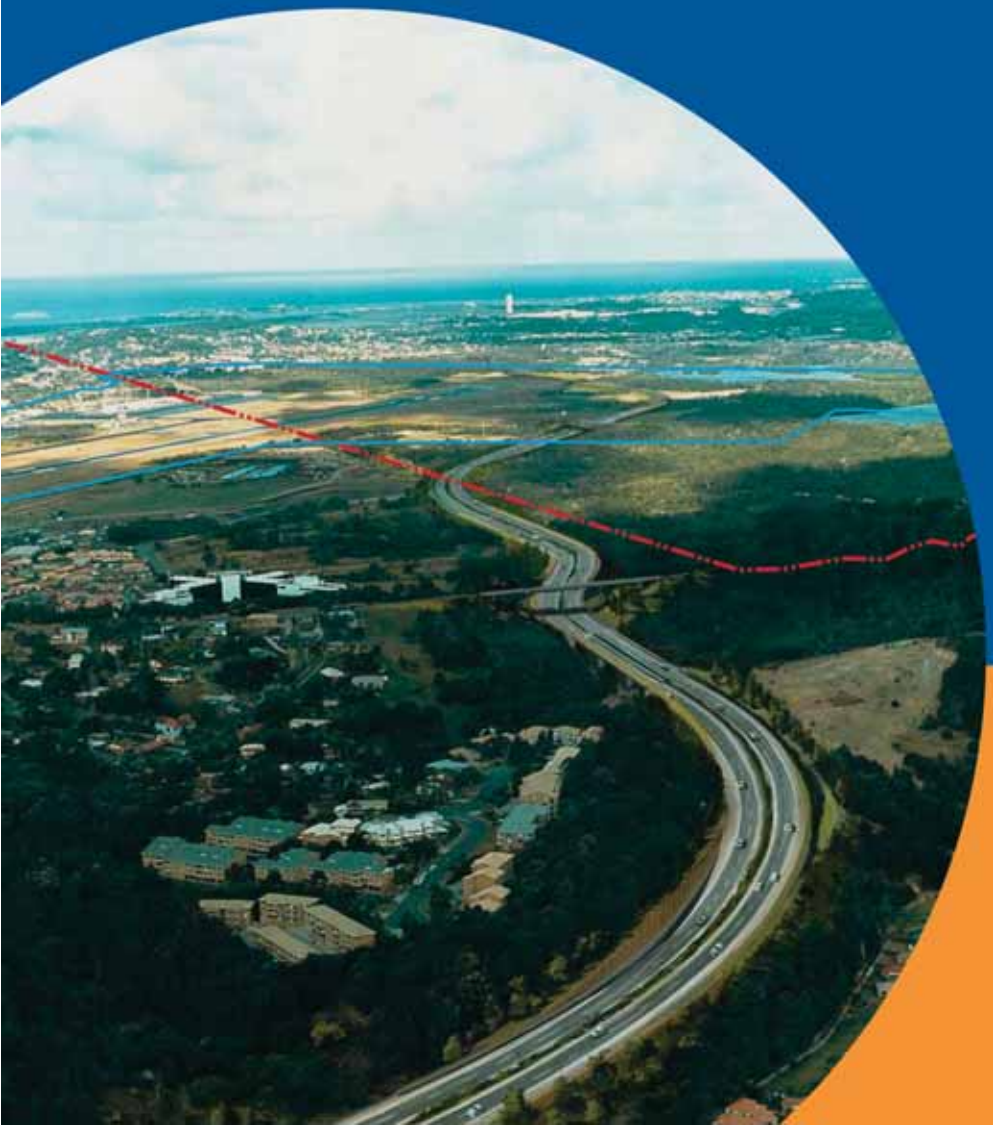
Australian Government
Department of Transport and Regional Services

RTA

Queensland Government
Department of Main Roads

TUGUN BYPASS

stewart road to kennedy drive



Technical Papers

December 2004

Tugun Bypass Environmental Impact Statement

Technical Paper Number 6 Contaminated Land

Tugun Bypass Alliance

Parsons Brinckerhoff

348 Edward Street
Brisbane Qld 4000
GPO Box 2907
Brisbane Qld 4001
Australia

Telephone: + 61 7 3218 2222
Facsimile: + 61 7 3831 4223
E-mail: brisbane@pb.com.au

ABN 84 797 323 433

NCSI Certified Quality System to ISO9001

Parsons Brinckerhoff Australia Pty Limited ACN 078 004 798 and
Parsons Brinckerhoff International (Australia) Pty Limited ACN 006 475 056 trading as Parsons Brinckerhoff
ABN 84 797 323 433

Queensland Department of Main Roads – South Coast Hinterland District

36-38 Cotton Street
Nerang Qld 4211
PO Box 442
Nerang Qld 4211
Australia

Telephone: + 61 7 5583 8111
Facsimile: + 61 7 5583 8100
E-mail: www.SouthCoast@mainroads.qld.gov.au

November 2004
2134070A-PR048Car

Contents

Contents (continued)

Page Number

List of Tables

List of Figures

List of Appendices

Glossary

Term	Meaning
Acid sulphate soils	Soils containing chemicals (generally sulphates) which have the potential to generate acid on oxidation.
AES	Airport Environmental Strategy
AFFF	Aqueous Film Forming Foam
AHD	Australian Height Datum. Zero is approximately mean sea level.
Aquifer	A geological strata containing groundwater.
AOX	Absorbable Oxygenated Halogens
BOD	Biological Oxygen Demand
BTEX	Benzene, Toluene, Ethly-benzene, xylenes
Buffering	A solution containing weak acid and its conjugate weak base, the pH of which changes only slightly on the addition of an acid or alkali.
Development of monitoring well	A process of removing a volume of water from monitoring wells equivalent to five times the volume of the water in the well. The process ensures that the sample collected from the well is representative of the groundwater within the aquifer.
EMR	Environmental Management Register
Gauging of a monitoring well	Measurement of the free standing water level in the well
KCl	Potassium chloride
MEK	Methy Ethyl Ketone, (2-butanone)
NATA	National Association of Testing Authorities
PAH	Poly-Aromatic Hydrocarbons
POCAS Test	Peroxide Oxidation Combined Acidity and Sulphate (POCAS) laboratory test. Undertaken to identify the presence of chemicals within the soil that have the potential to generate acid on oxidation.
Putrescible material	Nitrogenous organic matter that undergoes decomposition to form carbon dioxide, methane and organic chemicals.
Purging	Removal of water from a monitoring well.
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
UST	Underground Storage Tanks
Valency	A term used to denote oxidation state. Frequently used to designate the number of bonded neighbour atoms.
ANZECC	Australian and New Zealand Environment and Conservation Council
NHMRC	National Health and Medical Research Council

1. Introduction

1.1 Summary of the Technical Paper

This technical paper examines the potential for contamination from existing and previous land use activities to be exacerbated by the construction and operation of the proposed Tugun transport corridor.

The proposed transport corridor would traverse approximately 7 km of land that has been used for numerous purposes including sandmining, sewage treatment, landfill, airport activities and sand blasting.

The potential for contamination from sandmining activities is generally related to hydrocarbon spills and the concentration of radio-active materials. Mining activity may also disturb potential acid sulphate soils which are discussed in Technical Paper Number 5. Airport activities generally create potential for hydrocarbon contamination. Landfilling and sewage treatment involve the chemical breakdown of putrescible waste materials which generally result in higher ammonia and nutrient levels. Specific contaminants from wastes, landfilled or treated, are also of concern.

A field investigation was undertaken to supplement the available information. The investigation included the installation of a new monitoring well adjacent to Tugun Landfill in the area of the landfill that would be impacted by the construction of the proposed corridor. The investigation targeted parameters required by NSW Environment Protection Authority *Environmental Guidelines – Solid Waste Landfills* (1996). More general testing was undertaken in the area south of the landfill to allow an assessment of the quality of groundwater and likely contamination issues in the area.

The field testing determined that groundwater in the area around the Gold Coast Airport and Tugun Landfill has relatively high nutrient levels (nitrogen and phosphorus) and elevated zinc and iron concentrations. Groundwater in the area is acidic, with pH levels ranging from 4.35 to 6.85.

Test results from samples taken around Tugun Landfill indicated elevated levels of ammonia, total phenolics, nitrogen, phosphorus, zinc, manganese and iron. The highest levels were generally recorded in the new monitoring well (TGW7) which is located adjacent to the area proposed for excavation during construction of the transport corridor. This area was subject to significant disturbance at the time of sampling due to waste in the area being relocated by the landfill operator.

A supplementary survey was commissioned to determine if groundwater was contaminated within the vicinity of four routine monitoring bores located along the proposed bypass alignment. Results indicated concentrations of methane, methy ethyl ketone and 3- and 4-methylphenol were above recommended guidelines. Results from subsequent monitoring undertaken by Gold Coast Airport Limited have shown that levels for these analytes have returned to normal.

The potential impacts of the transport corridor predominantly relate to the excavation and removal of material from the Tugun Landfill. The elevated contaminant levels detected during the field investigation are of concern to the receiving ecosystems. The contaminants tested are generally not dangerous for human exposure, however they do indicate that leachate is being generated from the landfill and that there could be other

analytes which were not tested for that could be dangerous for human exposure. The location of the airport dump site is defined but the extent and content of the dump is unknown. However, the historical airport dump site has the same potential impacts as the Tugun Landfill if excavation of the material is required.

Other potential impacts relate to the disturbance of hydrocarbon and radioactive materials along the remainder of the proposed corridor. The only specific areas that have a potential for this impact are the quarry and borrow areas at the northern end of the alignment, and the sand blasting area at the southern end of the alignment. No operational impacts were determined for contaminated land issues.

The mitigation measures recommend the undertaking of soil testing and investigation in areas that may have been contaminated in the quarry and sand blasting areas. This would be undertaken prior to excavation works within these areas and in accordance with the requirements of relevant regulatory authorities.

The mitigation measures for the excavation of Tugun Landfill are to contain the leachate, prevent exposure to humans and ecosystems, and provide adequate methods for disposal of the leachate and solid waste that is excavated. Surface berms and a cut-off drain would be installed at the excavation site so that excavation occurs within a bunded area. A management plan would be required for the excavation detailing safe working practices, protective clothing requirements, hygiene procedures and procedures should accidental exposure occur. In addition, the management plan would also detail:

- environmental issues associated with leachate control;
- a procedure for the operation of the proposed collection sump; and
- any staging of proposed works to control impacts.

Disposal of the excavated material would occur either at Tugun Landfill or at another licensed facility in accordance with the licence conditions for the particular site.

1.2 Reporting of Study Findings in the EIS

The studies for the Tugun Bypass environmental impact assessment commenced in 2000. In the subsequent four years the results of the various studies have been used to refine the concept design of the proposal. Further studies were also commissioned to ensure that all aspects of the various environmental issues were fully understood.

The long time period of the assessment has meant that the content of some of the earlier reports has been superseded by newer work. Changes to the design of the bypass have also been introduced to take account of these studies.

In the event that there is a contradiction between the technical papers and the text of the EIS, the EIS takes precedence as it reports the current understanding of issues, impacts and the concept design.

2. Approach and Legislative Context

2.1 Study Area

This technical paper is based on the refined alignment of the proposed Option C4 route (Queensland Department of Main Roads (Main Roads) 1999). The proposed Tugun Bypass crosses the Queensland-NSW and Commonwealth land associated with Gold Coast Airport as shown on Figure 2.1.

2.2 Purpose and Approach

The purpose of this technical paper is to identify the sites along the proposed corridor that may be contaminated from previous or existing land uses. An assessment of the extent of potential impacts has been undertaken and mitigation or management measures during the construction and operation of the proposed road bypass are identified.

Specifically, the following works have been carried out during this investigation:

- obtaining and reviewing existing information from previous environmental investigations carried out in the vicinity of the proposed corridor;
- drilling a borehole on the boundary of Tugun Landfill to obtain samples of the soil profile and of the groundwater for laboratory testing;
- installation of a groundwater monitoring well (TGW7) within the borehole for subsequent groundwater sampling;
- groundwater sampling of existing monitoring wells within Tugun Landfill and Gold Coast Airport;
- an assessment of potential groundwater contamination in four groundwater monitoring wells in the vicinity of the Tugun Bypass alignment. Assessment was required when routine sampling of the bores identified potential contamination issues;
- acid sulphate soil laboratory testing on soils obtained during the construction of the monitoring well (TGW7) to assess the likely presence of potential or actual acid sulphate soils. Additional acid sulphate soil testing was completed as part of Technical Paper Number5;
- search of Queensland Environmental Protection Agency, Environmental Management and Contaminated Land Registers;
- a preliminary environmental site assessment of former landfill sites, located on the western side of the Gold Coast Airport area, south-west of the airport radio antenna area. The investigation comprosed three separate landfill sites, each having been used at different times, the extent and contents of each landfill was unknown; and
- contaminated site assessment report for the full length of the corridor presenting the factual data, together with discussion and recommendations covering Tugun Landfill and Gold Coast Airport.

Figure 2.1 **Proposed Tugun Bypass**

2.3 Legislative Context

The proposal passes through Queensland, NSW and Commonwealth land. It is therefore subject to State as well as Commonwealth environmental legislation. Legislation relevant to the proposed Tugun transport corridor is described briefly below.

2.3.1 Relevant Queensland Legislation

Environmental Protection Act 1994

In Queensland, the assessment and management of contaminated land is regulated by the Environmental Protection Agency under the *Environmental Protection Act 1994*.

The emphasis of the Environmental Protection Act is on the management of Queensland's environment within the principles of ecologically sustainable development and introduces; 'a person's general environmental duty not to carry out activities that cause or could cause environmental harm unless all practical measures have been undertaken to prevent or minimise harm.' Activities identified as being likely to cause land contamination are listed as 'notifiable activities' in Schedule 3 of the Act.

The Environmental Protection Agency maintains two public access registers to identify sites on the basis of risk — the Environmental Management Register and the Contaminated Land Register. The Environmental Management Register is a land use planning and management register. Land that has been or is being used for a notifiable activity or where site investigation his revealed some contamination present is recorded on the Environmental Management Register. This register provides information on historical and current land use, including whether the land has been or is currently used for a notifiable activity, or has been contaminated by a hazardous contaminant. Sites on the register in most circumstances pose a 'low risk' to human health or the environment under their current land use.

The Contaminated Land Register is a register of land with validated contamination ('high risk' sites) where the administering authority considers remedial works are required to prevent serious environmental harm or adverse public health risks (for example, technical measures to prevent contaminant migration and for on site remediation or contaminated material removal and off-site treatment).

In accordance with Section 118ZZF of the *Environmental Protection Act 1994* a person removing and disposing of contaminated soil from land which is recorded on the Environmental Management or Contaminated Land Registers to an off-site location must obtain a `disposal permit' from the Environmental Protection Agency. When deciding whether to grant or refuse an application for a disposal permit, the Environmental Protection Agency considers the standard criteria defined in the Environmental Protection Act, including:

- the principles of ecologically sustainable development as set out in the National Strategy for Ecologically Sustainable Development; and
- best practice environmental management.

The Environmental Protection Agency will only approve the removal of contaminated soil to a site that is listed on the Environmental Management Register or to a licensed landfill.

Environment Protection Regulation 1998

The Environment Protection Regulation 1998 lists fees, organisations and the qualifications of the members of these organisations that are able to prepare and submit contamination, validation, remediation and management reports for assessment by the Environmental Protection Agency contaminated lands section. Submitted reports must be accompanied by statutory declarations, which require certification of assessment and remediation work.

Integrated Planning Act 1997

Under the *Integrated Planning Act 1997*, development applications for material change of use and/or reconfiguration of lots for land, triggered under Schedule 2 of the Integrated Planning Regulation 1998 (for example, land listed on the Environmental Management and/or Contaminated Land Registers), are required to be referred to the Environmental Protection Agency. The Environmental Protection Agency may require contaminated land investigations to be conducted at this time.

Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998

Under the legislative blanket described above, the Environmental Protection Agency requires that assessments and reports are prepared in accordance with the draft *Guidelines for the Assessment and Management of Contaminated Land in Queensland* (Queensland Environmental Protection Agency 1998) before they will be considered and suitability statements issued. These guidelines provide Queensland contaminated sites assessment methodologies and requirements for conducting contaminated land investigations with the objective to provide best practice for the assessment and management of land contamination.

Where under the material change of use these sites are identified in Queensland as requiring contamination assessment it is understood that the assessment will be carried out in accordance with the *Guidelines for the Assessment and Management of Contaminated Land in Queensland*.

2.3.2 Relevant NSW Legislation

The management of contaminated land in NSW is shared by the NSW Environment Protection Authority, Planning NSW and local councils.

Contaminated Land Management Act 1997

Part 3 of the *Contaminated Land Management Act 1997* empowers the Environment Protection Authority to regulate contaminated sites that pose a significant risk of harm to human health and/or the environment. Other contaminated sites that do not pose a significant risk of harm to human health or the environment, and hence are suitable for the current or approved use, are managed by local councils through the land use planning process

The *Contaminated Land Management Act 1997* applies the polluter pays principle and outlines the role of the Environment Protection Authority and rights and responsibilities of parties it might direct to investigate or remediate contaminated land that is posing a significant risk of harm to human health or the environment. A person who is aware that land has been contaminated and is possibly posing a significant risk of harm must,

as soon as practicable after becoming aware, notify the Environment Protection Authority that the land is contaminated.

Part 4 of the Contaminated Land Management Act allows the Environment Protection Authority to approve guidelines for purposes connected with the Act. These guidelines must be taken into consideration when the Environment Protection Authority is making a decision on whether a site poses a significant risk of harm according to Section 9 of the Act. The following relevant guidelines have been developed or endorsed by the NSW Environment Protection Authority for use by contaminated sites consultants, auditors and other stakeholders in NSW:

- NSW Environment Protection Authority 1999, *Contaminated Sites: Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report*;
- NSW Environment Protection Authority 1998, *Contaminated Sites: Guidelines for NSW Site Auditor Scheme*;
- NSW Environment Protection Authority 1997, *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*;
- NSW Environment Protection Authority 1995, *Contaminated Sites, Sampling Design Guidelines*; and
- ANZECC/NHMRC 1992, *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.

2.3.3 Relevant Commonwealth Legislation

There is no Commonwealth legislation dealing specifically with site contamination, nor any formal policy to guide Commonwealth land management entities when dealing with such matters. Management of land owned or occupied by the Commonwealth is the responsibility of the land -owning or -managing department, authority or agency.

Commonwealth government bodies and statutory authorities may be required by Commonwealth legislation to comply with the requirements of States and Territories in which they operate. In other cases, whether Commonwealth organisations are legally obliged to follow State and Territory requirements depends on the legal situation in the particular case, based on the organisation concerned, its activities, and the relevant State or Territory law and any relevant Commonwealth law.

Airports Act 1996 and Airports (Environment Protection) Regulations 1997

The *Airports Act 1996* and Airports (Environment Protection) Regulations 1997 set out a comprehensive process for the assessment and remediation of contaminated sites on leased Federal airports. The process is centred on the polluter pays principle and allows for the Airport Environment Officer to require an expert assessor to be appointed to review and report against any site investigations undertaken. In carrying out an assessment an investigator must have regard to the 1992 ANZECC/NHMRC *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC 1992). Schedule 2 (Water Pollution) and Schedule 3 (Soil Pollution) of the Airports (Environment Protection) Regulations 1997 detailed the acceptable contamination limits for airport land and water.

3. Methodology

The methodology used for this contamination assessment consisted of:

- review of available information;
- field investigations; and
- analysis and reporting.

3.1 Review of Available Information

The following sources of information were reviewed to determine potential land and water contamination issues along the proposed transport corridor:

- the Environment Strategy for Gold Coast Airport (Gold Coast Airport Limited 1999);
- a groundwater assessment of the Gold Coast Airport fire training area (Queensland Health Scientific Services 2000);
- environmental investigations of Gold Coast Airport (Douglas Partners 1994, 1996);
- a review of land contamination issues at Gold Coast Airport (Lane Consulting 1998);
- the Pacific Highway at Tugun Route Selection Report, prepared by Connell Wagner (Main Roads 1999);
- groundwater monitoring results for Tugun Landfill supplied by Gold Coast City Council;
- Environmental Management and Contaminated Land Registers maintained by the Queensland Environmental Protection Agency;
- certificates of title; and
- aerial photography.

A desktop review of the information was undertaken prior to establishing a field investigation program to supplement the known data.

3.2 Field Investigations

Field investigations were carried out in selected sections of the proposed transport corridor and consisted of:

- a site inspection of the proposed corridor and surrounding area and discussions with staff from Gold Coast Airport Limited and Gold Coast City Council;
- a preliminary environmental site assessment of the former landfill sites at the Gold Coast Airport;
- construction of an additional monitoring well on the boundary of Tugun Landfill; and
- sampling of existing monitoring wells.

3.2.1 Site Inspections

Site inspections were undertaken to assist in determining the extent of additional fieldwork required. Sites inspected included:

- Gold Coast Airport;
- the sand blasting area; and
- Tugun Landfill.

3.2.2 Construction of an Additional Monitoring Well

An additional monitoring well (TGW7) was constructed to determine if leachate from the Tugun Landfill is likely to be encountered during the construction of the proposed transport corridor.

The position of TGW7 was determined by using the results of groundwater modelling (see Technical Paper Number 9). A location hydraulically down gradient of Tugun Landfill was selected to intercept any potential leachate in the groundwater.

The monitoring well was drilled using solid stem auger drilling techniques, to a depth of 3 m below ground level. No drilling additives were required or used. The test bore was lithologically logged from materials brought to the surface during the drilling process.

Six soil samples were taken at 0.5 m intervals and POCAS testing was carried out on each to assess the presence of acid sulphate soils. Technical Paper Number 5 assesses the acid sulphate soils for the area covered by the proposed transport corridor.

The acid sulphate soil sampling was conducted in general accordance with the *Sampling and Analysis Procedure for Lowland Acid Sulphate Soils (ASS) in Queensland* (Ahern *et al.* 1998) and *Acid Sulphate Soil Manual* by Acid Sulphate Soil Management Advisory Committee (ASSMAC) (Stone *et al.* 1998).

3.2.3 Groundwater Sampling

Groundwater samples were collected from monitoring wells. These wells were gauged and developed prior to samples being taken. Five well volumes were purged from each well to ensure that a representative groundwater sample was obtained. The parameters tested in each sample were determined based on the location in the study area and the potential contaminants that could result from previous or existing land uses (identified from the review of available information and site inspections). Surface water samples were also collected from a temporary water body adjacent to the Tugun Landfill.

Groundwater samples were collected using a stainless steel bailer and transferred to sample bottles supplied by the analytical laboratory. The bailer was washed in Decon 90 solution (or equivalent) and rinsed with potable water between sample collection to minimise the risk of cross contamination between samples. Immediately after collection, the samples were transferred to a chilled insulated container and a chain of custody form completed. Samples were stored overnight in a refrigerator (at a temperature of less than 4°C) and then transported to the laboratory in freshly chilled containers for National Association of Testing Authorities (NATA) certified analyses. Samples were sent by courier to the appropriate laboratories for analysis under 'chain of custody' requirements.

3.2.4 Subsequent Groundwater Survey

Four additional bores were drilled along the proposed bypass alignment to assess groundwater levels and quality. Sampling during February 2003 indicated the potential for groundwater contamination. A follow-up survey was conducted during March 2003

to assess the extent of contamination, specifically phase separated hydrocarbons (PSH) at the bore closest to the Tweed Heads Bypass interchange, and a range of volatile and semi-volatile compounds (VOC/SVOC), total petroleum hydrocarbons (TPH) and dissolved methane in the other three bores.

Following the monitoring in February 2003 the sampler showed signs of illness. Therefore PB prepared a site-specific health and safety plan to undertake the groundwater sampling. The work was undertaken in full-face respirator, disposable suit, inner and outer nitrile gloves. A 'buddy' was used to monitor the sampler during the work. In addition a photo-ionisation detector and landfill gas meter was used to monitor concentrations of gases in the breathing zone.

All bores were purged prior to the sampling event, with field parameters monitored to ensure representative water chemistry was present. Samples were obtained from each bore using a dedicated disposable bailer. A VOC sampling attachment was used for all semi-volatile and volatile analytes. All samples were dispatched under chain of custody documentation to a NATA accredited laboratory.

3.2.5 Preliminary Environmental Site Assessment

In January 2004, PB was engaged by Gold Coast Airport Limited to undertake a preliminary environmental site assessment of former landfill sites at the Gold Coast Airport. The airport landfill sites are located south-west of the airport and comprise three individual landfills situated along side an access track over spread over a 1,650m^2 length. Each site dimension is approximately 55 m by 30 m. While this work was undertaken for Gold Coast Airport Limited, the results obtained are relevant to the Tugun Bypass proposal.

The scope of the environmental site assessment included:

- implementation of appropriate health and safety procedures for the protection of project personnel;
- project organisation liaison and project control;
- conducting a site inspection to record general site observations, photographs and notes with respect to on-site vegetation and soil, photographs of topography, nature of surface, structures and location of any site services;
- test pitting (by backhoe) on a random stratified sampling plan, to assess waste composition and potential contaminants;
- field screening using both a photo ionisation detector (PID) and landfill gas meter (LGM) as each test pit as excavated. Undertaking screening of vapours from soil samples at each half-metre of depth to identify the presence of landfill gas or volatile vapours;
- collection of two soil samples from each test pit for analyses at a NATA accredited analytical laboratory. Analytes were selected from the following suite:
  - logging of the soil profile and collection of two samples from each test pit targeting potential contaminants of concern. Analysis included Asbestos, TPH/BTEX, PAHs and Heavy Metals (arsenic, cadmium, chromium, cobalt, copper, Mo, nickel, lead, zinc and Hg); and
  - constructing groundwater monitoring wells in the lowest hydraulic test pit (hydraulically down-gradient of majority of waste) at each of the three landfill locations and submitting groundwater samples for pH, electrical conductivity,

ammonia, biological oxygen demand (BOD), product identification in water (General Scan), and heavy metals (arsenic, cadmium, chromium, cobalt, copper, Mo, nickel, lead, and zinc) analysis.

Based on site inspection the following potential contaminants of concern were assessed for the site:

- Asbestos — potentially associated with building product fragments landfilled in the area;
- Total Petroleum Hydrocarbons(TPH) / Benzene, Toluene, Ethyl benzene, Xylene (BTEX) — potentially associated with hydrocarbon disposal;
- Polycyclic Aromatic Hydrocarbons (PAHs) — potentially associated with hydrocarbon disposal and combustion; and
- Heavy Metals — leached from hardfill wastes.

Soils

As part of this assessment for Gold Coast Airport Limited PB conducted test pitting to gain an insight into waste composition and potential contaminants. Test pit locations were undertaken using a random stratified sampling plan, based on 10 m x 10 m grids. The sampling location was selected by generating X and Y coordinates with a random number generator. A 95 percent upper confidence limit that 'hot-spots' up to 15 m in diameter would be identified was achieved by excavating a total of 35 test pits at the appropriate density over the three landfill sites.

Samples were obtained from the bucket of a backhoe at depths of 0.1m and 0.5m below ground level, and then at 1.0 m intervals and/or at areas of visual contamination. All soil samples were screened for volatile organic compounds (VOCs) using a calibrated photo-ionisation detector (PID). Soil samples at each half-meter of depth were screened for oxygen and methane using a calibrated landfill gas metre.

The samples were collected in laboratory-supplied and cleaned sample jars, and kept in coolers with ice during sampling and despatch to the laboratories. Samples were despatched to the laboratories under chain of custody documentation. Analytical data received in electronic format was transferred directly into summary tables.

Groundwater

A groundwater monitoring bore was constructed in a test pit at each landfill location by inserting a 50mm UPVC Class 18 screen and casing in to the test pit and backfilling the pit. Screen lengths were set to intercept the groundwater level. The groundwater sampling wells were developed by bailing five well volumes of water, (Note: This method of obtaining a groundwater sample is not in accordance with AS/NZS 5667.11). The following table summarises groundwater sample methodologies employed.

Table 3.1: Groundwater Assessment Methodology

Activity	Details
Well Construction	Wells were constructed in test pits using with 50 mm, class 18 uPVC screen and casing. Screen lengths were set to intercept the groundwater level.
Well Developing	Five bore volumes were removed from the well. A dedicated Teflon bailer was employed. The monitoring well was rested for a period of over seven days.
Well Purging	Groundwater wells were purged of five well volumes of water or until repeated physical parameters were within 10 percent indicating consistent groundwater chemistry had been achieved A dedicated Teflon bailer was employed. Water was disposed of by a licensed waste water contractor
Well Gauging	Monitoring well gauged using a Herron dip meter.
Sampling Method	Disposable Teflon bailer employed.
Sample Preservation	Sample bottles containing the appropriate preservatives were supplied by the laboratory. Heavy metal samples were field-filtered using a 0.45 μm disposable water filter prior to preservation. Samples were stored in a cooler (<4°C) while on site and in transit to the laboratory.

3.3 Analysis and Reporting

Samples were submitted for analysis with the detection limits as set by NSW Environment Protection Authority, *Environmental Guidelines - Solid Waste Landfills* (1996), where applicable.

Primary and duplicate analyses were performed by Amdel Laboratories in Sydney (Asquith), NSW. NATA certified methodologies were used for all analyses and laboratory Quality Assurance and Quality Control procedures are described within the laboratory reports.

Absorbable organic halogens (AOX) analysis was performed by ALS laboratories in Brisbane (Stafford), Queensland. NATA certified methodologies were used for AOX analyses and laboratory Quality Assurance and Quality Control procedures are described within the laboratory reports. For works undertaken at the Gold Coast Airport landfill sites, secondary duplicate samples were submitted for analysis to ALS to enable Relative Percentage Differences (RPDs) to be calculated.

The Amdel and ALS laboratories used by Parsons Brinckerhoff (PB) meet in-house compliance under the ISO 9001 quality assurance program, and are NATA registered.

Laboratory results were compared to criterion levels set by Australian and New Zealand Environmental Conservation Council (ANZECC) in their *National Water Quality Management Strategy – Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000). Criteria used were for Fresh and Marine Waters, Aquatic Ecosystems, Raw Water and Recreational Use. Where ANZECC (2000) guidelines had no criteria National Environmental Protection Measure (NEPM) Guidelines on Investigation Levels for Soils and Groundwater (1999) and Dutch Intervention

Guidelines (Ministry of Housing, Spatial Planning and Environment 1994) were used. International guidelines are used to illustrate the risk from potential contaminants of concern when Australian guidelines do not provide criterion levels. Where guideline criteria conflict, the governing criteria is chosen in the following order:

- ANZECC Guidelines for Aquatic Ecosystems;
- Australian Drinking Water Guidelines (NHRMC/ARMCANZ);
- ANZECC Guidelines for Recreational Waters;
- National Environmental Protection Measure guidelines; and
- Dutch Intervention level guidelines.

Additionally, soil and water investigations undertaken in January 2004, reference the Airports (Environmental Protection) Regulations, 1997 – Statutory Rules No. 13 as amended made under the *Airports Act 1996*. Specifically, the adopted criterion refers to the Airports EP Regulations Guideline Table 1 – Area of an Airport Generally, and Table 2 – Area of Environmental Significance.

3.3.1 Quality Assurance/Quality Control

Field sampling procedures conformed to PB protocols to prevent cross contamination and to preserve sample integrity.

The following procedures were followed:

- groundwater samples were collected in sampling containers appropriate for the selected analyses. The containers were approved and supplied by the testing laboratory;
- for sampling conducted at Tugun landfill a duplicate groundwater sample (labelled TGW7000) was collected and tested for laboratory Quality Assurance and control purposes;
- sampling investigations undertaken at the Gold Coast Airport included the collection of primary, primary duplicate and secondary duplicate samples (B7-1 and C5-1). Field duplicates provide an indication of the nature of the field samples in terms of their relative heterogeneity and media variance. Inter-laboratory field duplicate samples are collected on a frequency of one sample per 20 primary samples. Intra-laboratory duplicate samples are collected on a frequency of one sample per 20 primary samples;
- a field rinsate blank (labelled ROB) was collected at the Tugun landfill to verify decontamination procedures and to ensure that cross contamination of the well was not occurring; and
- A trip blank, field blank and rinsate blank were collected during sampling works at the Gold Coast Airport. The trip blank, sometimes referred to as a laboratory blank were reported within the prescribed acceptance criteria. The results of the field blank indicated that arsenic reported an exceedance of the data quality objectives in one sample. All other results were within data quality objectives or were due to near detection limit effects. The rinsate blank taken at the Gold Coast Airport recorded no detectable hydrocarbons.

4. Existing Environment

4.1 Topography

The section of the corridor north of chainage 2,500 presented in Figure 4.1, comprises steep hills and ridges, with levels ranging from 6 to 51 m AHD. Slope gradients in the area up to 35 percent are common. The southern section south of chainage 2,500 comprises relatively flat land with gradients not usually exceeding 3 percent except for localised batters. Existing ground levels in the southern section range from approximately 1.5 to 4 m AHD.

The proposed corridor crosses a tributary of Coolangatta Creek in the area known locally as Hidden Valley at chainage 1,950. A number of minor drainage systems are also crossed by the corridor. Site runoff flow from the Gold Coast Airport is anticipated to be limited with stormwater infiltrating the sand lithology. Stormwater runoff is expected to ultimately discharge into the Cobaki Broadwater located approximately 400 m south of the site. A full description of the drainage systems traversed by the proposed corridor is provided in Technical Paper Number 7.

4.2 Geology

Rocks of the Neranleigh-Fernvale Group of Devonian to Carboniferous age underlie the northern section of the study area. This unit primarily comprises inter-bedded fine to medium grained, grey-brown greywacke and argillite.

The southern section of the study area consists of sands with bedrock at depth. Quaternary sediments, including river gravels, alluvium, sand and clay which overlie the rocks of the Neranleigh-Fernvale Group.

A full description of the geology of the study area is provided in Technical Paper Number 4.

Near surface lithology encountered during field investigations at the Gold Coast Airport generally consisted of fine to medium grained sands and sandy clays. A generalised stratigraphic log is presented in the table below.

Table 4.1: Generalised Stratigraphic Log

Depth (mBGL)	Lithology
0-0.2	Fill: silty sand, dark brown, slightly moist, loose, friable. Traces of organic material (e.g. grass roots).
0.2 - 0.75	Fill: sand, fine, light grey/brown, slightly moist, loose, friable.
0.75 - 3.0	Sand: Fine to medium grain, light brown/grey, slightly moist to moist, loose, friable. Coffee rock lenses between 0.75 and 3.0mBGL.

Notes: mBGL = metres below ground level

4.3 Site Inspections

Review of available data was conducted to determine the potential land and water contamination issues along the proposed transport corridor. From this information site inspections of the Gold Coast Airport, the sand blasting area and Tugun Landfill were conducted by PB and discussions with staff from Gold Coast Airport Limited and Gold Coast City Council were held.

The purpose of the site inspections was to obtain all available information for the desktop review, and to assist in establishing the extent of fieldwork required. Considerable data was collected and is presented in Section 4.4.

4.4 Desktop Review of Land Use Information

The land use adjacent to the proposed corridor north of Hidden Valley (chainage 2,060) is predominantly urban residential. South of Hidden Valley, the corridor traverses disturbed and natural bushland and Commonwealth land associated with Gold Coast Airport before rejoining the Tweed Heads Bypass at Kennedy Drive. A full description of existing land uses along the proposed corridor is provided in Technical Paper Number 15.

Sites that have the potential to contaminate land through existing or previous land uses are shown in Figure 4.1 and are listed below:

- quarry/borrow areas (chainage 700 to 1,750);
- Tugun Landfill (chainage 3,300);
- Tugun Landfill - existing decommissioned sewage treatment plant (chainage 3,300);
- sandmining areas (chainage 3,300 to 6,200);
- night soil tip (chainage 3,300);
- fire training area (chainage 4,100);
- airport dump site (chainage 4,100);
- tower / fire station (chainage 4,400);
- Gold Coast Airport (chainage 4,500 to 5,100);
- aircraft burial site (chainage 5,200);
- Tweed Heads West Sewage Treatment Works (chainage 6,600); and
- sand blasting area (chainage 6,600).

Anecdotal evidence provided by Mr Lionel Perry of Gold Coast City Council identifies a decommissioned abattoir and cattle yards located on the southern side of the John Flynn Hospital and Medical Centre site. Its precise location, activities, and time of operation are unknown. However it was decommissioned sometime in the mid 1970s. It is understood that material from the site was disposed of in the initial operating stage of the Tugun Landfill.

The data collected included results from numerous investigations and studies at various locations and dates. Since the available data was generally the result of targeted investigations for a particular land use, it was considered prudent to undertake a field investigation examining a broad range of areas where various forms of contamination could have occurred.

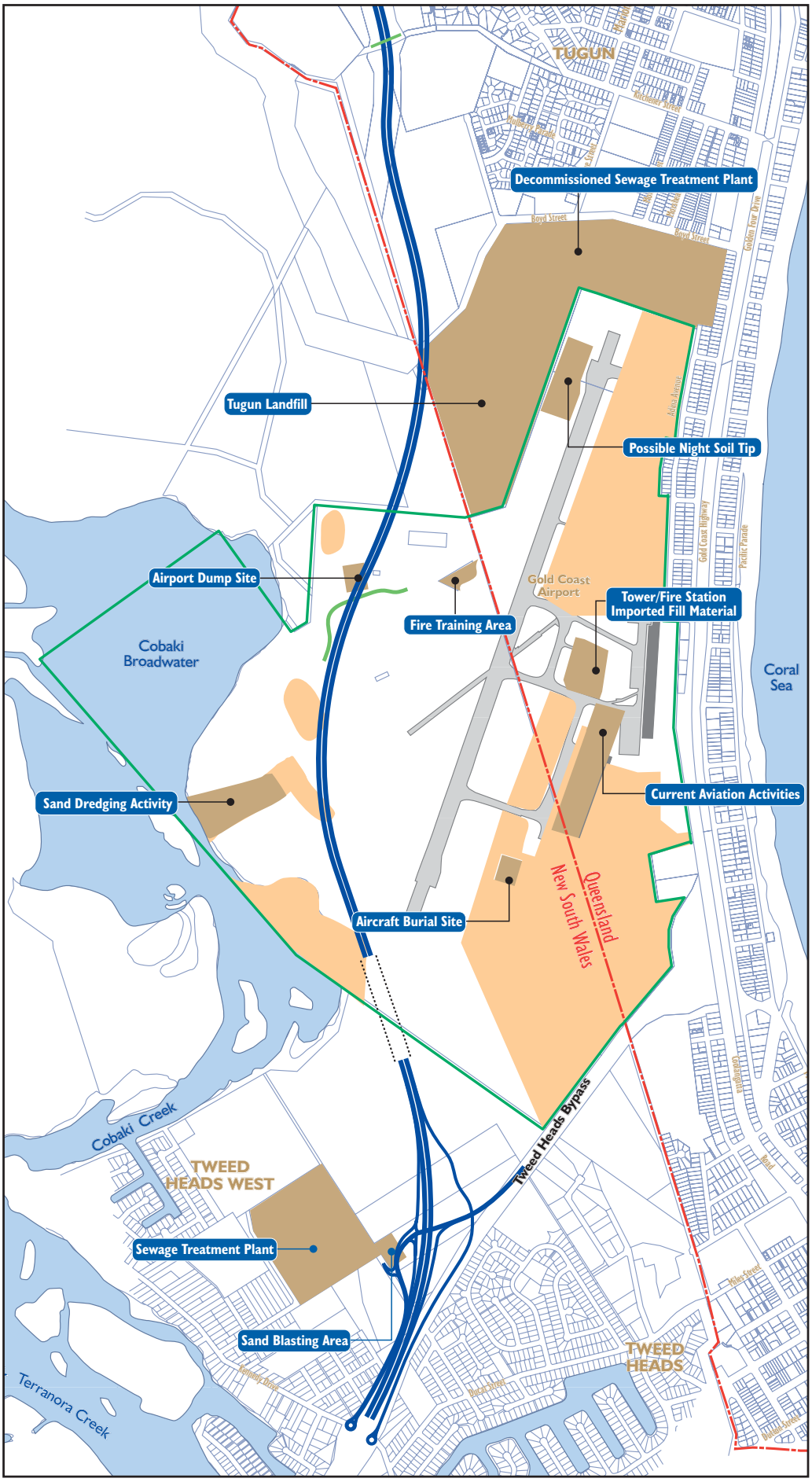


Figure 4.1 **Areas of Potential Contamination**

4.4.1 Quarry / Borrow Areas (Chainage 700 to 1,750)

Borrow areas have been identified immediately to the east of the proposed Stewart Road interchange and immediately to the west of the proposed corridor at chainage 1,750. The quarries have been used to extract material to fill lower lying land in the adjacent residential subdivisions. The quarries were operated by the landowners Tubuk Pty Ltd over the last 10 to 20 years. The operation is likely to have used machinery to cut the face of the hillside and to remove the excavated material. Potential contamination of the site is likely to be limited to hydrocarbon spills from machinery.

4.4.2 Tugun Landfill (Chainage 3,300)

Tugun Landfill (Lot 3 RP837321) is owned and operated by Gold Coast City Council. The waste disposal facility is located on Boyd Street, Tugun. Activities at the site are regulated by the Queensland Environmental Protection Agency, which administers the *Environmental Protection Act 1994*. The licence number for the site is SR 1346.

Operation of the site is classed as an Environmentally Relevant Activity (ERA) under the Act. The landfill receives between 2,000 and 5,000 tonnes of waste per year and the activity is therefore type *75(a)(ii): Waste disposal – operating a facility for disposing of only general waste or limited regulated waste*.

Tugun Landfill accepts only inert waste, which is described in the licence as:

'Aggregate, bituminous concrete, clay products, concrete, glass, masonry, metal reinforcing rods attached to concrete, plaster (other than paper covered plasterboard), plastic conduit and pipe, uncontaminated soil and wood (seasoned for six (6) months).'

Gold Coast City Council has advised that the site has only accepted inert waste since 1974. Prior to that time, the acceptance of material at the site was not regulated. According to Mr Bruce Lewins of Gold Coast City Council, landfilling at the north-eastern end of site commenced approximately 50 years ago. This area has now been covered and rehabilitated for recreational purposes. The area is now known as the Betty Diamond Sporting Complex, and includes a grassed playing field and a skate board park. This area is located at the northern end of Gold Coast Airport.

The site is not included on the Contaminated Land Register but is included on the Environmental Management Register. It has been subject to the following 'notifiable activities' pursuant to section 374 of the *Environmental Protection Act 1994:*

- 'Petroleum Product or Oil Storage - storing petroleum products or oil-
  - (a) in underground tanks with more than 200 L capacity; or
  - (b) in above ground tanks with –
    - (i) for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code – more than 2 500 L capacity; or
    - (ii) for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia – more than 25 000 L capacity.
- Landfill – disposing of waste (excluding inert construction and demolition waste).'

The current operating stage of the landfill is located to the east of the proposed corridor and commenced approximately 20 years ago. There is between one and five years life remaining in the facility. The timeframe will depend on the volume of waste received. The landfill was not constructed with an impervious liner and in some areas material may have been placed below the water table.

A condition of the licence requires that the landfill operator undertake six monthly monitoring of groundwater and any discharges to surface water quarterly. Monitoring results provided by Council are shown in Appendix A. These have been tabulated and compared to the ANZECC (2000) guidelines for aquatic ecosystems and Dutch Intervention Guidelines (1994).

The monitoring results show that groundwater pH is generally between 5.3 and 6.6 which is slightly acidic. All samples exceed the ANZECC (2000) guidelines recommended pH levels of 7.0 to 8.5. However, these pH levels are not uncommon in the area and cannot be directly attributed to materials within the landfill (see Technical Paper Number 9 for further information).

Levels of nitrogen as ammonia were also detected by the groundwater monitoring, which indicated that leachate is being generated from within the landfill. The samples were taken from wells TGW1 to TGW6 as shown in Figure 4.2. These wells are located around the circumference of the existing operation but not outside the previous landfill areas that have since been closed. Therefore, the measurements do not provide any baseline data.

Ammonia test results for 20 December 1999 indicate that wells TGW1, TGW3, TGW4 and TWG5 exceeded the ANZECC (2000) guideline for aquatic ecosystems of 0.32 mg/L. Ammonia test results for 18 December 2000 indicate that all wells except TGW6 exceeded the ANZECC (2000) guidelines. TGW2 was not tested for ammonia. Elevated ammonia results are discussed further in Section 4.5.5.

An elevated level of chloride was detected in TGW1 in the 18 December 2000 monitoring round. This was above the ANZECC (2000) recreational use guideline of 400 mg/L. Chloride results are discussed further in Section 4.5.3.

Elevated levels of total iron, exceeding ANZECC (2000) aquatic ecosystems guideline, were found in all monitoring wells (excluding TGW2 which was not tested for this analyte) on both monitoring rounds. A discussion of total iron results can be found in Section 4.5.14.

An elevated concentration of lead was observed in TGW1 on 20 December 1999. This exceeded the ANZECC (2000) guidelines for aquatic ecosystem of 0.001 mg/L. However, lead was not detected in the subsequent monitoring round. A discussion of lead contamination can be found in Section 4.5.14.

Levels of zinc exceeded ANZECC (2000) guidelines for aquatic ecosystems in all monitoring wells (excluding TGW2 which was not tested for this analyte) on 18 December 2000. A discussion of elevated zinc levels is provided in Section 4.5.14.

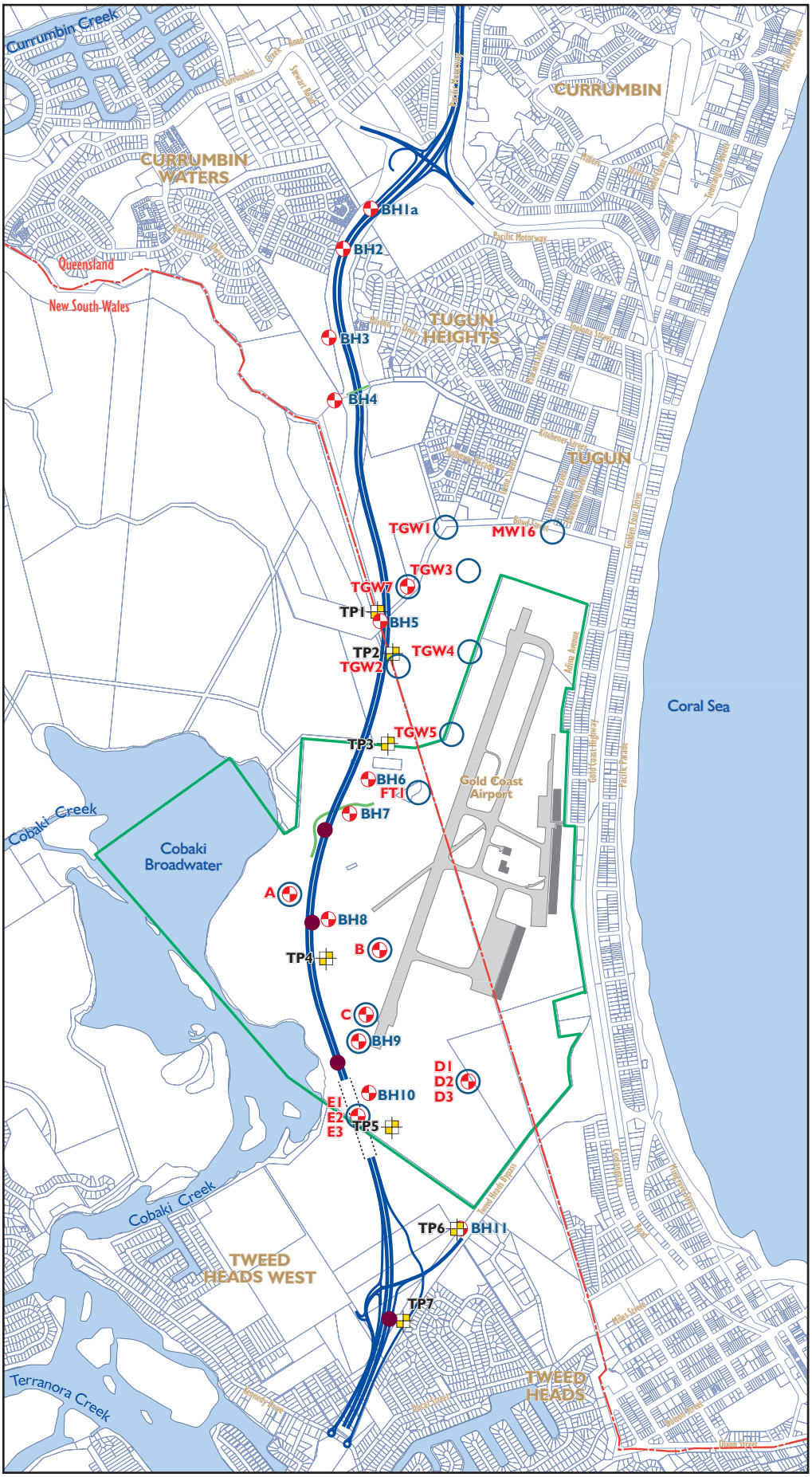


Figure 4.2 **Sampling Location Plan**

4.4.3 Tugun Sewage Treatment Plant (Chainage 3,300)

The Tugun sewage plant (now decommissioned) is owned and operated by the Gold Coast City Council and is currently used as a sewage pumping station. It is located adjacent to and to the east of the operating stage of the Tugun Landfill site. It comprises two lagoons, a pumping station and an emergency overflow pond, two thirds of which is currently being used as a sedimentation pond. The treatment plant has been decommissioned for over four years. Contamination from sewage can occur through faults in pipe reticulation. Sewage leakage can typically be detected through increased levels of ammonia and nutrients such as nitrates and phosphates. While removed from the proposed transport corridor, movement of contaminated groundwater could potentially impact on the construction site.

4.4.4 Sandmining (Chainage 3,300 to 6,200)

Heavy mineral sandmining has taken place in the airport grounds mostly in the area to the east of the main runway. Sandmining could have been undertaken either to obtain the sand for use without processing or for heavy minerals extraction. Heavy mineral sandmining has taken place in the general Coolangatta area. This activity has the potential to concentrate naturally occurring radioactive sands.

Sands found in the Coolangatta area contain heavy minerals, which include magnetite (Fe_3O_4), ilmenite ($FeTiO_2$) and rutile (TiO_2). The magnetite is not generally used for productive purposes. The titanium oxides are used for smelting titanium metal or for producing titanium dioxide, the white pigment in paint. All of these minerals are chemically inert and non toxic.

Other minerals found in the heavy mineral deposits include monazite, zircon, xenotime, apatite, garnet and tourmaline. Of these zircon and monazite are of commercial value and can be recovered from the heavy mineral deposits.

Monazite, which was naturally occurring in the area, is a source of rare earth elements particularly thorium. During commercial uranium mining these deposits are disturbed and as a consequence of mining operation concentrated. As a result the radioactivity levels observed post mining could be greater than naturally occurring levels. A study carried out by D.J. Douglas & Partners Pty Ltd (1994) investigated 110 ha of land to the east of the runway for concentrations of radioactive sands, which may have been concentrated by sandmining activities. A total of 118 recordings of radioactivity were taken from randomly selected locations. All readings were well below the given clean up threshold. Figure 4.1 shows the areas where sandmining has occurred.

4.4.5 Night Soil Tip (Chainage 3,300)

The Environmental Strategy for Gold Coast Airport contains a reference to anecdotal data suggesting that a sanitary waste tip existed in the northern part of the airport, to the west of the runway. Whilst it is unknown when dumping started and ceased, it is known that the dumpsite was either fully or partially removed in 1950 for an upgrade of the airport. No further dumping since that time has been recorded.

The dumping of sanitary waste in an unlined area could greatly impact groundwater quality. Tests for ammonia and nutrients such as nitrates and phosphates would indicate the presence of contamination by sanitary waste. Current impact to the site is

thought to be limited since dumping ceased over 50 years ago and the site has been either fully or partially removed.

4.4.6 Fire Training Area (Chainage 4,100)

The fire training ground is leased by Airservices Australia from Gold Coast Airport Limited. The site is used as emergency simulation training area and was identified within the Environment Strategy for Gold Coast Airport as a site with known soil and groundwater contamination (Gold Coast Airport Limited 1999).

The emergency training involves spraying and igniting a simulated aircraft fuselage with hydrocarbons before extinguishing them with various compounds, including detergent based foam and dry chemicals. The hydrocarbon used is usually aviation kerosene, though in the past other sources of hydrocarbon such as waste oil have been used.

The site comprises a simulated aircraft fuselage located within a large concrete bund and an above ground aviation kerosene storage tank with a capacity of 1,500 litres. The bund was designed to collect any remaining fuel that was extinguished before being combusted. Run-off from the bunded area is pumped through an oil separator, the effluent from which (until 2000) ran into an unlined pond. The Queensland Health Scientific Services (2000) report, found the oil separator to be inefficient as the effluent still contained 'a significant level of hydrocarbons'.

Eight boreholes were drilled during an investigation by D.J. Douglas & Partners Pty Ltd (1994). At two locations, monitoring wells were installed and the groundwater sampled. Soil samples closest to the above-ground tank and concrete slab were affected by hydrocarbons of the C_{10} – C_{14} range. One water sample had a total PAH reading slightly over the ANZECC (1992) raw water quality guidelines. No other water samples were affected. The conclusion of the investigation was that kerosene impact had occurred in the soil but had not reached the water table.

An investigation undertaken for Queensland Health Scientific Services by Water Studies (2000) installed eleven monitoring wells. These wells were monitored in September 1999 and February 2000. All monitoring wells with the exception of the two previously installed by D. J. Douglas & Partners Pty Ltd, which were re-sampled, showed slight hydrocarbon impacts. These impacts were below the Dutch Intervention Guidelines. There was no distinct spatial or preferential flow direction of hydrocarbon contamination across the site.

4.4.7 Airport Dump Sites (Chainage 4,100)

A preliminary environmental site assessment of former landfill sites was undertaken in January 2004 by Gold Coast Airport Limited. The landfill sites are located on the western side of the airport area south-west of the airport radio antenna area. The investigation area comprised three separate landfill sites (A, B and C) each having been used at different times. The location of these landfill sites are shown on Figure 4.1.

A geophysical survey was undertaken by G-tek Geophysical to assess the extent of the landfill and indicated the majority of impacts at Landfill A were within the delineated zone. This was an area measuring about 60 m by 40 m.

Fill material in Landfill B extended for between 5 m to 30 m wide, over a 50 m length. Investigations in Landfill C included test pits which were terminated in natural sands below waste. The fill material extended over a 30 m width for 50 m.

4.4.8 Tower / Fire Station (Chainage 4,400)

The control tower/fire station complex has been identified as an area in which a clay gravel fill material was used. The contamination status of this fill is unknown.

4.4.9 Gold Coast Airport (Chainage 4,500 to 5,100)

The airport is 385 ha in area. It straddles the Queensland-NSW border with most of the aviation facilities located in Queensland. The site is on Commonwealth land and as such is not listed on any state specific contamination registers.

The main potential source of contamination is leakage from the storage of fuels in underground storage tanks and accidental spillage of fuels or chemicals. All the tanks identified in this section are located around the main terminal and the general aviation hangers apron to the east of the runway.

The storage of fuel and chemicals and refuelling on the airport are regulated under the Airports (Environment Protection) Regulations 1997.

The Environment Strategy for Gold Coast Airport identifies as contaminated:

- five semi-buried tanks containing aviation turbine fuel and one underground storage tank containing diesel in the leased joint user hydrant installation compounds;
- two underground storage tanks in the Hertz rent-a-car site (has since been remediated);
- two underground storage tanks in the Budget rent-a-car site (has since been remediated); and
- a set of underground fuel lines and hydrants, which are part of the joint user hydrant installation lease, have confirmed contamination impacts to the surrounding soils along the regular passenger transport apron.

The airport environmental strategy identifies as 'contamination status unknown':

- seven underground storage tanks; and
- three above ground storage tanks.

Of these, the following have been removed and the sites validated as uncontaminated:

- an above-ground storage tank from the Broadhurst sand mine; and
- a former Mobile Oil Avgas underground storage tank site

Regulator integrity testing of the remaining underground storage tanks suggests that the tanks are in sound condition, as such contamination is considered unlikely.

4.4.10 Aircraft Burial Site (Chainage 5,200)

An area at the south of the airport and west of the main runway has been identified as a dumping ground in which an aircraft fuselage has been buried. It is unknown when the aircraft was buried. Potential contaminates include heavy metals and hydrocarbons.

4.4.11 Tweed Heads West Sewage Treatment Works (Chainage 6,600)

The Tweed Heads West Sewage Treatment Works is located adjacent to the southern section of the bypass alignment, to the west of the proposed Tweed Heads Bypass interchange. The facility is owned and operated by Tweed Shire Council and is

currently in use. Contamination from sewage can impact on ground and surface water. Sewage contamination can be detected by testing for ammonia and nutrients such as nitrates and phosphates.

4.4.12 Sand Blasting Area (Chainage 6,600)

A sand blasting area is located in the southern section of the study area to the west of the proposed Tweed Heads Bypass interchange. The area is currently used for sand blasting activities. The operator has advised that the parcel of land is approximately 47 ha, of which a small portion (approximately 100 m^2) in the southern corner of the property is used for sand blasting. Sand blasting activities can produce potential contaminants that include tributyl-tin (TBT), heavy metals (particularly lead and chromium), petroleum hydrocarbons and poly aromatic hydrocarbons (PAH).

4.4.13 Sand Dredging Area

Sand dredging operations were conducted in the Cobaki Broadwater by the Broadhurst-Hill Company, until 1999 when Gold Coast Airport Limited ceased all dredging operations on airport land. The site was located at the south end of runway 17/35. Sand was dredged from the Broadwater and piped back to a stockpile area on the bank. The water was drained and returned to the Broadwater via sedimentation ponds. Sand dredging activities create potential contamination impacts including:

- acid generation; and
- elevated concentrations of radioactive sands.

Acid generation and run-off may result from sand dredging operations, when exposure of acid sulphate soils to oxygen occurs. Previous testing of the soil from the sand dredging indicated that the sand possesses low potential acid sulphate characteristics. However, the silt stockpiles displayed potential acid sulphate characteristics. These silt stockpiles may have represented an environmental hazard and appropriate measures were implemented by Gold Coast Airport Limited for the storage and the disposal of the silt.

Radioactive sands occur naturally and can be concentrated when mineral sands are extracted. This concentration occurs because radioactive sands are denser than the surrounding sand. Concentration can occur during sand sedimentation as radioactive sands settle quicker than the surrounding material, which is generally carried further in the water.

4.5 Field Investigation Results

Following the site inspections, review of available information and a review of groundwater flow directions (see Technical Paper Number 9), it was determined that a new groundwater monitoring well (TGW7) should be installed in the area of the Tugun Landfill to be affected by the proposed transport corridor.

The new monitoring well was installed on 2 February 2001 to 3.05 m below the surface level and consists of a 50 mm diameter, class 18 uPVC pipe. The top casing is 0.8 m in length and was attached to a 3 m long slotted screen section below. This was installed and a sand pack was placed between the annulus of the borehole and the casing with a bentonite seal above the sand pack to prevent surface infiltration. In addition, a steel protective cover was installed over the monitoring well. The lithology observed during drilling was characterised by silty and slightly silty sands.

Groundwater was noted to be at 0.1 m below the surface. A schematic of the construction of TGW7 is shown in Appendix B.

Monitoring well TGW7 and 14 existing monitoring wells were gauged, developed, and sampled on 27 February 2001. Sampling was undertaken following a period of heavy rainfall. Two surface water samples were also collected from within an excavation on the south-western boundary of the landfill. Sampling locations are shown on Figure 4.2.

The results of the field investigation during March 2003 are discussed separately under Section 4.6.

Samples collected from locations in the vicinity of Tugun Landfill were tested for the full suite of parameters required by *NSW Environment Protection Authority Environmental Guidelines - Solid Waste Landfills,* Table 2 - Indicator Parameters for Groundwater Detection Monitoring Program. Detection levels as required by Table 2 of NSW Environment Protection Authority guidelines for Solid Waste Landfills were adhered to, with the exception of Total Organic Carbons, as laboratory testing to this level is not possible. A copy of Table 2 from the Guidelines is presented in Appendix C. A field test of salinity was also undertaken.

The following analytes were not required for the sampling locations at some distance from the landfill, as they are regarded as indicator parameters for the detection of leachate generated from landfill waste:

- ammonia (NH_3);
- absorbable organic halogens (AOX);
- fluoride;
- manganese;
- total phenolics; and
- total organic carbon (TOC).

Table 4.1 through Table 4.4 show the results of all testing undertaken for this investigation. Full laboratory reports are provided in Appendix D.

The data was compared to the ANZECC (2000) guidelines. ANZECC (2000) has a preferred hierarchy for deriving trigger values that include:

- most preferred – local or site specific data (ecotoxicity tests);
- less preferred – local reference data (from prior monitoring); or
- least preferred – default approach (generic guidelines).

In the absence of site-specific data a default approach using generic data has been used to assess this data.

The receiving water for groundwater is assessed as being estuarine waters used for aquatic ecosystems.

Table 4.2: Laboratory Test Results — General Analytes Part 1

Sample Location	Sample ID	Date Sampled	pH	EC µS/cm	Salinity mg/L	Temp °C	Chloride	Sulphate	Ammonia as N	Fluoride	Total Phenolics	TOC	AOX
Groundwater Samples Adjacent to Landfill													
Monitoring Well TGW 1	TGW 1	7-Feb-01	5.14	397	270	22.8	65	20	2.18	nd	0.02	49	0.200
Monitoring Well TGW 2	TGW 2	7-Feb-01	6.02	712	485	25	50	50	14.7	nd	0.02	57	0.235
Monitoring Well TGW 3	TGW 3	7-Feb-01	5.76	685	466	23.6	35	25	11.3	nd	0.02	38	0.088
Monitoring Well TGW 4	TGW 4	7-Feb-01	nt	nt		nt	55	8	4.15	nd	nd	23	0.049
Monitoring Well TGW 5	TGW 5	7-Feb-01	5.33	244.1	166	22.2	21	7	1.75	nd	nd	24	0.074
Monitoring Well TGW 7	TGW 7	7-Feb-01	6.85	2,227	1,514	25.3	98	220	61	nd	0.03	43	0.103
Monitoring Well FT 1	FT 1	7-Feb-01	6.33	444	302	21.2	12	16	0.67	0.2	nd	19	0.031
Monitoring Well MW16	MW16	7-Feb-01	6.46	350	238	24.8	28	28	0.08	0.1	0.02	18	0.079
Surface Water Samples Adjacent to Landfill													
landfill toe GW1	GW1	7-Feb-01	nt	nt		nt	40	410	12.5	0.1	nd	22	0.065
landfill toe GW2	GW2	7-Feb-01	nt	nt		nt	37	410	11.6	0.1	nd	22	0.065
Other Groundwater Samples													
Monitoring Well A	A	7-Feb-01	4.35	83.5	57	25.4	3	3	nt	nt	nt	nt	nt
Monitoring Well B	B	7-Feb-01	5.03	50.2	34	24.4	8	1	nt	nt	nt	nt	nt
Monitoring Well D1	D1	7-Feb-01	4.94	176.2	120	22.5	38	nd	nt	nt	nt	nt	nt
Monitoring Well E2	E2	7-Feb-01	6.24	915	622	21.8	180	4	nt	nt	nt	nt	nt
Monitoring Well BH9	BH9	7-Feb-01	5.54	251.6	171	24.4	11	34	nt	nt	nt	nt	nt
Quality Assurance Samples													
Monitoring Well TGW 7	TGW 7000	7-Feb-01	6.85	2,227	1,514	25.3	nt	nt	nt	nt	nt	nt	nt
ROB^	ROB	7-Feb-01	nt	nt		nt	nt	nt	nt	nt	nt	nt	nt
Guideline Levels													
Australian Drinking Water Guidelines			NC	NC	NC	NC	250	250	0.5	1.5	NC	NC	NC
ANZECC (2000) Guidelines (Recreational Use)			5.0 - 9.0	NC	NC	NC	400	400	0.01	NC	0.002	NC	NC
ANZECC (2000) Guidelines (Aquatic Ecosystems/Estuaries)			7.0 - 8.5		125 – 2,200		NC	NC	0.32 – 0.5[4]	NC	0.085	NC	NC
Dutch Intervention Guidelines			NC				NC	NC	0.02	NC	NC	NC	NC
National Environment Protection Measure Guidelines (NEPM)			NC				NC	NC	NC	NC	NC	NC	NC

See notes following Table 4.4

Table 4.3: Laboratory Test Results — General Analytes Part 2

Sample Location	Sample ID	Date Sampled	Total Nitrogen	Nitrate (as N)	Nitrite (as N)	Kjeldahl Nitrogen	Phosphorus	Total Dissolved Solids	Bicarbonate as CaCO3	Alkalinity as CaCO3
Groundwater Samples Adjacent to Landfill										
Monitoring Well TGW 1	TGW 1	7-Feb-01	3.8	0.01	nd	3.8	0.6	250	24	24
Monitoring Well TGW 2	TGW 2	7-Feb-01	17	nd	nd	17	2.2	500	220	220
Monitoring Well TGW 3	TGW 3	7-Feb-01	12	nd	nd	12	0.04	410	250	250
Monitoring Well TGW 4	TGW 4	7-Feb-01	5.2	0.02	nd	5.2	1.4	190	41	41
Monitoring Well TGW 5	TGW 5	7-Feb-01	2.6	0.01	nd	2.6	0.07	120	21	21
Monitoring Well TGW 7	TGW 7	7-Feb-01	63	nd	nd	63	2.3	1,100	730	730
Monitoring Well FT 1	FT 1	7-Feb-01	1.4	nd	nd	1.4	0.13	280	140	140
Monitoring Well MW16	MW16	7-Feb-01	5.2	0.14	nd	5.0	0.60	200	67	67
Surface Water Samples Adjacent to Landfill										
landfill toe GW1	GW1	7-Feb-01	20	4.4	0.6	15	0.06	1,000	300	300
landfill toe GW2	GW2	7-Feb-01	21	4.5	0.61	16	0.07	1,000	290	290
Other Groundwater Samples										
Monitoring Well A	A	7-Feb-01	0.9	0.09	nd	0.8	0.60	29	nd	nd
Monitoring Well B	B	7-Feb-01	0.3	nd	nd	0.3	0.01	33	nd	nd
Monitoring Well D1	D1	7-Feb-01	1.0	nd	nd	1.0	0.04	52	3	3
Monitoring Well E2	E2	7-Feb-01	0.4	0.05	nd	0.3	nd	390	47	47
Monitoring Well BH9	BH9	7-Feb-01	2.0	nd	nd	2.0	0.14	180	49	49
Quality Assurance Samples										
Monitoring Well TGW 7	TGW 7000	7-Feb-01	nt	nt	nt	nt	nt	nt	nt	nt
ROB^	ROB	7-Feb-01	nt	nt	nt	nt	nt	nt	nt	nt
Guideline Levels										
Australian Drinking Water Guidelines			NC	50	3	NC	NC	1,000	NC	NC
ANZECC 2000 Guidelines (Recreational Use)			NC	10	1	NC	NC	1,000	NC	NC
ANZECC 2000 Guidelines (Aquatic Ecosystems/Estuaries)			0.3	0.017	0.015(NOx)	NC	0.01	NC	NC	NC
Dutch Intervention Guidelines			NC	5.6	NC	NC	0.15	NC	NC	NC
National Environment Protection Measure Guidelines (NEPM)			0.1-0.75	NC	NC	NC	0.01-0.02	NC	NC	NC

See notes following Table 4.4

Table 4.4: Laboratory Test Results — Metals

Sample Location	Sample ID	Date Sampled	Arsenic	Chromium	Copper	Lead	Zinc	Cadmium	Manganese	Calcium	Iron	Potassium	Magnesium	Sodium
Groundwater Samples Adjacent to Landfill														
Monitoring Well TGW 1	TGW 1	7-Feb-01	0.002	0.004	0.002	0.002	0.218	nd	0.063	6.4	6.68	3.6	6.4	61
Monitoring Well TGW 2	TGW 2	7-Feb-01	0.005	0.004	0.005	0.001	0.357	0.0001	0.198	58	2.87	13	14	68
Monitoring Well TGW 3	TGW 3	7-Feb-01	0.002	0.004	0.002	nd	0.494	nd	0.150	61	4.06	11	15	46
Monitoring Well TGW 4	TGW 4	7-Feb-01	nd	0.003	0.001	0.002	0.089	nd	0.014	6.6	0.45	6.2	4.4	50
Monitoring Well TGW 5	TGW 5	7-Feb-01	0.001	0.003	0.002	0.002	0.069	nd	0.030	6.6	1.78	3.4	3.0	31
Monitoring Well TGW 7	TGW 7	7-Feb-01	0.007	0.007	0.004	nd	0.336	0.0001	1.430	170	10.9	46	56	110
Monitoring Well FT 1	FT 1	7-Feb-01	0.008	0.002	0.003	0.002	0.374	nd	0.187	28	0.49	56	4.6	25
Monitoring Well MW16	MW16	7-Feb-01	0.002	0.003	0.003	nd	0.691	0.0001	0.212	42	10.2	2.4	3.0	30
Surface Water Samples Adjacent to Landfill														
(landfill toe) GW1	GW1	7-Feb-01	0.003	0.002	0.007	0.002	0.084	0.0002	0.514	250	2.83	20	30	38
(landfill toe) GW2	GW2	7-Feb-01	0.003	0.002	0.007	0.003	0.084	0.0004	0.477	240	1.91	20	29	38
Other Groundwater Samples														
Monitoring Well A	A	7-Feb-01	0.002	0.002	0.006	nd	0.337	nd	nt	3.0	0.33	0.7	0.6	14
Monitoring Well B	B	7-Feb-01	nd	0.002	0.003	0.006	0.277	nd	nt	2.6	0.30	0.8	0.7	17
Monitoring Well D1	D1	7-Feb-01	0.001	0.002	0.002	0.003	0.493	nd	nt	3.4	1.86	2.0	2.2	32
Monitoring Well E2	E2	7-Feb-01	0.001	0.005	0.002	0.001	0.064	nd	nt	7.6	0.75	8.6	12	100
Monitoring Well BH9	BH9	7-Feb-01	0.001	0.002	0.001	0.001	0.014	nd	nt	25	3.12	3.6	5.6	9.4
Quality Assurance Samples														
Monitoring Well TGW 7	TGW 7000	7-Feb-01	0.004	0.008	0.002	nd	nd	nd	nt	160	2.24	48	61	110
ROB^	ROB	7-Feb-01	nd	nd	0.004	nd	0.002	nd	nt	0.1	nd	0.1	nd	nd
Guideline Levels														
Australian Drinking Water Guidelines			0.007	0.05	1	0.01	3	0.002	0.1	NC	0.3	NC	NC	180
ANZECC 2000 Guidelines (Recreational Use)			0.05	0.05	1	0.05	5	0.005	0.1	NC	0.3	NC	NC	300
ANZECC 2000 Guidelines (Aquatic Ecosystems/Estuaries)			0.0008-0.001	0.00001	0.001	0.0024	0.00006	0.0007	1.2	NC	NC	NC	NC	NC
Dutch Intervention Guidelines			0.06	0.03	0.075	0.075	0.8	0.006	NC	NC	NC	NC	NC	NC
National Environment Protection Measure Guidelines (NEPM)			0.05	0.01	0.002-0.005	0.001-0.005	0.001-0.05	0.0002-0.002	NC	NC	1	NC	NC	NC

See notes below

Notes Relating to Table 4.2, Table 4.3 and Table 4.4

1.	Units	All results in mg/L unless otherwise specified
2.	Results	Highlighted results indicate levels exceeding the governing criteria.
3.	Governing Criteria	Where guideline levels conflict, the governing criteria is chosen in the following order: - ANZECC Guidelines for Aquatic Ecosystems - Australian Drinking Water Guidelines (NHRMC/ARMCANZ) - ANZECC Guidelines for Recreational Waters - National Environmental Protection Measure guidelines - Dutch Intervention level guidelines
4.	Reporting of Ammonia	Ammonia can be reported as NH_3 or as N. To convert from Ammonia as N, multiply the results by 17/14, which is the ratio of molecular weights. ANZECC criteria for aquatic ecosystems is given as Ammonia as NH_3.
5.	nd	Indicates analyte not detected in this sample
6.	NC	Indicates no criteria currently specified for this analyte
7.	nt	Indicates that the sample was not tested for this analyte
8.	*	Indicates duplicate sample
9.	^	Indicates field rinsate blank
10.	ANZECC Guidelines for Aquatic Ecosystems	In determining the criteria for nutrient parameters, levels for rivers and streams were used.
11.	Salinity	Salinity is determined directly from EC using the formula Salinity (mg/L) = 0.68 x conductivity (S/cm) (ANZECC)
12.	Sampling Locations	Refer to Figure 4.2 for sampling locations

Table 4.5: Summary of Acid Sulphate Soil Testing Results from TGW7

Sample ID	Date Sampled	Depth	pH (KCl)	pH after Oxygenation	Calcium (acid reacted)	Calcium (KCl)	Calcium (peroxide)	Peroxide Oxidisable Sulphur S(Pos)	Total Actual Acidity (TAA)	Total Potential Acidity (TPA)	Total Sulphidic Acidity (TSA)
Unit		metres below ground level			percent	percent	percent	percent	mole / tonne	mole / tonne	mole / tonne
S1	2/2/01	0.5	6.2	4.1	<0.02	0.02	0.02	<0.02	<2	14	14
S2	2/2/01	1.0	6.2	6.8	0.04	0.08	0.12	0.04	<2	<2	<2
S3	2/2/01	1.5	6.2	4.4	<0.02	<0.02	<0.02	<0.02	<2	6	6
S4	2/2/01	2.0	6.1	4.1	<0.02	0.02	<0.02	<0.02	<2	8	8
S5	2/2/01	2.5	6.0	3.8	<0.02	<0.02	<0.02	<0.02	<2	10	10
S6	2/2/01	3.0	6.1	4	<0.02	<0.02	<0.02	<0.02	<2	10	10
Action Criteria								0.03	18	18	18

Notes: Highlighted results exceed action criteria.

4.5.1 pH

The reported pH levels varied between 4.35 (monitoring well A) and 6.85 (TGW7), which indicates that the water ranged from acidic to near neutral for the samples tested. The ANZECC (2000) guidelines recommend pH levels between 7.0 to 8.5 for south-east Australian estuarine aquatic ecosystems. All samples had pH values that are more acidic than the guideline value ranges.

The low pH values are likely to be linked to the presence of acid sulphate soils and previous activities in the area. For further discussion see Technical Paper Number 5. The levels measured are below the default ANZECC (2000) guideline recommended for aquatic ecosystems. It is unknown whether these levels are naturally occurring or have been induced by human activity. However, flora and fauna do not appear to be adversely affected by the acidic conditions and some species actually benefit from them. For further information, refer to Technical Paper Number 12. This indicates that site-specific studies are required to assess the ecosystem specific guidelines that the results should be assessed against.

The majority of results are below the lower default ANZECC (2000) recreational water quality guideline and therefore may represent a risk to humans who come into contact with the groundwater. For human contact, the ideal pH should approximately match the lacrimal fluid of the eyes, which is about pH 7.4. This fluid has a high buffering capacity, but if this capacity is exceeded, a pH change as small as 0.1 unit will cause irritation to the eyes (ANZECC 2000).

Human contact should be prevented where the pH is below 5, which was detected at monitoring wells A and D1. The water is generally not suitable for consumption based on the pH levels measured.

4.5.2 Salinity

The receiving waters are assessed as tidally influenced estuarine waterbodies. The salinity values are less than the ANZECC (2000) guideline range for lowland rivers of 125 to 2,200 and are therefore not expected to adversely impact the receiving estuary. The elevated salinity level at TGW7 appears to be associated with Tugun Landfill.

Salinity levels assessed at TGW7 do not present a risk in terms of human exposure. However, there are potential problems to groundwater dependent ecosystems, which are located down gradient of the well.

It is possible that the excavation of the landfill has caused the higher levels and that these levels may have the potential to cause die-back of particular flora species.

4.5.3 Chloride

Chloride was detected in all groundwater monitoring wells, at concentrations of between 3 mg/L (monitoring well A) and 180 mg/L (monitoring well E2). Chloride results were all below the ANZECC (2000) default guideline for recreational use of 400 mg/L and the Australian Drinking Water Guideline of 250 mg/L. No criteria are set for aquatic ecosystems.

4.5.4 Sulphate

The sulphate levels ranged in concentrations from none detected in monitoring well D1 to 410 mg/L in surface water samples GW1 and GW2. The levels in GW1 and

GW2 exceeded the ANZECC (2000) default guideline for recreational use of 400 mg/L and the Australian Drinking Water Quality Guideline of 250 mg/L.

High concentrations of sulphate can result in gastrointestinal irritation. The guideline value is based on taste considerations for drinking water. No criteria are set for aquatic ecosystems.

4.5.5 Ammonia

The most common sources of ammonia entering ground and surface waters are domestic sewage, landfill leachate and industrial effluent. It is formed from the decomposition of nitrogenous organic matter (ANZECC 1992). When water percolates through decomposing solid wastes, biological materials and chemical constituents are leached into solution. Together with Total Organic Carbons, ammonia may be used as an indicator of landfill leachate impact in groundwater as it is one of the elements that characterise landfill leachate.

Ammonia was detected at all sites adjacent to Tugun Landfill and all exceeded the ANZECC (2000) 99 percent species protection guideline levels (0.32 to 0.5 mg/L), the ANZECC (2000) recreational use guideline (0.01 mg/L) and the Australian Drinking Water Guideline (0.5 mg/L) with the exception of MW 16. This indicates that putrescible materials are undergoing decomposition within the landfill and leachate is impacting surrounding groundwater.

MW 16 is in an area that was landfilled more than 30 years ago, and it is likely that decomposition in this area is nearing completion. During sampling ammonia levels at MW 16 were the lowest in the area.

Ammonia present in natural or polluted waters is not physiologically damaging (ANZECC 1992). However its presence is indicative of pollution, and consumption or exposure should be avoided.

The toxicity of ammonia, for ecosystems, is dependent on the concentration of the undissociated form NH_3, which is controlled by pH and temperature. Ammonia is a non-persistent and non-cumulative toxicant to aquatic life (ANZECC 1992). Particular species within the aquatic ecosystem can be affected by ammonia toxicity. Invertebrates are generally more tolerant than fish and phytoplankton and aquatic vascular plants are more tolerant again (ANZECC 1992). For further information refer to Technical Paper Number 12.

4.5.6 Fluoride

No criteria are currently specified for this analyte in the ANZECC (2000) guidelines. However, as a guideline, the Australian Drinking Water Guidelines recommend a maximum level of 1.5 mg/L based on health considerations. Fluoride levels in the samples tested did not exceed these criteria.

4.5.7 Total Phenolics

Phenols are a large volume industrial chemical used for the preparation of other chemicals (ANZECC 2000). They are also produced during the coking of coal, distillation and preparation of wood products, oil refining, and occur as a degradation product of polycyclic aromatic hydrocarbons.

The presence of phenols suggests that some leaching of hydrocarbons from the landfill maybe occurring.

The phenol levels for all samples were under the criteria for aquatic ecosystems based on the 99 percent species protection trigger levels for the protection of fresh or marine water aquatic ecosystems.

All results exceeded the ANZECC (2000) guideline value for recreational purposes of 0.002 mg/L

The monitoring wells located closest to Tugun Landfill (with the exception of MW 16) had the highest elevations of total phenolics. The highest concentration, at 0.03 mg/L, was located in TGW7 immediately to the west and hydraulically down-gradient of the Tugun Landfill.

Phenols in high concentrations are toxic to humans and lower concentrations will produce unpleasant taste and odours. The guideline level of 0.002 mg/L is based on taste and odour criteria.

4.5.8 Total Organic Carbons (TOC)

Total Organic Carbons (TOC) are a bulk measure of the organic compounds in solution. Since they are composed of numerous compounds, from both naturally occurring and potentially anthropogenic sources with varying toxicity, there are no criteria set for this parameter. TOC is used in the ANZECC (2000) guidelines to normalise guidelines derived for organic compounds.

A higher level of this parameter compared to background levels is an indicator that there is a higher concentration of organic carbon and could reflect possible pollutants in the solution. Since no background data is available no conclusions can be drawn from this test as to whether there has been contamination. However, these levels could be used as background levels for future studies. This parameter is required by the *NSW Environment Protection Authority Environmental Guidelines – Solid Waste Landfill*.

4.5.9 Absorbable Organic Halogens (AOX)

The absorbable organic halogens (AOX) parameter is bulk measure of particular types of compounds. Halogens are elements with a valency of -1 and include chlorine, fluorine, bromine and iodine.

Not all compounds in this group are harmful to humans or the aquatic ecosystems, but the group includes many pesticides and chemicals used in industrial processes. Some of these chemicals can be extremely harmful to humans and the ecosystem and include some carcinogens.

As the test is a bulk measure of various compounds, there are no criteria that can be applied for the parameter as a measure of water quality. When parameter levels are higher than background levels, this indicates that further investigation should be undertaken. No background level data is available for the site. Since no background data is available no conclusions can be drawn from this test as to whether there has been contamination. However, the three most elevated results (TGW7 0.103 mg/L, TGW1 0.2 mg/L, TGW2 0.235 mg/L) also reported the most elevated TOC and two of the most elevated ammonia concentrations suggesting impacts from AOX maybe derived from landfill leachate.

Further investigation of the potential for specific toxic AOX compounds is recommended.

4.5.10 Nitrogen and Phosphorus

Nitrogen and phosphorus are essential nutrients required for plant growth. Both are used in photosynthesis, a chemical reaction that uses the energy provided by sunlight to convert carbon dioxide and water into plant mass. In waterways, plant growth can often be limited by the amount of available nitrogen (in the form of nitrate NO_3^-) and phosphorus (in the form of orthophosphate (PO_4^{2-})).

Problems can arise in waterways when excessive algal growth occurs as a result of an oversupply of nitrogen or phosphorus. This process, known as eutrophication, can limit the amount of sunlight penetrating water bodies, change the water temperature, and subsequently have a detrimental effect on water quality. The decay of the algae also causes an increase in Biological Oxygen Demand (BOD).

Nitrogen exceeded the ANZECC (2000) default trigger levels for total nitrogen (0.3 mg/L) for aquatic ecosystems in estuaries in south-east Australia (this includes south-east Queensland) in all samples.

Phosphorus levels exceed ANZECC (2000) default trigger levels for aquatic ecosystems for estuaries in south-east Queensland of 0.01 mg/L for all samples except monitoring well B.

The nutrient levels in bores away from the landfill show that there are high nutrient levels in the natural state, given the depositional history of this environment these results would normally be expected. In estuarine environments, estuarine muds accumulate with high nutrient composition from both dead estuarine organisms and decaying accumulated plant matter. In the area of Tugun Landfill, the nutrient levels were higher, the highest being at TGW7 for both nitrogen and phosphorus.

Human exposure to these nutrients is not a health risk until highly elevated levels are encountered and forms such as nitrites are present. However, their elevated levels can be indicative of wastewater discharges, possibly from the pumping station, or leachate/diffuse run-off from Tugun Landfill.

4.5.11 Nitrate, Nitrite and Kjeldahl Nitrogen

The total nitrogen referred to in Section 4.5.10 is the sum of organic nitrogen and inorganic nitrogen. The test for organic nitrogen is Kjeldahl nitrogen and this includes ammonia. Hence Kjeldahl nitrogen should always be greater than or equal to ammonia. Inorganic nitrogen is nitrate and nitrite (often referred to as NO_X).

Since Kjeldahl nitrogen can include numerous organic nitrogen compounds, there are no water quality criteria for this parameter. See Section 4.5.5 for discussion on ammonia.

Nitrate and nitrite are important parameters for drinking water quality, as elevated levels of nitrate can be converted to nitrite in an acidic environment of pH less than 4. This can occur in the stomach of infants, the absorbed nitrite causing a reduction in oxygen transport capacity. There is also evidence that nitrite can be converted to carcinogens in the human digestive tract (ANZECC 2000).

Individual combined nitrate and nitrite concentrations exceeded the ANZECC (2000) aquatic ecosystem guideline for NO_x (oxides of nitrogen) of 0.015 mg/L in TGW4, (0.02 mg/L), GW1 (4.4 mg/L), GW2 (4.5 mg/L), monitoring well A (0.09 mg/L) and monitoring well E2 (0.05 mg/L).

ANZECC (2000) provides trigger values for nitrate in freshwater (values for marine waters are yet to be determined) for 99 percent species protection levels (0.017 mg/L). TGW4. MW 16, GW1, GW2, monitoring well A and monitoring well E2 exceeded this guideline.

Nitrate and nitrite concentrations were below the ANZECC (2000) guideline values for recreational water use.

4.5.12 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) influence other water quality parameters such as taste, hardness, corrosion properties and the tendency to encrustation (ANZECC 2000). The ANZECC (2000) recreational water quality guideline and Australian Drinking Water Guideline of 1,000 mg/L were exceeded by TGW7 and equalled by GW1 and GW2. Other samples were below this guideline level.

4.5.13 Carbonates and Alkalinity

Alkalinity is a measure of the amount of the buffering capacity of water. It is the sum of bicarbonate, carbonate and hydroxide. When dissolved in water, carbon dioxide will form one or two of these compounds depending on pH and temperature. Thus, a higher level of alkalinity generally means that there is more carbon dioxide dissolved in the water and that the solution will have a higher buffering capacity.

The results show that alkalinity is higher for the samples taken adjacent to the landfill. When correlated with the other test results such as ammonia concentrations, this indicates that decay of putrescible material is occurring and forming carbon dioxide. The buffering provided by the alkalinity will raise pH. The pH levels in the landfill are slightly higher, on average, than that for the other samples taken.

These indicators are not harmful to humans or the environment and hence no criteria are provided by the various water quality guidelines. The levels of these parameters can be used to indicate other processes that could be occurring and affecting the environment.

4.5.14 Metals

Arsenic (total) concentrations equalled or exceeded the ANZECC (2000) trigger values for aquatic ecosystems based on the 99 percent species protection level (As III). There are no guidelines determined for marine waters. Samples TGW7 and FT1 equalled or exceeded the Australian Drinking Water guideline of 0.007 mg/L. All results were within ANZECC (2000) recreational water quality guidelines.

Chromium (total) was within the ANZECC (2000) trigger values for aquatic ecosystems based on the 99 percent species protection level of chromium(III) in marine waters. However, chromium (total) exceeded the chromium(VI) trigger values for 99 percent species protection for both fresh and marine waters. Total chromium was within the ANZECC (2000) recreational water quality guidelines and Australian Drinking Water guideline for chromium (VI) of 0.05 mg/L.

Concentrations of copper met or exceeded the ANZECC (2000) default trigger level guidelines for freshwater aquatic ecosystems with a 99 percent species protection level and exceeded the trigger values for marine water in all samples.

The levels detected were below drinking water guideline levels and ANZECC (2000) recreational guidelines. Copper is an essential element for humans and poisoning is rare. Guideline drinking water levels are set to prevent staining to laundry fixtures and plumbing.

Copper is toxic to aquatic ecosystems and the level of toxicity depends on the water hardness and dissolved oxygen concentration.

All samples with detectable lead met or exceeded the ANZECC (2000) default trigger level guidelines for freshwater aquatic ecosystems with 99 percent species protection level. Samples GW2, monitoring well B and monitoring well D1 exceeded the ANZECC (2000) default trigger levels for marine water with 99 percent species protection.

The level detected was below the drinking water guidelines and ANZECC (2000) recreational water quality guidelines. Lead is toxic to some species in aquatic ecosystems and the level of toxicity depends on the water hardness (ANZECC 1992).

All samples exceeded the ANZECC (2000) trigger levels for 99 percent species protection for zinc in either fresh or marine aquatic ecosystems.

Zinc was within Australian drinking water guideline based on aesthetic considerations of 3 mg/L.

Zinc is an essential element for humans. Water hardness and pH (ANZECC 2000) influence zinc toxicity in aquatic ecosystems. Zinc was found to bio-accumulate in freshwater animals. The exceedances are consistent across the area and the higher zinc concentrations may be occurring naturally.

Cadmium was within the ANZECC (2000) trigger levels for 99 percent species protection in marine aquatic ecosystems water and for recreational water quality. It exceeded the guideline for freshwater aquatic ecosystems.

Manganese is an essential element for animals and humans. Aesthetic and human health considerations set guideline levels for drinking water. Samples TGW2, TGW3, TGW7, FT1, MW 16, GW1 and GW2 exceeded the aesthetic based Australian Drinking Water Guideline and the ANZECC (2000) recreational water quality guideline. Monitoring well TGW7 exceeded the ANZECC (2000) default trigger levels for 99 percent species protection in freshwater aquatic ecosystems. There is no guideline determined for marine aquatic ecosystems.

Iron is an essential trace element for human and animal nutrition and guideline levels for drinking water are set by aesthetic considerations. It is the fourth most abundant element in the earth's crust and is present in natural waters depending on geology. Acute toxicity to aquatic insects can occur above guideline levels. Iron concentrations equalled or were above drinking water guidelines across the samples, with higher concentrations being reported adjacent to Tugun Landfill. There is no ANZECC (2000) trigger level for fresh or marine aquatic ecosystems. All samples equalled or exceeded the ANZECC (2000) guideline for recreational water quality.

4.5.15 Quality Control Testing

The duplicate groundwater sample (TGW7000) reported duplicate results within a data quality objective (DQO) of 20 percent of the primary result for five of the analytes assessed for QA/QC. Three QA/QC analytes results reported concentrations close to non-detection limits and could not be assessed for QA/QC against the 20 percent data quality objective. Three analytes arsenic, copper and iron reported duplicate results in excess of the 20 percent DQO. This suggests that these analytes maybe distributed heterogeneously within the aquifer.

The field rinsate blank (ROB) reported concentrations of selected heavy metals less than laboratory limits of reporting with the exception of copper, zinc, calcium and potassium. The metal levels are considered to be consistent with the bottled water, which was used as the rinsate media. The levels of the analytes reported confirm that PB decontamination procedures were successful.

4.5.16 Acid Sulphate Soil Testing

Samples collected during the construction of monitoring well TGW7 were analysed to assess the presence of acid sulphate soils. Selected laboratory results are presented in Table 4.4, and laboratory results are shown in Appendix D.

A total of six soil samples, taken at 0.5 m intervals over the 3 m depth of the new well, were submitted for POCAS analysis. All samples reported total actual acidity (TAA) and total potential acidity (TPA) levels below the recognised action criteria.

However, one of the six samples (S2) reported a peroxide oxidisable sulphur (Spos) level of 0.04 percent which marginally exceeds the action criteria of 0.03 percent.

The reported levels of Ca (reacted) and Ca (KCl) for sample S2 indicate the soil sample has a neutralising capacity sufficient to neutralise the potential acidity after oxidation. In addition the pH (KCl) and pH after oxidation results for S2 confirm the soil has some neutralising capacity. Refer to Technical Paper Number 5 for further test results and discussion of the acid sulphate soil issues for the transport corridor.

4.6 Supplementary Field Investigation

The supplementary field investigation was used to determine if the groundwater at an additional four bores along the proposed bypass alignment was contaminated. Phase separated hydrocarbons (PSH) were reported at the bore in the vicinity of the proposed Tweed Heads Bypass interchange, which could have arisen from dumping or spills of fuels or oils. The bore was sampled for total petroleum hydrocarbons (TPH), benzene, ethylbenzene, toluene, xylene (BTEX) and dissolved lead to assess if the source contaminant was a fuel or an oil.

The other three bores were reported to evolve yeasty odours. These wells were analysed for a range of volatile and semi-volatile compounds (VOC/SVOC), TPH and dissolved methane.

To assess the recorded concentrations, reference is made to regulatory environmental investigation levels. In the absence of specific regulatory guidelines, state, national and international guidelines have been adopted. The levels assessed against are shown in Table 4.6.

Table 4.6: Assessment Criteria – Groundwater

Adopted Assessment Criteria	Contaminant	Threshold Concentration (µg/L)
Primary Guideline Criteria		
▪ ANZECC 2000 – Freshwater (Level of species protection 95 %)	Benzene	950
	Lead	3.4
▪ NEPM 1999	Toluene	300
▪ ANZECC 1992 – Freshwater Aquatic Ecosystem	Ethyl Benzene	140
	Total Xylene	300
Additional Guideline Criteria		
▪ Dutch Intervention 1994		
Guideline indicator of 'significant' level of impact impairing multifunctional lane use	TPH C_{10}-C_{36}) (via mineral oil)	600
▪ US EPA Preliminary Remedial Goals		
Guideline for tapwater	MEK	1,900
Guideline for tapwater	3 and 4 – methylphenol	180 (3-methylphenol) 1,800 (4-methylphenol)

Water level measurements prior to sampling indicated that they were generally higher than prior water levels, possibly due to rainfall since the previous monitoring. The pH was acidic, ranging from 3.5 to 4.7, more acidic than previous monitoring, possible due to the rise in water level flushing acid generation from acid sulphate soils into the groundwater. Anomalous results from the monitoring wells are summarised below.

The groundwater sampling reported dissolved petroleum hydrocarbons, dissolved lead, dissolved methane, MEK and 3 and 4 -methylphenol.

The bore closest to the proposed Tweed Heads Bypass interchange reported petroleum hydrocarbon dominantly in the C6--C14 chain length range. This is the common range of hydrocarbons derived from motorcar fuels, kerosenes and jet fuels. The presence of dissolved lead could be due to acid sulphate soil leaching of lead from soils and/or lead from leaded fuels. Values of 115 µg/L MEK and 764 µg/L 3- and 4-methylphenol were also reported from this bore.

The remaining three wells reported total petroleum hydrocarbons in the C15—C36 and C10—C14 chain length fractions. This is the common range for contaminant sources such as fuel oils, lubricating oils and parrafins, plus motor car fuels, kerosenes and jet fuels. MEK values ranged from 78 µg/L to 9,450 µg/L, while 3- and 4–methylphenol from 379 µg/L to 1,070 µg/L.

MEK can be sourced either from inappropriate disposal at landfills or as a component of aqueous film forming foam (AFFF) concentrates, 3- and 4–methylphenol can be sourced as either a remnant additive of jet fuel or from use in oils, lubricants or other forms inappropriately disposed to landfill.

4.7 Preliminary Environmental Site Assessment Results

Soil samples collected from the Gold Coast Airport for the assessment undertaken by Gold Coast Airport Limited were analysed for heavy metals (arsenic, cadmium, chromium, copper, lead, nickel and zinc), organochlorine and organophosphorous pesticides (OC/OPPs), total petroleum hydrocarbons (TPH), polycylic aromatic hydrocarbons (PAHs) and benzene, toluene, ethylbenzene and xylene (BTEX). The results are summarised in the following sections and tabulated in Appendix E.

4.7.1 Landfill A

Physical Results

Test pitting at Landfill A did not identify widespread landfill material. Test pit A1 intercepted landfill material on the edge of an area with a dense vegetation of trees. Test pit A1 intersected steel, timber, concrete and suspected asbestos containing materials in the top 0.5 m of the soil profile. This extended to 0.9 m depth. Groundwater was apparent at 0.95 m. The test pit was terminated in natural sands at 1.6 m below ground level. Other test pits did not intersect waste materials.

It appeared that if the landfill was of any size it would extend into the area of trees. Upon consultation with Gold Coast Airport Limited it was decided to cease excavations and use alternate (ie geophysical) methods to map the extent of the landfill before further investigations were undertaken.

Analytical Soil Results

None of the metals analysed reported results in excess of Airport (Environment Protection) Regulations 1997 Table 2 guidelines for areas of environmental significance. No detectable TPH or BTEX were reported. Total detectable PAHs (7.2 mg/kg) exceeded the Airport (Environment Protection) Regulations 1997 Table 2 guideline for total PAHs (5 mg/kg) while benzo(a)pyrene (the most carcinogenic PAH) equalled the health based investigation level (1 mg/kg) for residential land use.

Analytical Groundwater Results

The groundwater well GWA reported copper (0.023 mg/L), lead (0.007 mg/L)and zinc (0.294 mg/L) in excess of Airport (Environment Protection) Regulations 1997 (copper 0.005 mg/L, lead 0.005 mg/L, zinc 0.05 mg/L) criteria while cobalt exceeded ANZECC 2000 criteria. Ammonia also exceeded the Airport (Environment Protection) Regulations 1997 criterion.

4.7.2 Landfill B

Physical Results

Test pitting at landfill B identified landfill material. Test pits intersected up to 0.3m of sand overlying waste comprising household plastics, absestos containing material, metal, glass, concrete, brick, blue corroded metal, rubber tyres, timber and refuse varying in thickness through the top 0.2 to 1.8 m of the soil profile. Groundwater was apparent at 1.75 m to 2.1 m depth. The test pit was terminated in natural sands below waste. The fill material extended for between 5m to 30m wide over a 50 m length.

Analytical Soil Results

No detectable TPH, BTEX or total detectable PAHs were recorded. Elevated metals were reported in test pits B3 (300 mg/kg lead, 61 mg/kg nickel and 270 mg/kg zinc), B5 (360 mg/kg zinc), B7 (210 mg/kg zinc), B10 (320 mg/kg zinc) and B11 (290 mg/kg zinc) in excess of Airport (Environment Protection) Regulations 1997 Table 2 guidelines for areas of environmental significance. However, test pit B11 was observed to have no waste material suggesting elevated zinc concentrations maybe a reflection of background soils.

Analytical Groundwater Results

The groundwater well GWB reported copper (0.013 mg/L), nickel (0.033 mg/L), lead (0.008 mg/L) and zinc (1.29 mg/L) in excess of Airport (Environment Protection) Regulations 1997 (copper 0.005 mg/L, nickel 0.015 mg/L, lead 0.005 mg/L, zinc 0.05 mg/L) criteria while cobalt exceeded ANZECC 2000 criteria. Ammonia also exceeded the Airport (Environment Protection) Regulations 1997 criterion.

4.7.3 Landfill C

Physical Results

Test pitting at Landfill C identified landfill material in all test pits. Test pits intersected 0.2 m to 0.4 m of sand overlying waste comprising asbestos containing material, metal, glass, concrete, brick, metal, timber and refuse varying in thickness through the top 0.2 to 1.5 m of the soil profile. Groundwater was apparent at 1.1 m and had a characteristic rotten egg odour indicating reducing H_2S generation. Test pit C5 contained 44 gallon drums while test pit 7 had a strong hydrocarbon odour and reported 60 ppm VOC on the PID. The test pits were terminated in natural sands below waste. The fill material extended over a 30m width for 50 m.

Analytical Soil Results

Detectable TPH was reported in test pits C5 and C7 below Airport (Environment Protection) Regulations 1997 criteria. No BTEX or PAHs were reported.

Elevated metals were reported in test pits C1 (7.6 mg/kg cadmium, 84 mg/kg copper and 440 mg/kg zinc), C10 (880 mg/kg copper in excess of Airport (Environment Protection) Regulations 1997 Table 2 guidelines for areas of environmental significance.

Analytical Groundwater Results

The groundwater well GWC reported zinc (0.315 mg/L) in excess of Airport (Environment Protection) Regulations 1997 (zinc 0.05 mg/L) criteria while cobalt exceeded ANZECC 2000 criteria. Ammonia also exceeded the Airport (Environment Protection) Regulations 1997 criterion.

Wells GWA, GWB and GWC were installed at the location of the three airport landfill sites.

These were analysed for heavy metals, ammonia and biological oxygen demand to assess potential landfill leachate impacts.

The results are discussed with respect to landfill leachate processes below.

Leachate in landfills is generated by the decomposition of the waste material by microbes (especially bacteria). The initial decomposition begins within a few days of

fill placement. The aerobic phase usually occurs rapidly and compounds generally breakdown to carbon dioxide and water. The carbon dioxide dissolves in water to form carbonic acid and is also released as a gaseous phase.

The biological oxygen demand of the groundwaters was 24 mg/L in GWA and 7 and 9 mg/L in GWB and GWC respectively. Well GWA reported elevated biological oxygen demand indicative of landfill decomposition.

Once the available oxygen in the landfill has been consumed by the microbes and reactions during decomposition, further breakdown of materials occurs by anaerobic degradation. This is also termed fermentation. During anaerobic decomposition various organic acids (ie: acetic, formic, pyruvic acid) are produced. These acids breakdown to carbon dioxide and methane.

The carbon dioxide dissociates to bicarbonate and buffers the leachate from becoming highly acidic. The pH of the landfill leachates is generally in the range 6.5-7.0. The EC of leachate plumes is usually elevated.

Wells GWB and GWC reported pH of 6.6 and 6.63 respectively while GWA reported a pH of 5.98.

Wells GWA, GWB and GWC reported an EC of 183 us/cm, 384 us/cm and 428 us/cm respectively. None of these are significantly elevated, however well GWB and GWC recorded EC in the upper end of the range observed at the site.

Additionally nitrates and nitrites are reduced to ammonium (NH_3) and then ammonia (NH_4), and sulphate is reduced to hydrogen sulphide. This also acts to buffer the water.

Well GWA and GWB reported 0.2 mg/L ammonia while GWC reported 0.5 mg/L ammonia.

Leachate plumes at landfills generally have three zones. The landfill and the leachate it contains are an anaerobic zone, and this anaerobic zone extends along the mixing plume of leachate and groundwater. Methane and ammonia are produced in this zone.

As the plume mixes with an oxygenated groundwater, it becomes a less reducing transition zone. Most organic matter has been decomposed in this zone, and trace metals are precipitated with hydroxides of iron and manganese.

Wells GWA and GWB reported elevated concentrations of cobalt, copper ,lead and zinc with respect to aquatic ecosystem guidelines. Well GWC reported elevated cobalt, copper and zinc.

Further along the plume an aerobic zone is present. The native groundwater quality has been changed but insufficient to produce anaerobic conditions.

The ratio of TKN (the sum of organic nitrogen and ammonia) to nitrate is greatest in the anaerobic zone (ammonia is present here), this ratio decreases in the transition zone and is low in the aerobic zone.

Methane is produced in the anaerobic zone, and if the receiving groundwater is oxidising it will contain dissolved oxygen.

Wells GWA and GWB reported low levels of dissolved oxygen 0.84 to 1.0 mg/L while well GWC 1.48 mg/L dissolved oxygen.

The results do not indicate the presence of a concentrated leachate plume at the site. While, some elevated biological oxygen demand, metals, slightly elevated NH_4 and EC is present it does not indicate a major leachate plume at these locations.

This maybe due to the lack of putrescible materials at the sites and the age since deposition of the materials. The slightly more elevated ammonia result at GWC with the reported rotten egg and hydrocarbon odours suggests this is the most recent of the landfills and is a site where decomposition is still active.

As it has been many years since deposition of the materials an initial decomposing plume may have already completed its cycle and the remaining material may have little leachate generating capacity remaining.

4.7.4 Asbestos

Nineteen samples of fibrous cement sheeting debris from all landfills were analysed for the presence of asbestos. All of the samples contained identifiable asbestos as either chrysotile or amosite, confirming the presence of asbestos in all landfills.

4.7.5 Geophysical Survey

A geophysical survey was conducted for Gold Coast Airport Limited by G-tek Geophysical within the Gold Coast Airport site in the vicinity of Landfill's A, B and C using a magnetometer and analogue assessment.

Results of the assessment indicated that the surface area is heavily impacted with cultural debris, with some areas of disturbance as a result of intrusive investigations. Results show that at least three potential pits across the area exist.

The majority of impacts were within the delineated zone. This was an area measuring about 60 m by 40 m.

A number of objects and contamination were identified during the assessment; however most of this was within previously delineated boundaries.

5. Potential Impacts

The proposed transport corridor is shown on Figure 4.1. The alignment directly affects Tugun Landfill and is in the proximity of the quarry area in the north and the airport dumpsite, south-west of Tugun Landfill. The approach ramps of the Tweed Heads Bypass interchange are in the proximity of an area previously used for sand blasting.

A significant feature of the transport corridor is the inclusion of a road tunnel at the southern end of the main Gold Coast Airport runway. Potential impacts of the tunnel with regard to contaminated land issues are also considered during construction and operation.

5.1 Construction

5.1.1 Quarry / Borrow Area

Construction through the quarry area would require some cut and fill to achieve the levels required for the transport corridor. As outlined in Section 4.4.1 there is some potential for hydrocarbon spills in the area. If hydrocarbons are noted during excavation, further investigation would be undertaken as defined in Chapter 6.

5.1.2 Tugun Landfill

The construction of the proposed transport corridor would require excavation of the landfill in the vicinity of TGW7. The material from the excavation would either be replaced in Tugun Landfill, or transported to an alternate site. The test results from this area indicate that material to be removed would have elevated levels of ammonia, elevated levels of phenolics, high nutrient levels for nitrogen and phosphorus, high salinity and total dissolved solids. These parameters indicate that decay of putrescible material is occurring in the area and any material or water from the excavation should be treated as solid waste or leachate respectively.

The potential impacts associated with the excavation and construction are:

- an increase in the rate of decay of putrescible materials by exposure to air and rainfall, leading to an increase in the volume of leachate produced;
- acceleration of the migration of leachate from Tugun Landfill to down-gradient areas by exposure of the material to rainfall and run-off;
- potential to increase any harmful effects on the environment from the migration of leachate down gradient. Possible effects include a change to pH, an increase in nutrients, an increase in the levels of dissolved solids, or an escape of pesticides or other harmful chemicals;
- exposure of construction workers to harmful chemicals within the landfill material or leachate during the excavation and removal operation. The chemicals of particular concern are those included in the phenolics and absorbable organic halogens (AOX). It is not known which particular compounds would be present;
- escape of leachate or solid waste during the transport process (if required); and
- the effects of leachate at the location where the material is received.

5.1.3 Airport Dump Sites

The exact location, contents, and contaminants of the airport dump sites are not known. The general location and size has been determined and it is possible that the construction of the transport corridor would require excavation of dumped material. If material is encountered and it is putrescible or contaminated, the possible impacts are as described for Tugun Landfill in Section 5.1.2.

The following conclusions have been drawn from the results of the investigations undertaken at the Gold Coast Airport landfill sites.

- the landfills contain a range of wastes including predominantly hardfill material such as building materials and metals;
- the depth of landfilled material was less than 1.5 m and often 0.3 m to 0.5 m;
- all landfills contained asbestos containing materials;
- Landfill A contained Total PAHs (7.2 mg/kg) exceeding the Airport (Environment Protection) Regulations 1997 Table 2 guideline for total PAHs (5 mg/kg) and benzo(a)pyrene (a carcinogenic PAH) equalled the health based investigation level (1 mg/kg) for residential land use;
- Landfill B contained lead, nickel and zinc in excess of the Airport (Environment Protection) Regulations 1997 Table 2 guideline;
- Landfill C contained cadmium, copper and zinc in excess of the Airport (Environment Protection) Regulations 1997 Table 2 guideline and detectable TPH below Airport (Environment Protection) Regulations 1997 guidelines;
- zinc was generally elevated in all samples and exceeded Airport (Environment Protection) Regulations 1997 criteria in samples with no visible wasting suggesting it may naturally be present in elevated concentrations in soils at the site;
- groundwater reported ammonia (an indicator of landfill leachate) in excess of Airport (Environment Protection) Regulations 1997 criteria at all landfills and elevated metals concentrations in all landfills;
- Landfill A has limited characterisation in terms of content or extent.

5.1.4 Road Tunnel Excavation

The construction of the road tunnel and ramps would require the excavation and removal of approximately 400,000 m^3 of material. This material would be used as fill elsewhere along the alignment if it is suitable.

The characteristics of the groundwater within this material, in terms of potential contaminants, are:

- high acidity (low pH levels);
- elevated nutrient (nitrogen and phosphorus) levels; and
- elevated iron and zinc levels.

The soils have not been tested for contaminants. However, based on the results of the site inspection, land use analysis and groundwater testing, it can be concluded that the soils are characteristic for the area and not likely to be contaminated.

If the material is used on site and treated as recommended in Technical Paper Number 5, then it is unlikely that contamination issues would cause environmental impacts.

If excess or unsuitable material is disposed of off-site, there is a potential for the acidity, nutrient levels and presence of metals to affect the receiving environment.

5.1.5 Sand Blasting Area

The construction of the ramps for the Tweed Heads Bypass interchange could affect an area of land previously used for a sand blasting operation. Potential contaminants in this area could include tributyl-tin (TBT), heavy metals (particularly lead and chromium), petroleum hydrocarbons and polyaromatic hydrocarbons (PAH).

Impacts of construction would be related to the disturbance of these materials and the exposure of the potential contaminants to humans and the ecosystem.

5.1.6 Sandmining

The bypass through Gold Coast Airport crosses a significant portion of an area previously used for heavy sandmining (Figure 4.1). A survey of this area was undertaken by D.J. Douglas & Partners Pty Ltd (1994) to investigate radioactive sands which may have been concentrated by sandmining activities. This study found that all readings were well below the given clean up threshold. It concluded that the mining process had not left a concentration of radioactive sands within the airport grounds and that previous mining activities on the site did not constitute either an environmental or health risk.

5.2 Operation

Potential operational impacts relate to the exposure of humans or ecosystems to particular contaminants. Potential contamination land issues are related to traffic emissions and spills, pollution from brake pads and general pollution of traffic including hydrocarbons on roads. For further information on these issues refer *to* Technical Paper Number 11 and Technical Paper Number 8. Discussion of risks and hazards is contained within Technical Paper Number 16.

6. Mitigation Measures

6.1 Construction

6.1.1 Quarry Area

Potential impacts from contaminated land associated with the quarry area would be mitigated through the implementation of environmental management measures. Prior to excavation works, soil testing would be undertaken for the following parameters:

- polyaromatic hydrocarbons (PAH);
- total petroleum hydrocarbons (TPH); and
- metals.

The extent of testing would be determined in accordance with the Queensland Environmental Protection Agency *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* (1998). Soil contamination levels would be assessed in accordance with these Guidelines and the *National Environmental Protection (Assessment of Site Contamination) Measure 1999*. All investigations are to be carried out by a suitably qualified person in accordance with Section 381 of the *Environmental Protection Act 1994* and site investigation reports submitted must be accompanied by a certification in the form of a statutory declaration by the investigator and report preparer. An application for assessment of a site investigation and/or validation report must also be accompanied by the relevant form and statutory fee.

The extent of contamination found will determine appropriate treatment methods if required. Treatment methods available include removal and disposal to a licensed landfill, containment and capping. The Queensland Environmental Protection Agency should be consulted with respect to the proposed remediation or mitigation measures.

The removal of any contaminated soils from site within Queensland requires prior approval from the Queensland Environmental Protection Agency Contaminated Land Unit under the *Environmental Protection Act 1994*. Any on-site containment of contamination should be managed in accordance with the Guidelines and *Environmental Protection Act 1994*. In these circumstances, once sufficient investigations have been carried out, a draft Site Management Plan must be submitted to the Queensland Environmental Protection Agency Contaminated Land Unit for approval.

6.1.2 Tugun Landfill

As shown in Figure 6.1, mitigation measures for Tugun Landfill would focus on the capping of exposed areas of waste, minimising exposure of humans and ecosystems, and disposing of any leachate and solid waste material in an appropriate manner. Once in place, the mitigation measures would continue to restrict leachate migration from the landfill in the area where they have been implemented.

A management plan would be prepared detailing safe working practices for construction workers involved in the excavation and transport of the solid waste. The management plan would provide details of protective clothing required, hygiene procedures and any action to be taken should accidental exposure occur.

6.1.3 Airport Dump Site

As the three areas of known contamination are beneath the proposed alignment the waste material will be excavated and disposed of either to a suitable containment cell within the tugun Landfill or disposed of to a suitably licensed facility.

6.1.4 Sand Blasting Area

Potential impacts associated with the sand blasting area would be mitigated through implementation of environmental management measures. Prior to excavation soil testing would be undertaken for the following parameters:

- polyaromatic hydrocarbons (PAH);
- total petroleum hydrocarbons (TPH);
- tributyl-tin (TBT); and
- metals.

Testing would be undertaken in accordance with the following guidelines:

- *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC/NHMRC 1992);
- *Guidelines for Consultants Reporting on Contaminated Sites* (NSW Environment Protection Authority 1997); and
- *Contaminated Sites Sampling Design Guidelines* (NSW Environment Protection Authority 1995).

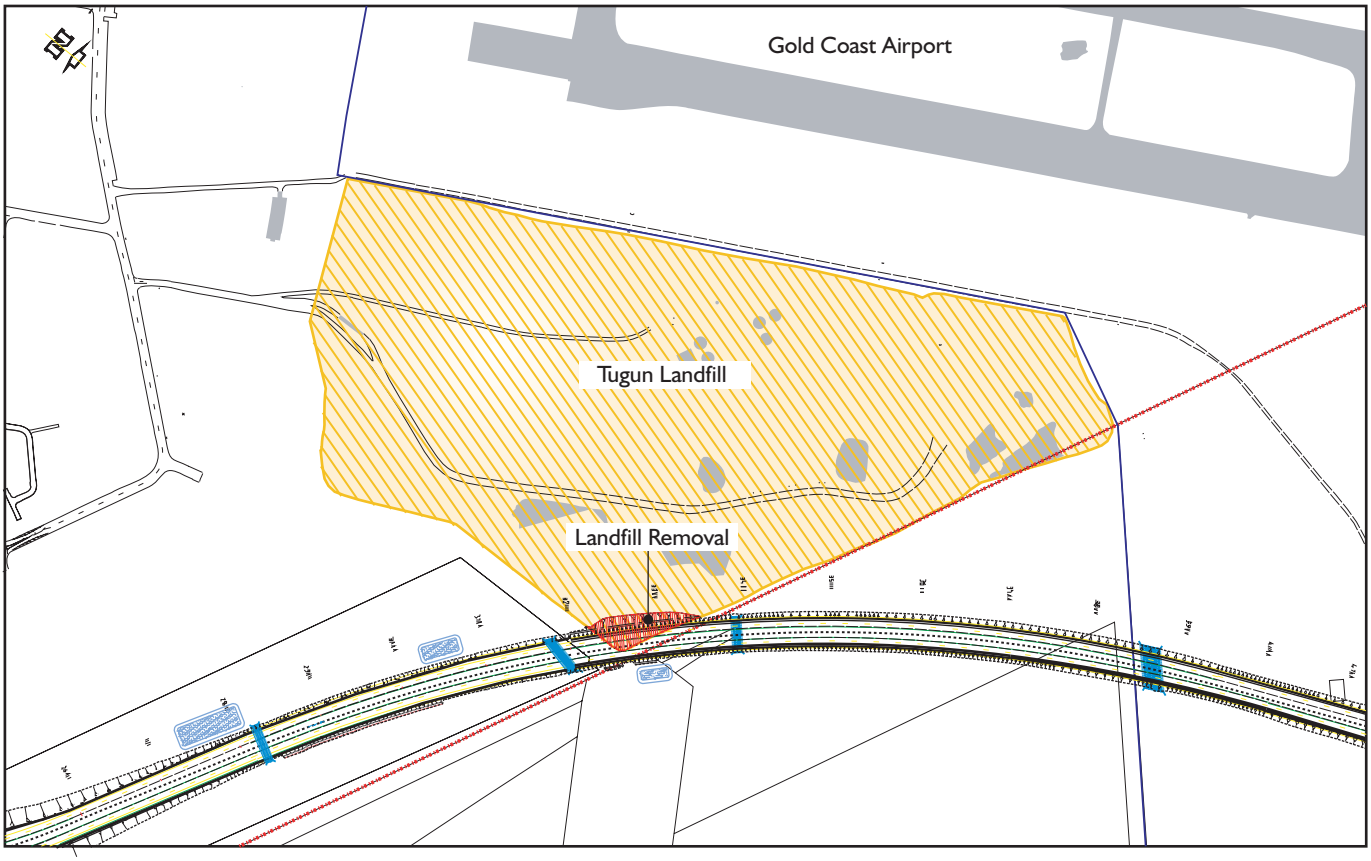
The extent of contamination found will determine appropriate treatment methods if required. The treatment methods available include removal and disposal to a licensed landfill, containment and capping.

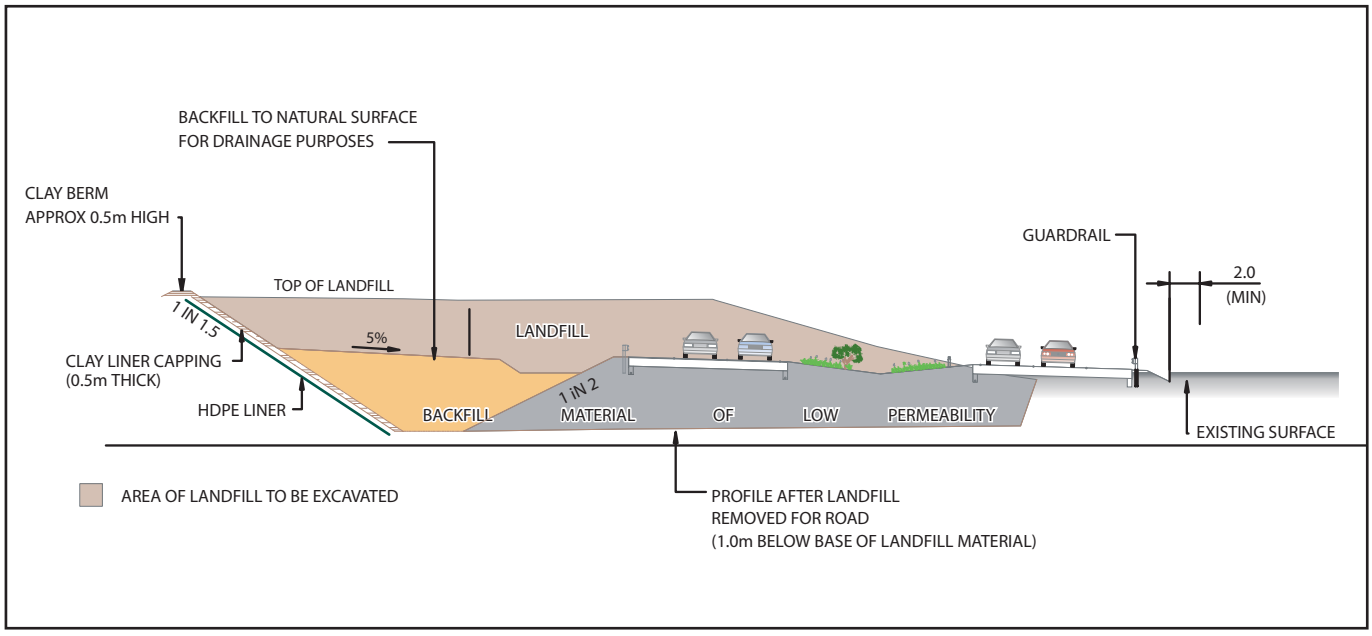
6.1.5 Occupational Health and Safety

Given the earlier recorded concentrations of methane, MEK and 3- and 4-methylphenol in groundwater during the supplementary surveys and taking into consideration results from subsequent monitoring by Gold Coast Airport Limited, which showed that levels of these analytes have returned to normal, it is recommended if necessary (i.e. return to elevated levels) that appropriate occupational health and safety measures are taken in any interaction with groundwater at the site.

6.2 Operation

No specific mitigation measures are required during the operation of the bypass in addition to those determined in Technical Paper Number 11, Technical Paper Number 8 and Technical Paper Number 16.





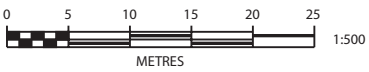


Figure 6.1 **Proposed Landfill Mitigation Measures at the Tugun Landfill**

References

Ahern C.R., Ahern M.R. and Powell B. 1998, Guidelines for Sampling and Analysis of Lowland Acid Sulphate Soils (ASS) in Queensland, Queensland Acid Sulphate Soils investigation Team (QASSIT), Queensland Department of Natural Resources, Brisbane.

Australian and New Zealand Conservation Council (ANZECC) 1992, *Australian Water Quality Guidelines For Fresh and Marine Waters*, National Water Quality Management Strategy Paper Number 4, Canberra.

Australian and New Zealand Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC) 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 1*, National Water Quality Management Strategy Paper Number 4, Canberra.

Australian and New Zealand Environment and Conservation Council and National Health and Medical Research Council 1992, *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.

Australian Government 1992, *National Strategy for Ecologically Sustainable Development*, Australian Government Publishing Service, Canberra.

D.J. Douglas & Partners Pty Ltd 1994, *Environmental Investigation, Coolangatta Airport*.

Douglas Partners 1996, *Further Environmental Investigation Coolangatta Airport*.

Gold Coast Airport Limited 1999, *Coolangatta Airport Environment Strategy*.

Lane Consulting 1998, *Review of Land Contamination Issues, Gold Coast Airport*.

Ministry of Housing, Spatial Planning and the Environment 1994, *Dutch Intervention* Guidelines, *Environmental Quality Objectives in the Netherlands*.

National Environment Protection Council Service Corporation 1999, *National Environmental Protection (Assessment of Site Contamination) Measure 1999*.

National Environment Protection Measure Guidelines on Investigation Levels for Soils and Groundwater 1999, *Protection of Aquatic Ecosystems (Fresh Waters)*.

National Health and Medical Research Council, Agriculture and Resource Management Council of Australia and New Zealand 1996, *National Water Quality Management Strategy - Australian Drinking Water Guidelines*.

NSW Environment Protection Authority 1999, *Contaminated Sites: Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report*.

NSW Environment Protection Authority 1998, *Contaminated Sites: Guidelines for NSW Site Auditor Scheme*.

NSW Environment Protection Authority 1997, *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*.

NSW Environment Protection Authority 1996, *Environmental Guidelines - Solid Waste Landfills.*

NSW Environment Protection Authority 1995, *Contaminated Sites, Sampling Design Guidelines*;

Queensland Department of Main Roads 1999, *Pacific Highway at Tugun — Route Selection Report*, prepared by Connell Wagner.

Queensland Environmental Protection Agency 1998, *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland*.

Queensland Health Scientific Services 2000, *Coolangatta Airport Fire Training Area, Groundwater Assessment*, prepared by Water Studies Pty Ltd.

Standards Australia 1993, AS1940 – *The Storage and Handling of Flammable and Combustible Liquids*.

Stone Y., Ahern C.R. and Blunden B. 1998, *Acid Sulphate Soils Manual 1998*, Acid Sulphate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

Legislation

Commonwealth

Airports Act 1996.

Airports (Environment Protection) Regulations 1997.

NSW

Contaminated Land Management Act 1997.

Queensland

Environmental Protection Act 1994.

Environmental Protection Regulation 1998.

Integrated Planning Act 1997

Appendix A

Tugun Landfill Monitoring Results provided by Gold Coast City Council

Laboratory Test Results — Gold Coast City Council

Monitoring well ID	Date Sampled	pH	Chloride	Conductivity mS/cm	Ammonia as N	Nitrate Nitrogen	TOC	Bicarbonate	Sulphate	Calcium	Total Iron	Lead	Potassium	Sodium	Zinc
Groundwater Samples Adjacent to Landfill															
TGW 1	20-Dec-99	5.3	81	0.39	3.9	0.05	12	28	29	3.2	4.2	0.1	3.9	59	
TGW 2	20-Dec-99	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	
TGW 3	20-Dec-99	6.4	30	0.76	9.8	0.03	6	300	13	100	30	nd	12	34	
TGW 4	20-Dec-99	6.1	86	0.50	8.3	nd	8	76	12	8.5	0.64	nd	11	74	
TGW 5	20-Dec-99	5.3	20	0.06	0.59	0.01	2	8	nd	0.6	0.48	nd	2	10	
TGW 6	20-Dec-99	6.2	nd	0.02	nd	nd	32	8	nd	1.8	0.47	nd	1.3	2	
TGW 1	18-Dec-00	5.4	600	0.3	3.4	0.026	29	30	8	3.6	3.0	nd	4.4	44	0.05
TGW 2	18-Dec-00	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
TGW 3	18-Dec-00	6.5	50	0.80	10	0.077	47	300	7	92	7.9	nd	11	31	0.04
TGW 4	18-Dec-00	6.2	70	0.33	4.7	0.010	24	66	nd	6.7	0.4	nd	8.5	36	0.02
TGW 5	18-Dec-00	5.4	25	0.96	0.50	0.020	17	12	5	0.9	2.2	nd	2.4	14	0.07
TGW 6	18-Dec-00	6.6	50	0.33	4.8	0.025	48	110	3	20	2.0	nd	11	30	0.04
Guideline Levels															
ANZECC (2000) Guidelines (aquatic ecosystems/estuaries)		7.0-8.5	NC	NC	0.32-0.5[4]	0.017	NC	NC	NC	NC	0.3	0.001	NC	NC	.0024
ANZECC (2000) Guidelines (recreational use)		5.0-9.0	400	NC	0.01	10	NC	NC	400	NC	0.3	0.05	NC	300	5
National Environment Protection Measure Guidelines (NEPM)		NC	400??	NC	NC	NC	NC	NC	NC	NC	1	0.001-0.005	NC	NC	0.001-0.05
Dutch Intervention Guidelines		NC	NC	NC	0.02	5.6	NC	NC	NC	NC	NC	0.075	NC	NC	0.8

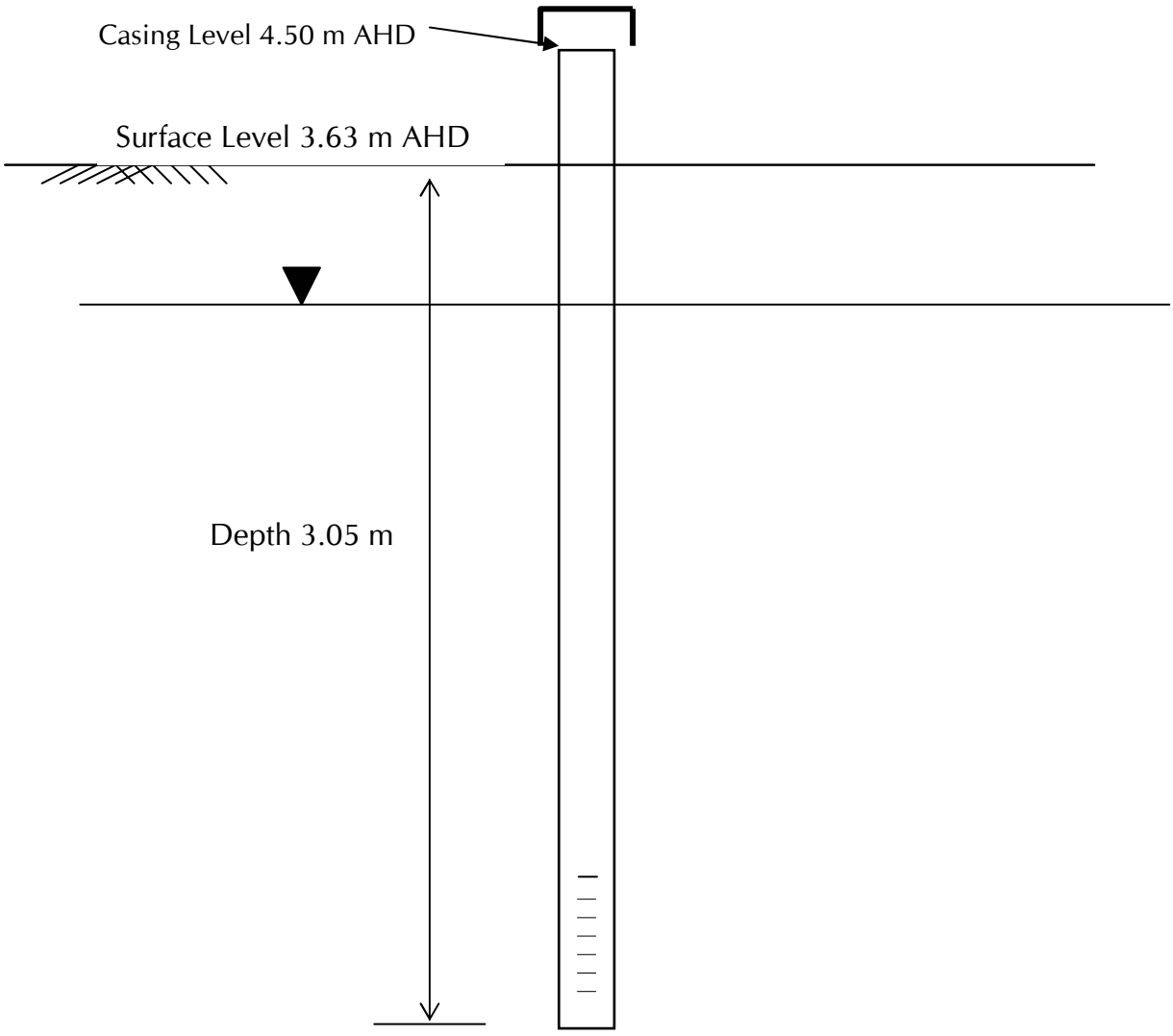
Notes

1. Units — All results in mg/L unless otherwise specified
2. Results — Highlighted results indicate levels outside the governing criteria.
3. Governing Criteria — Where guideline levels conflict, the governing criteria is chosen in the following order:
   - ANZECC Guidelines for Aquatic Ecosystems
   - Australian Drinking Water Guidelines (NHRMC/ARMCANZ)
   - ANZECC Guidelines for Recreational Waters
   - National Environmental Protection Measure guidelines
   - Dutch Intervention level guidelines
4. Reporting of Ammonia — Ammonia can be reported as NH_3 or as N. To convert from Ammonia as N, multiply the results by 17/14, which is the ratio of molecular weights. ANZECC criteria for aquatic ecosystems is given as Ammonia as NH_3.
5. nd — Indicates analyte not detected in this sample
6. NC — Indicates no criteria currently specified for this analyte
7. nt — Indicates that the sample was not tested for this analyte
8. ANZECC Guidelines for Aquatic Ecosystems — In determining the criteria for nutrient parameters, levels for rivers and streams were used.
9. Salinity — Salinity is determined directly from EC using the formula. Salinity (mg/L) = 0.68 x conductivity (:S/cm) (ANZECC)

Appendix B

Schematic of New Groundwater Monitoring Well TGW7

Easting 548 546
Northing 6 884 687



Schematic - New Monitoring Well TGW7

Appendix C

Table 2 from NSW Environment Protection Authority Environmental Guidelines — Solid Waste Landfill

Table 2: Indicator Parameters For Groundwater Detection Monitoring Program

Chemical or Property	Required Detection Level (RDL) (µg/L)
Absorbable organic halogens	10
Alkalinity	1,000
Ammonia	50
Calcium	5,000
Chloride	5,000
Fluoride	500
Iron	300
Magnesium	5,000
Manganese	50
Nitrate	100
pH	0.1 pH unit
Total phenolics*	50
Potassium	5,000
Sodium	5,000
Sulphate	5,000
Total organic carbon**	50

Notes:* Total phenolics or summation of 17 individual phenol-containing compounds identified by USEPA Method 8040 (USEPA 1192)
** For groundwater analyse filtrate from a 0.45 micron pore diameter filter; for surface water analyse TOC on an unfiltered water sample.

Source: NSW Environment Protection Authority 1996.

Appendix D

Groundwater Testing Reports

Water Analytical Results (GCA)

Sample Location	Sample ID	Date Sampled	Depth (mBGL)	Total Petroleum Hydrocarbons (mg/L)				B	T	E	m&p-X	o-X
				C_6-C_9	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
"GWA "	"GWA "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND
"GWB "	"GWB "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND
"GWC "	"GWC "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND
"RB "	"RB "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND
"TB "	"TB "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND
Laboratory Detection Limit (ug/L)				20	50	100	50	NC	NC	NC	NC	NC
Airport EP Regulation Schedule 2 Guidelines for Marine Waters ug/L				150		600		300	300[1]	140[1]	NC	NC
ANZECC 2000 AWQ 95% Species Protection Marine Water (ug/L)				NC	NC	NC	NC	950	NC	NC	NC	350

Sample Location	Sample ID	Date Sampled		Arsenic (mg/L)	Cadmium (mg/L)	Cobalt (mg/L)	Chromium (mg/L)	Copper (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Mercury (mg/L)	Ammonia	BOD
"GWA "	"GWA "	29/01/2004		0.001	0.0004	0.002	0.001	0.023	0.002	0.012	0.007	0.264	<0.0001	0.22	24
"GWB "	"GWB "	29/01/2004		0.002	0.0005	0.008	<0.001	0.013	0.003	0.033	0.008	1.29	<0.0001	0.22	7
"GWC "	"GWC "	29/01/2004		0.005	ND	0.008	<0.001	0.002	0.002	0.006	0.003	0.316	<0.0001	0.5	9
"RB "	"RB "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
"TB "	"TB "	29/01/2004		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Laboratory Detection Limit (ug/L)				0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001		
Airport EP Regulation Schedule 2 Guidelines for Marine Waters ug/L				50	2	NC	50	5	NC	15	5	50	0.1	5	NC
ANZECC 2000 AWQ 95% Species Protection Marine Water (ug/L)				NC	5.5	1	31.8	1.3	NC	70	4.4	15	0.5		NC

Notes

All results in ug/L unless otherwise specified

Results in red indicate levels exceeding Airport Environment Protection Guidelines

Results in black bold indicate exceedance of ANZECC 2000

NC Indicates no criteria currently specified for this analyte

-- analyte not tested in this sample

Adopted Criteria Airports (Environment Protection) Regulations, 1997 Statutory Rules 1997 No.13 as amended made under the Airports Act 1996.

Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland; Queensland Department of Environment, 1995.

nd Indicates analyte not detected in this sample

[1] Freshwater guideline used in absence of Marine Water criteria

Appendix E

Soil Testing Reports

Table E1: Soil Analytical Results Metals (GCA)

Sample Location	Sample ID	Date Sampled	Depth (m BGL)	Arsenic	Cadmium	Chromium*	Cobalt	Copper	Molybdenum	Nickel	Lead	Zinc	Boron	Mercury
A1	A1/0.5	22.01.04	0.5	nd	0.7	nd	nd	25	nd	4	110	190	nd	nd
A1	A1/1.0	22.01.04	0.9	nd	0.7	nd	nd	34	nd	3	47	180	nd	nd
C1	C1	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	nd	6	nd	nd
C1	C1	22.01.04	0.2	nd	7.8	39	10	84	55	17	230	440	nd	nd
C3	C3	22.01.04	1	nd	nd	nd	nd	11	nd	nd	50	75	nd	nd
C4	C4	22.01.04	1	nd	nd	8	9	16	nd	7	21	110	nd	nd
C4	C4	22.01.04	1.5	nd	0.7	11	9	14	nd	9	29	120	nd	nd
C5	C5	22.01.04	0.5	nd	nd	6	nd	14	nd	5	59	140	nd	nd
C5	C5	22.01.04	1	nd	nd	6	nd	5	nd	3	37	51	nd	nd
C5	C5	22.01.04	1.5	nd	nd	nd	nd	6	nd	3	12	120	nd	nd
C6	C6	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	nd	19	nd	nd
C7	C7	22.01.04	1	nd	nd	8	7	13	nd	9	11	160	nd	nd
C8	C8	22.01.04	1.5	nd	nd	nd	nd	7	nd	2	18	62	nd	nd
C9	C9	22.01.04	1	nd	nd	7	nd	14	nd	4	32	120	nd	nd
C10	C10	22.01.04	1	nd	nd	23	nd	880	nd	50	30	160	nd	nd
C11	C11	22.01.04	1	nd	nd	7	nd	9	nd	3	33	100	nd	nd
C12	C12	22.01.04	0.5	nd	nd	8	8	13	nd	5	19	110	nd	nd
C12	C12	22.01.04	1	nd	1.2	nd	nd	44	nd	5	210	80	nd	nd
B1	B1	22.01.04	1.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B2	B2	22.01.04	0.5	nd	nd	nd	nd	7	nd	nd	nd	6	nd	nd
B3	B3	22.01.04	0.5	nd	1.4	19	nd	300	nd	61	87	270	nd	nd
B4	B4	22.01.04	1.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B5	B5	22.01.04	0.5	nd	nd	nd	nd	15	nd	nd	11	120	nd	nd
B5	B5	22.01.04	1	nd	nd	nd	nd	39	nd	nd	63	360	nd	nd
B6	B6	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B7	B7	22.01.04	1	nd	nd	nd	nd	8	nd	nd	9	210	nd	nd
B8	B8	22.01.04	1	nd	nd	nd	nd	17	nd	nd	7	13	nd	nd
B9	B9	22.01.04	1.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B10	B10	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B10	B10	22.01.04	1.5	nd	10	nd	nd	17	nd	4	73	320	nd	nd
B11	B11	22.01.04	1	nd	nd	nd	nd	40	nd	nd	42	290	nd	nd
B12	B12	22.01.04	0.5	nd	0.7	nd	nd	25	nd	4	110	190	nd	nd
B12	B12	22.01.04	1	nd	0.7	nd	nd	34	nd	3	47	180	nd	nd
B13	B13	22.01.04	0.5	nd	1.2	nd	nd	35	nd	3	66	120	nd	nd
Trip	Trip	22.01.04	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Field	Field	22.01.04	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Field	Field	22.01.04	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Rinse	Rinse	22.01.04	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Rinse	Rinse	22.01.04	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Laboratory Detection Limit				5	0.5	5	5	5	5	2	5	5	10	0.05
Airports EP Regulation Guidelines Table 1 Area of an Airport Generally				500	100	600,000/500^	NC	5000	NC	3000	1500	35000	NC	75
Airports EP Regulation Guidelines Table 2 Area of Environmental Significance				20	3	50	170	60	20	60	300	200	NC	1
Environmental Investigation Levels EIL[1]				20	3	50^	NC	60	NC	60	300	200	NC	1

Notes

All results in mg/kg unless otherwise specified
Results in red indicate levels exceeding Airport Environmental Protection Table 2 Guidelines

nd — Indicates analyte not detected in this sample
NC — Indicates no criteria currently specified for this analyte
Adopted Criteria — Airports (Environment Protection) Regulations, 1997- Statutory Rules 1997 No.13 as ammended made under the Airports Act 1996.
Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland; Queensland Department of Environment, 1998.

EIL[1] — Environmental Investigation levels
^ — Total Chromium Results shown, criteria exists for two valency forms,Chromium Cr (III) and Cr (IV). Hexavalent chromium (IV) is the more toxic of the two forms
^^ — Health Based Investigation Level Exposure Setting is based on chromium (VI) valency
^^^ — Health Based Investigation Level Exposure Setting is based on hexavalent chromium (IV)

Table E2: Soil Analytical Results TPH, BTEX (GCA)

Sample Location	Sample ID	Date Sampled	Depth (mBCL)	Total Petroleum Hydrocarbons (mg/kg)				B	T	E	m&
				C_6-C_9	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	(mg/kg)	(mg/kg)	(mg/kg)	(m
C3_0.5	C3_0.5	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	
C5_0.5	C5_0.5	22.01.04	0.5	nd	nd	nd	140	nd	nd	nd	
C5_1.0	C5_1.0	22.01.04	1	nd	nd	90	120	nd	nd	nd	
C7_1.5	C7_1.5	22.01.04	1.5	nd	20	160	nd	nd	nd	nd	
C10_1.5	C10_1.5	22.01.04	1.5	nd	nd	nd	nd	nd	nd	nd	
B4_0.5	B4_0.5	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	
B5_1.0	B5_1.0	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	
B7_1.0	B7_1.0	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	
B10_0.5	B10_0.5	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	
B10_1.0	B10_1.0	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	
B13_1.0	B13_1.0	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	
A1_1.0	A1_1.0	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	
A1_1.5	A1_1.5	22.01.04	1.5	nd	nd	nd	nd	nd	nd	nd	
Detection Limit				20	50	100	50				
Airports EP Regulation Guidelines Table 1 Area of an Airport Generally				500		5000		1	50	130	
Airports EP Regulation Guidelines Table 2 Area of Environmental Significance				100		1000					
Environmental Investigation Levels				100	1000	1000	1000	1	NC	NC	N

Notes

All results in ug/L unless otherwise specified

Results in red indicate levels exceeding Airport Environmental Protection Guidelines

NC Indicates no criteria currently specified for this analyte

-- analyte not tested in this sample

Adopted Criteria Airports (Environment Protection) Regulations for areas of environmental significance, 1997- Statutory Rules 1997 No.13 as ammended made under the Airports Act 1996.

Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland; Queensland Department of Environment, 1998.

Table E3: Soil Analytical Results PAH Compounds (GCA)

Sample Location	Sample ID	Date Sampled	Depth (mBGL)	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)&(k)fluorant	Benzo(a)pyrene
C5	C5	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
C7	C7	22.01.04	1.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B4	B4	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B5	B5	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B10	B10	22.01.04	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
B13	B13	22.01.04	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
A1	A1	22.01.04	1	nd	nd	nd	nd	0.7	nd	0.5	1.2	0.7	0.8	1	1
Detection Limit				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.05	0.5	0.5	0.05	0.5
Airports EP Regulation Guidelines Table 1 Area of an Airport Generally				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	5
Airports EP Regulation Guidelines Table 2 Area of Environmental Significance				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Environmental Investigation Levels EIL [1]				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
NEPM HBIL "A" Guideline				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	1

Notes

All results in mg/kg unless otherwise specified

Results in red indicate levels exceeding Airport Environment Protection Guidelines

nd Indicates analyte not detected in this sample

NC Indicates no criteria currently specified for this analyte

-- analyte not tested in this sample

Adopted Criteria Airports (Environment Protection) Regulations, 1997- Statutory Rules 1997 No.13 as ammended made under the Airports Act 1996.
Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland; Queensland Department of Environment, 1998.

EIL[1] Environmental Investigation levels

Commercial/Indust Commercial/Industrial: includes premises such as shops and offices as well as factories and industrial sites. (If however, a commercial site is also used for residential purposes or regular soil access by children is possible, then the appropriate 'residential' setting should be used). It is assumed that thirty years is the duration of the exposure.

Table E4: Relative Percentage Difference (GCA)

Sample ID:					
Analyte	**Primary Result B7-1**	**Primary Duplicate Result**	**Secondary Duplicate Result**	**Primary Sample RPD**	**Secondary Sample RPD**
Arsenic	2.5	2.5	11.1	0	**-126.5**
Boron	5	5	0.5	0	163.636
Cadmium	0.25	0.25	5	0	-160.95
Cobalt	2.5	2.5	0.5	0	133.333
Chromium	2.5	2.5	2	0	22.2222
Copper	39	40	36	-2.532	8
Molybdenum	2.5	2.5	0.5	0	133.333
Nickel	1	1	2	0	-66.667
Lead	63	42	54	40	15.3846
Zinc	360	290	345	21.54	4.25532
Mercury	0.025	0.025	0.05	0	-66.667

Notes: RPD - Relative Percent Difference (%)
Shading indicates results above acceptance criteria range (30-50%, AS4482.1)

* - Indicates RPD result where one or more sample results were below reporting limits

Sample ID:					
Analyte	**Primary Result C5-1**	**Primary Duplicate Result**	**Secondary Duplicate Result**	**Primary Sample RPD**	**Secondary Sample RPD**
Arsenic	2.5	2.5	7	0	-94.737
Boron	5	5	5	0	0
Cadmium	0.7	0.25	0.5	**94.7**	33.3333
Cobalt	9	8	7	11.76	25
Chromium	11	8	5	31.58	75
Copper	14	13	12	7.407	15.3846
Molybdenum	2.5	2.5	2	0	22.2222
Nickel	9	5	4	**57.1**	76.9231
Lead	29	19	15	41.67	63.6364
Zinc	120	110	99	8.696	19.1781
Mercury	0.025	0.025	0.05	0	-66.667

Notes: RPD - Relative Percent Difference (%)
Shading indicates results above acceptance criteria range (30-50%, AS4482.1)
* - Indicates RPD result where one or more sample results were below reporting limits