted by the report to have been removed from the site in 1995;
- Former paint store buildings, with evidence of extensive use and spillage of paints and solvents;
- Tank bunds where former 15,000L above ground diesel tanks supplied diesel to a hot water heater in the engine room via an underground fuel line (Removed from the site prior to the writing of the report);
- An engine room that contained a coal fired boiler. There was evidence of an oil spill in the engine room, and also a boiler blow-down pit with potential hydrocarbon contamination;
- A workshop building with two underground fuel storage tanks containing super and standard (leaded) petrol, as well as spillage of oils around a former maintenance pit.

- An open carport area filled with boiler ash and stained with sump oil, in close proximity to the Manning River;
- Gully area partly filled with boiler ash and formerly containing a slipway used for boat maintenance.
- Railway line with heavily greased points
- Burial pits adjacent to Sheathers machinery store used for former burial or farm machinery and parts.

The report summarised the above areas of known or suspected contamination and recommended additional assessment in these areas.

6.2.8 Conclusions

The report concluded that there were risks of contamination in each of the above areas and recommended targeted soil and groundwater sampling and analysis to assess contamination. This was undertaken and described in subsequent reports discussed below.

6.3 Envirosafe Australia , 2004

6.3.1 Scope

This report, which was conducted by Envirosafe Australia Pty Ltd for Synnott & Wilkinson is referenced as ESAM-04.084 “Sampling & Site Contamination Results, Dairy Farmers, Pitt Street Taree NSW” October 2004. The report describes sampling and analysis undertaken to target the areas of environmental concern identified by the previous Synnott & Wilkinson report.

Field sampling procedures are described in the report, and appear appropriate for work of this nature. The extent of the sampling undertaken and the findings of the work are outlined in the following sections.

6.3.2 Lot 6 and Lot D – The former fuel depot

Sampling was undertaken on the downslope perimeter of the fuel depot in the locations shown in Figure 3 below.

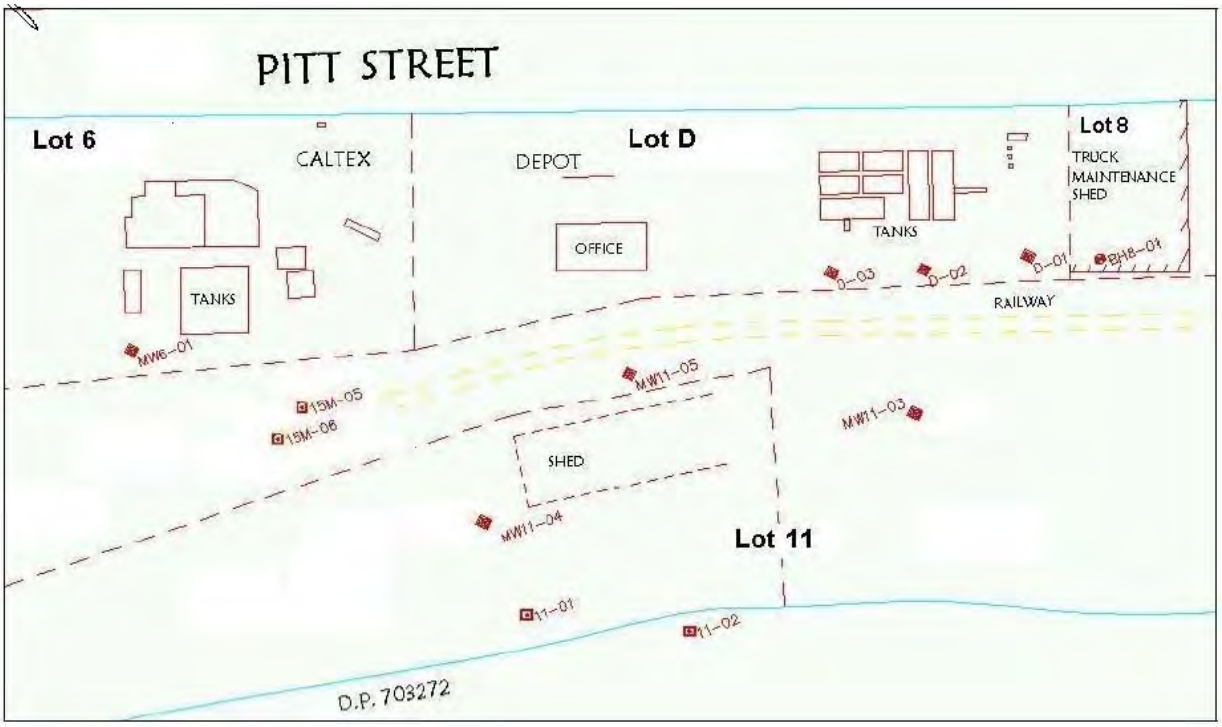


Figure 3: Extract from Envirosafe 2004 report showing sample locations on Lot 6, Lot D, the southwestern end of Rail Siding, and Vacant Lot 11.

Samples taken from this area were analysed for petroleum hydrocarbons and lead. Sampling included a borehole to 10.2m deep at location MW6-01. Soil samples taken at approximately 1m intervals in this location revealed no concentrations of hydrocarbons above guideline criteria. Sample locations D-01 to D-03 involved surface sampling and sampling to a maximum depth of 2.9m. Analysis revealed no concentrations of hydrocarbons or lead exceeding guideline criteria for residential development.

6.3.3 Lot 8 and C – The Concrete Plant

Sample Locations within the concrete plant area are shown in Figure 3 and Figure 4. These soil samples were taken from the ground surface and to maximum depths of 0.48m and were tested for petroleum hydrocarbons, heavy metals and PAH, which commonly accompany the presence of heavy oils and greases or partially combusted coal ash. Concentrations were below guideline values for residential development in all samples analysed.

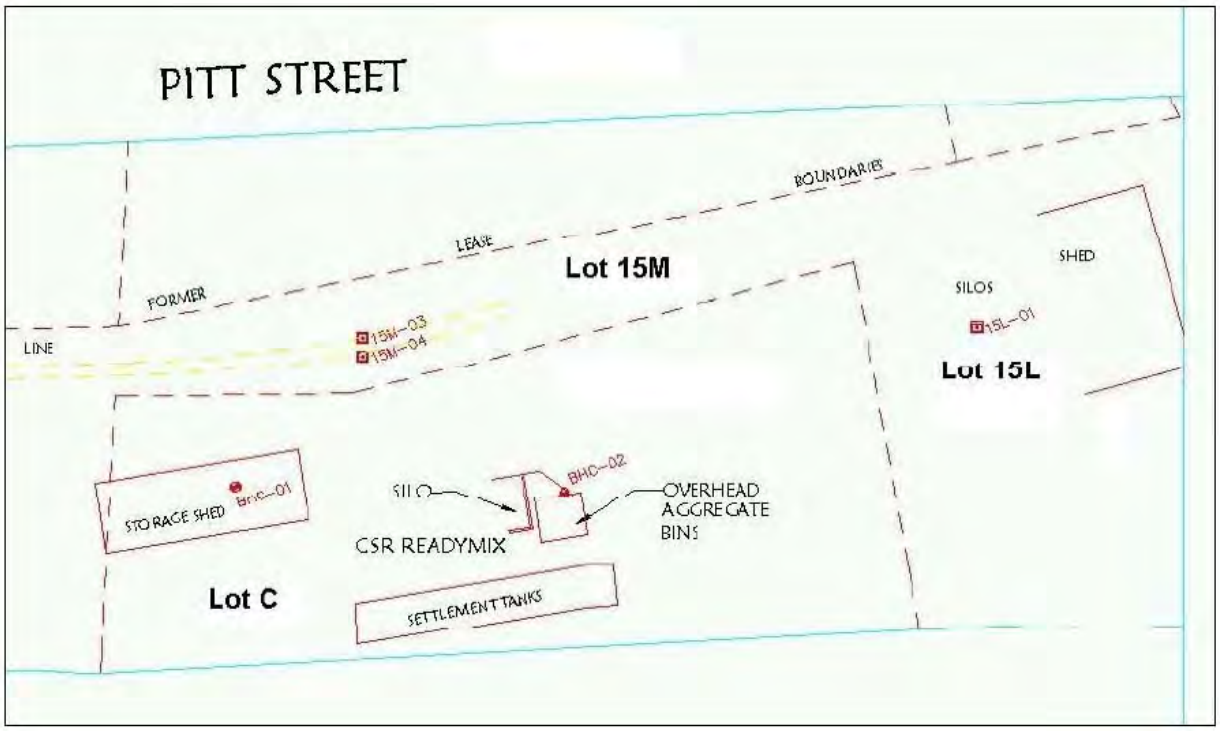


Figure 4: Extract from Envirosafe 2004 report showing sample locations within the existing Concrete Plant, part rail siding, and storage shed on vacant lot adjacent.

6.3.4 Lot 11 – The Vacant Filled Area

Sample locations within this area are shown on Figure 3 above. Samples were taken from the surface and to depths of up to 4m and analysed for petroleum hydrocarbons and heavy metals. A review of the results indicates no concentrations were encountered above guideline soil investigation levels for residential development in any of the samples analysed.

6.3.5 Lot B and E – The former Rural Store

Sampling undertaken in the former rural store is shown in Figure 4 as Lot 15L. Three samples were taken at this location at the surface, 0.45m deep and 1.5m deep. The samples were analysed for phenols, organophosphorus pesticides and organochlorine pesticides, polycyclic aromatic hydrocarbons (PAH) and Polychlorinated Biphenyls (PCB). A minor concentration of organochlorine pesticide was encountered in the surface sample. No other analytes were detected in any of the samples.

6.3.6 Lot F – The Fishermans Co-operative

Although the Fishermans Co-operative building itself was not an area of concern in relation to contamination, it was noted that the land in the adjacent gully had formerly contained a boat repair slipway and also contained fill believed to have consisted largely of ash from the coal fired boiler in the dairy factory. This area was therefore targeted by the sampling program at the locations shown in Figure 5. Samples were analysed for petroleum hydrocarbons and heavy metals. Concentrations of

these analytes were below guideline concentrations for residential development in all locations, with the exception of a cadmium concentration of 24mg/kg in location BH15K-03 that exceeded the guideline value of 20mg/kg for residential development, and lead concentration in location 15J-04 that exceeded concentrations for residential and recreational landuse but was within guidelines for commercial/industrial landuse.

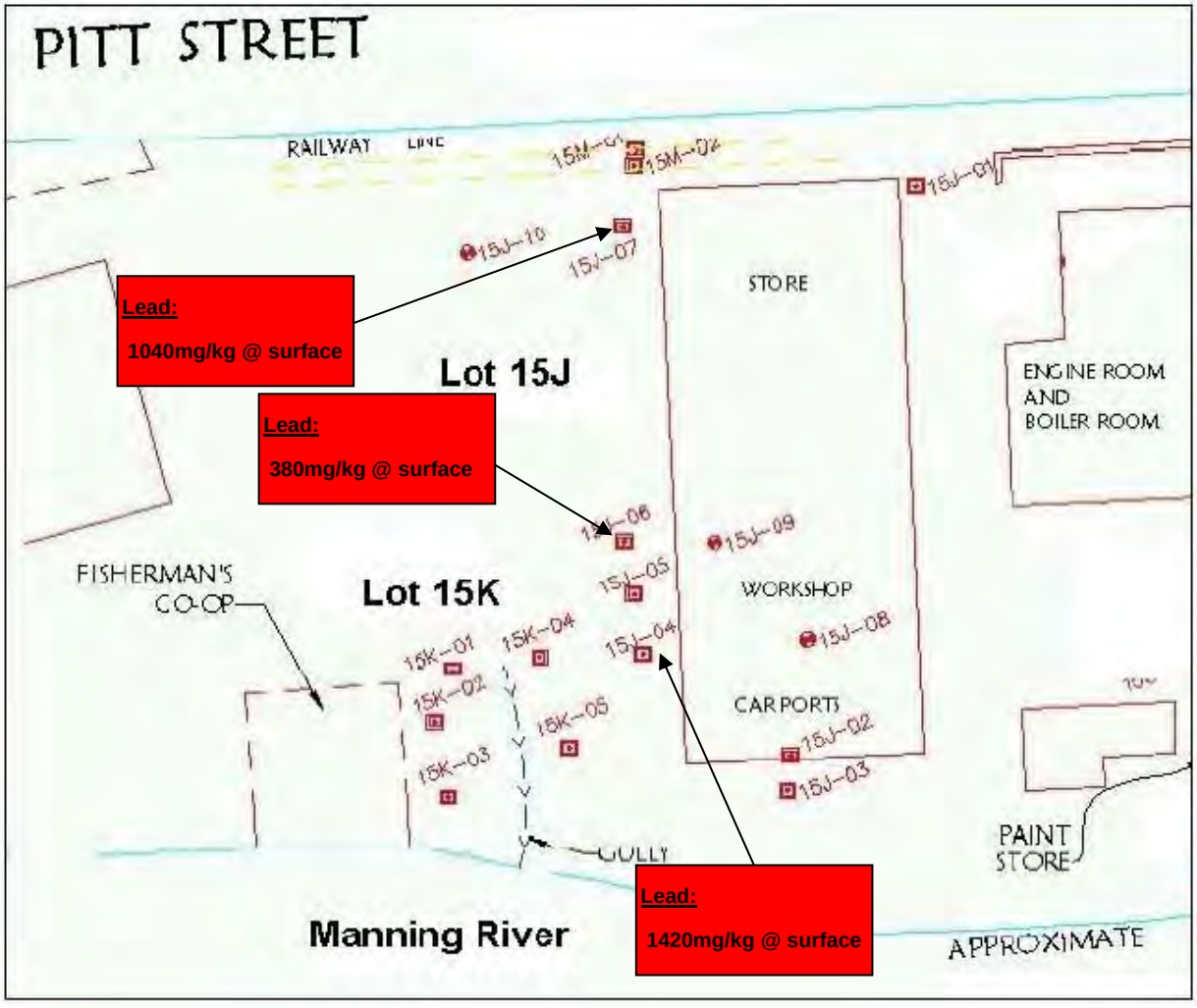


Figure 5: Extract from Envirosafe 2004 report showing sample locations in the filled gully adjacent to the Fishermans Co-operative building.

In relation to the investigations undertaken in this area it is notable that the analysis undertaken did not include contaminants commonly associated with the past landuses. In areas of former boat repair slipways it is good practice to analyse for polycyclic aromatic hydrocarbons (PAH) and Polychlorinated Biphenyls (PCB), that are often associated with engine oils, marine oils, refrigeration oils, and antifouling agents such as tar pitch often used on older timber boats. Testing for PAH should also be undertaken in soils containing coal ash. Tributyl-tin is also a common contaminant associated with former marine antifouling agents used up until the 1980's and should be tested for around older boat repair facilities.

6.3.7 Lot 15 – the Former Dairy Factory

Extensive sampling and analysis was undertaken in the former dairy factory, targeting areas of concern identified in the preliminary report. These are discussed below.

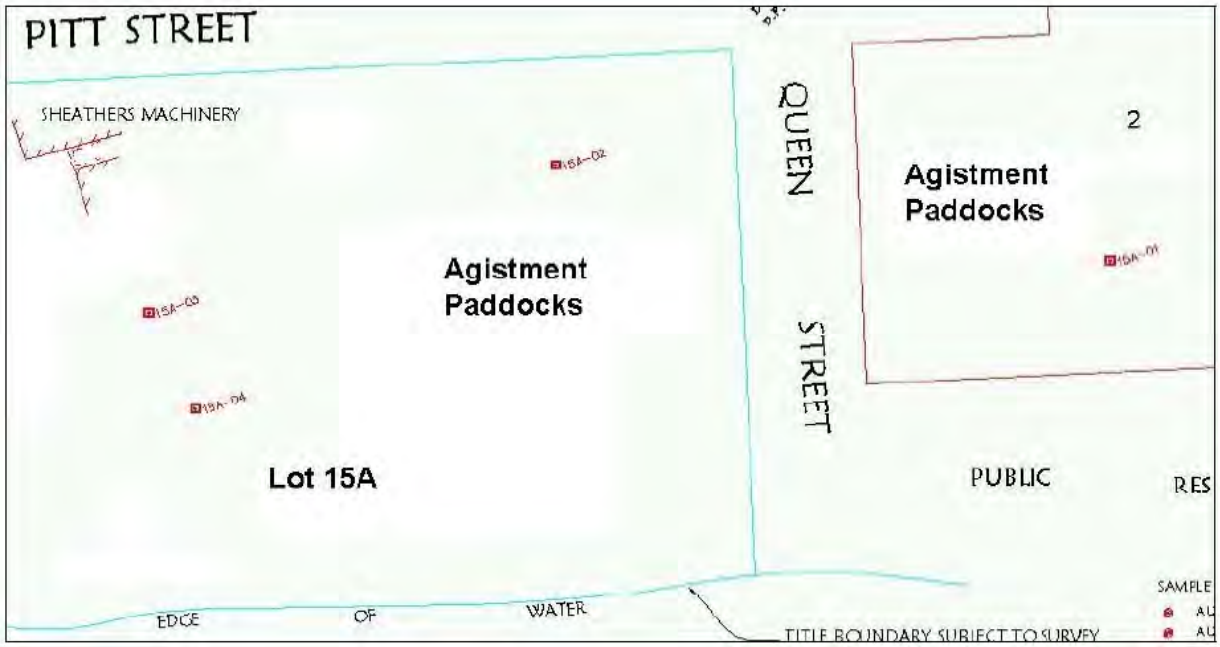


Figure 6: Extract from Envirosafe 2004 report showing sample locations in the agistment paddocks at the eastern end of Pitt Street.

Agistment paddocks

Samples were obtained from the agistment paddocks due to the presence of fill from unknown sources and the potential for the use of pesticide for rural application. The sample locations are shown on Figure 6. Samples were analysed for petroleum hydrocarbons, heavy metals, organochlorine pesticides, organophosphorus pesticides, and asbestos. No concentrations exceeding guideline values for residential development were detected.

Sheathers Farm Machinery

The previous investigations identified visible oil staining behind the Sheathers farm machinery building and also noted that this area was used to bury machinery parts in the past. Deposits of partially combusted ash were also noted. This area was sampled in the locations shown on Figure 7 and samples were tested for petroleum hydrocarbons, heavy metals and asbestos.

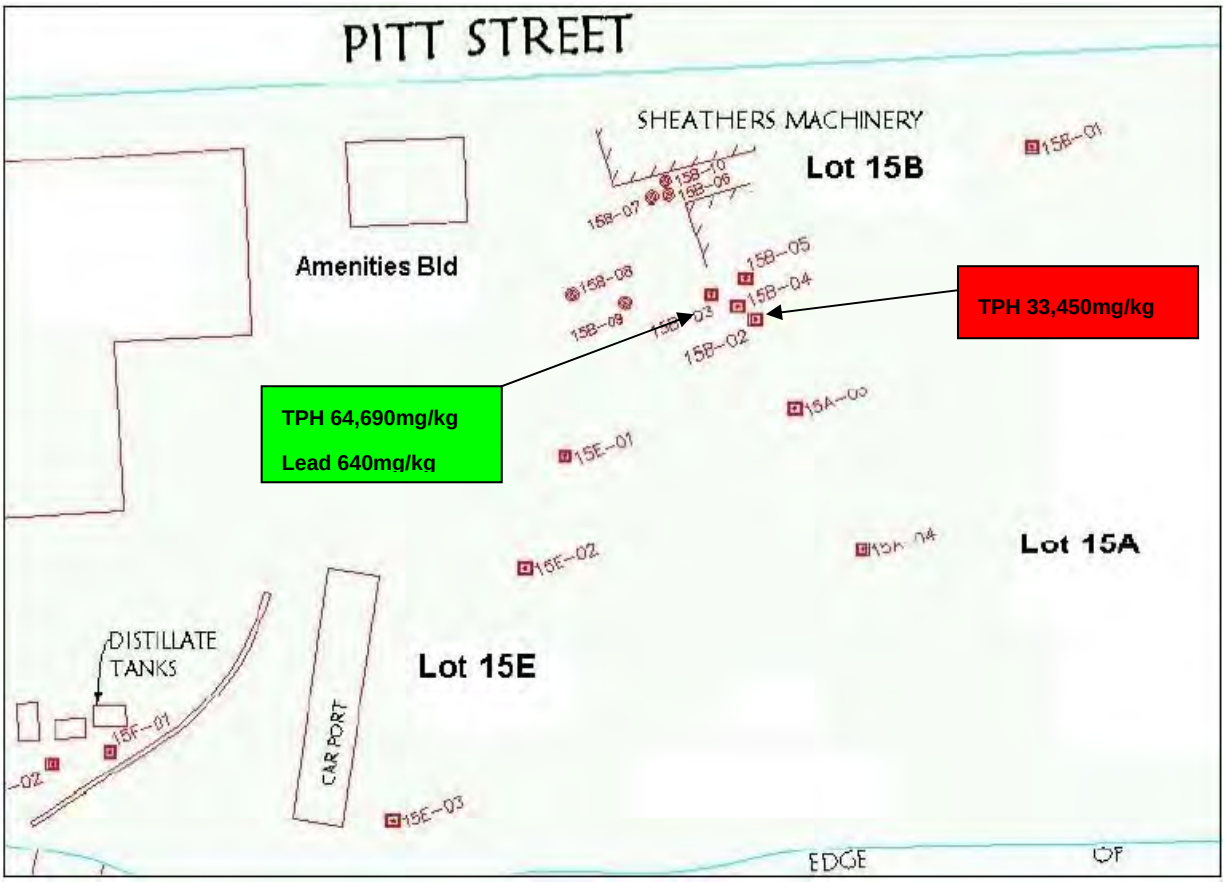


Figure 7: Extract from Envirosafe 2004 report showing sample locations behind the Sheathers building.

The results of the analyses indicate the following:

- Petroleum hydrocarbon concentrations in surface samples at locations 15B-02 (33,450mg/kg) and 15B-03(64,690mg/kg) exceed the guidelines in the C_{10}-C_{36} range for residential, recreational/open space, and commercial/industrial site usage. These locations are highlighted on Figure 7.
- Lead exceeded the concentration for residential land use in the surface sample at location 15B-03. The concentration of 640mg/kg also exceeded the guideline for parks and open spaces but was within guidelines for commercial/industrial land use.
- All other contaminants encountered were within guideline concentrations for residential development.

It is notable that the sampling and analysis did not include PAH which should be tested for in any area containing oil staining, disposed machinery, or ash fill.

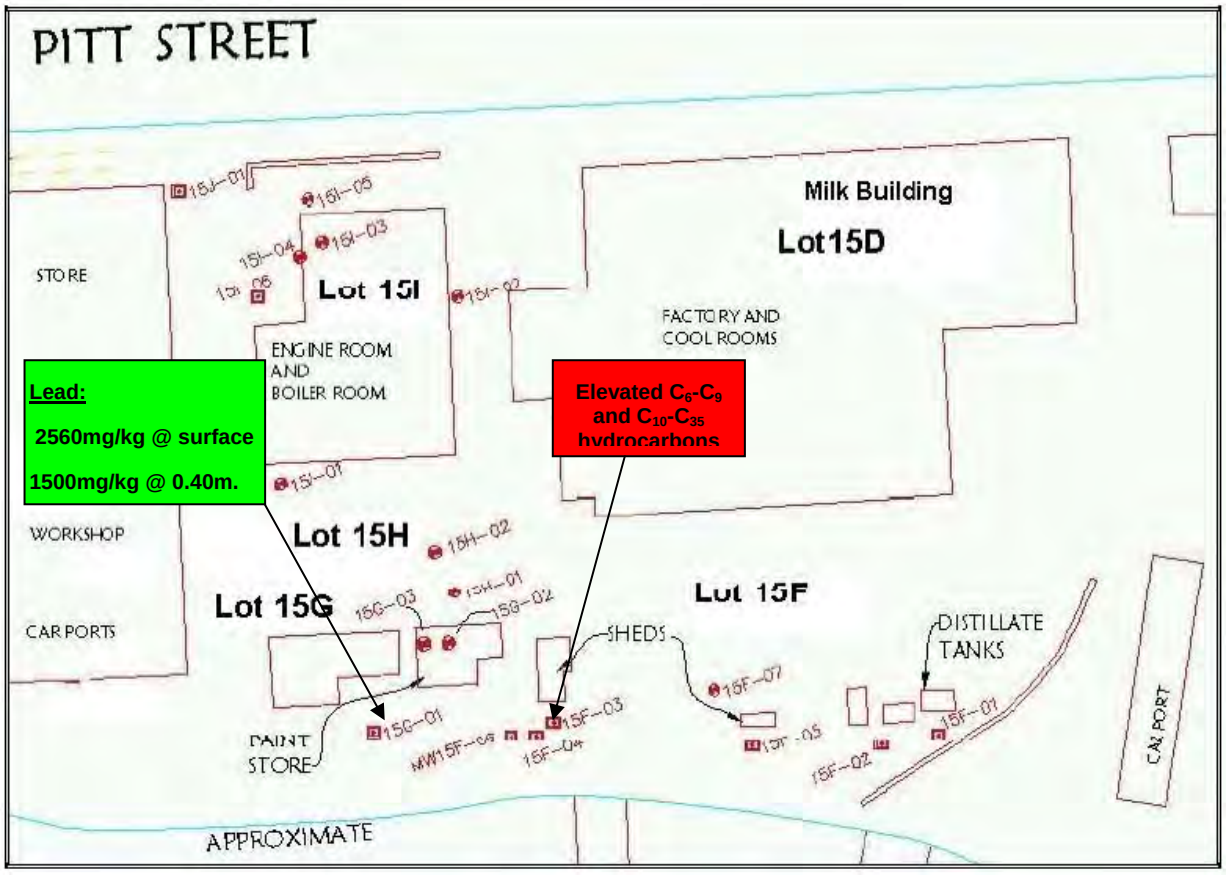


Figure 8: Extract from Envirosafe 2004 report showing sample locations over the remainder of the dairy factory.

Sample locations over the remainder of the dairy factory area are shown in Figures 7 and 8. The following points are noted in relation to this sampling and analysis:

- Petroleum hydrocarbon concentrations in the $C_{10} – C_{35}$ range in samples from location 15F-03 at depths of 2.7 and 4.0m exceeded guideline concentrations for residential land development, but were within guidelines for parks/recreational open spaces and commercial/industrial landuse.
- Concentrations in the short chain C_6-C_9 hydrocarbon range in these two locations, exceeded guideline values for residential, parks/recreational and commercial/industrial landuse. This is likely to have resulted from the presence of solvents or similar associated with the nearby paint shed;
- Lead concentrations in samples from 15G-01 exceeded guideline values for residential, parks/recreational and commercial/industrial landuse. This was also in close proximity to the paint store;
- Lead concentrations were also elevated in the locations shown on Figure 4.

6.3.8 Railway line

The sampling outlined in the report included numerous samples taken from the existing railway line. These were analysed for the presence of petroleum hydrocarbons, heavy metals and asbestos. Although petroleum hydrocarbons were detected in some samples, no concentrations in excess of residential landuse guidelines were encountered.

6.3.9 Groundwater

The investigations included an installation and sampling of groundwater monitoring wells at five locations. Analysis of groundwater samples indicated the following:

- Samples from MW6-01 and MW11-04, located between the Caltex Fuel depot and the river, revealed the presence of petroleum hydrocarbons. The concentrations encountered did not exceed threshold concentrations presented in NSW EPA "Guidelines for Assessing Service Station Sites, 1994";
- Concentrations of all other contaminants in all other locations did not exceed guideline values.

6.4 Synnot & Wilkinson, November 2004 - Remediation Action Plan

6.4.1 Objectives

This report presents a remediation action plan (RAP) based on the findings of the reports discussed above. The objectives of the RAP are stated as:

- Provide a site suitable for ongoing industrial landuse;
- Remove all known underground fuel tanks;
- Remove all underground structures that could in the future pose any risk; and
- Remove contaminated material close to the river bank which is above environmental investigation levels and for which there is a transport path to the river.

6.4.2 Adopted cleanup criteria

The RAP adopted criteria for industrial and commercial landuse presented in the National Environment Protection (Assessment of Site Contamination) Measure (NEPM), 1999 for the majority of the site. The only exception being areas close to the Manning River where there was deemed a risk of environmental harm due to contaminant transport into the river. For these areas NEPM Ecological Investigation levels were adopted. For assessment of petroleum hydrocarbons, where there were no guidelines provided by NEPM, the NSW EPA Guidelines for Assessing Service Station Sites (1994) were adopted. A summary of the adopted site acceptance criteria is presented in Table 3.

Table 3. Site Acceptance Criteria adopted by the RAP (mg/kg dry soil)

Contaminant	Health Investigation Level Commercial/Industrial	Ecological Investigation Level Interim Urban
TPH C_6-C_9	65	65
TPH C_{10}-C_{36}	1000	1000
Arsenic	500	20
Cadmium	100	3
Copper	5000	100
Lead	1500	600
Mercury (Inorganic)	75	1
Nickel	3000	60
Zinc	35000	200
Total PAH	100	
Organochlorine Pesticides	0	0

The adopted criteria are considered appropriate for the assessment of industrial/commercial landuse. It should be noted that since the time of the RAP and remediation works, new petroleum hydrocarbon guidelines have been published by NSW DEC. The new guideline concentrations exceed the 1994 Service Station guidelines adopted in the RAP and therefore cleanup to the criteria presented in the RAP would be over-conservative by comparison with current guideline values.

6.4.3 Remedial Actions

Remediation was separated into two categories – hydrocarbon contamination and heavy metal contamination. Areas of hydrocarbon contamination were excavated and the soil removed to an on-site biopile for remediation. Based on test results and on site observations the following areas were designated hydrocarbon remediation areas:

- Eastern and southern corners of Sheather's workshop
- Agistment paddock directly downslope from Sheathers workshop
- Former loading bay of Milk Building of the dairy factory
- Beneath tank bund between Paint Store and Engine Room of the dairy factory
- Next to concrete apron southern side of dairy factory workshop

- In the gully next to Fisherman's Co-operative
- At several places along the railway spur line

The RAP included a validation testing program aimed at indicating remaining soils were within guideline criteria. This involved sampling the base and sides of all excavations and submitting samples for analysis.

The excavated soils were to be stockpiled on a concreted and bunded section of the site, with straw and nutrients added for breakdown of hydrocarbons. Stormwater collected in the bunded area was to be sprayed back over the stockpile. Soils were to be tested on a monthly basis and if meeting criteria were to be either removed to Taree Council landfill or placed as backfill on site. The hydrocarbon remediation was also to include identified areas of Ethylene Glycol and Ammonia contamination.

Heavy metal concentrations were deemed to warrant remediation in the following locations:

- Vacant land at southwestern end of the site (Lot 11)
- Between the Paint Store and the river in the dairy factory site
- Adjacent to coal storage yard in dairy factory site
- In the gully next to the Fishermans Co-op.

Waste classifications using NSW EPA Guidelines were applied to all soil requiring removal. Soil meeting Solid Waste or Industrial Waste criteria was then to be removed to Taree Council Landfill. Soils classified as Industrial or Hazardous Waste were to be taken to the Readymix Concrete Plant on site where the following process was proposed:

- Add sulphuric acid to convert metals to sulphides;
- Add sodium silicate to polymerise;
- Mix the treated soil with concrete to form blocks, then allow to cure for 1 month;
- Conduct TCLP leachate tests on the cured blocks;
- If these tests pass criteria for Solid Waste, remove blocks to Taree Council landfill for disposal.

As with the hydrocarbon contamination, validation testing was to be undertaken on the sides and base of all excavations and additional soil removed if acceptance criteria were not met.

In addition to the above, a small quantity of asbestos cement sheeting was to be removed by a licensed contractor.

The proposed validation program involved collection and analysis of 116 soil samples from the remediated areas.

6.5 Synnot & Wilkinson. February 2006 - Site Investigation Report

6.5.1 Scope

A further report was prepared by Synnot & Wilkinson following the site remediation works. The objectives of the additional work were stated as:

- Conduct soil and groundwater sampling in identified areas of contamination as part of the RAP;
- Present the results as part of the clients management strategies;
- Remediate identified contamination to acceptable levels.

The report provides a summary of the site background, history, and setting as presented in the previous reports, and summarises the areas investigated and the areas deemed as contaminated and requiring remediation.

6.5.2 Groundwater

The information presented indicates a standing groundwater level beneath the site varying from 0.6m to 4.4m depth. Groundwater beneath the site was deemed to flow north to south, towards the river. Groundwater was not encountered in site excavations up to 6m deep, indicating the water to be present within confined aquifers in the sediment profile at greater depth than the measured standing water levels.

Groundwater monitoring was undertaken by sampling and analysis of monitoring wells placed during previous investigations. The samples were taken from six existing bores, checked for the presence of non-aqueous phase liquids (eg oils) and monitored for field parameters prior to submission to laboratories for chemical analysis. The following analyses were undertaken:

- Benzene, Toluene, Ethyl-benzene, Xylene (BTEX);
- Total Recoverable Hydrocarbons (TRH);
- Polycyclic Aromatic Hydrocarbons (PAH)
- Heavy metals
- Ethylene Glycol

Samples were also obtained from some standpipes found on the Caltex site (Lot 6). These samples were tested for TRH.

Results of groundwater analysis indicated the concentrations of TRH exceed guideline values in samples from the bores found on the Caltex fuel depot site, in bore MW6-01 installed on the downslope gradient of the site and in bore MW11-05 located beyond the down-gradient boundary. Laboratory analysis undertaken to identify the type of hydrocarbons present indicated the product encountered is likely to be diesel. Benzene concentrations and heavy metals concentrations in MW06 also exceeded adopted guideline values for recreational water usage or stock watering. The locations of groundwater bores in which contamination was encountered are shown in Figure 9.

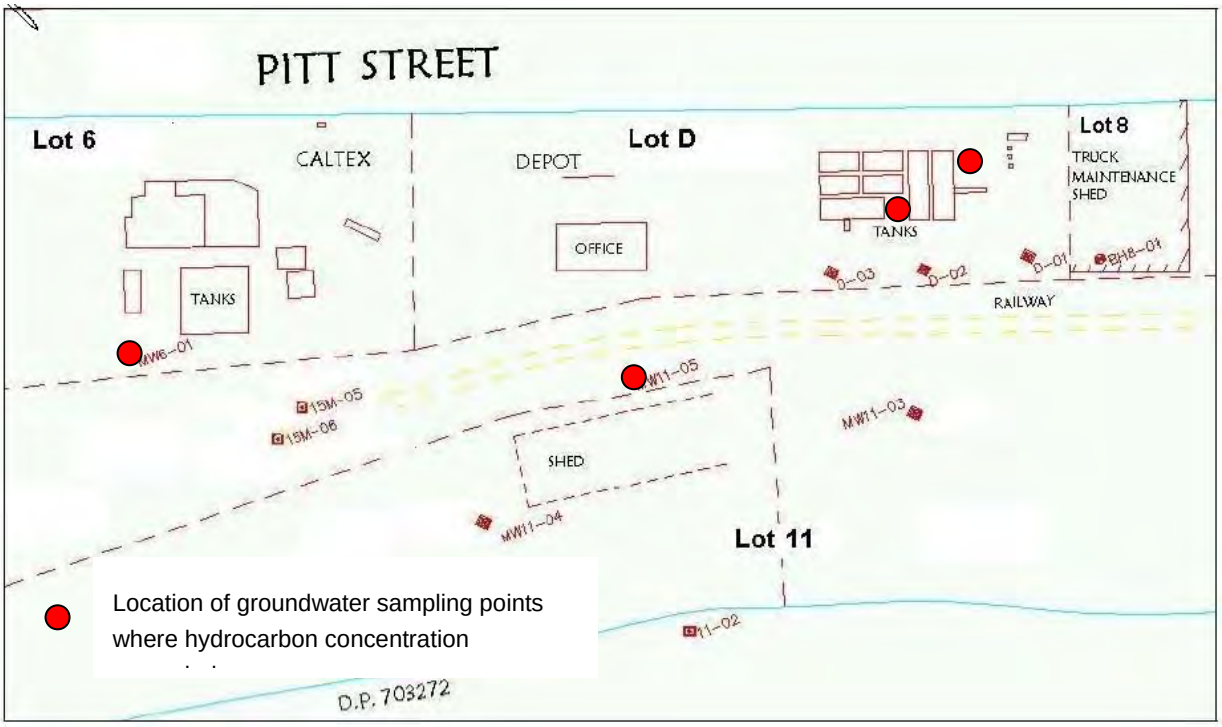


Figure 9: Groundwater sampling locations where hydrocarbon concentrations exceeded guidelines.

6.5.3 Soil

Soil sampling and analysis was undertaken to validate the excavations in remediated areas. This involved sampling in the base and walls of all excavations and some stepout sampling where required. Sampling was also undertaken periodically in the biopile to confirm remediation to acceptable levels. Soil samples were tested for TRH, PAH, Heavy metals, and some for ethylene glycol.

The validation sampling was undertaken in four stages. A total of 270 soil samples were collected and analysed. The majority of results were within ecological investigation levels and TRH concentrations were generally within NSW EPA guidelines for “Sensitive” landuse. The following exceedances were noted in the Stage 1 sampling:

- Fishermans Gully (adjacent to Fishermans Co-operative – concentrations of nickel (3630mg/kg) and chromium (5660mg/kg) exceeding health based guidelines for commercial/industrial sites;
- Dairy Factory site – one sample with a lead concentration exceeding commercial/industrial guidelines. The sample was taken adjacent to a former septic tank;

Several exceedances of the adopted TRH guideline of 1,000mg/kg were noted. However, in comparison with revised current day guidelines of 5600mg/kg for residential landuse only two samples exceeded guidelines. Compared to current guidelines exceedances occurred in 2 samples of fill from the agistment paddocks and one from the railway siding adjacent to Pitt Street, although some additional analysis should be undertaken to confirm that these concentrations do not contain aromatic species in excess of the more stringent 90mg/kg guideline range.

Soil samples from the bio-remediation pile were turned and doused with nutrient until testing indicated them to be within acceptable levels. Soil samples from heavy metal affected areas were stockpiled, leach tested, and subsequently classified as Solid waste. This allowed removal to Taree Council landfill.

Repeated excavation and validation sampling was undertaken. By the fourth stage of this work, all samples returned concentrations within the guideline values.

The report concluded that all identified issues of soil and groundwater contamination on the site had been remediated to acceptable levels. It is noted in the report that potential hydrocarbon contamination within the Caltex fuel depot site has not been addressed in the investigation. The report also notes that the site has a long history of industrial usage and there may be additional areas of contamination on the site that have not been identified during the investigations undertaken.

6.6 Robert Carr & Associates Pty Ltd. September 1999 - Big Oyster Site

The report addresses a site contamination assessment and remediation works undertaken for the former service station that occupied the Big Oyster site from September 1988 for a period of approximately 10 years.

According to information in the report, an earlier investigation had been undertaken involving ten boreholes targeting areas at the front of the site where underground fuel tanks and bowsers were located. No significant contamination was encountered in the boreholes and no recorded incidents of spillage or product loss were identified.

In the period July to August 1999 all underground fuel tanks, lines, and bowsers were excavated and removed from the site. In all, six 42,000 litre tanks were removed. The walls and bases of tank excavations were sampled and samples also taken from excavations below fuel lines.

Water encountered in tank excavations was treated by a specialist contractor prior to removal from the site. Excavated soils were placed in an on-site landfarm area for remediation. This mainly consisted of sand backfill from around the tanks which emitted a hydrocarbon odour. This was remediated over a period of three months. Samples collected after this remediation indicated the soils to meet the guideline criteria for hydrocarbons of that time, which were more sensitive than current guidelines.

The site was considered suitable for continued commercial/industrial usage on completion of the works. An appraisal of the results indicates no exceedances of current guidelines for more sensitive land uses such as residential or recreational.

6.7 DCP 45

Greater Taree City Council Development Control Plan No.45 “Procedures for the handling of Development Applications and Draft Local Plan - Requests Involving Contaminated Land” was reviewed as part of this project. The document outlines procedures for Council in recognition of its duty of care in relation to State Environmental Planning Policy (SEPP)55 – “Remediation of Land”, in particular in relation to consideration of the suitability of land for development or rezoning where the requests involve contaminated or potentially contaminated land.

The DCP includes a description of the type of materials which can cause contamination, and lists commercial activities and specific industrial land uses associated with site contamination. Of the listed

landuses, the following are known to have occurred or have a high likelihood of having occurred on the subject site:

- Disposal of wastes;
- Accidental spillage or leakage during plant operation;
- Migration of contaminants onto a site from neighbouring land;
- Agricultural/horticultural activities;
- Oil production and storage;
- Railway yards;
- Service station.

Section 6 of the DCP outlines procedures for an initial site evaluation to be conducted as part of any Development Application, which involves an assessment of past landuse and any previous site investigation reports undertaken for the site. If, on the basis of this initial evaluation, Council is satisfied that the initial evaluation does not suggest the land might be contaminated, the Development Application may proceed without further investigation. On this site, there is significant evidence of past contaminating activities, and under the DCP, further investigation would be required.

The DCP then outlines a sequence of further investigation based on NSW EPA Guidelines for Consultants Reporting on Contaminated Sites (1997), involving:

- Preliminary Investigation
- Detailed site investigation
- Remedial Action Plan
- Validation and Monitoring

The DCP also indicates that at any time throughout the above process, Council may request an independent site audit of the work undertaken.

The reports reviewed as part of this assessment indicate that there has been significant work undertaken and the majority of areas of environmental concern have been investigated and remediated. The work undertaken would not, however, satisfy current requirements for a detailed site investigation and should Council require an independent site audit by an accredited contaminated lands auditor, it is highly likely that an auditor would require further investigations be undertaken prior to issuing an audit statement indicating the site to be suitable for rezoning to a more sensitive landuse.

6.8 Council correspondence

Two items of Council correspondence were viewed in relation to the site.

6.8.1 Letter of 13 January 2005

Letter from DS Pasfield, Acting Manager, Environmental Health in relation to the Dairy Farmers Site, Lot 15, DP 703722, Pitt Street, Taree. The letter indicates several businesses have existed on the site that may have caused contamination, including a fuel storage depot, mechanical workshops, a milk

factory, agricultural stores and a concrete batching plant. The letter also notes that in relation to the Caltex Fuel depot, an extensive spill did occur "several years ago". The letter further states that Councils records do not indicate that a certificate of remediation was received following the spill.

6.8.2 Letter of 2 August 2005

This letter, from DS Pasfield, Acting Manager, Environmental Health, indicates a water pollution incident occurred at the fuel depot on 29 June 2005. It notes that there is acknowledgement of a revised maintenance schedule for the oil separator and main storage tank on site, and further notes that water sampling and testing by a NATSA approved laboratory is required, the results of which should be forwarded to Council.

There is no further correspondence to indicate whether this was carried out.

7 ADDITIONAL SAMPLING AND ANALYSIS

7.1 Sampling Plan

Following the site walkover and review of the available previous reports, some additional targeted sampling and analysis was undertaken. The purpose of this work was to check concentrations in areas identified in the walkover as potentially contaminated. The work was not aimed at satisfying all deficiencies in previous reports. The sampling rationale are outlined below:

- There is known contamination in the fuel storage depot in close proximity to the river. It will be important to gain an early indication of whether the fuel depot has impacted on groundwater adjacent to the river. Therefore two groundwater sampling and monitoring wells were installed between the existing fuel depot and the river as part of this initial study;
- In areas where the rail line did not appear to have been remediated, shallow soil sampling was undertaken at four locations to check for the presence of hydrocarbons due to fuels or oil spillage/leakage, and for residue from the spraying of pesticides.;
- Two samples obtained in the agistment paddock downslope of the Big Oyster to check for contamination due to runoff from the vehicle workshops or former service station.
- One sample from the filled area with visible surface ash within the southwestern corner of the Dairy Farmers site.

7.2 Sampling method

Field work was completed on 21 and 22 August 2007 and comprised two boreholes drilled using a 4WD mounted rig equipped with continuous spiral flight augers as well as surface sampling at targeted locations. Boreholes BH1 and BH2 were drilled between the fuel depot and the river, in the locations shown on Figure 9 attached.

The boreholes were drilled to depths of 5.6m sand 6.5m, and groundwater monitoring wells were installed in each, sealed from the surface with a bentonite seal to prevent ingress of surface water.

Groundwater was encountered at depths of 4.5m in each hole. The wells were left to stand for one week and then purged to remove stagnant water. Water samples were then obtained using disposable bailers, placed in laboratory supplied pre-treated sample bottles and placed on ice in cooler boxes on site for transport to the testing laboratory under Chain of Custody conditions.

Near surface soil samples were then taken from the remainder of the locations marked on Figure 10. These samples were obtained using a stainless steel trowel and were placed in laboratory supplied sample jars and placed on ice in cooler boxes on site for transport to the testing laboratory under Chain of Custody conditions.

All field work was completed in the full time presence of a Senior Geotechnician or Principal Engineer who located the boreholes, collected samples and produced field logs. The engineering logs are presented in Appendix A, together with explanation sheets defining the terms and symbols used in their preparation.

7.3 Subsurface Conditions

The boreholes at the southern end of the site near the fuel depot encountered a profile of imported fill overlying high plasticity alluvial clays. These were underlain at depths of 3m and 4.1m in BH1 and BH2 respectively by residual clay soils, also of high plasticity. Groundwater was encountered 4.5m below ground level in each location which would be close to the level of the adjacent river. Weathered rock was encountered at approximately 5.5m depth.

7.4 Field Quality Assurance/ Quality Control

Environmental sampling activities were based on procedures and protocols outlined in Coffey's Environmental Field Manual (QP15/5-E, June 1995, revised September 1997) which is based on industry accepted standard practice.

The stainless steel trowel and hand auger used for sampling were decontaminated between samples by washing in a solution of phosphate free decontaminant and deionised water.

7.5 Laboratory Analysis

Soil samples were dispatched under chain of custody conditions to ALS, a NATA registered laboratory for the analysis undertaken. Soil samples were analysed for:

- Heavy Metals in soil (Cu, Pb, Zn, Cr , Ni, As, Hg);
- Total Petroleum Hydrocarbons (TPH;
- Benzene, ethylbenzene, toluene and xylene (BTEX);
- Polycyclic aromatic Hydrocarbons (PAH);
- Organochlorine and Organophosphorus Pesticides (OC/OPP);

The analytical report is included in Appendix B.

7.6 Analysis Results

Analysis results are presented in Appendix B. Concentrations of all analytes in all soil samples tested were within ecological and health based guideline values for residential and less sensitive land uses.

Groundwater samples from BH1 revealed no contaminants within detectable limits. In location BH2A concentrations of petroleum hydrocarbons were encountered up to 690 micrograms per litre for petroleum hydrocarbons, which exceed the Dutch (1994) Intervention Value of 325ug/L normally used for evaluation of hydrocarbons in groundwater in NSW. These are likely to be a result of fuel spillages at the former fuel depot rail loading facility and/or leakages from the fuel depot itself. The extent of this groundwater plume should be further investigated.

7.7 Conclusions regarding contamination

On the basis of the site walkover, review of past reports, and limited sampling and analysis undertaken as part of this assessment, the following points are noted:

- The fuel depot at the southwestern end of the site is a significant area of concern from a contamination perspective;
- The facility has been decommissioned and is undergoing demolition;
- Groundwater beneath the fuel depot contains contamination by petroleum hydrocarbons that from the test results obtained appear to be related to the presence of diesel;
- This area should be subjected to a detailed site contamination assessment;
- Remediation will be required within and adjacent to the fuel depot area;
- The extent of contamination downslope of the fuel depot should be investigated further. In particular, further wells should be installed and monitoring undertaken, to assess the extent and degree of groundwater contamination.
- The majority of the site on the southern, or river side of Pitt Street has been used for a variety of industrial purposes;
- Several phases of site investigation have been conducted over this area, resulting in identification of areas of contamination that were subsequently remediated;
- On the basis of the above the majority of the site would be considered suitable for landuses including residential, recreational, or commercial uses;
- The previous assessment and remediation work, although comprehensive, were not exhaustive, and therefore there may be some areas of contamination present within the study area. In particular, areas containing ash fill or visible surface staining should be further assessed;
- The Big Oyster site was formerly used as a service station. Underground tanks and associated lines were removed in 1999. The area was remediated and validated following the removal of the tanks.

7.8 Recommended further investigation

It is noted that the sampling densities undertaken on the site to date do not fully comply with NSW EPA Contaminated Sites Sampling Design Guidelines (1995), and as such the work conducted to date would not support a change to a more sensitive landuse. Additional work will therefore be required which should include, but not be limited to:

Fishermans co-op

Testing in this area and in particular the adjacent gully did not include analysis for In relation to the investigations undertaken in this area it is notable that the analysis undertaken did not include polycyclic aromatic hydrocarbons (PAH) or Polychlorinated Biphenyls (PCB). Tributyl-tin is also a common contaminant associated with former marine antifouling agents used up until the 1980's and should be tested for.

It is therefore recommended that further sampling and analysis of surface soils around the former slipway and fill soils in the gully be undertaken and these soils should be tested for:

- Heavy Metals
- PAH
- TRH
- PCB's
- Tributyl-tin (near slipway/repair area)

In relation to the area previously remediated on this part of the site, further TRH analysis should be undertaken to confirm that remaining hydrocarbons do not include aromatics above the more stringent 90mg/kg range.

Lot 15 – The dairy factory

It is notable that the sampling and analysis did not include PAH which should be tested for in any area containing oil staining, disposed machinery, or ash fill.

The filled areas of the site should be re-sampled and analysed for PAH, particularly in areas towards the southern site boundary where there is visible ash and oil staining.

As with the Fishermans Co-operative area, further TRH analysis should be undertaken to confirm that remaining hydrocarbons do not include aromatics above the more stringent 90mg/kg range.

The fuel depot

The fuel depot at the southwestern end of the site is a significant area of concern from a contamination perspective, with only limited information available on past site investigations. Groundwater beneath the fuel depot contains contamination by petroleum hydrocarbons. This area should be subjected to a detailed site contamination assessment.

The assessment should follow DEC guidelines for investigation of soil and groundwater and should include a systematic grid of sample locations from across the site as well as specific sample locations to target areas of most likely contamination. These will include:

- Bunded areas of former above ground tanks
- Underground storage tanks
- Truck and train tanker loading and unloading facilities
- Former bowsers and fuel lines
- Area surrounding drum storage and filling sheds.

Groundwater from on and off site locations should be sampled and analysed. Investigations should also include screening for ionisable vapours within the site soils and surrounding areas.

Samples should be analysed for:

- Heavy Metals
- PAH
- TRH
- BTEX compounds

Given the nature of the past site usage and the likelihood of contamination, an accredited Contaminated Lands Auditor should be appointed for the purposes of auditing the investigations, prior to accepting the status of the land and its suitability for rezoning to a more sensitive landuse.

Lot 11 – The vacant area downslope of the fuel depot

The extent of contamination downslope of the fuel depot should be investigated further. In particular, further wells should be installed and monitoring undertaken to assess the extent and degree of groundwater contamination. Additional soil sampling is required in areas adjacent to the fuel depot, in particular adjacent to rail tanker unloading areas. The filled areas should also be further investigated for the presence of unknown contamination.

Investigations in this area should be designed on a systematic grid basis to ensure a thorough coverage of the site in accordance with NSW EPA Sampling Design Guidelines.

Area behind Sheathers machinery

This area was previously investigated and remediated, however, the appeared to be insufficient testing for the presence of PAH's. Considering the use of the area to bury and burn machinery it is recommended that a grid of sampling points be established to further sample for the presence of PAH in the remaining soils.

Prior to rezoning, it is recommended that a site auditor be engaged to discuss the provision of a site audit statement for rezoning to a more sensitive landuse.

8 ACID SULFATE SOILS

8.1 Background information regarding ASS

Acid Sulfate Soils (ASS) are soils which contain significant concentrations of pyrite which, when exposed to oxygen, in the presence of sufficient moisture, oxidises, resulting in the generation of sulfuric acid. Unoxidised pyritic soils are referred to as potential ASS. When the soils are exposed, the oxidation of pyrite occurs and sulphuric acids are generated, the soils are said to be actual ASS.

Pyritic soils typically form in waterlogged, saline sediments rich in iron and sulfate. Typical environments for the formation of these soils include tidal flats, salt marshes and mangrove swamps below about RL.2m AHD. They can also form as bottom sediments in coastal rivers and creeks.

Pyritic soils of concern on low lying NSW and coastal lands have mostly formed in the Holocene period, (ie, 10,000 years ago to present to day) predominantly in the 7,000 years since the last rise in sea level. It is generally considered that pyritic soils which formed prior to the Holocene period (ie. >10,000 years ago) would already have oxidised and leached during periods of low sea level which occurred during ice ages, exposing pyritic coastal sediments to oxygen.

8.2 Possible impacts of ASS

Disturbance or poorly managed development and use of acid sulfate soils can generate significant amounts of sulfuric acid, which can lower soil and water pH to extreme levels (generally <4) and produce acid salts, resulting in high salinity.

The low pH, high salinity soils can reduce or altogether preclude vegetation growth and can produce aggressive soil conditions which may be detrimental to concrete and steel components of structures, foundations, pipelines and other engineering works.

Generation of the acid conditions often releases aluminium, iron and other naturally occurring elements from the otherwise stable soil matrices. High concentrations of some such elements, coupled with low pH and alterations to salinity can be detrimental to aquatic life. In severe cases, affected waters flowing off-site into aquatic ecosystems can have detrimental effect on aquatic ecosystems.

8.3 ASS Risk Maps

Reference to the Taree 1:25,000 Acid Sulfate Soils Risk map published by the NSW Department of Land and Water Conservation indicates the site contains no known occurrence of ASS in elevated areas of residual soils.

Adjacent to the Manning River, particularly in the low lying area at the northeastern end of the agistment paddocks, an alluvial plain with a high probability of ASS between 1m and 3m from ground surface is marked. The low-lying drainage depression surrounding the creek that flows through the eastern end of the site is identified as an alluvial channel with a high probability of ASS between 1m and 3m below the ground surface.

8.4 Sampling and ASS Screening Tests

Eight locations were sampled to the depths of up to 4.5m in the locations shown on Figure 10 attached.

Samples were obtained at 0.5m intervals and returned to our Tuncurry Laboratory where they were screened for the presence of actual or potential ASS using methods 21Af and 21Bf of the ASSMAC Acid Sulfate Soils Manual. Acid sulphate screening was also conducted on samples from the groundwater monitoring well boreholes. Results of ASS screening tests are presented in Appendix C.

The boreholes BH3 to BH5 and BH16 located in the northern and eastern part of the site revealed shallow alluvial clay soils overlying residual clays and weathered rock within 3m of the ground surface. Along the frontage to the Manning River, in locations BH17 to BH20, deeper alluvial clays were encountered to the maximum depth investigated of approximately 3.5m.

The following points are noted in relation to the screening:

- pH values of less than 4 in samples in distilled water are considered indicative of actual ASS. Such values were obtained in none of the samples screened;
- pH values of less than 3 in soil samples mixed in 30% hydrogen peroxide are considered indicative of Potential ASS. Values of less than 3 were encountered in the samples summarised below:

  - BH16; 1.5-2.0m: 1.48
  - BH17; 2.5-3.0m: 2.06
  - BH17; 3.0-3.5m 2.35
  - BH18; 2.5-3.0m: 2.11
  - BH20; 3.0-3.5m 1.56

On the basis of the above it appears that there are potential acid sulfate soils within natural soils adjacent to the Manning River.

8.5 Results of ASS Analysis

On the basis of the screening test results, samples from the low lying area adjacent to the manning River were selected for more detailed analysis. Samples from the locations outlined above were delivered to ALS analytical laboratories under chain of custody conditions. Results are presented in Appendix C. To evaluate the results of the ASS analysis, Action criteria from the ASSMAC ASS Manual were adopted. Results are compared to these criteria in Table 4.

TABLE 4. RESULTS OF ASS ANALYSIS

Location	Depth (m)	Tiratable Peroxide Acidity (TPA)		Peroxide Oxidisable Sulfur (S_{POS} %)	Liming Requirement (kg $_{lime}$/t_{soil})
		Total (mol/t)	Sulfidic (%)		
BH17	2.5 – 3.0	**1150**	**1.85**	**2.00**	95
BH17	3.0 -3.5	**454**	**0.73**	**0.92**	44
BH18	2.0 – 2.5	<2	<0.02	**0.04**	2
BH18	2.5 -3.0	**840**	**1.35**	**1.62**	77
BH19	2.0 -2.5	<2	<0.02	0.02	2
BH19	2.5 – 3.0	<2	<0.02	<0.02	<1
BH20	2.0 – 2.5	<2	<0.02	<0.02	1
BH20	3.0 -3.5	**78**	**0.12**	**0.16**	9
Action Criteria for disturbance of less than 1,000 tonnes of soil					
Coarse (Sands to loamy sands)		18	0.03	0.03	
Medium (Sandy loams to light clays)		36	0.06	0.06	
Fine (Medium to heavy clays and silty clays)		62	0.1	0.1	
Action criteria for disturbance of more than 1,000 tonnes of soil					
All soils		18	0.03	0.03	

The results shown in Table 4 indicate that there are strong acid sulfate soils in the area adjacent to the Manning River. These results indicate the ASS potential to be predominantly in the silty sands and clays below 1m depth. The extent of the potential acid sulfate soils is delineated approximately on Figure 11.

8.6 Possible ASS Management Strategies

It is understood some possible development proposals include dredging a marina in the low lying eastern part of the site adjacent to the Manning River. Testing indicates potential ASS in this area as estimated on Figure 10. There is therefore a high likelihood that these excavations, and other detailed excavations for service trenches etc will expose ASS.

There are several options for managing ASS. One method is to design the development in such a way that excavation of ASS is avoided. This however, is not always practical and for the purposes of the proposed development such a strategy would sterilize a significant proportion of otherwise developable waterfront land.

The most common method of treating ASS is to treat the excavated soil with lime. This then allows the soil to either be disposed of, or if suitable from a geotechnical perspective, be re-used on the site as fill once neutralised to acceptable levels. The results of the testing undertaken to date indicate large quantities of lime may be required for this option to be effective.

An alternative that would seem to be available on this site is to delineate the lateral and vertical extent of ASS, then excavate soils as required. In ASS areas, over-excavate, removing non-ASS soil from beneath the ASS layer, and bury the potential ASS back below the water table so that oxidation cannot occur. For bulk excavation such as in the proposed marina this may be more economic that the alternative treatments such as liming.

Other technologies are available and could be explored once more details of the proposed development are known. It is recommended that more detailed investigations be undertaken to define the extent and concentrations of ASS prior to developing a management plan once more details of the proposed development are known.

9 LIMITATIONS

The findings of this assessment are the result of discrete and specific sampling methodologies, involving sampling from predetermined locations within the soil profile. Whilst it is considered that the results obtained are likely to be representative of conditions on the site, the existence of undetected contamination or ASS between sampling locations cannot be precluded.

The report has incorporated the findings contained within reports prepared by other parties. The information obtained from the reports has been adopted in good faith by Coffey and no check of the accuracy or otherwise of the information have been undertaken.

For and on behalf of Coffey Geotechnics Pty Ltd

Steven Morton

Principal

Figures

drawn	SRM
approved	
date	10-9-07
scale	nts
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	SINCLAIR KNIGHT MERZ
project:	PITT STREET WATERFRONT, CHATHAM ACID SULPHATE SOILS AND CONTAMINATION ASSESSMENT
title:	EXTENT OF STUDY AREA
project no: GEOTTUNC01736AA-AC	figure no: FIGURE 1

LEGEND:

- AEC1: Former Fuel depot
- AEC2: Rail siding
- AEC3: Vacant filled area
- AEC4: Concrete plant
- AEC5: Dairy factory
- AEC6: Rural store
- AEC7: Big Oyster, car retailer and former service station
- AEC8: Filled gully adjacent to Fishermans Co-operative

drawn	SRM
approved	
date	11-9-07
scale	NTS
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: **SINCLAIR KNIGHT MERZ**

project: **PITT STREET WATERFRONT, CHATHAM ACID SULPHATE SOILS AND CONTAMINATION ASSESSMENT**

title: **AREAS OF ENVIRONMENTAL CONCERN**

project no: **GEOTTUNC01736AA-AD**

figure no: **FIGURE 2**

LEGEND:

- Groundwater well
- X Contamination sample
- X ASS Sample

drawn	SRM	client:	GREATER TAREE CITY COUNCIL
approved		project:	PITT STREET MARINA PRECINCT TAREE
date		title:	PROPOSED SAMPLE LOCATIONS
scale		project no: GEOTTUNC01736AA-AB	figure no: FIGURE 3
original size	A4		

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

LEGEND:

- Groundwater well
- Contamination sample
- ASS Sample

drawn	SRM
approved	
date	14/9/07
scale	nts
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

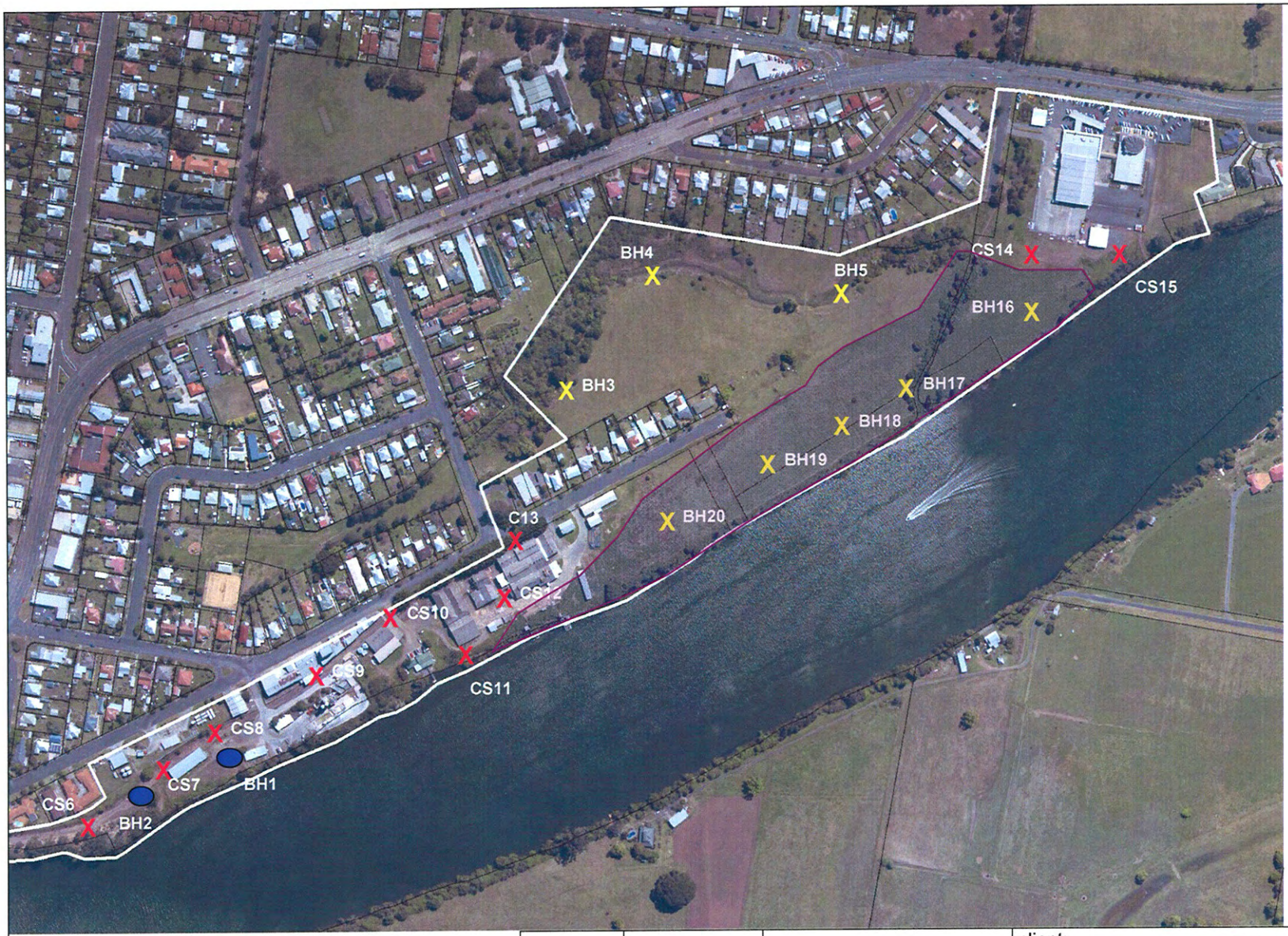
client: GREATER TAREE CITY COUNCIL

project: PITT STREET MARINA PRECINCT TAREE

title: SAMPLE LOCATIONS

project no: GEOTTUNC01736AA-AD

figure no: FIGURE 10



LEGEND:

- Groundwater well
- Contamination sample
- ASS Sample
- Inferred extent of ASS

drawn	SRM
approved	
date	14/9/07
scale	nts
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	GREATER TAREE CITY COUNCIL
project:	PITT STREET MARINA PRECINCT TAREE
title:	INFERRED ZONE OF POTENTIAL ASS
project no: GEOTTUNC01736AA-AD	figure no: FIGURE 11

Appendix A

Borehole logs and explanation sheets

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material — Structure and fabric of parent rock visible.

Residual soil — Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil — Deposited by wind.

Alluvial soil — Deposited by streams and rivers.

Colluvial soil — Deposited on slopes (transported downslope by gravity).

Fill — Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.

Lacustrine soil — Deposited by lakes.

Marine soil — Deposited in ocean basins, bays, beaches and estuaries.

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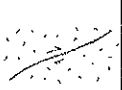
Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(About the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
		SILTS & CLAYS Liquid limit less than 50	**DRY STRENGTH**	**DILATANCY**	**TOUGHNESS**			
			None to Low	Quick to slow	None		ML	SILT
			Medium to High	None	Medium		CL	CLAY
			Low to medium	Slow to very slow	Low		OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium		MH	SILT
			High	None	High		CH	CLAY
			Medium to High	None	Low to medium		OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit W_L less than 35%. • Modium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, I_S50 (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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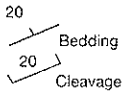
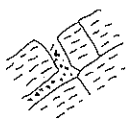
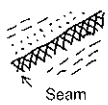
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS	
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS	
Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS	
Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS	
Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

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