A summary of the soil analytical results are presented in Table 1 and 2 of Appendix C. Copies of the NATA certified results are presented in Appendix D.

Test results for heavy metals are generally commensurate with ANZECC B criteria except for samples collected from boreholes BH1 and BH4, in the vicinity of the UST and the drum burial pits, where chromium concentrations marginally exceed ANZECC B criteria.

Test results for TPH and BTEX indicate concentrations below adopted criteria. Sample BH1-2.0-P collected from borehole BH1 at 2m depth shows minor TPH concentrations at levels below Dutch B criteria. The observed TPH's comprise C_{10}-C_{36} fractions, commensurate with diesel and heavy oils.

6.3.2 Groundwater

The groundwater test results (refer Table 3 of Appendix C) have been compared with ANZECC (1992a) reference criteria for protection of aquatic ecosystems (AQUATIC) and raw drinking water (DRINK). For contaminants where no criteria are available, the Dutch standards have been used (ANZECC, 1990). Dutch B criteria have been used in the past by the VicEPA as guideline notification levels for potable groundwater with further investigation being warranted where the criteria have been exceeded. Dutch C criteria have been used as an upper limit for potable use and guideline Notification Level for non-potable use (VicEPA, 1991).

* **BH2-Basalt Aquifer**

The groundwater is mildly acidic with a pH of 7.3, highly saline with a conductivity of 10,200 µS/cm and is predominantly a sodium chloride water.

Dissolved heavy metal concentrations for groundwater at bore BH2 are generally below AQUATIC criteria (ANZECC,1992a) except for copper, nickel and zinc. The concentrations at which these metals were detected are likley to be commensurate with naturally occurring or 'background' conditions.

BTEX and TPH concentrations were at levels below laboratory detection limits.

* **BH5 Residual Clay Aquifer**

The groundwater is mildly acidic with a pH of 7.4, relatively fresh with a conductivity of 1,800 µS/cm and is predominantly a sodium chloride water.

Dissolved heavy metal concentrations for groundwater at bore BH2 are generally below AQUATIC criteria (ANZECC,1992a) except for copper and zinc. As with borehole BH2 the measured concentrations are likely to be representative of 'background' conditions.

BTEX concentrations were at levels below laboratory detection limits. TPH concentrations comprising C_{15}-C_{28} fractions at 0.4 mg/L exceeded Dutch B criteria.

6.3.3 QC Results

QC results are presented in Table 4 of Appendix C. The analytical laboratory also completed an internal QC program comprising blanks, duplicates, and recoveries on 5% of samples tested and these results are presented in Appendix D.

Data validation was carried out by calculation of relative percent differences (RPDs) between samples, as prescribed by APHA 17th edn (1989), as the difference between duplicate results divided by the average and expressed as a percentage. Zero percent corresponds to perfect agreement whilst 200% corresponds to total disagreement.

For the intra-laboratory coded-blind soil duplicate pair (BH4-1.0P:BH40-1.0P) and groundwater duplicate pair (BH2-P:BH20-P), good agreement was observed between the duplicate pairs for all analytes.

Good agreement was also observed between laboratory duplicates. Results of laboratory blanks were below detection limits indicating that no significant sample contamination had occurred as a result of handling in the laboratory.

For the soil equipment rinsate blank, insignificant inorganic and organic concentrations were detected and were well below the concentrations detected in the original deionised water, which was used for the decontamination process.

The laboratory also conducted sample spikes to assess the extent of matrix bias or interference on analyte recovery and sample-to-sample precision (refer Appendix D). Percentage recoveries between spiked matrix samples and spiked laboratory blanks were generally within acceptable limits.

On the basis of the field and laboratory QC results, it is considered that the laboratory has provided an acceptable QA/QC program and accurate data confirmation. The overall data quality for this investigation is considered acceptable and the results of the samples collected can be taken as quantitative.

7.0 SUMMARY AND CONCLUSIONS

The drilling and monitoring bore installation program reported above indicates a general absence of significant groundwater resources on the Ballan site. Where groundwater was encountered it appears to be of limited extent and the water bearing zones are of low permeability.

The investigations indicate a low potential for contaminant migration either on or off-site via subsurface groundwater systems.

The single deep bore (BH2) which intersected groundwater showed no indication of hydrocarbon contamination and detected heavy metals are considered to be commensurate with likely 'background' conditions.

The shallow borehole which intersected groundwater (borehole BH5) was located immediately adjacent to the backfilled drum burial trenches. Water intersected in this borehole is probably a consequence of locally enhanced recharge occurring in the trench backfill materials. Detected TPH contamination in this borehole is commensurate with this recharge scenario.

The hydrocarbon contamination found in borehole BH5 is likely to represent a localised effect. Given the nature of the residual clays significant contaminant migration from such localised contaminant sources is unlikley unless local permeability conditions are enhanced by clay fissuring or man-made features such as service trench backfill or surface construction fill placement. Management of such localised effects will be best achieved by removing the contaminants at source. As such, the primary site cleanup goals should be the identification and cleanup of localised areas of upper soil profile contamination such as has already been identified in the former buried sludge pits (refer Coffey Report E3517/1-AD).

For and on behalf of
COFFEY PARTNERS INTERNATIONAL PTY LTD

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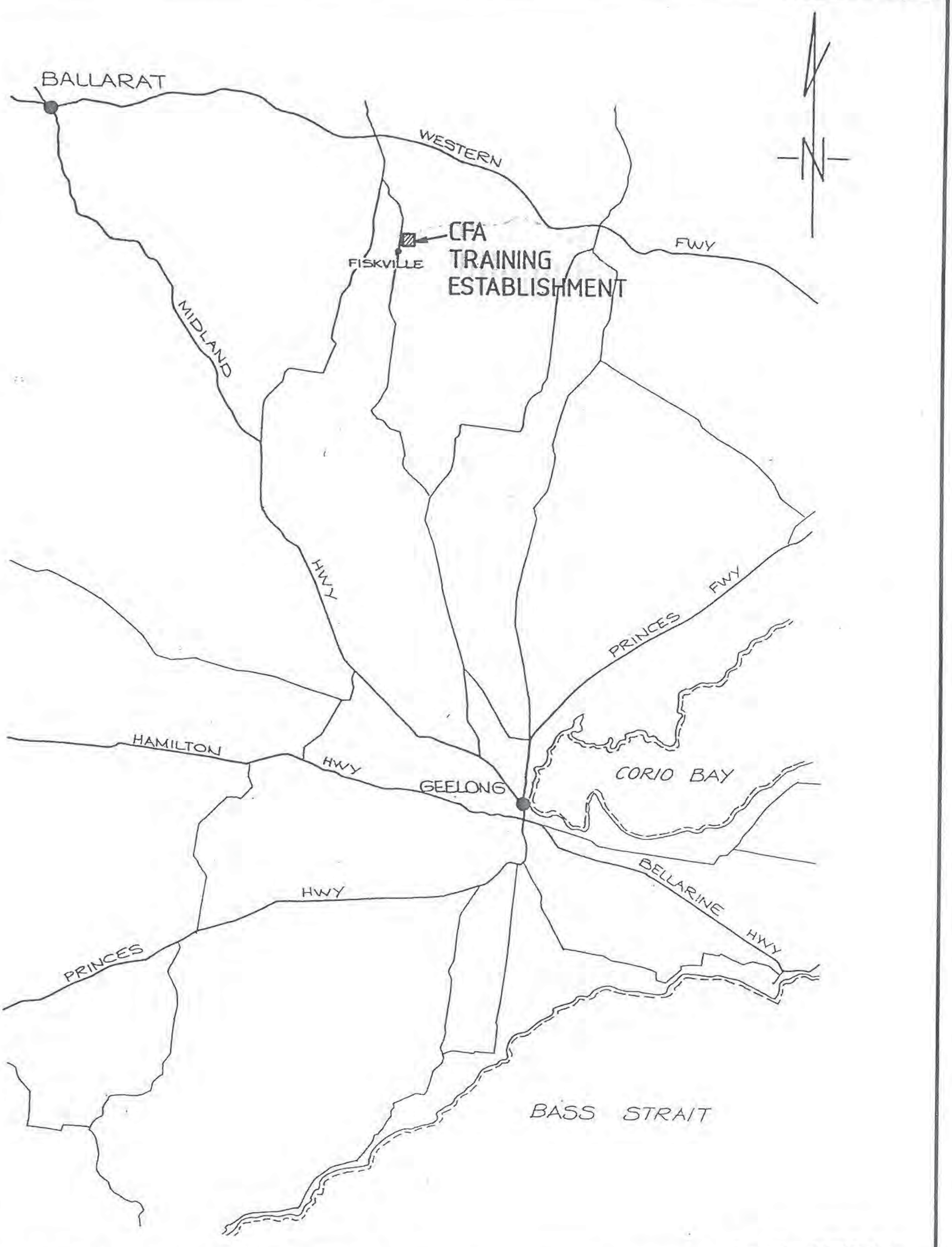

Dwg. No. E3523/1-1

Coffey Partners International Pty Ltd A.C.N. 003 692 019

Consulting Engineers, Managers and Scientists
Environment • Geotechnics • Mining • Water Resources

drawn	MP/SA	CFA TRAINING COLLEGE GROUNDWATER MONITORING - BALLAN, VICTORIA LOCALITY PLAN	COFFEY	drawing no:
approved	mp			FIGURE 1
date	17/9/96			
scale	1:500,000			job no: E3523/1

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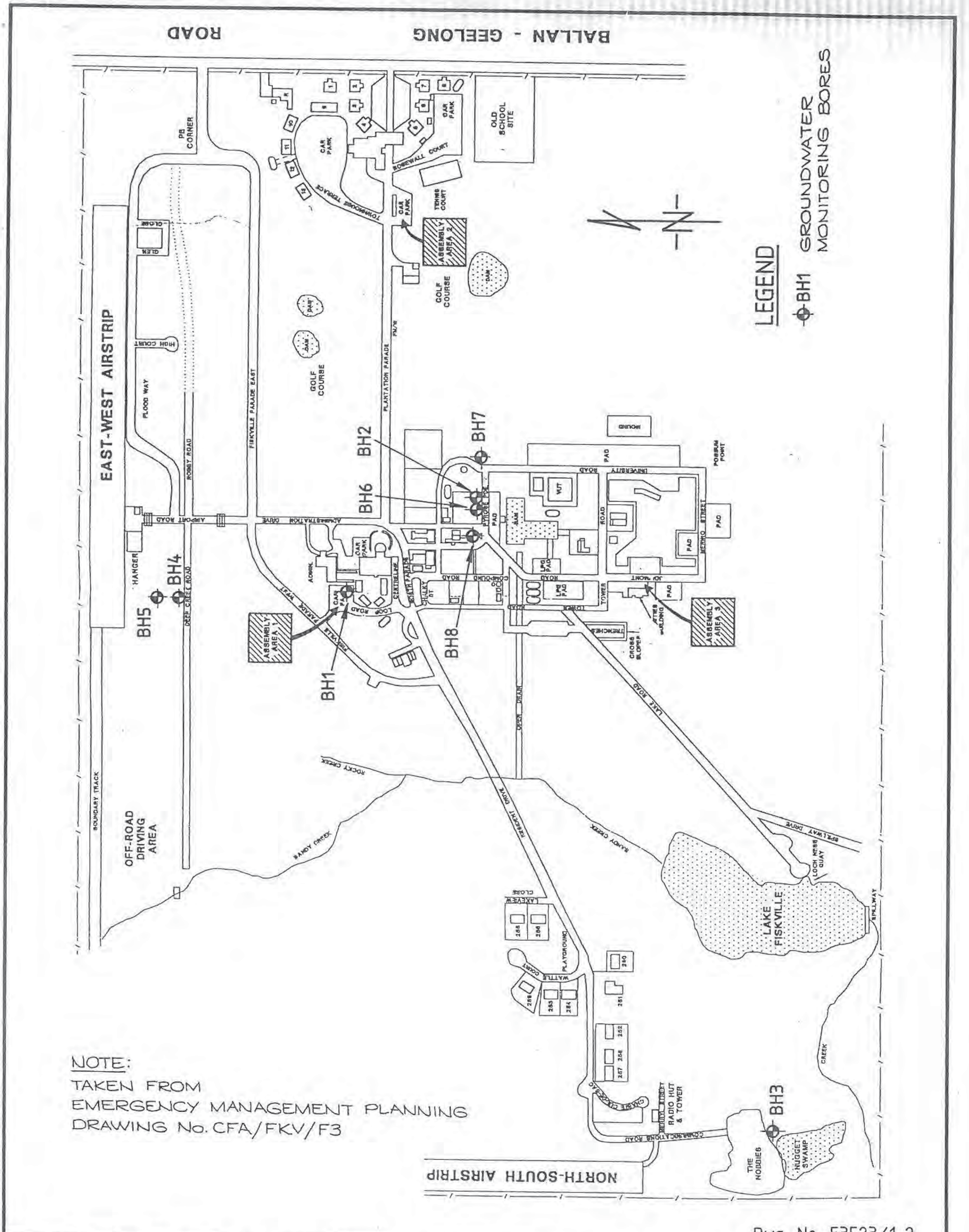

Dwg. No. E3523/1-2

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drawn	MP/SA	CFA TRAINING COLLEGE GROUNDWATER MONITORING BALLAN, VICTORIA GROUNDWATER SAMPLING LOCATIONS	COFFEY	FIGURE 2
approved	MJ			
date	10/10/96			
scale	N.T.S.			job no: E3523/1

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

As the client of a consulting geotechnical engineer, you should know that site subsurface conditions cause more construction problems than any other factor. ASFE/The Association of Engineering Firms Practicing in the Geosciences offers the following suggestions and observations to help you manage your risks.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS
Your geotechnical engineering report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. These factors typically include: the general nature of the structure involved, its size, and configuration; the location of the structure on the site; other improvements, such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask your geotechnical engineer to evaluate how factors that change subsequent to the date of the report may affect the report's recommendations.

Unless your geotechnical engineer indicates otherwise, do not use your geotechnical engineering report:

- when the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size, elevation, or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership; or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems that may occur if they are not consulted after factors considered in their report's development have changed.

SUBSURFACE CONDITIONS CAN CHANGE
A geotechnical engineering report is based on conditions that existed at the time of subsurface exploration. Do not base construction decisions on a geotechnical engineering report whose adequacy may have been affected by time. Speak with your geotechnical consultant to learn if additional tests are advisable before construction starts.Note, too, that additional tests may be required when subsurface conditions are affected by construction operations at or adjacent to the site, or by natural events such as floods, earthquakes, or ground water fluctuations. Keep your geotechnical consultant apprised of any such events.

MOST GEOTECHNICAL FINDINGS ARE PROFESSIONAL JUDGMENTS
Site exploration identifies actual subsurface conditions only at those points where samples are taken. The data were extrapolated by your geotechnical engineer who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your geotechnical engineer can work together to help minimize their impact. Retaining your geotechnical engineer to observe construction can be particularly beneficial in this respect.

A REPORT'S RECOMMENDATIONS CAN ONLY BE PRELIMINARY
The construction recommendations included in your geotechnical engineer's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Because actual subsurface conditions can be discerned only during earthwork, you should retain your geotechnical engineer to observe actual conditions and to finalize recommendations. Only the geotechnical engineer who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations are valid and whether or not the contractor is abiding by applicable recommendations. The geotechnical engineer who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS
Consulting geotechnical engineers prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your geotechnical engineer prepared your report expressly for you and expressly for purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the geotechnical engineer. No party should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.

GEOENVIRONMENTAL CONCERNS ARE NOT AT ISSUE
Your geotechnical engineering report is not likely to relate any findings, conclusions, or recommendations

about the potential for hazardous materials existing at the site. The equipment, techniques, and personnel used to perform a geoenvironmental exploration differ substantially from those applied in geotechnical engineering. Contamination can create major risks. If you have no information about the potential for your site being contaminated, you are advised to speak with your geotechnical consultant for information relating to geoenvironmental issues.

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION
Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid misinterpretations, retain your geotechnical engineer to work with other project design professionals who are affected by the geotechnical report. Have your geotechnical engineer explain report implications to design professionals affected by them, and then review those design professionals' plans and specifications to see how they have incorporated geotechnical factors. Although certain other design professionals may be familiar with geotechnical concerns, none knows as much about them as a competent geotechnical engineer.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE REPORT *
Geotechnical engineers develop final boring logs based upon their interpretation of the field logs (assembled by site personnel) and laboratory evaluation of field samples. Geotechnical engineers customarily include only final boring logs in their reports. Final boring logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes, and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, give contractors ready access to the complete geotechnical engineering report prepared or authorized for their use. (If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared and that developing construction cost estimates was not one of the specific purposes for which it was prepared. In other words, while a contractor may gain important knowledge from a report prepared for another party, the contractor would be well-advised to discuss the report with your geotechnical engineer and to perform the additional or alternative work that the contractor believes may be needed to obtain the data specifically appropriate for construction cost estimating purposes.) Some clients believe that it is unwise or unnecessary to give contractors access to their geotechnical engineering reports because they hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems. It also helps reduce the adversarial attitudes that can aggravate problems to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY
Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical engineers. To help prevent this problem, geotechnical engineers have developed a number of clauses for use in their contracts, reports, and other documents. Responsibility clauses are not exculpatory clauses designed to transfer geotechnical engineers' liabilities to other parties. Instead, they are definitive clauses that identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report. Read them closely. Your geotechnical engineer will be pleased to give full and frank answers to any questions.

RELY ON THE GEOTECHNICAL ENGINEER FOR ADDITIONAL ASSISTANCE
Most ASFE-member consulting geotechnical engineering firms are familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a construction project, from design through construction. Speak with your geotechnical engineer not only about geotechnical issues, but others as well, to learn about approaches that may be of genuine benefit. You may also wish to obtain certain ASFE publications. Contact a member of ASFE of ASFE for a complimentary directory of ASFE publications.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, National Headquarters, Canberra, 1987.

ASFE THE ASSOCIATION OF ENGINEERING FIRMS PRACTICING IN THE GEOSCIENCES
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APPENDIX A

APPENDIX A

BOREHOLE LOGS AND PIEZOMETER CONSTRUCTION DETAILS

Coffey Partners International Pty Ltd
A.C.N. 003 692 019

descriptive terms soil and rock

explanation

sheet 1

SOIL DESCRIPTIONS

Classification of Material based on Unified Classification System (refer SAA Site Investigation Code AS1726-1975 Add. No. 1 Table D1).

Moisture Condition based on appearance of soil.

dry Looks and feels dry; cohesive soils usually hard, powdery or friable, granular soils run freely through hands.

moist Soil feels cool, darkened in colour; cohesive soils usually weakened by moisture, granular soils tend to cohere, but one gets no free water on hand on remoulding.

wet Soil feels cool, darkened in colour; cohesive soils weakened, granular soils tend to cohere, free water collects on hands when remoulding.

Consistency based on unconfined compressive strength (Qu) (generally estimated or measured by hand penetrometer).

term	very soft	soft	firm	stif	very stiff	hard
Qu kPa	25	50	100	200	400	

If soil crumbles on test without meaningful result, it is described as **friable**.

Density Index (generally estimated or based on penetrometer result).

term	very loose	loose	medium dense	dense	very dense
density index ID %	15	35	65	85	

ROCK DESCRIPTIONS

Weathering based on visual assessment.

term	**criterion**
Fresh:	Rock substance unaffected by weathering.
Slightly Weathered:	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Moderately Weathered:	Rock substance affected by weathering to the extent that staining extends throughout whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Highly Weathered:	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and signs of chemical or physical decomposition of individual minerals are usually evident. Porosity and strength may be increased or decreased when compared to the fresh rock substance, usually as a result of the leaching or deposition of iron. The colour and strength of the original fresh rock substance is no longer recognisable.
Extremely Weathered:	Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.

Strength based on point load strength index, corrected to 50mm diameter - Is(50) (refer to I.S.R.M., Commission on Standardisation of Laboratory and Field Tests, Suggested Methods for Determining the Uniaxial Compressive Strength of Rock Materials and the Point Load Strength Index, Committee on Laboratory Tests Document No. 1) (Generally estimated: × indicates test result).

classification	extremely low	very low	low	medium	high	very high	extremely high
Is (50) MPa	0.03	0.1	0.3	1	3	10	

The unconfined compressive strength is typically about 20 × I_{S50} but the multiplier may range, for different rock types, from as low as 4 to as high as 30.

Defect Spacing

classification	extremely close	very close	close	medium	wide	very wide	extremely wide
spacing m	0.03	0.1	0.3	1	3	10	

Defect description uses terms contained on AS1726 table D2 to describe nature of defect (fault, joint, crushed zone, clay seam (etc.) and character (roughness, extent, coating etc.).

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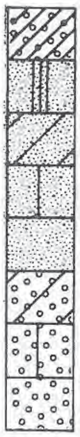
graphic symbols soil and rock

COFFEY

explanation sheet 2

soil

asphaltic concrete or hotmix
concrete
topsoil
fill
peat, organic clays and silts (Pt, OL, OH)
clay (CL, CH)
silt (ML, MH)
sandy clay (CL, CH)
silty clay (CL, CH)

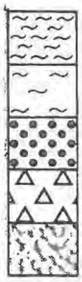


gravelly clay (CL, CH)
sandy silt (ML)
clayey sand (SC)
silty sand (SM)
sand (SP, SW)
clayey gravel (GC)
silty gravel (GM)
gravel (GP, GW)

rock

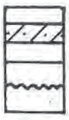
claystone (massive)
siltstone (massive)
shale (laminated)
sandstone (undifferentiated)
sandstone, fine grained
sandstone, coarse grained
conglomerate

limestone
coal
dolerite, basalt
tuff
porphyry
granite
pegmatite



schist
gneiss
quartzite
talus
alluvium

seams



seam >0.1m thick (on a sclae 1:50)
seam 0.01m to 0.1m thick (on a scale of 1:50)

inclusions (special purposes only)

rock fragments
swamp

ironstone, gravel, laterite
shale breccia in sandstone

water level

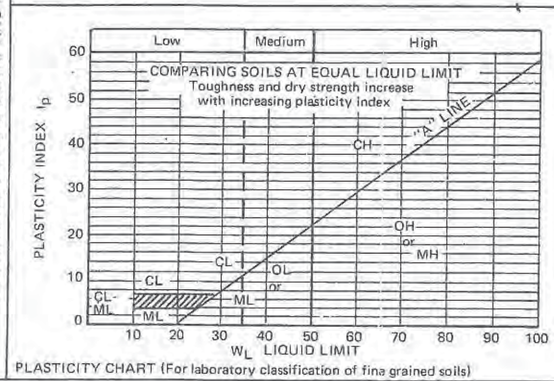
surfaces ______ known boundary	___ ___ ___ probable boundary	______ ? ______ ? possible boundary

T84 - 147

SOIL CLASSIFICATION
INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)				GROUP SYMBOLS	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS — More than 50% of material less than 60 mm is larger than 0.06 mm (The 0.06 mm particle is about the smallest particle visible to the naked eye)	GRAVELS — More than half of coarse fraction is larger than 2.0 mm.	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel—sand mixtures, little or no fines.	SYMBOL Give typical name, indicate approximate percentages of sand and gravel, max. size, angularity, surface condition, and strength of the coarse grains: colour, amount, plasticity of fine component. For undisturbed soils add information on moisture condition, degree of compactness, stratification, cementation, odour.	USE GRAIN SIZE CURVE IN IDENTIFYING THE FRACTIONS AS GIVEN UNDER FIELD IDENTIFICATION. Determine percentages of gravel and sand from grain size curve. Depending on percentage smaller than 0.06 mm size coarse grained soils are classified as follows:— Less than 5%: GW, GP, SW, SP. More than 12%: GM, GC, SM, SC. 5% to 12%: Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 & 3
			Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel—sand mixtures, little or no fines.			Not meeting all gradation requirements for GW.
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	GM	Silty gravels, poorly graded gravel—sand—silt mixtures.			Atterberg limits below "A" line or I_p less than 4. — Above "A" line with Pi between 4 and 7 are borderline cases requiring use of dual symbols.
			Plastic fines (for identification procedures see CL below).	GC	Clayey gravels, poorly graded gravel—sand—clay mixtures.			Atterberg limits above "A" line with I_p greater than 7.
	SANDS — More than half of coarse fraction is smaller than 2.0 mm.	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	SW	Well graded sands, gravelly sands, little or no fines.	Give local or geologic name and/ other pertinent descriptive information. Example: SM,-Gravelly Silty SAND coarse to fine, pale brown, about 20% strong angular gravel particles — 10 mm maximum size, rounded and sub-angular sand, about 15% non-plastic fines, moist, dense, alluvial sand.		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 & 3
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.			Not meeting all gradation requirements for SW.
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	SM	Silty sands, poorly graded sand—silt mixtures.			Atterberg limits below "A" line or I_p less than 4. — Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols.
			Plastic fines (for identification procedures see CL below).	SC	Clayey sands, poorly graded sand—clay mixtures.			Atterberg limits above "A" line with I_p greater than 7.

FINE GRAINED SOILS — More than 50% of material less than 60 mm is smaller than 0.06 mm	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 mm: DRY STRENGTH †	DILATANCY †	TOUGHNESS †	GROUP SYMBOLS	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS
SILTS AND CLAYS — Liquid limit less than 50	None to Low	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with low plasticity. Silts of low to medium Liquid Limit. *	SYMBOL Give typical name, indicate degree and character of plasticity, colour, amount and size of coarse grains. For undisturbed soils add information on moisture condition, consistency, structure, stratification, odour.
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, * gravelly clays, sandy clays, silty clays.	
	Low to medium	Slow	Low	OL	Organic silts and organic silt — clays of low to medium plasticity. *	
SILTS AND CLAYS — Liquid limit greater than 50	Low to medium	Slow to none	Low to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, silts of high Liquid Limit.	Give local or geologic name, and other pertinent descriptive information.
	High to very high	None	High	CH	Inorganic clays of high plasticity. *	Example: CL—Sandy CLAY of low plasticity, pale grey and brown; Sand fine to medium, trace of fine gravel, dry, firm, numerous vertical root holes; (FILL).
	Medium to high	None to very slow	Low to medium	OH	Organic clays of high plasticity. *	
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	Peat and other highly organic soils.	



PLASTICITY CHART (For laboratory classification of fine grained soils)

1. Boundary classifications — Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW—GC, well graded gravel-sand mixture with clay binder.

* Low plasticity — Liquid Limit W_L less than 35%. Medium plasticity — W_L between 35% and 50%.

Adapted from A.S. 1726-1981 (App.D)

FIELD IDENTIFICATION PROCEDURES FOR FINE GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus 0.2 mm size particles. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

† TOUGHNESS (Consistency near plastic limit)

After removing particles larger than 0.2 mm size, a specimen of soil about 10cm³ in size is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3 mm in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil.

Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

† DILATANCY (Reaction to shaking)

After removing particles larger than 0.2 mm size, prepare a pat of moist soil with a volume of 10 cm³. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles.

The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

† DRY STRENGTH (Crushing characteristics)

After removing particles larger than 0.2 mm size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group.

A typical inorganic silt possesses only very slight dry strength.

Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

COFFEY

Coffey Partners International

Consulting Engineers in the geotechnical sciences

SOIL CLASSIFICATION CHART

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH1

sheet 1 of 4

office job no: E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	9/9/96
principal:	-	hole completed:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	logged by:	GWE
borehole location:	REFER TO DRAWING E3523/1-2	checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L.Surface: 441.47 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
RAB		NIL	▽			0		GP	FILL: CRUSHED ROCK, dark grey,	D	D		FILL
					441			CH	SILTY CLAY: high plasticity, grey, mottled orange,	M	VSt		RESIDUAL
						1							
				E	440								
DHH				E		2			BASALT: brown-grey, medium strength, highly to moderately weathered				NEWER VOLCANICS Description based on rock chips
					439								
						3							
					438								
						4							
					437								
						5							
					436								
						6							
					435								
						7							
					434								
						8							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
X not measured O none observed
▽ water level
◁ water outflow
▷ water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH1
sheet 2 of 4

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	9/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA

drill model and mounting:	FAILINGS 750, TRUCK	slope:	-90 DEG	R.L.Surface:	441.47 m
hole diameter:	150, 140mm	bearing:	-	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
DHH				D					BASALT: brown-grey, medium strength, highly to moderately weathered				NEWER VOLCANICS Description based on rock chips
					433								
						9							
					432								
						10							
					431								
						11							
					430								
						12							
					429								
						13							
					428								
						14							
					427								
				D		15			15 to 16m, highly weathered seam, brown				
					426								
						16							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PV pressuremeter
CP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no	BH1
sheet	3 of 4

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	9/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L.Surface: 441.47 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
DHH				D	425	17		BASALT: grey, high strength, slightly weathered		02		SLIGHTLY WEATHERED
					424							
			▷	D	423	18	CH	SILTY CLAY: high plasticity, dark brown-black, traces of organic matter		VSt		VOLCANIC ASH
					422	19						No water after 5 to 10m wait
				D	421	20	CH	SILTY CLAY: high plasticity, red-brown, mottled orange, trace medium to coarse grained, sand sized particles, ?weakly developed layering		H		VOLCANIC ASH OR TUFF?
					420	21						
					419	22		BASALT: brown-grey, high strength, highly weathered				?AGGLOMERATE Description based on brown rock flour with chips of basalt
					418	23						
						24						

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
X not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH1

sheet 4 of 4

office job no: E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	9/9/96
principal:	-	hole completed:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	logged by:	GWE
borehole location:	REFER TO DRAWING E3523/1-2	checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope:	-90 DEG
hole diameter:	150, 140mm	bearing:	-
R.L. Surface:	441.47 m	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
DHH				D	417	25			BASALT: brown-grey, high strength, highly weathered				?AGGLOMERATE Description based on brown rock flour with chips of basalt

Borehole BH1 Terminated at 25.00 m

Piezometer comprises:
0.0 to 15.0m 50mm Class 18 screw threaded PVC
15.0 to 21.0m 50mm PVC screen, 0.3mm machine slots
Caps & Borehead Protector installed

Backfill comprises:
0.0 to 5.6m Backfill
5.6 to 6.5m Bentonite granules
6.5 to 25.0m Washed Sand (8/16) filter
Stickup = 0.4m

R.L. scale: 416, 415, 414, 413, 412, 411, 410
Depth scale: 26, 27, 28, 29, 30, 31, 32

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support, M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
X not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH2

sheet 1 of 3

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	9/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L. Surface: 440.48 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
RAB		NIL				0	GP	FILL: CRUSHED ROCK, fine to coarse grained, dark grey.	M	D		FILL
					440							
							CH	SILTY CLAY: high plasticity, grey, mottled orange.		VSt		RESIDUAL
				E		1						
				E	439							
DHH						2		BASALT: grey-brown, medium strength, moderately weathered				NEWER VOLCANICS Description based on recovered rock chips
					438							
						3						
					437							
						4						
					436							
						5						
					435							
						6						
					434							
						7						
					433							
						8						

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
* not measured 0 none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH2
sheet 2 of 3

office job no: E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	9/9/96
principal:	-	hole completed:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	logged by:	GWE
borehole location:	REFER TO DRAWING E3523/1-2	checked by:	PC

drill model and mounting:	FAILINGS 750, TRUCK	slope:	-90 DEG	R.L. Surface:	440.48 m
hole diameter:	150, 140mm	bearing:	-	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
DHH									BASALT: grey-brown, medium strength, moderately weathered				NEWER VOLCANICS Description based on recovered rock chips
					432								
						9							
					431								
			water inflow	D		10							
					430								
						11							
					429								
						12			BASALT: light brown, medium to high strength, highly weathered				
					428								
				D		13							
					427								
						14							
					426								
						15							
					425								
						16							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH2
sheet 3 of 3

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	9/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	9/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L. Surface: 440.48 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
DHH				D	424			CL-CH	SILTY CLAY: medium to high plasticity, red-brown, with red-brown, basalt and scoria fragments, extremely to highly weathered				VOLCANIC ASH?
						17							
					423				Borehole BH2 Terminated at 17.00 m Piezometer comprises: 0.0 to 11.0m 50mm Class 18 screw threaded PVC 11.0 to 17.0m 50mm PVC screen, 0.3mm machine slots Caps & Borehead Protector installed Backfill comprises: 0.0 to 9.6m Backfill 9.6 to 10.2m Bentonite 10.2 to 17.0m Washed Sand (8/6) filter Stickup = 0.5m				
						18							
					422								
						19							
					421								
						20							
					420								
						21							
					419								
						22							
					418								
						23							
					417								
						24							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
* not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

187-230

Coffey Partners International Pty. Ltd
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH3

sheet 1 of 3

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	9/9/96
project:	GROUNDWATER MONITORING	hole completed:	9/9/96
borehole location:	BALLAN, VICTORIA	logged by:	GWE
drill model and mounting:	FAILINGS 750, TRUCK	checked by:	PCA
hole diameter:	150, 140mm	slope: -90 DEG	R.L. Surface: 439.96 m
		bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
RAB		NIL						CL-CH	SILTY CLAY: medium to high plasticity, brown,	M	Fb - St		RESIDUAL includes 100mm root zone
			▽										
DHH					439	1			BASALT: grey-brown, moderate to high strength, moderately weathered				NEWER VOLCANICS Description based on recovered rock chips
					438	2							
				D	437	3							
					436	4							
				D	435	5			5.0 to 7.0m becoming brown, moderate strength, highly weathered				
					434	6							
					433	7			Becoming grey brown, high strength, moderately weathered				
					432	8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION 1 2 3 4
little resistance ranging to very slow progress

WATER
- X not measured
- ☐ none observed
- ▽ water level
- ◁ water outflow
- ▷ water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test
- N* SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no:	BH3
sheet	2 of 3
office job no:	E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	9/9/96
principal:	-	hole completed:	9/9/96
project:	GROUNDWATER MONITORING	logged by:	GWE
borehole location:	BALLAN, VICTORIA	checked by:	RCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L. Surface: 439.96 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
DHH									BASALT: grey-brown, moderate to high strength, moderately weathered				NEWER VOLCANICS Description based on recovered rock chips
					431	9							
					430	10							
					429	11							
					428	12							
					427	13							
					426	14							
					425	15			BASALT: grey, high strength, slightly weathered				
					424	16							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH3
sheet 3 of 3

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	9/9/96
project:	GROUNDWATER MONITORING	hole completed:	9/9/96
borehole location:	BALLAN, VICTORIA	logged by:	GWE
		checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L.Surface: 439.96 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
DHH									BASALT: grey, high strength, slightly weathered		02		NEWER VOLCANICS Description based on recovered rock chips
					423	17							
					422	18							
					421	19							
					420	20		CL-CH	SILTY CLAY: medium to high plasticity, grey-brown, including fragments of brown, extremely to highly weathered basalt fragments				VOLCANIC ASH?
					419	21							
					418	22							
					417	23							
					416	24							

Borehole BH3 Terminated at 21.00 m

Piezometer comprises.
0.0 to 15.0m 50mm Class 18 screw threaded PVC
15.0 to 21.0m 50mm PVC screen, 0.3mm machine slots
Caps & Borehead Protector installed

Backfill comprises:
0.0 to 11.7m Backfill
11.7 to 12.1m Bentonite granules
12.1 to 21.0m Washed Sand (8/16) filter
Stickup = 0.4m

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
* not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PV pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH4

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	10/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	10/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA

drill model and mounting:	FAILINGS 750, TRUCK	slope:	-90 DEG	R.L.Surface:	442.53 m
hole diameter:	150, 140mm	bearing:	-	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
RAB		NIL	▷ (water inflow)		442			CH	SILTY CLAY: high plasticity, grey, mottled orange,	M	VSt		RESIDUAL includes 100mm root zone
				E	441	1							
				E		2							
DHH					440				BASALT: grey-brown, high strength, moderately weathered				NEWER VOLCANICS Rock description based on recovered rock chips
				D	439	3							
					438	4							
					437	5							
					436	6							
					435	7							
						8							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support
M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
✕ not measured
O none observed
▽ water level
◁ water outflow
▷ water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH4
sheet 2 of 3

office job no: E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	10/9/96
principal:	-	hole completed:	10/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	logged by:	GWE
borehole location:	REFER TO DRAWING E3523/1-2	checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L.Surface: 442.53 m
hole diameter:	150, 140mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
DHH									BASALT: grey-brown, high strength, moderately weathered				NEWER VOLCANICS Rock description based on recovered rock chips
					434								
						9							
					433								
				D		10							
					432								
						11							
					431								
						12			Becoming grey brown, medium strength, moderately weathered from 12.0 to 13.0m				
					430								
				E		13							
					429								
						14			BASALT: brown, medium strength, highly weathered				
					428								
						15							
					427								
						16							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
X not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH4
sheet 3 of 3

office job no: E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	10/9/96
principal:	-	hole completed:	10/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	logged by:	GWE
borehole location:	REFER TO DRAWING E3523/1-2	checked by:	PCA

drill model and mounting:	FAILINGS 750, TRUCK	slope:	-90 DEG	R.L.Surface:	442.53 m
hole diameter:	150, 140mm	bearing:	-	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material (soil type: plasticity or particle characteristics colour, secondary and minor components)	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
DHH				D	426				BASALT: brown, medium strength, highly weathered		02		Rock description based on recovered rock chips
					425	17			BASALT: grey, high strength, slightly weathered				
				D	424	18			BASALT: brown, medium to high strength, moderately to highly weathered				
					423	19			VOLCANIC ASH? red-brown, comprises very low to low strength, highly weathered volcanic fragments				?VOLCANIC ASH Sample comprises red brown powder and small low strength rounded chips
					422, 421, 420, 419	20, 21, 22, 23, 24			Borehole BH4 Terminated at 20.00 m Piezometer comprises: 0.0 to 14.0m 50mm Class 18 screw threaded PVC 14.0 to 20.0m 50mm PVC screen, 0.3mm machine slots Caps & Borehead Protector installed Backfill comprises: 0.0 to 4.6m Backfill 4.6 to 5.3m Bentonite granules 5.3 to 20.0m Washed Sand (8/16) filter Stickup = 0.5m				

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
X not measured O none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH5
sheet 1 of 1

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	11/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	11/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA

drill model and mounting:	HAND AUGER	slope:	-90 DEG	R.L. Surface:	442.59 m
hole diameter:	100mm	bearing:	-	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
HA		NIL	▽					CL	SILTY CLAY: low to medium plasticity, dark brown,	M	Fb		TOPSOIL
								CL CH	SILTY CLAY: low to medium plasticity, grey, some buckshot gravel	W	St VSt		SUBSOIL
					442				SILTY CLAY: high plasticity, grey, orange, mottled orange,				RESIDUAL
						1							
					441								
						2			Borehole BH5 Terminated at 1.80 m				
					440				Piezometer comprises: 0.0 to 0.8m 50mm Class 9 PVC 0.8 to 1.8m 50mm Class 9 PVC screen, 0.3mm slots				
						3			Caps & Borehead Protector installed Backfill comprises: 0.0 to 0.2m Concrete collar 0.2 to 0.4m Bentonite granules 0.4 to 1.8m Sand (8/16) filter Stickup = 0.45m				
					439								
						4							
					438								
						5							
					437								
						6							
					436								
						7							
					435								
						8							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
X not measured D none observed
▽ water level
◁ water outflow
▷ water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

COFFEY

engineering log - borehole

borehole no: BH6
sheet 1 of 1

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	11/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	11/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope:	-90 DEG
hole diameter:	100mm	bearing:	-
R.L. Surface:	440.58 m	datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
RAB		NIL						GP	FILL: SANDY GRAVEL, fine to coarse grained, grey-red, some scoria and crushed rock	M	D		FILL
					440			CH	SILTY CLAY: high plasticity, grey-orange, mottled orange,		VSt		RESIDUAL
						1							
					439								
						2			BASALT: grey-brown, moderately to highly weathered				
									Borehole BH6 Terminated at 2.00 m				
					438				Piezometer comprises: 0.0 to 0.3m 50mm Class 9 PVC 0.3 to 2.0m 50mm Class 9 PVC screen, 0.3mm slots				
						3			Caps & Borehead Protector installed Backfill comprises: 0.0 to 0.1m Concrete collar 0.1 to 0.2m Bentonite granules 0.2 to 2.0m Sand (8/16) filter Stickup = 0.4m				
					437								
						4							
					436								
						5							
					435								
						6							
					434								
						7							
					433								
						8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- ✶ not measured
- D none observed
- ▽ water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test
- N* SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH7
sheet 1 of 1

client:	CFA TRAINING COLLEGE	office job no:	E3523/1
principal:	-	hole commenced:	11/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	hole completed:	11/9/96
borehole location:	REFER TO DRAWING E3523/1-2	logged by:	GWE
		checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L.Surface: 440.47 m
hole diameter:	100mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
RAB		NIL							CRUSHED ROCK:	M	-		CRUSHED ROCK
								CL	SILTY CLAY: medium plasticity, dark brown		D-Fb		TOPSOIL
					440			CH	SILTY CLAY: high plasticity, grey-orange, mottled orange,		VSt		RESIDUAL
						1							
					439								
						2							
					438								
									BASALT: brown, highly weathered				
						3			Borehole BH7 Terminated at 2.80 m				
					437				Piezometer comprises: 0.0 to 1.3m 50mm Class 9 PVC; 1.3 to 2.8m 50mm Class 9 PVC screen, 0.3mm slots				
						4			Caps & Borehead Protector installed. Backfill comprises: 0.0 to 0.2m Concrete collar; 0.2 to 0.6m Backfill; 0.6 to 0.8m Bentonite granules; 0.8 to 2.8m Sand (8/16) filter; Stickup = 0.45m				
					436								
						5							
					435								
						6							
					434								
						7							
					433								
						8							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
* not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

18/-230

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

COFFEY

borehole no: BH8
sheet 1 of 1

office job no: E3523/1

client:	CFA TRAINING COLLEGE	hole commenced:	11/9/96
principal:	-	hole completed:	11/9/96
project:	GROUNDWATER MONITORING, BALLAN, VICTORIA	logged by:	GWE
borehole location:	REFER TO DRAWING E3523/1-2	checked by:	PCA
drill model and mounting:	FAILINGS 750, TRUCK	slope: -90 DEG	R.L.Surface: 441.09 m
hole diameter:	100mm	bearing: -	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
RAB		NIL			441	0			CRUSHED ROCK:	M	D		CRUSHED ROCK
								CL	SILTY CLAY: medium plasticity, brown,		Fb		TOPSOIL
								CH	SILTY CLAY: high plasticity, grey-brown, mottled orange,		VSt		RESIDUAL
					440	1							
					439	2							
									BASALT: brown, highly weathered				NEWER VOLCANICS
					438	3			Borehole BH8 Terminated at 2.30 m				
					437	4							
					436	5							
					435	6							
					434	7							
						8							

Piezometer comprises:
0.0 to 1.3m 50mm Class 9 PVC
1.3 to 2.3m 50mm Class 9 PVC screen, 0.3mm slots

Caps & Borehead Protector installed
Backfill comprises:
0.0 to 0.2m Concrete collar
0.2 to 0.4m Bentonite granules
0.4 to 2.3m Sand (8/16) filter
Stickup = 0.30m

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing
PENETRATION
1 2 3 4
little resistance ranging to very slow progress
WATER
* not measured D none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system
MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

APPENDIX B

APPENDIX B

WBCM BOREHEAD ELEVATION DATA

WBCM group

Engineers
Surveyors
Planners

WBCM Surveys Limited A.C.N. 006 937 506
71 Palmerston Crescent South Melbourne Victoria 3205 Australia
P O Box 243 South Melbourne 3205 DX20524 Emerald Hill
Facsimile 03) 9699 5992 Telephone 03) 9699 1400

Facsimile Transmittal

Attention: Michael Probert	Date: 4 October 1996
Company: Coffey Partners	Job Number: 2236
From: Shane Jackson	Fax Number: 98530189
CFA Training Centre Boreholes	Pages Including This Sheet: 1

Message:

Michael,

The coordinates (AMG)and reduced levels (AHD) of the boreholes are as follows.

Unfortunatelly we were not informed, by you that the borehole protectors were padlocked and inaccessable. Levels and coordinates were taken to the top of the cover, and a drop to ground surface was measured.

	Bore Easting	Hole Northing	Protector RL	Ground RL
BH-1	254652.1	5825705.2	442.01	441.47
BH-2	254752.5	5825518.3	441.12	440.48
BH-3	253973.1	5825251.8	440.51	439.96
BH-4	254649.0	5825950.6	443.13	442.53
BH-5	254649.1	5825953.0	443.14	442.59
BH-6	254750.6	5825518.0	441.13	440.58
BH-7	254780.3	5825511.2	440.92	440.47
BH-8	254695.8	5825543.6	441.54	441.09

Regards

Shane Jackson

WBCM Consultants Limited, Signed: John Fanshaw

APPENDIX C

APPENDIX C

SUMMARY OF ANALYTICAL RESULTS

TABLE 1
SUMMARY OF SOIL RESULTS FOR HEAVY METALS

COFFEY

Job Reference : E3523/1
Location: CFA Training College, Fiskville near Ballan VIC
Results expressed in mg/kg dry weight

Sample No	Depth (m)	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
	Lab Detection Limits:	2	1	2	2	0.01	2	2	2
	ANZECC B	*20*	*3*	*50*	*60*	*1*	*60*	*300*	*200*
BH1-1.5-P	1.5-1.6	<2	<1	24	5	0.02	9	7	9
BH1-2.0-P	2.0-2.1	<2	<1	52	10	0.02	16	22	12
BH2-1.0-P	1.0-1.1	<2	<1	46	7	0.05	15	8	9
BH2-1.5-P	1.5-1.6	<2	<1	42	6	0.02	9	9	9
BH4-1.0-P	1.0-1.1	<2	<1	55	9	0.05	13	10	13
BH4-2.0-P	2.0-2.1	<2	<1	40	6	0.15	16	7	11

[ ] Concentrations exceeding ANZECC B criteria

TABLE 2
SUMMARY OF SOIL RESULTS FOR PETROLEUM HYDROCARBONS

COFFEY

Job Reference : E3523/1
Location: CFA Training College, Fiskville near Ballan VIC
Results expressed in mg/kg dry weight

Sample No	Depth (m)	BENZENE	TOLUENE	ETHYL BENZENE	XYLENES	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36
Lab Detection Limits:		0.02	0.02	0.02	0.02	20	20	20	20
	ANZECC B	*1*							
	Dutch B	*1*	*3*	*5*	*5*	*100*	*{------ ---- 1000 ---*		*-----------}*
	Dutch C	*5*	*30*	*50*	*50*	*800*	*{------ ---- 5000 ---*		*-----------}*
BH1-1.5-P	1.5-1.6	<0.02	<0.02	<0.02	<0.02	<20	<20	26	<20
BH1-2.0-P	2.0-2.1	<0.02	<0.02	<0.02	<0.02	<20	73	370	110
BH2-1.0-P	1.0-1.1	<0.02	<0.02	<0.02	<0.02	<20	<20	38	<20
BH2-1.5-P	1.5-1.6	<0.02	<0.02	<0.02	<0.02	<20	<20	80	<20
BH4-1.0-P	1.0-1.1	<0.02	<0.02	<0.02	<0.02	<20	<20	<20	<20
BH4-2.0-P	2.0-2.1	<0.02	<0.02	<0.02	<0.02	<20	<20	48	40

TABLE 3
SUMMARY OF GROUNDWATER RESULTS

Job Reference : E3523/1
Location: CFA Training College, Fiskville near Ballan VIC
Results expressed in mg/L.

Borehole	Date Sampled	Sample No	BENZENE	TOLUENE	ETHYL BENZENE	XYLENES	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36
		Lab Detection Limits:	*0.001*	*0.005*	*0.005*	*0.005*	*0.1*	*0.1*	*0.1*	*0.1*
		ANZECC (AQUATIC)	*0.3*	*0.3*						
		ANZECC (DRINK)	*0.01*							
		Dutch B:	*0.001*	*0.015*	*0.02*	*0.02*	*0.04*	*(------ ---- 0.2 ----- ----------)*		
		Dutch C:	*0.005*	*0.05*	*0.06*	*0.06*	*0.15*	*(------ ---- 0.6 ----- ----------)*		
BH5	26-Sep-96	BH5-P	<0.001	<0.005	<0.005	<0.005	<0.1	<0.1	0.4	<0.1
BH2	26-Sep-96	BH2-P	<0.001	<0.005	<0.005	<0.005	<0.1	<0.1	<0.1	<0.1

Borehole	Date Sampled	Sample No	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
		Lab Detection Limits:	*0.005*	*0.0002*	*0.005*	*0.002*	*0.0001*	*0.01*	*0.001*	*0.005*
		ANZECC (AQUATIC)	*0.05*	*0.0002*	*0.01*	*0.002*	*0.0001*	*0.015*	*0.001*	*0.005*
		ANZECC (DRINK)	*0.05*	*0.005*	*0.05*		*0.001*	*0.100*	*0.05*	*5.0*
BH5	26-Sep-96	BH5-P	<0.005	<0.0002	<0.005	0.01	<0.0001	0.013	<0.001	0.095
BH2	26-Sep-96	BH2-P	<0.005	<0.0002	<0.005	0.007	<0.0001	0.058	<0.001	0.13

Borehole	Date Sampled	Sample No	pH (units)	Ec (μS/cm)	CL	SO_4	CO_3	HCO_3	NO_3-N	Na	K	Ca	Mg	Fe	Mn
		Lab Detection Limits:					*5*	*1*	*0.3*		*0.1*				
		ANZECC (AQUATIC)	*6.5-9*	*1500*										*1*	
		ANZECC (DRINK)	*6.5-8.5*	*1500*	*400*	*400*			*10*	*300*				*0.3*	*0.1*
BH5	26-Sep-96	BH5-P	7.4	1800	520	84	<5	110	<0.3	370	<0.1	12	21	0.2	0.05
BH2	26-Sep-96	BH2-P	7.3	10500	4900	150	<5	140	0.7	1600	17	180	380	0.2	0.9

TABLE 4
SUMMARY OF FIELD QC RESULTS

Job Reference : E3523/1
Location: CFA Training College, Fiskville near Ballan VIC
Results expressed in mg/kg dry weight unless otherwise specified

Sample No	Sample Type	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
BH40-1.0-P	soil-duplicate	< 2	< 1	50	6	0.07	14	10	11
BH4-1.0-P	soil	< 2	< 1	55	9	0.05	13	10	13
	RPD(%)	0	0	10	40	33	7	0	0
Water Blank	deionised water-mg/L	< 0.005	< 0.0001	< 0.005	0.004	< 0.0001	< 0.01	0.001	1.1
Wash Blank	equip. rinsate-mg/L	< 0.005	< 0.0001	< 0.005	0.004	< 0.0001	< 0.01	0.001	1.0
BH20-P	gw-duplicate-mg/L	< 0.005	< 0.0002	< 0.005	0.007	< 0.0001	0.063	< 0.001	0.13
BH2-P	groundwater-mg/L	< 0.005	< 0.0002	< 0.005	0.007	< 0.0001	0.058	< 0.001	0.13
	RPD(%)	0	0	0	0	0	8	0	0

Sample No	Sample Type	BENZENE	TOLUENE	ETHYL BENZENE	XYLENES	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36
BH40-1.0-P	soil-duplicate	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	< 20	< 20
BH4-1.0-P	soil	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	< 20	< 20
	RPD(%)	0	0	0	0	0	0	0	0
Water Blank	deionised water-mg/L	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1
Wash Blank	equip. rinsate-mg/L	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1
BH20-P	gw-duplicate-mg/L	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1
BH2-P	groundwater-mg/L	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1
	RPD(%)	0	0	0	0	0	0	0	0

Sample No	Sample Type	pH (units)	Ec (µS/cm)	CL	SO_4	CO_3	HCO_3	NO_3-N	Na	K	Ca	Mg	Fe	Mn
BH20-P	gw-duplicate-mg/L	7.3	10400	5100	160	< 5	160	0.5	1900	16	180	480	0.1	0.89
BH2-P	groundwater-mg/L	7.3	10500	4900	150	< 5	140	0.7	1600	17	180	380	0.2	0.9
	RPD(%)	0	1	4	6	0	13	33	17	6	0	23	67	1

APPENDIX D

APPENDIX D

NATA CERTIFIED LABORATORY ANALYTICAL RESULTS

NATIONAL ANALYTICAL LABORATORIES
A division of Gribbles Pathology (Vic.) Pty. Ltd. A.C.N. 006 823 089
585 BLACKBURN ROAD NOTTING HILL VICTORIA AUSTRALIA 3168
TELEPHONE 03 9562 5899 FACSIMILE 03 9562 0336

COFFEY PARTNERS INTERNATIONAL
- 3 OCT 1996

National Association of Testing Authorities, Australia
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CERTIFICATE OF ANALYSIS

DATE 25 September 1996

LABORATORY NUMBER SEPF3743

CLIENT Coffey Partners International Pty Ltd - Michael Probert

SAMPLE Sample/s received 18/9/96 - Job Ref: E3523/1

METHODS

Metals	NAL E102.21, E102.34, E102.C3
Benzene, Toluene, Ethyl Benzene, Xylene	NAL E106.01
Total Petroleum Hydrocarbons	NAL E104.52, E104.12

RESULTS

Please refer to attached page/s for results

Approved By
E D Jones BSc M R A C I
LABORATORY MANAGER

DATE : 4/10/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1
Results expressed in mg/L.

LABID	Received	Sample	pH	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	BENZENE	TOLUENE	ETHYL BENZENE	XYLENE	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36
SEPF4246	18/09/96	WASH BLANK		< 0.005	< 0.00010	< 0.005	0.004	< 0.0001	< 0.010	0.001	1.0	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1
SEPF4247	18/09/96	WATER BLANK		< 0.005	< 0.00010	< 0.005	0.004	< 0.0001	< 0.010	0.001	1.1	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1

A blank space indicates no test performed.

DATE :25/09/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1

Results expressed in mg/kg Dry Weight

LABID	Received	Sample	pH	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	BENZENE	TOLUENE	ETHYL BENZENE	XYLENE	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36
SEPF3743	16/09/96	BH1 1.5-P	5.0	< 2	< 1	24	5	0.02	9	7	9	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	26	< 20
SEPF3744	16/09/96	BH1 2.0-P	5.5	< 2	< 1	52	10	0.02	16	22	12	< 0.02	< 0.02	< 0.02	< 0.02	< 20	73	370	110
SEPF3745	16/09/96	BH2 1.0-P	6.1	< 2	< 1	46	7	0.05	15	8	9	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	38	< 20
SEPF3746	16/09/96	BH2 1.5-P	6.4	< 2	< 1	42	6	0.02	9	9	9	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	80	< 20
SEPF3747	16/09/96	BH4 1.0-P	8.3	< 2	< 1	55	9	0.05	13	10	13	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	< 20	< 20
SEPF3748	16/09/96	BH4 2.0-P	8.4	< 2	< 1	40	6	0.15	16	7	11	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	48	40
SEPF4245	18/09/96	BH40 1.0-P		< 2	< 1	50	6	0.07	14	10	11	< 0.02	< 0.02	< 0.02	< 0.02	< 20	< 20	< 20	< 20

A blank space indicates no test performed.

QUALITY ASSURANCE REPORT

DATE :25/09/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1
Results expressed in mg/L.

LABID	Received	Sample	pH	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	BENZENE	TOLUENE	ETHYL BENZENE	XYLENE	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36	
SEPF5079	18/09/96	BLANK														< 0.1	< 0.1	< 0.1	< 0.1	
SEPF5080	18/09/96	QA/QC SPIKE														1.8				spike/SEPF5079
SEPF5080	18/09/96	QA/QC SPIKE														1.8				Expected Result
SEPF5080	18/09/96	BLANK														100				% Recovery
SEPF5079	18/09/96	BLANK														< 0.1				

A blank space indicates no test performed.

QUALITY ASSURANCE REPORT

DATE :25/09/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1
Results expressed in mg/kg Dry Weight

LABID	Received	Sample	pH	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	BENZENE	TOLUENE	ETHYL BENZENE	XYLENE	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36	
SEPF4273	16/09/96	BLANK										< 0.02	< 0.02	< 0.02	< 0.02					
SEPF4274	16/09/96	QA/QC SPIKE										1.1	1.0	0.95	2.0					spike/SEPF4273
SEPF4274	16/09/96	QA/QC SPIKE										1.1	1.0	0.95	2.0					Expected Result
SEPF4274	16/09/96	BLANK										100	100	100	100					% Recovery
SEPF4273	16/09/96	BLANK										< 0.02	< 0.02	< 0.02	< 0.02					
SEPF4385	16/09/96	BLANK						< 0.01												
SEPF4495	16/09/96	BH2 1.5-P	6.4																	dupl/SEPF3746
SEPF3746	16/09/96	BH2 1.5-P	6.4																	
SEPF4495	16/09/96	BH2 1.5-P	0																	Rel % Difference
SEPF4550	16/09/96	BLANK		< 2	< 1	< 2	< 2		< 2	< 2	< 2									
SEPF4854	16/09/96	BLANK														< 20	< 20	< 20	< 20	
SEPF5061	18/09/96	BH40 1.0-P						0.07												dupl/SEPF4245
SEPF4245	18/09/96	BH40 1.0-P						0.07												
SEPF5061	18/09/96	BH40 1.0-P						0												Rel % Difference
SEPF5142	18/09/96	BH40 1.0-P														< 20	< 20	< 20	< 20	dupl/SEPF4245
SEPF4245	18/09/96	BH40 1.0-P														< 20	< 20	< 20	< 20	
SEPF5142	18/09/96	BH40 1.0-P														0	0	0	0	Rel % Difference
SEPF5143	18/09/96	BH40 1.0-P														600				spike/SEPF4245
SEPF5143	18/09/96	BH40 1.0-P														780				Expected Result
SEPF5143	18/09/96	BH40 1.0-P														76.9				% Recovery
SEPF4245	18/09/96	BH40 1.0-P														< 20				
SEPF5158	18/09/96	BLANK		< 2	< 1	< 2	< 2		< 2	< 2	< 2									
SEPF5159	18/09/96	BH40 1.0-P		360	59	160	110		130	120	120									spike/SEPF4245
SEPF5159	18/09/96	BH40 1.0-P		370	62	170	130		140	130	130									Expected Result
SEPF5159	18/09/96	BH40 1.0-P		97.3	95.2	91.7	83.9		92.1	91.7	91.6									% Recovery
SEPF4245	18/09/96	BH40 1.0-P		< 2	< 1	50	6		14	10	11									

A blank space indicates no test performed.

NATIONAL ANALYTICAL LABORATORIES
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CERTIFICATE OF ANALYSIS

DATE 3 October 1996

LABORATORY NUMBER SEPF5465

CLIENT Coffey Partners International Pty Ltd - Michael Probert

SAMPLE Sample/s received 27/9/96 - Job Ref: E3523/1

METHODS

Metals	NAL E102.31, E102.C3
Benzene, Toluene, Ethyl Benzene, Xylene	NAL E106.01
pH	NAL E100
Total Petroleum Hydrocarbons	NAL E104.12
Anions	NAL E118.11

RESULTS

Please refer to attached page/s for results

Approved By
E D Jones BSc M R A C I
LABORATORY MANAGER

DATE : 3/10/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1

Results expressed in mg/L.

LABID	Received	Sample	K	Na	Ca	Mg	Fe	Mn	HCO3	CO3	pH	CHLORIDE	NO3-N	SO4	CONDUCTIVITY
															uS/cm
SEPF5465	27/09/96	BH5-P	< 0.1	370	12	21	0.2	0.05	110	< 5	7.4	520	< 0.3	84	1800
SEPF5466	27/09/96	BH2-P	17	1600	180	380	0.2	0.90	140	< 5	7.3	4900	0.7	150	10500
SEPF5467	27/09/96	BH20-P	16	1900	180	480	0.1	0.89	160	< 5	7.3	5100	0.5	160	10400

DATE : 3/10/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1
Results expressed in mg/L.

LABID	Received	Sample	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	BENZENE	TOLUENE	ETHYL BENZENE	XYLENE	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36
SEPF5465	27/09/96	BH5-P	< 0.005	< 0.00020	< 0.005	0.010	< 0.0001	0.013	< 0.001	0.095	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	0.4	< 0.1
SEPF5466	27/09/96	BH2-P	< 0.005	< 0.00020	< 0.005	0.007	< 0.0001	0.058	< 0.001	0.13	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1
SEPF5467	27/09/96	BH20-P	< 0.005	< 0.00020	< 0.005	0.007	< 0.0001	0.063	< 0.001	0.13	< 0.001	< 0.005	< 0.005	< 0.005	< 0.1	< 0.1	< 0.1	< 0.1

A blank space indicates no test performed.

QUALITY ASSURANCE REPORT

DATE : 3/10/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1

Results expressed in mg/L.

LABID	Received	Sample	K	Na	Ca	Mg	Fe	Mn	HCO3	CO3	pH	CHLORIDE	NO3-N	SO4	CONDUCTIVITY uS/cm	
OCTF5705	27/09/96	BH5-P							110	< 5						duplt/SEPF5465
SEPF5465	27/09/96	BH5-P							110	< 5						
OCTF5705	27/09/96	BH5-P							0	0						Rel % Difference
OCTF5860	27/09/96	BH20-P	14	1800	190	480	0.3	0.90								duplt/SEPF5467
SEPF5467	27/09/96	BH20-P	16	1900	180	480	0.1	0.89								
OCTF5860	27/09/96	BH20-P	13.3	5.4	5.4	0	100	1.1								Rel % Difference
OCTF5861	27/09/96	BH20-P	20				5.3	3.2								spike/SEPF5467
OCTF5861	27/09/96	BH20-P	21				5.1	2.9								Expected Result
OCTF5861	27/09/96	BH20-P	80.0				104	115								% Recovery
SEPF5467	27/09/96	BH20-P	16				0.1	0.89								

QUALITY ASSURANCE REPORT

DATE : 3/10/96 Client : COFFEY PARTNERS INTERNATIONAL PTY. LTD. Job Reference : E3523/1
Results expressed in mg/L.

LABID	Received	Sample	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	BENZENE	TOLUENE	ETHYL BENZENE	XYLENE	TPH C6-C9	TPH C10-C14	TPH C15-C28	TPH C29-C36	
OCTF5699	27/09/96	BLANK									< 0.001	< 0.005	< 0.005	< 0.005					
OCTF5700	27/09/96	QA/QC SPIKE									1.0	1.0	0.94	2.0					spike/OCTF5699
OCTF5700	27/09/96	QA/QC SPIKE									1.1	1.0	0.95	2.0					Expected Result
OCTF5700	27/09/96	BLANK									90.9	100	98.9	100					% Recovery
OCTF5699	27/09/96	BLANK									< 0.001	< 0.005	< 0.005	< 0.005					
OCTF5762	27/09/96	BLANK													< 0.1	< 0.1	< 0.1	< 0.1	
OCTF5763	27/09/96	QA/QC SPIKE													1.3				spike/OCTF5762
OCTF5763	27/09/96	QA/QC SPIKE													1.8				Expected Result
OCTF5763	27/09/96	BLANK													72.2				% Recovery
OCTF5762	27/09/96	BLANK													< 0.1				
OCTF5833	27/09/96	BH20-P	< 0.005	< 0.00020	< 0.005	0.007	< 0.0001	0.063	< 0.001										duplt/SEPF5467
SEPF5467	27/09/96	BH20-P	< 0.005	< 0.00020	< 0.005	0.007	< 0.0001	0.063	< 0.001										
OCTF5833	27/09/96	BH20-P	0	0	0	0	0	0	0										Rel % Difference
OCTF5834	27/09/96	BLANK	< 0.005	< 0.00020	< 0.005	< 0.002	< 0.0001	< 0.010	< 0.001										
OCTF5860	27/09/96	BH20-P								0.14									duplt/SEPF5467
SEPF5467	27/09/96	BH20-P								0.13									
OCTF5860	27/09/96	BH20-P								7.4									Rel % Difference
OCTF5861	27/09/96	BH20-P								1.9									spike/SEPF5467
OCTF5861	27/09/96	BH20-P								2.0									Expected Result
OCTF5861	27/09/96	BH20-P								94.7									% Recovery
SEPF5467	27/09/96	BH20-P								0.13									

A blank space indicates no test performed.

APPENDIX E

APPENDIX E

SITE HEALTH & SAFETY PLAN
REFERENCE E3523/1-AG DATED 3 SEPTEMBER 1996

CFA TRAINING COLLEGE SITE HEALTH AND SAFETY PLAN

PROJECT NAME : GROUNDWATER MONITORING
SITE LOCATION : CFA TRAINING COLLEGE
JOB NUMBER : E3523/1
PROJECT MANAGER : TIM MARSHALL
SITE REPRESENTATIVE: GRANT EGGLESTON TEL NO: 9853-3396

1.0 SCOPE

This Site Health and Safety Plan (hereafter referred to as the Plan), provides a general framework for protection against the chemical and physical hazards associated with site drilling and sampling activities. This Plan describes the general safety procedures to be followed and specifies the personal protective equipment (PPE) to be worn by site staff. All staff will comply with CFA's Health and Safety requirements.

It should be noted that this Plan does not replace the need for site staff to use common sense and to undertake site activities in a sensible manner. Potential or actual problems in using this Plan on site should be brought to the attention of the Site Representative and / or the Project Manager.

Modifications made to this Plan as a result of the above or changed operational conditions are to be documented, reviewed and approved by the Project Manager and attached to this Plan. Inapplicable parts of the original and subsequent plans are to be deleted by crossing out in ink, dating and initialling by the Site Representative.

2.0 PROJECT WORK

2.1 Outline Description

Site works will comprise installation of groundwater monitoring bores and soil and groundwater sampling for laboratory analysis and ancillary activities.

2.2 Field Work

Sampling will be undertaken from 7 groundwater bores as per Field Advice.

3.0 SITE SAFETY MANAGEMENT

3.1 Responsibilities

The Project Manager's responsibilities for site safety include;

- issuing this Plan, and subsequent updating, and,
- assessing training needs on site specific safety management, and instituting such training,
- ensuring all necessary checks and clearances have been completed prior to initiating work.

The Site Representative's responsibilities for site safety include;

- ensuring the implementation of this Plan on site by Coffey staff and sub contractors staff,
- overseeing the proper use and maintenance of the site safety equipment, including staff personal protective equipment (PPE) and first aid equipment.

The Site Representative is authorised by the Project Manager to request Coffey staff *and Subcontractors staff* to leave the site where such staff do not follow this Plan.

3.2 Site Control

For the purposes of containing and controlling potential contamination transfer during field work, the following field work zones are to be set up and maintained;

- **Sampling Zone** - this is the area(s) where field work is taking place and there is a potential for contamination of personnel and equipment. Only personnel essential to the work process are to be admitted into this zone. Such personnel are required to wear the PPE specified in Sections 4.0 & 5.0.
- **Decontamination Zone** - this area is used for primary decontamination of equipment and personnel and is located in *an area to be designated by the CFA Representative.*
- **Support Zone** - Areas outside the Sampling and Decontamination Zones and assessed by the Site Representative to be suitable for no PPE to be worn by personnel. *This includes the administrative facilities and /or other support facilities.*

The Site Representative will inform site staff of the locations of the above three zones at the commencement of their work on site and provide updates of changes to the locations of the zones.

3.3 Decontamination Procedures

All equipment used in the drilling process will be decontaminated prior to mobilisation. Drill rods, bits, etc, will be decontaminated between boreholes in the Decontamination Zone. The procedures for decontamination comprise;

- high pressure wash/steam clean or applicable of drill rods, etc and rinse with water;
- brush scrubbing of sampling tools (trowel) with a Decon 90 detergent solution (a phosphate free detergent solution) or equivalent, rinse with water;
- rinse sampling equipment with deionised water.

The spent solution used in the decontamination process will *be disposed on site in a suitable manner as advised by the CFA Representative.*

COFFEY

4.0 SITE HAZARDS AND CONTROLS

The chemical and physical hazards known or suspected to be on the site are primarily petroleum based hydrocarbons found in contaminated soils and groundwater. Drilling and sampling operations may result in the emission of volatile hydrocarbons into the air from soils and groundwater.

Health and safety concerns often associated with such a sampling program are:

- dermal contact, ingestion, inhalation of mists, vapours, dusts, waters containing chemicals;
- vehicle movements throughout the work site;
- underground services and above ground oil pipelines.

Site personnel should be aware that any PPE required to be worn may limit manual dexterity, hearing, visibility and may increase the difficulty of performing tasks. PPE places an additional strain on the user when performing work that requires physical activity.

4.1 General Air Monitoring

General air monitoring will be performed using a portable photoionisation detector equipped with a 10.6eV lamp. If ambient-air readings in excess of 5 ppm above background are obtained within the breathing zone, respiratory protection will be required.

4.2 Chemical Hazards

Potentially toxic petroleum hydrocarbons and the respective safety equipment recommended is summarised below.

Contaminants Present	Hazard	Symptoms of Overexposure	Recommended Precautionary Measures
volatile hydrocarbons (benzene, toluene, ethyl benzene, xylenes)	highly volatile and flammable; benzene is a carcinogen	Inhalation of vapours may cause irritant effects to eyes, nose and throat, dizziness, headaches, nausea. Absorption of liquid/free product into skin may result in poisoning.	coveralls, gloves, organic vapour respirator may be required in some situations
petroleum hydrocarbons, polycyclic aromatic hydrocarbons	some are reasonably volatile, however most have low volatility	Inhalation of vapours may cause irritant effects to eyes, nose and throat, dizziness, headaches, nausea. Absorption of liquid/free product into skin may result in poisoning.	*organic vapour respirator in some situations*

COFFEY

4.3 Physical Hazards

The following table summarises the physical hazards associated with the site at the and what safety measures are required.

Physical Hazard	Safety Measures
Underground services	Located and clearances issued prior to drilling. If in doubt, advance hole slowly or move hole site if necessary. The possibility of services which have not been placed in trenches should be considered.
Above ground pipelines and services	Be vigilant and careful. Standard clearances will be provided between all rig masts and overhead power cables. Clearances to be adopted are 6.5m minimum in proximity to low and high voltage lines. All movement of elevated machinery in the vicinity of overhead powerlines should only be done with a "spotter" who must be within sight and audible communications of the rig operator at all times. *(A 2m minimum clearance is applicable only where machinery is fully insulated and authorised by the State Electricity Department.)*

* General notes:

Drilling: Upon completion of drilling, boreholes are to be backfilled and capped to produce a level surface. If standpipes are installed they will be covered with an appropriate protective cover. Dispersion of drill cuttings, drill muds, etc, should be minimised by using bund-control. All drill wastes are to be consolidated into drums and transferred to an on-site storage area prior to disposal off-site. Waste waters from drilling activities may require special treatment. Do not discharge to stormwater or sewer without CFA approval.

Excavations: Excavations deeper than 1m shall in no circumstances be entered on this project without safe trenching supports. All excavtions left open or unattended should be clearly fenced with fluorescent webbing or equivalent. When personnel are required to work in a trench (i.e. less than 1m depth) and operations dictate that one's head is below the ground surface, respiratory protection may be required to avoid inhalation of contaminated dusts, vapours, etc. Personnel should never work in an excavation alone, but always ensure there is another person to render assistance if necessary.

5.0 SAFE WORK PRACTICES

5.1 Recommended PPE

The following PPE is recommended to be worn by personnel involved in all activities:

Body Protection	Work overalls or disposable coveralls (eg Ty-vek). Vests with fluorescent markings should be worn in areas subjected to vehicular movements.
Head Protection	Hard hats must be worn by all personnel working in the vicinity of drilling or backhoe operations. Hard hats may also be required in certain areas across the site, as designated by the CFA Representative.
Eye Protection	Eye protection is required at all times to prevent eye injuries resulting from contact with airborne particulates or drilling wastes.
Foot Protection	Safety boots will be worn by all on-site personnel.
Skin Protection	Glove protection will be required to prevent absorption of drilling fluids, drilling returns or contaminants into the body.
Hearing Protection	All personnel who are likely to be exposed to excessive noise levels on site (eg. in the vicinity of drilling rigs) should wear hearing protection (eg. ear plugs/ear muffs).
Respiratory Protection	Respiratory protection should be accessible during drilling and excavtation activities, should the need arise. *Wearing respirators over facial hair could interfere with good respirator fit.*

5.2 Safe Work Procedures

The most important person responsible for your safety is you.

* Personal Hygiene

Eating, drinking, chewing gum or tobacco, smoking, or any practice that involves hand to mouth transfer increases the probability of ingesting foreign matter into the body. Hands must be thoroughly washed before eating, drinking, or smoking.

* **Drugs & Alcohol on Site**

No alcohol or illegal drugs should be brought onto or consumed on site. It is recognised that alcohol contributes to industrial accidents, particularly where machinery is operated, and exacerbates the effects of heat stress.

* **Smoking**

Smoking is prohibited on the work-site at all times.

* **Contaminated Clothing**

Contaminated coveralls should be disposed on site in an approved industrial waste-bin or as directed by the CFA Representative. Non-disposable PPE such as boots, hard hat, etc should be cleaned and rinsed with water before leaving the site.

* **Personnel Communication**

Personnel not involved in the drilling/sampling activities should be kept away from the work site and, as a general rule, should not be closer than 10m to the sampling site.

CFA personnel in the immediate vicinity of the sampling work shall be informed of any necessary safety requirements, should the need arise.

6.0 EMERGENCY MEASURES

6.1 Checklist

- First-Aid kit;
- Project manager's contact phone number and location;
- CFA first-aid and medical assistance.

An accident or mishap occurring such as:

- Personal injury;
- A fire or explosion on-site;
- A near miss incident,

to a Coffey employee, or its sub-contractor, shall be reported to the Site Representative *(and the CFA Site Representative)* who shall make a record of the date, time and nature of the incident and advise the Project Manager. The Project Manager will investigate the cause of the injury to enable changes in work procedures to be undertaken and for filing copies of site specific injury reports in an employees personal file.

The injured Coffey employee is responsible for completing an **accident report form** on return to the office.

The Site Representative shall take appropriate first-aid measures where appropriate or shall direct a responsible person to take such measures.

7.0 CERTIFICATION

This certification is relevant to all on site personnel and sub-contractors on site.

I have read the above **Site Health and Safety Plan and attachments listed below.** I have been informed of the potential hazards associated with on-site activities and agree to abide by its provisions under the instruction of the Coffey Site Representative. I agree to be alert to site health and safety conditions at all times.

NAME	ORGANISATION	SIGNATURE	DATE
G. Eggleston	Coffey	[signature]	9/9/96

Attachments - **None**

End of Site Safety Plan

12/1968

CRA ATD Technology for CRA

A Report prepared for
Country Fire Authority

Fiskville Training College Review of Site Assessments and Remediation Options

CONFIDENTIAL

28 November 1996

Client: Grant James
Country Fire Authority

CONFIDENTIAL

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Fiskville Training College Review of Site Assessments and Remediation Options

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Paul Nash

Responsible Manager: Steve Roden
03 9242 3170

Internal copy to: B Kelley/File

Date: 28 November 1996

Implications

Total volumes of contaminated soil requiring treatment and/or disposal appear to be in excess of $2000m^3$.

Disposal to off site landfill of the estimated total volume of soil can be expected to cost a minimum of $90,000. On site bioremediation using a simple landfarming or similar process can be expected to cost in the range $50-90,000.

These cost estimates do not include costs of excavation and transport, which may be significant for off site disposal, nor the cost of replacement clean fill.

It is recommended that

- the FLP/FMA area be reviewed, and improvements in prop design, firewater collection, drainage and water treatment be implemented as soon as practicable to prevent further contamination of soil and dam sediment.
- contaminated soils from the FLP/FMA and fire training pits be excavated for on site treatment, and backfilled with clean fill.
- once these improvements have been made, and hydrocarbons are being intercepted and removed from surface waters, Dam 1 may be rehabilitated.
- contaminated soils from the drum burial pits be excavated, and, subject to the presence of drums, be treated on site, or otherwise disposed of off site to appropriate landfill. The trenches should be backfilled with clean soil.
- surface water monitoring be continued at appropriate intervals, including at least one more sampling round before the FLP/FMA improvements mentioned above are implemented.
- the groundwater monitoring wells be dipped and sampled annually.

SUMMARY

Project Focus

This report reviews the environmental status of the Country Fire Authority (CFA) Training College at Fiskville, Victoria The objectives of this report are to:

- identify the areas containing contaminated soils and sediments,
- assess and describe the risks associated with such contamination, particularly any impacts on groundwater and surface water,
- review and evaluate various options for carrying out remediation.

Findings

The environmental investigations reviewed reveal localised soil, sediment and surface water contamination at the Fiskville Training College. This contamination has been principally the result of storage and handling of fuels, fire training activities, and disposal of fuel residues.

Levels of soil contamination at the Fiskville site exceed soil investigation guidelines for total petroleum hydrocarbons at several locations, including

- the Flammable Liquids Pad (FLP),
- the decommissioned fire training pits east of the FLP, and
- the drum burial pits.

Significant hydrocarbon contamination is also evident in sediments in Dam 1, and near the inlet to Dam 2.

Some low level soil contamination with phenols, BTEX and lead was also encountered, but only where TPH concentrations were also above investigation guidelines. Slightly elevated levels of chromium in most soils are considered to represent site background.

No significant groundwater contamination has been identified.

All contaminated soil is accessible for excavation ie is not constrained by storage tanks or buildings. Of the available *on site* remediation alternatives, bioremediation (by landfarming or similar process) should achieve soil remediation objectives at low cost for hydrocarbon impacted soil from the FLP/FMA and fire training pit.

Excavation and removal to a suitable landfill also appears to be an appropriate remediation strategy. Soil from the drum disposal pits may contain drums or other containers, so that on site treatment would be difficult, and disposing of the material off site in this case is likely to be the most appropriate remedial action.

CONTENTS

DETAILS

Project Focus

Introduction

CRA ATD, formerly Minenco Pty Limited (Environmental Services), was commissioned in April 1996 to review the environmental status of the Country Fire Authority (CFA) Training College at Fiskville, Victoria, and evaluate remedial options for the site.

This review encompassed a series of environmental investigations, which are the subject of this report.

Objectives and Scope

The review comprised the following :

- site inspections on 14 May and 2 July 1996,
- scoping site investigations required to characterise site contamination,
- collation and interpretation of the investigation data
- evaluation of remediation options.

The objectives of this report are to:

- summarise the areas identified in the investigations as containing contaminated soils and sediments,
- assess and describe the risks, if any, associated with such contamination, particularly any impacts on groundwater and surface water,
- discuss the basis for any remediation work that may be required,
- review and evaluate various options for carrying out the remediation,
- discuss the timing of the remediation work,
- provide a recommendation as to the most cost effective remedial strategy, in the context of CFA business plans for the site.

Background

Location

The CFA Training College is located at Fiskville, approximately 50 km north of Geelong and 10 km south of Ballan. The site covers an area of approximately 146 ha, and is situated on the western side of the Ballan-Geelong Road.

Land Use

The site is in a rural pasture setting, and is currently used by CFA as a Training College for fire and emergency services personnel from within CFA, and from external organisations. This principally involves fire fighting exercises at a number of "props", using both gas and liquid fuels.

The site has been used for such training for approximately 20 years. Prior to this few buildings existed on the site.

The main areas of the site comprise:

- Flammable Liquid Pad (FLP) and Fuel Mix Areas used for fire training
- Two interconnecting dams, collecting run off from the FLP, and draining to Lake Fiskville
- Fuel storage area
- Light industrial facilities, including stores, workshops and underground diesel storage tanks
- Decommissioned fire training pits east of the FLP
- Drum burial pits south of the western end of the airstrip
- A landfill, west of Lake Fiskville
- Training centre, administration and accommodation facilities.

Surrounding land is essentially rural.

Topography and Drainage

The college is located on a flat to gently undulating plateau, with lakes and wetlands formed in local depressions. Lake Fiskville is situated immediately west of the training complex.

A central north-south ridge forms a break in the site drainage.

The site drains generally towards the south, via Yaloak Creek on the eastern side, and Beremboke Creek to the west. Drainage to the east is towards the Werribee River water supply catchment.

Geology and Hydrogeology

The site lies over Quaternary Olivine Basalts. Surface soils are residual silts and clays, generally no more than 2-3m deep, overlying very stiff, high plasticity residual clays, grading to variably weathered basalt.

Shallow fill, comprising gravel or road base, is found in parts of the site, particularly in the area of the Flammable Liquids Pad. A summary of the site stratigraphy is given in Table 1.

The groundwater table is likely to comprise of an unconfined aquifer within the variable weathered basalt at depths ranging between approx 8 and 15m below existing ground surface level.

Table 1. Generalised Subsurface Profile

Soil Unit	Depth to Top of Layer (m)	Thickness (m)	Description
1	0	0.1 - 0.8	FILL: fine to coarse grained sandy gravel, silty clay or medium plasticity red clay.
2	0.2 - 1.0	0.1 - 0.2	RESIDUAL SILTY CLAY: medium plasticity, grey to grey-brown, may comprise rounded buckshot gravel (2 to 5mm) with clay.
3	0.3 - 1.2	0.5 - 1.8	SILTY CLAY: high plasticity, yellow-grey to yellow-brown, mottled orange-yellow. Residual clay formed on basalt.
4	0.8 - 2	14 - 18	BASALT
5	16 - 18.8	3.2 - 6.0	VOLCANIC ASH

Previous Investigations

Four site investigations were carried out at Fiskville during 1996. The following reports on these individual investigations are reviewed here:

- Diomides & Associates, Environmental Site Assessment (27 June 1996),
- Coffey Partners International, Field Site Appraisal and Sampling (August 1996),
- Coffey Partners International, Groundwater Monitoring Network Installation (October 1996),
- Coffey Partners International, Sediment and Surface Water Sampling (October 1996).

The scope of these investigations is outlined below, for soil, sediment, groundwater and surface water.

Soil

Diomides & Associates was commissioned in May 1996 to investigate the nature and extent of soil contamination. The **Environmental Site Assessment** (Report No DA1108/SD3000, 27 June) included:

- inspection of areas of buried drums containing solvents and other flammable liquids, decommissioned fire training pits, sludge burial pits, areas of ground saturated with petroleum hydrocarbons, contaminated sediment in a dam near the flammable liquid pad,
- drilling of boreholes with solid auger, soil sampling and soil vapour testing carried out in May 1996,
- nine (9) bores drilled to a maximum depth of 2.6m in the FLP area,
- three (3) bores to 1.0m at the drum burial pits near the airstrip,
- four (4) bores to a maximum depth of 2.8m near underground fuel storage tanks in the training centre - administration area,
- soil samples collected at depths of 0.5, 1.0 and 2.5m, and
- 46 soil samples and 12 composites analysed for total petroleum hydrocarbons (TPH), BTEX (Benzene, Toluene, Ethylbenzene, Xylene), polynuclear aromatic hydrocarbons (PAH), phenols, organochlorine pesticides, polychlorobiphenyls (PCBs) and selected heavy metals.

The bore locations are shown in Figures 1 and 2.

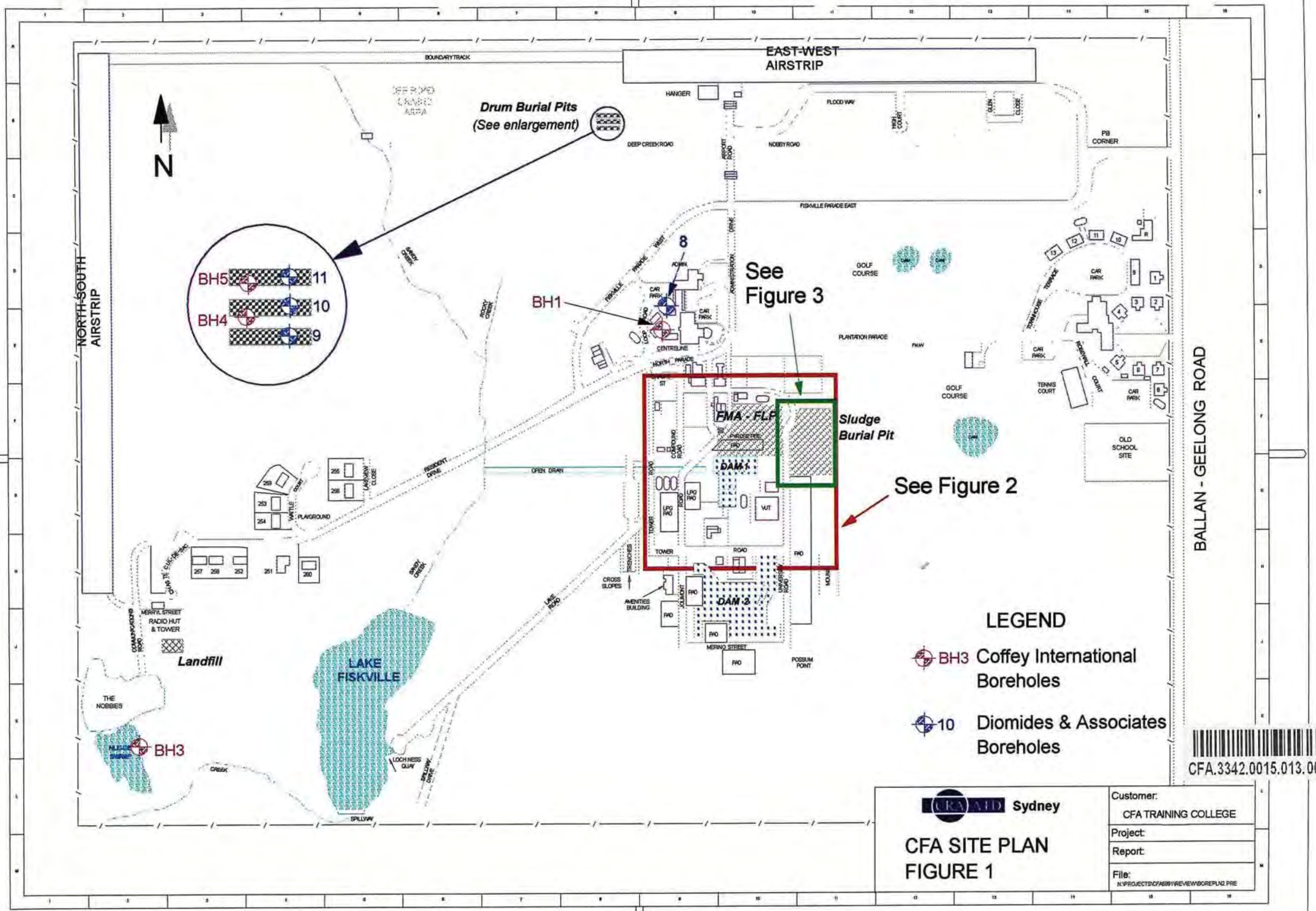
Coffey Partners International. Field Site Appraisal and Sampling (Report No E3517/1-AD, August 1996) included:

- excavation of 20 test pits to a maximum depth of 1.4m in the area of the fire training pits east of the FLP,
- visual and olfactory observations,
- *in situ* soil vapour survey, and
- 10 soil samples analysed for TPH and BTEX

to locate and define the extent of hydrocarbon sludge and contaminated soil from the previous fire training pits. Test pit locations are shown in Figure 3.

Coffey Partners International. Groundwater Monitoring Network Installation (Report No E3523/1-AK, October 1996) included:

- drilling of 8 boreholes to a maximum depth of 25m,
- soil vapour survey, and
- 7 soil samples analysed for TPH, BTEX and selected heavy metals.



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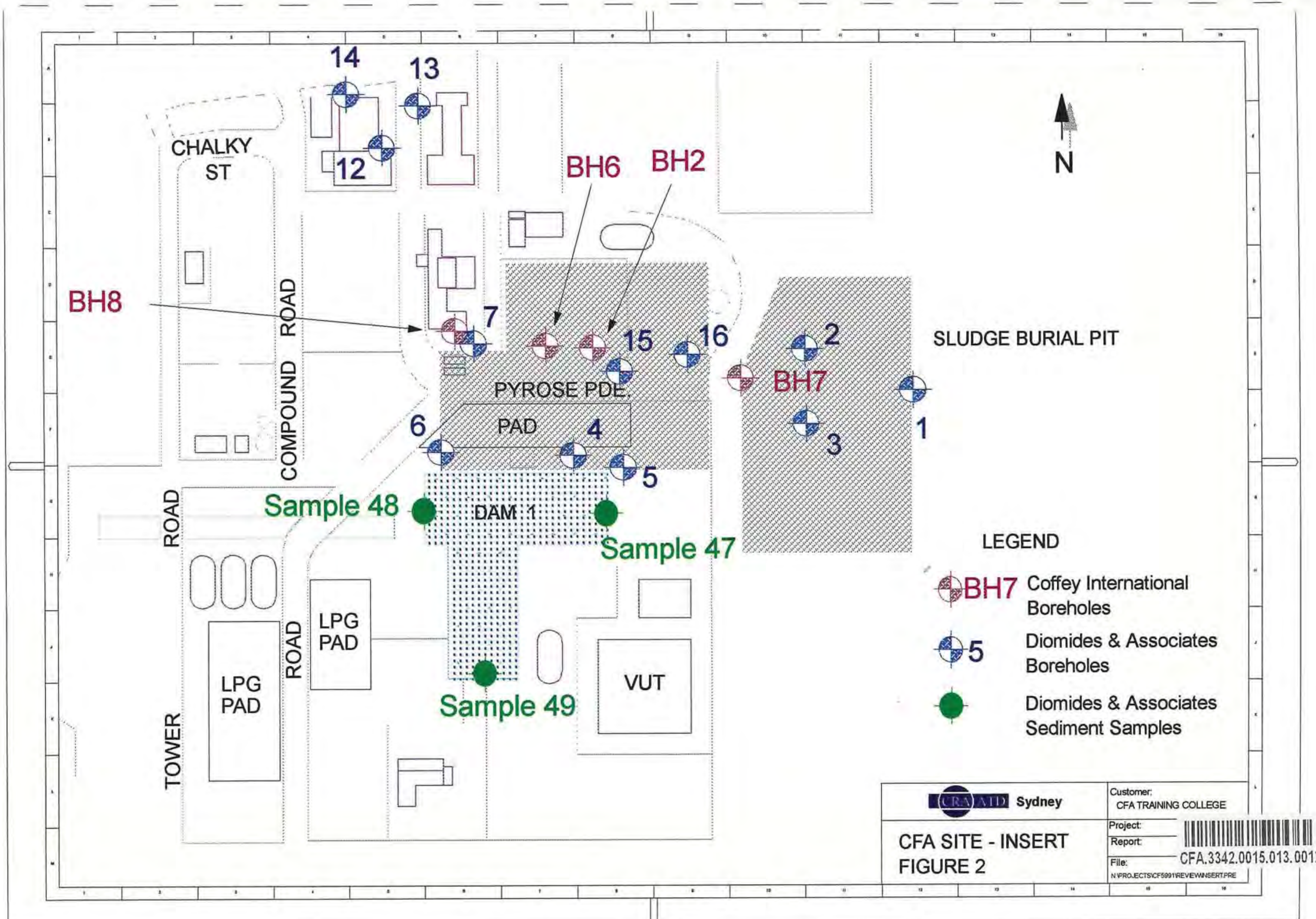

14
13
12
CHALKY ST
BH6
BH2
N
BH8
7
15
16
2
SLUDGE BURIAL PIT
BH7
PYROSE PDE.
PAD
6
4
1
3
5
COMPOUND ROAD
ROAD
Sample 48
DAM 1
Sample 47
LEGEND
BH7 Coffey International Boreholes
5 Diomides & Associates Boreholes
Diomides & Associates Sediment Samples
LPG PAD
ROAD
LPG PAD
Sample 49
VUT
TOWER
Sydney
CFA SITE - INSERT
FIGURE 2
Customer: CFA TRAINING COLLEGE
Project:
Report:
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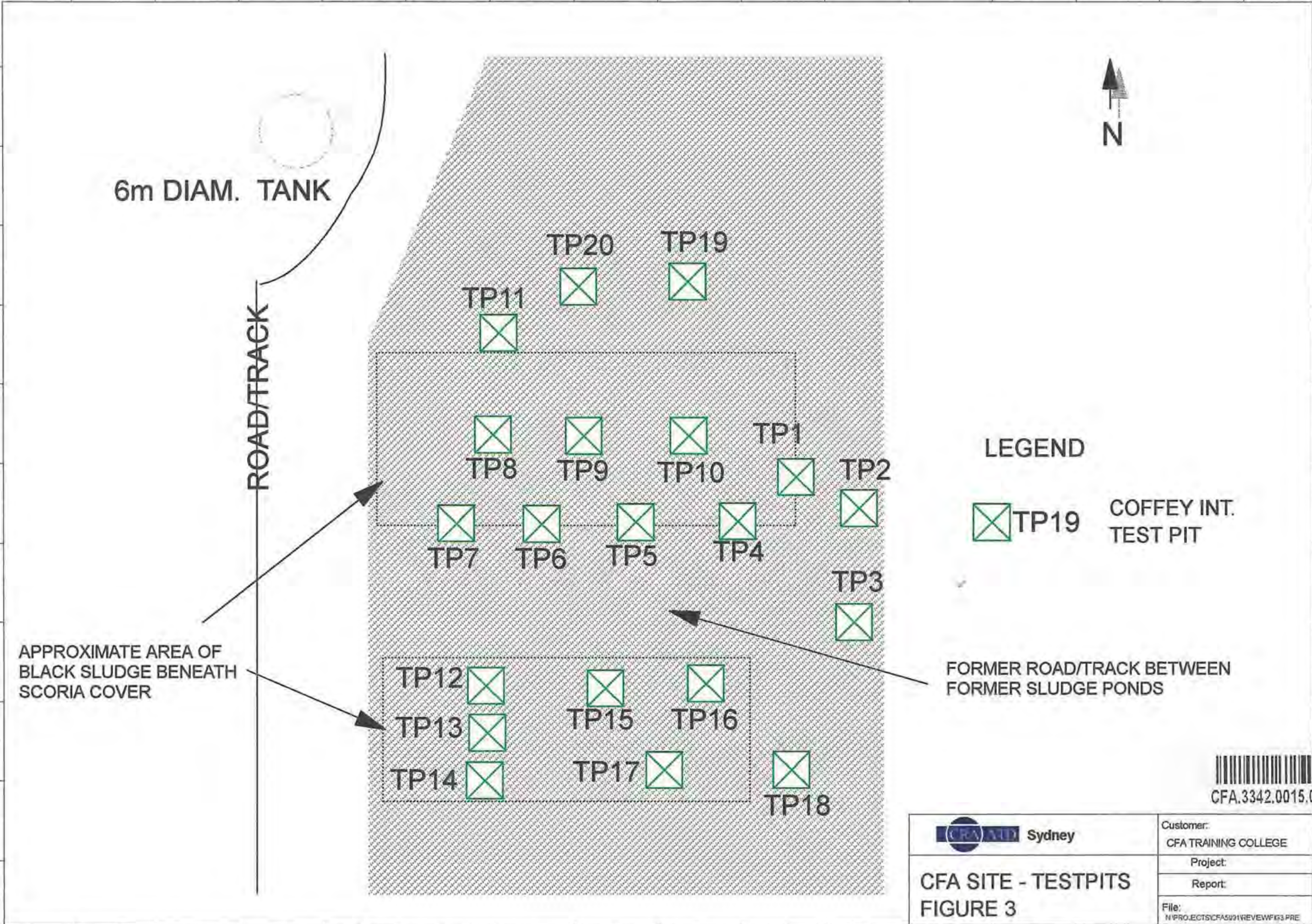

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Sydney

Customer: CFA TRAINING COLLEGE

Project:

Report:

CFA SITE - TESTPITS
FIGURE 3

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Sediment

Diomides & Associates. Environmental Site Assessment. (Report No DA1108/SD3000, 27 June) included:

- 3 sediment samples retrieved from Dam 1, analysed for total petroleum hydrocarbons, BTEX, polynuclear aromatic hydrocarbons and selected heavy metals.

Coffey Partners International. Sediment and Surface Water Sampling (Report No E3523/2-AD, October 1996) included:

- 3 sediment samples retrieved from Dam 2 on 26 September 96, analysed for total petroleum hydrocarbons, phenols and selected heavy metals.

Surface Water

Diomides & Associates. Environmental Site Assessment. (Report No DA1108/SD3000, 27 June) included a single water sample from Dam 1, analysed for TPH, BTEX, PAH, phenols, organochlorine pesticides, PCBs and selected heavy metals.

Coffey Partners International. Sediment and Surface Water Sampling (Report No E3523/2-AD, October 1996) included surface water samples collected on 26 September 96 from

- Dam 1 inlet
- Dam 2 inlet
- Dam 2 outlet
- Lake Fiskville - Sandy Creek inlet
- Lake Fiskville - Inlet from Dam 2
- Lake Fiskville outlet
- Creek draining from Lake Fiskville, down-gradient and downstream from landfill.

Groundwater

Coffey Partners International. Groundwater Monitoring Network Installation (Report No E3523/1-AK, October 1996) included drilling and construction of four (4) deep (17 - 25m) and four (4) shallow (approx 2m) groundwater monitoring bores, targeted at known or suspected sources of soil contamination, from 9 to 11 September.

Groundwater samples were collected on 26 September, and analysed for water quality parameters, TPH, BTEX and selected heavy metals.

Findings

Assessment Criteria

Soil and sediment

The significance of analytical results can be assessed against health or environmental investigation guidelines, or against background concentrations of the analytes (Table 2). Health and environmental investigation levels are set on the basis that concentrations below these levels are unlikely to present unacceptable risks to human health or the environment.

No background data exists for hydrocarbon and other organic contaminants and so results of these analyses are compared with published guidelines only.

Because of the limited data set, the presence of a large number of non-detect results and the localised nature of contaminated areas, no statistical analysis has been attempted.

Health and Environmental Investigation levels

Health and environmental investigation guideline values for Australia have been published by ANZECC[1], and these are recognised by Victorian EPA, and should be used as the basis for determining whether investigation of the significance of any contamination is required. The environmental guideline values are set for protection of environmental receptors, for example effects on plants. Where concentrations in soil exceed these values, further investigation may be required.

In the absence of guideline values for specific contaminants, ANZECC recommend Dutch B levels be used. However, since the ANZECC guidelines were published, the Dutch guidelines have been significantly revised[2], and the previous B level or threshold for further investigation has been deleted. The new Dutch guidelines contain two values:

- a "target" value, above which there is considered to be pollution, and
- an "intervention" value requiring management and/or remediation.

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1 Australian and New Zealand Environment and Conservation Council and NHMRC (1992). Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites.

2 Netherlands Ministry of Housing, Spatial Planning and the Environment (1994). Environmental Quality Objectives in the Netherlands.

Australian health risk based investigation guidelines have also recently been published[3]. These propose values for various "exposure settings" eg residential, recreational and commercial/industrial land uses. The main areas of environmental concern at the Training College could be considered to be used for commercial/industrial purposes, although since large unsealed areas exist and site activities can involve contact with soil and surface water, these guidelines may not be appropriate for use here. No specific guidelines are set for rural or agricultural land.

Background

Background concentration ranges for some analytes in Australian soils have been published by ANZECC and elsewhere [1,4].

Water

Water quality guidelines from several sources have been used for evaluating results of analyses of surface water [2,5,6] and groundwater [7].

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3 Imray, P. and A. Langley (1996). "Health-Based Soil Investigation Levels." National Environmental Health Forum Monographs, Soil Series No. 1.

4 Olszowy et al (1995). Trace Element Concentrations in Soils from Rural and Urban Areas of Australia. South Australian Health Commission, Contaminated Sites Monograph Series, No. 4.

5 ANZECC (1992). Australian Water Quality Guidelines for Fesh and Marine Waters.

6 EPA Victoria (1988). State Environment Protection Policy (Waters of Victoria) No. S13.

7 EPA Victoria (1994). Draft State Environment Protection Policy (Groundwaters of Victoria) Publication 288.

Table 2. Soil, Water and Sediment Reference Criteria [a]

	ANZECC (1992) A level - Background	SAHC (1995) Rural Background	Dutch (1994) Target Value [c]	ANZECC (1992) B level - Environmental	Dutch (1990) B level	SAHC (1995) Health Risk [d]	Dutch (1994) intervention value [c]	VicEPA (1988) Surface Water	ANZECC (1992) Aquatic systems
TPH			50		1000		5000	none [b]	
PAHs	0.95 - 5		1		20	100	40		0.003
benzene	0.05 - 1		0.05	1	0.5		1		0.3
toluene	0.1 - 1		0.05		3		130		0.3
ethylbenzene			0.05		5		50		
xylenes			0.05		5		25		
phenol	0.03 - 0.5		0.05		1	42500	40		0.05
arsenic	0.2 - 30	<5 - 53	29	20	30	500	55	0.5	0.05
cadmium	0.04 - 2	<0.5	0.8	3	5	100	12	0.1	0.0002
chromium	0.5 - 110	<5 - 56	100	50	250	500	380	0.3	0.01
copper	1 - 190	<5 - 412	36	60	100	5000	190	0.2	0.002
mercury	0.001 - 0.1	<0.1	0.3	1	2	75	10	0.005	0.0001
nickel	2 - 400	3 - 38	35	60	100	3000	210	0.5	0.015
lead	<2 - 200	<5 - 56	85	300	150	1500	530	0.1	0.001
zinc	2 - 180	<5 - 92	140	200	500	35000	720	0.5	0.005
pH								6 - 9	6.5 - 9
BOD								40	

[a] Soil criteria in mg/kg dry weight. Waters as mg/L.
[b] No visible oil and grease
[c] Values for standard soil
[d] Health risk based criteria for commercial/industrial exposure setting

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CRA ATD

Site Contamination

Soil and sediment contamination, predominantly petroleum hydrocarbons, has been found on the CFA Training College site.

The following sections discuss soil, sediment, surface and groundwater data collected at the site.

Soil

The initial soil contamination investigation was conducted by Diomides and Associates in May 1996.

Levels of TPH, PAH, BTEX, phenols, lead, chromium and zinc in soil samples are shown in Table 3 and Table 4. No organochlorines (PCBs or pesticides) were detected in any sample.

Results from Coffeys test pits in the area of the fire training pits east of the FLP are summarised in

Table 5. Soil samples were also taken from boreholes 1, 2 and 4 (Figures 1 and 2) by Coffeys in September 1996. The results are shown in Table 6.

The findings of these investigations for different areas of the Training College site are summarised as:

- **Fire Training Pits.** A 0.1 to 0.8m thick layer of surface fill comprises silty clay, silt and gravel. A thin (less than 10cm) layer of black hydrocarbon sludge is found at a depth of 0.1 to 0.6m. High TPH levels, up to 88,000mg/kg are found in soil sampled from 0.6 to 1.0m. Hydrocarbon contamination appears to have penetrated a short distance into the underlying clay soil layer. Elevated lead levels (710mg/kg) were found in one sample only, with all other heavy metals staying below ANZECC and Dutch intervention values.
- **Flammable liquids fire pad (FLP).** This large area contains obvious superficial soil contamination with fuel residues from fire training activities. Bores located within the FLP area or near Dam 1 revealed crushed rock fill contaminated with hydrocarbons between depths of 0.1 to 0.5m. Total petroleum hydrocarbons at depth 0.2 - 0.7m exceeded the Dutch B value (1000mg/kg), but none was more than the intervention value. BTEX, PAH, and selected heavy metals in this area all registered below Dutch intervention values. A composite sample taken in this area showed slightly elevated chromium levels exceeding ANZECC guidelines.

Table 3. Soil Analyses Results - May 1996

Sample (Bore)	Location	Depth (m)	TPH (mg/kg)	BTEX (mg/kg)	PAH (mg/kg)	Lead (mg/kg)
ANZECC Guidelines						300
Dutch B Value			1000	12	20	
Dutch intervention value			5000	1*	40	530
Sa1 (1)	Fire Training Pit	0.7	<140	<2	<5	13
Sa2 (1)	"	1.0	<140	<2	<5	39
Sa3 (1)	"	2.5	<140	<2	<5	36
Sa4 (2)	"	0.1	<140	<2	<5	60
Sa5 (2)	"	0.5	60	<2	<5	11
Sa6 (2)	"	1.0	<140	<2	<5	12
Sa7 (3)	"	0.1	<140	<2	<5	38
Sa8 (3)	"	0.5	14132	4.8	<5	710
Sa9 (3)	"	1.0	<140	<2	<5	13
Sa10 (4)	FLP	0.1	1070	<2	<5	24
Sa11 (4)	"	0.5	<140	<2	<5	20
Sa12 (4)	"	1.0	<140	<2	<5	12
Sa13 (5)	"	0.5	1585	<2	<5	16
Sa14 (5)	"	1.0	<140	<2	<5	14
Sa15 (6)	"	0.3	76	<2	<5	30
Sa16 (6)	"	0.8	<140	<2	<5	28
Sa17 (6)	"	1.2	<140	<2	<5	28
Sa18 (7)	FMA	0.5	152	1	<5	19
Sa19 (7)	"	1.0	<140	<2	<5	11
Sa20 (7)	"	2.5	<140	<2	<5	24
Sa21 (8)	UST, Admin	0.5	<140	<2	<5	15
Sa22 (8)	"	1.0	<140	<2	<5	13
Sa23 (8)	"	2.1	<140	<2	<5	20
Sa24 (9)	Drum Burial Area	0.1	<140	<2	<5	18
Sa25 (9)	"	0.5	2548	<2	<5	12
Sa26 (10)	"	0.1	1185	<2	<5	16
Sa27 (10)	"	0.5	289	<2	<5	15
Sa28 (10)	Drum Burial Pits	1.0	7040	62	13	11

* Benzene 1mg/kg, Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

Table 3. (cont.) Soil Analyses Results - May 1996

Sample (Bore)	Location	Depth (m)	TPH (mg/kg)	BTEX (mg/kg)	PAH (mg/kg)	Lead (mg/kg)
ANZECC Guidelines						300
Dutch B Value			1000	12	20	
Dutch intervention value			5000	1*	40	530
Sa29 (11)	"	0.1	<140	<2	<5	24
Sa30 (11)	"	0.5	320	<2	<5	18
Sa31 (11)	"	1.0	<140	<2	<5	9.9
Sa32 (12)	USTs, Centre Ave	0.5	<140	<2	<5	5.8
Sa33 (12)	"	1.0	<140	<2	<5	13
Sa34 (12)	"	2.5	<140	<2	<5	11
Sa35 (13)	"	0.5	<140	<2	<5	13
Sa36 (13)	"	1.0	<140	<2	<5	14
Sa37 (13)	"	2.5	<140	<2	<5	26
Sa38 (14)	"	0.5	<140	<2	<5	21
Sa39 (14)	"	1.0	<140	<2	<5	12
Sa40 (14)	"	2.5	<140	<2	<5	12
Sa41 (15)	FLP	0.2	97	<2	<5	18
Sa42 (15)	"	0.6	120	<2	<5	24
Sa43 (15)	"	1.1	190	<2	<5	13
Sa44 (16)	"	0.5	102	<2	<5	18
Sa45 (16)	"	1.0	83	<2	<5	14

* Benzene 1mg/kg, Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

Table 4. Soil Composite Analyses Results - May 1996

Composite (Bore)	Location	Phenols (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)
ANZECC Guidelines			200	50
Dutch B Value		1		
Dutch intervention value		40	720	380
Composite A10 (2,3,4,6,15)	Fire Training Pit & FLP	<0.1	30	75
Composite A50 (2,3,4,6,15)	"	<0.1	50	110
Composite A100 (2,3,4,6,15)	"	<0.1	18	95
Composite B50 (1,5,7,16)	Fire Training Pit, FLP	<0.1	16	68
Composite B100 (1,5,7,16)	& FMA	<0.1	16	86
Composite B250 (1,5,7,16)	"	<0.1	20	140
Composite C50 (8,12,13,14)	USTs	<0.1	20	72
Composite C100 (8,12,13,14)	"	<0.1	16	41
Composite C250 (8,12,13,14)	"	<0.1	12	92
Composite D10 (9,10,11)	Drum Burial Area	1.9	29	45
Composite DV (9,10,11)	"	1.3	16	76

Table 5. Soil Analyses - Fire Training Pit Area (June 1996)

Test Pit	Depth (m)	BTEX (mg/kg)	TPH (mg/kg)
ANZECC Guidelines		1 *	
Dutch B Value		20	1000
Dutch Intervention Criteria		1 ª	5000
TP1	0.3	<0.08	470
TP5	0.8	<0.08	<80
TP6	0.3	<0.08	2890
TP6	0.8	<0.08	<80
TP8	0.6	1.26	85610
TP8	1.0	<0.08	87910
TP12	0.7	3.17	260
TP12	1.1	<0.08	<80
TP13	1.0	<0.08	<80
TP14	0.2	<0.08	2934

* Benzene 1mg/kg (ANZECC B), Toluene 130mg/kg, Ethylbenzene 50mg/kg,, Xylenes 25mg/kg

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Table 6. Soil Analyses Results - September 1996

Bore	Location	Depth (m)	TPH	BTEX	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC B				1 *	20	3	50	60	1	60	300	200
Dutch intervention value			5000	1 *	55	12	380	190	10	210	530	720
BH1	Training Centre UST	1.5-1.6	26	<0.08	<2	<1	24	5	0.02	9	7	9
BH1	"	2.0-2.1	553	<0.08	<2	<1	52	10	0.02	16	22	12
BH2	FLP	1.0-1.1	38	<0.08	<2	<1	46	7	0.05	15	8	9
BH2	"	1.5-1.6	80	<0.08	<2	<1	42	6	0.02	9	9	9
BH4	Drum Burial Pits	1.0-1.1	<80	<0.08	<2	<1	55	9	0.05	13	10	13
BH4	"	2.0-2.1	88	<0.08	<2	<1	40	6	0.15	16	7	11

* Benzene 1mg/kg, Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

All data expressed in mg/kg dry weight

- **Fuel Mix Area**. This smaller area also contains some obvious superficial soil contamination with fuel. Samples of soil taken at this location at depths of 0.35-1.5m showed detectable levels of total petroleum hydrocarbons and BTEX, but none exceeding investigation guidelines. No PAH, phenols or heavy metals exceeded investigation guidelines. A composite sample taken from the fire training pit, flammable liquids pad and fuel mix areas showed slightly elevated levels of chromium, exceeding ANZECC Guidelines.
- **Drum Burial Pits**. While no drums were encountered during the investigations, soil samples were retrieved with total petroleum hydrocarbons levels exceeding the Dutch B value from Bore 9 at a depth of 0.4-0.9m, and exceeding the intervention guideline at Bore 10 (1.0m). Ethylbenzene levels also exceeded the intervention guideline. Composite samples taken in the area showed elevated phenol and chromium levels exceeding the Dutch B values. Two samples from Coffeys bore BH4 only showed elevated levels of chromium, slightly exceeding the ANZECC guidelines.
- **Underground Storage Tanks**. Samples from Coffeys bore BH1 contained detectable total petroleum hydrocarbons, but all TPH, BTEX, phenols, PAH and heavy metals were below ANZECC or equivalent investigation guidelines. Two of the three composite samples showed chromium levels slightly exceeding the ANZECC guidelines.

Sediment

Initial sediment sampling in Dam 1 revealed extensive petroleum hydrocarbon contamination (Table 7). Three samples collected around the dam showed total petroleum hydrocarbons at concentrations exceeding intervention criteria, and up to 15%.

Phenols, BTEX and PAHs were all less than investigation levels. Heavy metals, arsenic, cadmium, copper, mercury, nickel, lead and zinc were all less than ANZECC B levels, while chromium was slightly elevated, at 70mg/kg in a composite sample.

Results of analyses of three sediment samples from Dam 2 are also shown in Table 7.

Sample 2A, closest to Dam 1, contained elevated TPH (C_{10}-C_{36}) at concentrations exceeding Dutch B, and equal to the Dutch Intervention Criteria. Samples 2B and 2C were lower than the Dutch B level.

All sediment samples show heavy metals concentrations below ANZECC B criteria except for chromium, which ranges between 52 and 70mg/kg.

Table 7. Summary of Sediment Analysis

Sample	Location	TPH	BTEX	PAH	Phenols	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC B			1 *	20		20	3	50	60	1	60	300	200
Dutch B		1000			1								
Dutch intervention value		5000	1 *	40	40	55	12	380	190	10	210	530	720
Sa47	Dam 1, East	155300	<2	<5								53	
Sa48	Dam 1, West	123275	<2	<5								79	
Sa49	Dam 1, South	98850	<2	<5								29	
Composite SED					0.9			70					140
2A	Dam 2	5000			0.3	<2	<1	52	14	0.06	25	12	81
2B	Dam 2	130			0.2	<2	<1	66	8	0.04	13	23	29
2C	Dam 2	110			0.2	5	<1	70	6	0.04	18	19	65

* Benzene 1mg/kg (ANZECC B), Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

All data expressed in mg/kg dry weight

These findings clearly indicate that petroleum hydrocarbons are accumulating in Dam 1 sediments. These contaminants enter the dam in run off from the FLP/FMA during fire training activities and in wet weather. There is also evidence that contaminants are being transported from Dam 1 to Dam 2.

Surface Water

Results of surface water sampling conducted by Diomides & Associates in May 1996, and Coffey Partners International in September 1996 are shown in Table 8.

Surface water samples were neutral to mildly alkaline, pH 7.1 - 7.9. Dam 1 inlet and Dam 2 outlet exceeded Victorian EPA State Environment Protection Policy criteria for suspended solids.

Water entering Dam 1 also contained elevated BOD and total petroleum hydrocarbons. Elevated TPH concentrations were also present at the inlet and outlet of Dam 2.

Phenol levels were mostly below detection limits, with the exception of samples taken within Dam 1 and Dam 2 in May 1996, where levels exceed the Dutch intervention value, but not the ANZECC aquatic guideline level.

These results confirm hydrocarbon contaminated run off from the FLP/FMA is impacting on the water quality of Dam 1 and Dam 2.

BTEX, PAH, PCBs and organochlorine pesticides were below laboratory detection levels.

Copper concentrations in four out of seven samples tested in September 1996 were above ANZECC guidelines for protection of aquatic ecosystems, but all were below Victorian EPA criteria.

The nickel concentration in the water sample taken at the outlet of Dam 2, while within Victorian EPA guidelines, exceeded the Dutch limit value, and was above the lower limit of the ANZECC guidelines. Lake Fiskville outlet also had detectable levels of nickel, on the lower bound of the ANZECC guideline. Nickel was below laboratory detection limits in all other samples.

Samples taken within Dam 1 (May 1996) and at the inlet of Dam 2 (September 1996) show high levels of zinc, significantly exceeding ANZECC guidelines, but less than Victorian EPA guidelines.

Water at the Lake Fiskville outlet marginally exceeded ANZECC guidelines for lead. Chromium levels in all samples were below ANZECC guidelines.

Other heavy metals (arsenic, cadmium and mercury) were below detection levels in all samples.

Table 8. Summary of Surface Water Analyses Results

Sample	Date	pH	TSS	BOD	TPH	BTEX	PAH	Phenols	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC (Aquatic)		6.5-9.0				0.3 *	0.003	0.05	0.05	0.0002 - 0.002	0.01	0.002 - 0.005	0.0001	0.015 - 0.15	0.001 - 0.005	0.005 - 0.05
ANZECC (Drink)								0.001	0.05	0.01	0.05		0.001		0.05	5.0
Vic EPA SEPP		6 - 9	80	40	**				0.5	0.1	0.3	0.2	0.005	0.5	0.1	0.5
Dutch limit value								0.002	0.01	0.0002	0.02	0.003	0.0003	0.01	0.025	0.03
Dam 1	31/5/96	na	na	na	**1.2**	<0.004	<0.01	0.032	na	na	<0.01	na	na	na	na	**0.24**
Dam 2	31/5/96	na	na	na	<0.3	<0.004	<0.01	0.006	na	na	<0.01	na	na	na	na	<0.01
Dam 1 Inlet	26/9/96	7.5	190	95	**4.9**	na	na	<0.05	<0.005	<0.0002	0.006	**0.013**	<0.0001	<0.01	0.002	<0.005
Dam 2 inlet	26/9/96	7.9	41	11	**0.3**	na	na	<0.05	<0.005	<0.0002	<0.005	**0.01**	<0.0001	<0.01	0.002	**0.21**
Dam 2 outlet	26/9/96	7.9	270	6	**0.5**	na	na	<0.05	<0.005	<0.0002	0.009	0.003	<0.0001	0.037	0.002	<0.005
Lake Fiskville inlet Dam 2	26/9/96	7.6	300	8	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	**0.013**	<0.0001	<0.01	0.004	<0.005
Lake Fiskville Sandy Ck inlet	26/9/96	7.1	35	<7	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	0.004	<0.0001	<0.01	<0.001	<0.005
Lake Fiskville outlet	26/9/96	7.2	45	7	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	**0.013**	<0.0001	0.015	**0.006**	0.014
Creek draining Lake Fiskville	26/9/96	7.2	47	6	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	0.005	<0.0001	<0.01	<0.001	<0.005

* Benzene only

** Victorian EPA SEPP criterion for surface water "no visible oil and grease".

All Data expressed in mg/L

na = not analysed

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In summary, concentrations of copper, nickel, lead and zinc were elevated in surface waters, at levels exceeding ANZECC aquatic guidelines. However, the distribution is considered not indicative of any specific source, and the concentrations appear to be consistent with local background conditions.

Groundwater

Eight bores (four deep bores to 20m, and four shallow to 2m) were installed by Coffey Partners International with the objective of investigating groundwater quality in areas of environmental concern (drum burial pits, fire training pits, underground storage tanks, flammable liquid pad, fuel mix area, adjacent to Dam 1 and at the landfill. Figures 1 and 2).

Groundwater was intercepted only in two bores:

- BH2, a deep bore located in basalt aquifer in the flammable liquids pad area.
- BH5, a shallow bore located immediately adjacent to the backfilled drum burial trenches.

Where groundwater was encountered it appears to be of limited extent and the water bearing zones of low permeability. Water intersected in BH5 is probably a consequence of locally enhanced recharge occurring in the trench backfill materials.

No permanent groundwater was encountered within the residual clays investigated. Coffey Partners International suggested that from experience of groundwater conditions gathered in the general area, none would normally be expected within the residual basaltic clays.

Table 9 summarises the bore installation data and groundwater analysis results, from samples taken in September 1996.

TPH levels were below detection in BH2, and below the Dutch intervention value in BH5. BTEX, arsenic, cadmium, chromium, mercury, and lead were below laboratory detection limits. Nickel levels were below both ANZECC (Drink and Aquatic) Guidelines and the Dutch intervention value.

Copper levels in BH2 exceeded the ANZECC Aquatic Guideline, but were below the Dutch intervention value. BH5 showed levels below both criteria.

In both boreholes the levels of zinc were above ANZECC Aquatic Guidelines, while not exceeding ANZECC Drinking Guidelines or the Dutch intervention value. The heavy metals detected in BH2 are consistent with expected background levels.

These investigations suggest that the potential for contaminant migration via groundwater systems is very limited.

Table 9. Summary of Groundwater Analyses (September 1996)

Borehole	SWL (m PVC *)	Depth (m)	Screened Interval (m)	pH	TPH	BTEX	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC Criteria (Drink)				6.5-8.5			0.05	0.005	0.05		0.001	0.1	0.05	5
ANZECC Criteria (Aquatic)				6.5-9.0			0.05	0.0002	0.01	0.002	0.0001	0.015	0.001	0.005
Dutch Intervention Criteria					0.6	1.25	0.06	0.006	0.03	0.075	0.0003	0.075	0.075	0.8
BH1	dry	25	15.0 - 21.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH2	14.8	17	11.0 - 17.0	7.5	<0.4	<0.016	<0.005	<0.0002	<0.005	0.01	<0.0001	0.013	<0.001	0.095
BH3	dry	21	15.0 - 21.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH4	dry	20	14.0 - 20.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH5	0.3	1.8	0.3 - 1.8	7.5	0.4	<0.016	<0.005	<0.0002	<0.005	0.007	<0.0001	0.013	<0.001	0.13
BH6	dry	2.0	0.3 - 2.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH7	dry	2.8	1.3 - 2.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH8	dry	2.3	1.3 - 2.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* mPVC = m below top of PVC casing.

All concentration data expressed in mg/L

n/a = not applicable (dry well)

Remediation Options

Levels of soil contamination at the Fiskville site exceed soil quality guidelines for total petroleum hydrocarbons at several locations (Table 10):

- the FLP,
- the decommissioned fire training pits east of the FLP, and
- the drum burial pits

In addition, significant hydrocarbon contamination is evident in sediments in Dam 1, and near the inlet to Dam 2.

No significant groundwater contamination has been identified. Removal of contaminated soils and buried wastes will remove future risks to groundwater.

Low level hydrocarbon contamination was found at the UST at the training centre, but in the absence of groundwater does not constitute an unacceptable health or environmental risk.

Some low level contamination with phenols, BTEX and lead was also encountered, but only where TPH concentrations were also above investigation guidelines. Slightly elevated levels of chromium in most soils are considered to represent site background.

Remediation decisions should be made in the context of a site specific evaluation of risks to human health and the environment.

In general, risks associated with the contamination at Fiskville Training College appear to arise from

- worker and trainee exposure to contamination. This is most likely to occur in the FLP/FMA area during training events or normal site operations. The area is largely unsealed.
- surface water run-off and erosion from the FLP/FMA into Dam 1, and off-site via Dam 2.
- exposure during excavation in areas containing buried contamination.

There appears to be little impact on groundwater from any of the identified sources, because of the depth of groundwater in the basalt, and relative impermeability of the residual silty clay soil.

Table 10. Fiskville Training College Soil Contamination Summary

Location	Borehole or Sample No.	Sample Depth (m)	Contaminant	Concentration (mg/kg)	Criteria exceeded (highest) (mg/kg)
Flammable Liquids Pad	BH4	0.1 (fill)	TPH	1070	clean fill (1000)
	BH5	0.5 (clay)	TPH	1580	clean fill (1000)
Fire Training Pits	BH3	0.5 (fill)	lead	710	Dutch Intervention (600)
			TPH	14,000	LLCS (10,000)
	TP 6	0.3	TPH	2890	clean fill (1000)
	TP 8	0.6	TPH	85,610	LLCS (10,000)
	TP 8	1.0	TPH	87,910	LLCS (10,000)
	TP14	0.2	TPH	2930	clean fill (1000)
Drum Burial Pits	BH9	0.5 (clay)	TPH	2550	clean fill (1000)
	BH10	0.1 (fill)	TPH	1120	clean fill (1000)
		1.0 (clay)	TPH	6920	Dutch Intervention (5000)
			BTEX	62	clean fill (7)
	Composite D10	0.1 (fill)	phenols	1.9	clean fill (1.0)
	Composite DV	0.5 - 1.0	phenols	1.3	clean fill (1.0)
Dam 1	sample 47	sediment	TPH	155,000	LLCS (10000)
	Sample 48	sediment	TPH	123,000	LLCS (10000)
	Sample 49	sediment	TPH	99,000	LLCS (10000)

LLCS limit refers to the max concentration of contaminant allowed in soil to be disposed of as Low Level Contaminated Soil

Contaminant migration in groundwater away from the localised sources identified appears unlikely, unless local permeability conditions are enhanced by clay fissuring or man-made features such as service trenches, backfill or surface construction fill placement. No evidence of this has been observed in the investigations to date.

Factors which are usually used as criteria for evaluating various remediation alternatives include :

- effectiveness,
- technical feasibility,
- cost,
- time required to achieve remediation objectives.

Effectiveness is normally defined as a reduction in environmental and health risks.

In order to assess and compare remediation alternatives, a set of evaluation criteria was defined (Table 11).

Table 11. Evaluation Criteria

Criteria	Description
Effectiveness	Reduction in health and environmental risks
Cost	Capital expenditure
	Operation and maintenance of remediation
Site impacts	Disruption of services, equipment on site etc
Implementability	Is it practical for the site
Time	When will the remediation objective be achieved
Acceptability	To EPA, local community
Technical risk	Risk that the remediation method will fail

Remediation Objectives

Remedial action at the Fiskville Training College should be initially focussed at source removal, that is, prevention of further soil and water contamination from fire training and other site activities, particularly in the Flammable Liquids Pad and Fuel Mix areas.

The primary objective of subsequent remediation works should then be the removal of the contaminated soils and buried wastes. Some of the contaminated areas identified are not impacted by present activities, and their remediation is not contingent on improvements in the FLP/FMA.

Remediation of existing areas of soil contamination to a standard such that soil exceeding ANZECC or Dutch B level criteria is removed, and suitably treated or disposed off site, will minimise future risks of surface or groundwater contamination.

Victorian EPA provides guidelines for off site disposal of contaminated soil[8]. These indicate that soil can be disposed of as clean fill where concentrations of contaminants are less than the following:

- total petroleum hydrocarbons (TPH) ($\leq C_9$) 100mg/kg
- total petroleum hydrocarbons (TPH) ($>C_9$) 1000mg/kg
- phenols 1mg/kg
- mono-aromatic hydrocarbons (BTEX) 7mg/kg
- polynuclear aromatic hydrocarbons (PAH) 20mg/kg
- lead 300mg/kg

Where concentrations exeed these values, soil is classified "low level contaminated soil", and must be disposed of, with EPA approvals, to an appropriately licenced landfill.

Remediation Options

A number of potential approaches exist for remediation of the contaminated areas identified at Fiskville Training College, including excavation and treatment or disposal, and *in situ* techniques (Table 12).

Ex situ soil treatment alternatives include bioremediation, soil washing and thermal treatment. All contaminated soil is accessible for excavation ie is not constrained by storage tanks or buildings. Of the available *on site* remediation alternatives, bioremediation (by landfarming or similar process) could achieve soil remediation objectives at low cost for hydrocarbon impacted soil from the FLP/FMA and fire training pit.

8 EPA Victoria (1991). Information Bulletin WM91/01

On site treatment of selected material would provide CFA an opportunity to demonstrate application of best environmental practice.

In situ remediation techniques provide no advantages over excavation in this case.

Excavation and removal to a suitable landfill also appears to be an appropriate remediation strategy. Off site disposal is usually adopted where treatment technologies are likely to be ineffective or take too long to achieve remediation goals, and is often the least costly approach, especially if soil volumes prove to be small.

Different approaches may be adopted for different contaminated areas. These are discussed below.

Remediation of FLP/FMA

The principal contaminants in the FLP/FMA area are petroleum hydrocarbons, derived from liquid fuels used in fire training. TPH concentrations in soil samples range up to 1600mg/kg, but higher concentrations can be expected in surface fill. The area affected by superficial contamination is extensive. There is crushed rock fill and soil contaminated with hydrocarbons to a depth of probably no more than 0.8m. There is also an accumulation of petroleum hydrocarbons in sediments in Dam 1, and near the inlet of Dam 2.

Volatile hydrocarbons may be lost to ambient air, with potential for exposure of site personnel or visitors. Contaminant spread from the affected areas may occur via surface water run-off and erosion. There is no demonstrable impact on groundwater.

CFA intend that the site will continue to be used for fire training using both liquid fuels and gas. In the absence of significant groundwater contamination, and given the shallow depth of soil contamination, remediation will involve soil excavation, followed by on site treatment or off site disposal.

Any remediation action requires permanent removal of the source. Therefore, improvements in prop design, firewater collection, drainage and water treatment will be required before resumption of training activities, or otherwise as soon as practicable to prevent further contamination of soil and dam sediment. Concurrently, contaminated soil should be removed for treatment and/or disposal.

Table 12. Summary of remediation options available for hydrocarbon contaminated soil/sediment

Remediation Option	Effective	Site impact	Implement-ability	Risk	Cost	Time (months)	Acceptability	Considered Further	Reason not considered further
Excavate & dispose off site	yes	excavations; short term	yes	low	low	1 - 2	good	yes	
Excavate & on site bioremediation	yes	excavations; short term;, requires soil treatment area	yes	low	low	6 - 12	very good	yes	
Excavate & thermal desorption	yes	excavations; short term; requires soil treatment area	yes	low	high	2 - 3	medium	no	high cost
Excavate & soil washing	unknown	excavations; short term; requires soil treatment area	yes	high	high	3 - 6	unknown	no	high risk, cost
In situ bioventing/soil vapour extraction	not for heavy hydrocarbons, clay soil	few, long term	yes	high	low	indefinite	no	no	probably not effective - unacceptable treatment time
In situ soil flushing	not for heavy hydrocarbons, clay soil	few long term	yes	high	moderate	indefinite	no	no	probably not effective - unacceptable treatment time
Intrinsic remediation (deferred action)	unknown	none	yes	high	low	indefinite	no	no	high risk

On site treatment by landfarming or similar bioremediation process will be feasible for this soil, since no contaminants other than hydrocarbons are present.

Fire Training Pit area

Contamination in this area is again shallow, and in a limited area defined by the previous pit locations. The total affected area is estimated at $1200m^2$.

The volume of sludge is estimated at $20\text{-}50m^3$. In some locations sludge has been mixed with soil. Some contamination may have migrated a short distance into the underlying clay soil.

Contaminants comprise weathered and partially combusted fuel residues, occurring in a relatively thin (less than 100mm) black sludge layer. Concentrations of TPH occur exceeding Victorian EPA low level contaminated soil and Dutch intervention values, and up to 8.7%w/w. One sample from borehole 3 also contained 710mg/kg lead. No other significant contaminants have been found at this location.

Remediation of this area could be undertaken by excavating the two pits, and either disposing of soil off site, or retaining on site for treatment by landfarming or similar bioremediation process.

With the possibility of high lead levels in the sludge (which will not be removed by bioremediation), some further assessment of lead will be required after excavation to confirm the appropriateness of such treatment.

This soil would not be suitable for off site disposal as low level contaminated soil, due to the high concentrations of total petroleum hydrocarbons, exceeding VIC EPA guidelines.

Drum Burial Pits

Three pits near the air strip were used for disposal of drums containing solvent and other residues. No drums were encountered during the investigations. Nevertheless, soil samples from these pits at depths up to 1m showed concentrations of TPH and BTEX exceeding the intervention guidelines. Samples also showed phenol and chromium levels exceeding the Dutch B values.

This contaminated soil appears to be inhibiting revegetation of the three backfilled trenches.

Remediation of this area could be undertaken by excavating the three trenches to the underlying basalt, and backfilling with clean soil. The excavated soil may contain drums or other containers. If this is the case, on site treatment would be difficult, so that disposing of the material off site is likely to be the most appropriate remedial action.

This soil appears to be suitable for off site disposal as low level contaminated soil, since concentrations of contaminants meet Victorian EPA guidelines.

Dam Sediments

Sediments in Dam 1 and Dam 2 contain petroleum hydrocarbons at concentrations exceeding intervention value and should be removed for treatment or disposal.

As with the contaminated soils, the main alternatives are off site disposal or on site treatment. However, off site disposal of sediments with concentrations of more than 10000mg/kg TPH requires disposal to secure landfill as prescribed waste.

Water in Dam 1 is currently also contaminated with petroleum hydrocarbons. It can be anticipated that following improvements to prop design, firewater collection, drainage and water treatment, inputs of hydrocarbons to Dam 1 would be significantly reduced, and water quality in Dam 1 should therefore improve over time. Were Dam 1 to be drained for remediation of the sediment, it may be acceptable to dispose of the water by irrigation on site, and may not require other treatment before disposal.

Remediation of Dam 1 should not be commenced until remediation of the FLP/FMA and improvements to prop design, firewater collection, drainage and water treatment have been completed to prevent hydrocarbon contaminated water from entering the Dam.

When this occurs, removal and remediation of contaminated sediments in Dam 1 should be the main priority. A limited amount of sediment from Dam 2, near the Dam 1 overflow should also be removed.

The volume of sediment requiring treatment/disposal is unknown at present. One advantage of on site treatment for contaminated soils is that the facilities and general procedures established can also be used later for sediment remediation.

Remediation Costs

Remediation costs for off site disposal are a direct function of the volume of soil requiring disposal. Preliminary estimates of contaminated soil volumes are given in Table 13 (not including sediment in Dams 1 and 2).

Table 13. Estimated soil volumes

Location	Area (m^2)	Average depth (m)	Volume (m^3)
FLP	3000 - 5000	0.5	1500 - 2500
FMA	100	0.3	30
Drum burial pit	200 - 500	1	200 - 500
Fire training pits	1200	0.3 - 0.5	360 - 600

Disposal to landfill (not including haulage) can be expected to cost in the range \$28 - \$45 per tonne depending on the landfill and waste type. For the total volume of soil estimated above, and assuming a bulk density of 1.6 tonnes/m^3, the cost would then be at least \$90,000.

Bioremediation techniques are usually quoted as costing in the order of \$30-50per m^3. For the volumes of soil anticipated, treatment costs are not highly sensitive to the volume of soil to be treated, and the process is such that CFA should be able to implement and manage the treatment using site resources and with limited external supervision (essentially restricted to initial design, construction supervision, and monitoring and auditing functions). In this case, on site treatment using a simple landfarming or similar process can be expected to cost in the range \$50-90,000.

Note that these costs do not include excavation and transport of soil, which may be significant for off site disposal, nor the cost of replacement clean fill.

Disposal of contaminated sediments from Dams 1 and 2 is also not included in these estimates.

Implications

The environmental investigations reviewed reveal localised soil, sediment and surface water contamination at the Fiskville Training College. This contamination has been principally the result of storage and handling of fuels, fire training activities, and disposal of fuel residues. No groundwater contamination has been detected, nor has any significant contamination been found associated with underground storage tanks.

Any response by CFA should recognise future risks and liabilities associated with the contamination, as well as current requirements. Remedial actions can be taken consistent with CFA's requirement to continue fire training and related operations at the site.

It is recommended that

- the FLP/FMA area be reviewed, and improvements in prop design, firewater collection, drainage and water treatment be implemented as soon as practicable to prevent further contamination of soil and dam sediment.
- contaminated soils from the FLP/FMA be excavated for on site treatment, and backfilled with clean fill.
- once these improvements have been made, and hydrocarbons are being intercepted and removed from surface waters, Dam 1 may be rehabilitated.
- the fire training pits be excavated for on site treatment, and backfilled with clean soil
- contaminated soils from the drum burial pits be excavated, and subject to the presence of drums, be treated on site, or otherwise disposed of off site to appropriate landfill. The trenches should be backfilled with clean soil.
- surface water monitoring be continued at appropriate intervals, including at least one more sampling round before the FLP/FMA improvements mentioned above are implemented.
- the groundwater monitoring wells be dipped and sampled annually.

RIO TINTO

Research and Technology Development

Draft

Fiskville Training College Remediation Action Plan

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SUMMARY

This document details the remediation action plan for the petroleum hydrocarbon contaminated areas at CFA, Fiskville.

The areas of contamination have been identified and the proposed/agreed actions for each of the participatory organisations are highlighted.

In summary, the Site Supervisor and the Contractor will excavate and stockpile two areas;

i) the flammable liquids pad (FLP), and
ii) the old fire training pits. *The drum burial pits have not been included in this remediation action plan.*

Rio Tinto R&TD will provide design and operational support for the composting process, including turning of the windrows.

CFA will procure inputs for the process and carry out the field work required for executing the process.

Management plans for construction and operation of a landtreatment facility are detailed in this document including those for health and safety issues.

CONTENTS

REMEDIAL ACTION PLAN

1. Introduction

Bioremediation Services (now Rio Tinto research and Technology) was commissioned in April 1996 to review the environmental status of the Country Fire Authority (CFA) Training College at Fiskville, Victoria, and evaluate remedial options for the site.

The results of this review were reported in November 1996 (CRA ATD Report, 5991rpt1.doc), and were also provided to EPA. EPA indicated their agreement with the conclusions of this review, and to the proposed remedial actions.

1.1. Purpose

This document constitutes the Remedial Action Plan (RAP) for the Fiskville Training College site. It reviews the contamination present, provides details of the remediation objectives and methodology, and outlines the management plans required for various aspects of the remedial works.

These procedures are intended to ensure that the remediation is undertaken in a safe and effective manner, with appropriate measures to minimise impacts on the surrounding areas.

1.2. Limitations

This RAP has been prepared specifically and only for remediation of two areas of hydrocarbon contamination at the Fiskville Training College site.

The plan relies on information gathered and reported in previous investigations, and from a number of other sources. Uncertainties in site investigation data, and changes in site conditions over time mean that some of this information may prove to be inaccurate when remediation activities commence. This must be recognised by those involved in the remediation work, and appropriate contingencies made.

1.3. Background

1.3.1. Location

The CFA Training College is located at Fiskville, approximately 50km north of Geelong and 10 km south of Ballan. The site covers an area of approximately 146ha, and is situated on the western side of the Ballan-Geelong Road.

1.3.2. Land Use

The site is in a rural pasture setting, and is currently used by CFA as a Training College for fire and emergency services personnel from within CFA, and from external organisations. This principally involves fire fighting exercises at a number of "props", using both gas and liquid fuels.

The site has been used for such training for approximately 20 years. Prior to this few buildings existed on the site.

The main areas of the site comprise (Figure 1):

- Flammable Liquid Pad (FLP) and Fuel Mix Areas used for fire training
- Two interconnecting dams, collecting run off from the FLP, and draining to Lake Fiskville
- Bulk fuel storage area
- Light industrial facilities, including stores, workshops and underground diesel storage tanks
- Training centre, administration and accommodation facilities.

Surrounding land is essentially rural.

1.3.3. Topography and Drainage

The college is located on a flat to gently undulating plateau, with lakes and wetlands formed in local depressions. Lake Fiskville is situated immediately west of the training complex.

A central north-south ridge forms a break in the site drainage. The site drains generally towards the south, via Yaloak Creek on the eastern side, and Beremboke Creek to the west. Drainage to the east is towards the Werribee River water supply catchment.

1.3.4. Geology

The site lies over Quaternary Olivine Basalts. Surface soils are residual silts and clays, generally no more than 2-3 m deep, overlying very stiff, high plasticity residual clays, grading to variably weathered basalt.

Shallow fill, comprising gravel or road base, is found on parts of the site, particularly in the area of the Flammable Liquids Pad. A summary of the site stratigraphy is given in Table 1.

Table 1. Generalised Subsurface Profile

Soil Unit	Depth to Top of Layer (m)	Thickness (m)	Description
1	0	0.1 - 0.8	FILL: fine to coarse grained sandy gravel, silty clay or medium plasticity red clay.
2	0.2 - 1.0	0.1 - 0.2	RESIDUAL SILTY CLAY: medium plasticity, grey to grey-brown, may comprise rounded buckshot gravel (2 to 5mm) with clay.
3	0.3 - 1.2	0.5 - 1.8	SILTY CLAY: high plasticity, yellow-grey to yellow-brown, mottled orange-yellow. Residual clay formed on basalt.
4	0.8 - 2	14 - 18	BASALT
5	16 - 18.8	3.2 - 6.0	VOLCANIC ASH

1.3.5. Hydrogeology

Groundwater investigations were undertaken as part of the previous environmental assessments. Eight bores (four deep bores to 20 m, and four shallow to 2 m) were installed to investigate groundwater quality at the site (Figure 2).

Groundwater was intercepted only in two of these bores:

- BH2, a deep bore located in basalt aquifer in the FLP area, intersected water at 10 m bgl. This water was sampled and contained no organic contaminants.
- BH5, a shallow bore located immediately adjacent to the backfilled drum burial trenches contained 0.4 mg/L total petroleum hydrocarbons. This is probably a consequence of locally enhanced recharge occurring in the trench backfill.

It was concluded that the water bearing zones are of low permeability and the potential for contaminant migration via groundwater systems is very limited.

1.4. Type of Contamination

Soil and sediment contamination is present on the CFA Training College site, predominantly as petroleum hydrocarbons, with lower concentrations of phenol, BTEX and lead at two locations (Figure 2).

This contamination has arisen principally as the result of storage and handling of fuels, use of liquid fuels in fire training activities, and disposal of fuel residues such as sludges.

The nature of the petroleum hydrocarbons has not been characterised in detail, but in general are medium to heavier fractions (C_{15}-C_{36}), as expected from the nature of the activities on the site. Significant concentrations of lighter hydrocarbons (C_6-C_9 and C_{10}-C_{14}), including BTEX constituents, are present in the drum burial area. This area also contains slightly elevated concentrations of phenols.

One sample from the old fire training pits contained elevated lead (710 mg/kg).

No significant concentrations of polynuclear aromatic hydrocarbons or heavy metals have been found at the site. No organochlorine pesticides or PCBs were detected in any sample tested.

1.5. Extent of Remediation

Two areas of soil contamination requiring remediation, as part of the current work plan, have been identified as follows (Figure 3):

- **Flammable liquids fire pad (FLP).** This large area contains obvious superficial soil contamination with fuel residues from fire training activities. Crushed rock fill is contaminated with hydrocarbons at depths of 0.1-0.5 m, but generally no deeper than 0.8 m. Total petroleum hydrocarbon concentrations range up to 1600 mg/kg.
- **Old Fire Training Pits.** Two decommissioned fire training pits, east of the FLP contain a thin layer (less than 10 cm thick) of black hydrocarbon sludge, at a depth of 0.1 to 0.6 m. The sludge is covered by a 0.1 to 0.8 m thick layer of surface fill comprising silty clay, silt and gravel. High concentrations of total petroleum hydrocarbons, up to 88,000 mg/kg, are found in the sludge layer and soil from 0.6 to 1.0 m. Elevated lead levels (710 mg/kg) were found in one sample.

No groundwater contamination was identified requiring remedial action. The depth to groundwater in the basalt (greater than 20-25 m), and relative impermeability of the residual silty clay soil affords a high degree of protection to any groundwater resource which might be present.

Contaminated sediments, particularly in Dam 1, are not addressed in this RAP. Following the soil remediation works, CFA plans to upgrade facilities in the FLP/FMA, with the objective of preventing further hydrocarbon contamination in Dam 1.

Remediation of Dam 1, and the drum burial pits, will then be the subject of a future RAP.

2. Remediation Objectives

The goal of remedial action at the Fiskville Training College is prevention of further soil and water contamination from fire training and other site activities.

The primary objective of this remedial action plan is the removal of the contaminated soils and buried wastes identified in the FLP, and fire training pits.

In the FLP area this will prevent further contamination of Dam 1, and allow upgrading works to take place to provide better management of hydrocarbon contaminated effluent from fire training activities in this area.

2.1. Excavations

Remediation of the areas with identified soil contamination will be to a standard such that all soil exceeding specified criteria for organic contaminants and lead is removed, and treated elsewhere on the Fiskville site.

The criteria to be adopted for the excavation phase are the Victorian EPA guidelines for off site disposal of contaminated soil as clean fill:

• total petroleum hydrocarbons (TPH) ($\leq C_9$)	100 mg/kg
• total petroleum hydrocarbons (TPH) ($>C_9$)	1000 mg/kg
• phenols	1 mg/kg
• mono-aromatic hydrocarbons (BTEX)	7 mg/kg
• lead	300 mg/kg

2.2. Treated Soil

The contaminated soil, to be treated by composting, will be processed to the stage where the rate of degradation of petroleum hydrocarbons reach a very low, and steady state.

This can be considered as the 'natural', or environmental endpoint for the process. At this stage of the process, any residual petroleum hydrocarbons can be considered to be 'biostabilised' or effectively inert and unavailable for causing any environmental or health effects, or otherwise adversely affecting the quality of the soil, or other parts of the environment.

Depending on the concentration of any residual petroleum hydrocarbons, various tests can be readily conducted to assess any potential toxicity, including a TCLP (i.e. a leach test), Microtox® tests, and phytotoxicity tests. Such tests can either be conducted or overseen by Rio Tinto R&TD.

3. Remediation Method

The proposed remediation will be in two phases.

1. All contaminated soil will be excavated and removed to a treatment facility to be established on the site. The excavations will be backfilled with clean fill although not as part of the present RAP.
2. Excavated soil, contaminated with hydrocarbons, phenols and BTEX, will be treated on site by a process of soil composting.

3.1. Preliminaries

- appointment of Site Supervisor to supervise all works conducted on the site
- appointment of Contractor for earthworks - Contractor to provide equipment
- safety inductions and familiarisation - Contractor and Site Supervisor

3.2. Excavation

3.2.1. Service Locations

Before any work commences, the Site Supervisor will ensure that all services such as power, water, electricity and telephones have been located and appropriately marked.

3.2.2. Open Excavations

During excavation and backfilling, the site supervisor will ensure that safety barricades or markers are erected around open pits or trenches, to prevent persons or machinery falling into them unawares.

3.2.3. Equipment Decontamination

Trucks, excavators and other machinery coming into contact with contaminated soil will be washed down before leaving the site. This will prevent soil from being caught on the wheel/underbodies of cars or trucks and distributed outside the facility.

The washdown will be located so that wash water containing sediment and any contaminants can be retained in the treatment facility sump, or drain directly into Dam 1.

3.2.4. Excavation of Contaminated Soils

The contaminated soil, once excavated, is to be transported and stockpiled within this area, ready for processing. It should be stockpiled in a manner such that it allows the systematic mixing and placement of the compost mix in the windrow configuration.

3.3. Clean Fill

This *will not* be sourced and placed as part of the current work program.

4. Soil Treatment and Disposal

4.1. Soil Composting

Bioremediation involves the use of microbial processes to convert environmental pollutants to harmless products such as carbon dioxide, water and simple inorganic salts. Microorganisms, which can degrade petroleum hydrocarbons and simple phenols, occur naturally in soil. Accelerated biodegradation of soil contaminants can be achieved by adjustment of soil conditions (e.g. by addition of nutrients, moisture, pH and structure). Composting of soil is a form of bioremediation.

Composting systems have been used for many years for disposal of agricultural, municipal and domestic wastes, and more recently have been applied to remediation of contaminated soils. Composting has several advantages over conventional land treatment processes.

In well managed compost systems the number and diversity of microorganisms is much higher than in most soils, which can allow for more effective degradation of organic contaminants.

Secondly, addition of organic matter in a blending operation enhances the physical structure of the soil, allowing for more rapid exchange of air and other nutrients required for the biodegradation processes.

Finally, the high proportion of biodegradable organic matter in composting processes normally results in the temperature of compost windrows gradually rising as microbial decomposition proceeds, releasing heat. Temperatures in large compost windrows (or piles) may reach 55° to 60°C. These higher temperatures increase the rates of biological and chemical reactions involved in contaminant removal. Given the relatively high proportion of soil in the compost mixture, and based on Rio Tinto R&TD's previous experience, it is highly unlikely that the windrows will spontaneously combust during the process.

Soil composting therefore has particular application where conventional bioremediation processes are limited by the properties of the soil, or the nature of contaminants, for example the heavy (high boiling point) hydrocarbons in clay soil, present at Fiskville.

4.2. Treatment Objectives

Treatment objectives have been discussed with the Victorian EPA (EPA). Based on the proposed remedial actions outlined by Rio Tinto R&TD in the review report, we have agreement from the EPA that a composting process will be an acceptable treatment technology for the CFA, Fiskville site.

The key measure for obtaining a "clean site" will be the concentration at which the rate of petroleum hydrocarbon degradation has reached a plateau (as indicated in Section 2.2). Although the actual concentrations of petroleum hydrocarbons may plateau at a value above the EPA guidelines (of 1000 mg/kg), as a result of the composting process, Rio Tinto R&TD is in a position to assess the potential risks of any residual contaminants (as described in Section 2.2).

4.3. Treatment Facility

4.3.1. Location and Design

The soil composting facility is to be located immediately south of the old fire training pits, and east of University Road (Figure 3).

This facility will consist of a clay, compacted, unlined bunded area.

Bunds will be of compacted local clay soil, and be a minimum of 300 mm, and a maximum of 500 mm high.

4.3.2. Collection and Disposal of Stormwater

The proposed treatment facility will cover a relatively small area. Any runoff generated within the area will be captured by bunding to be constructed around the treatment area.

Potential runoff, generated externally to the treatment facility, will also be prevented from entering the treatment area, through the presence of the bunding.

Any runoff collected in the facility area will be diverted to Dam No. 1.

4.3.3. Access and Equipment Decontamination

Access to the site will be controlled so that only machinery directly involved in the process comes into contact with the contaminated soil.

Trucks, excavators and other machinery will be washed down after handling contaminated soil and compost, and before leaving the site. This washdown will be located so that wash water containing sediment and any contaminants can be retained in the facility sump, or drain into Dam 1. This will prevent soil from being caught on the wheel/underbodies of vehicles and distributed outside the facility.

4.4. Materials Requirements

4.4.1. Organic Soil Amendments

CFA will provide suitable organic materials from local sources. The types of materials that should be used are described in this section.

In broad terms, there are three major types of material needed as organic amendments for composting. These are;

- *bulking material* to improve soil structure, improve moisture retention and promote aeration, and
- *'green' material* to provide readily biodegradable components (cellulose, protein).
- Inoculum to provide a source of microorganism

Bulking materials may be in the form of dry or aged plant materials such as straw, dry 'brown' weeds, wood chips, straw, saw dust, remnants from board manufacturers and old grass clippings. These materials are composed mostly of plant polymers such as cellulose (long chains of simple sugar molecules linked together) and the more complex (cross-linked) lignins. The relatively high proportion of resistant lignins means these materials are physically robust, and do not rapidly break down in the compost. The biodegradable component contributes a source of energy for the composting microorganisms. Because they tend to be dry, 'browns' often need to be moistened before they are put into a compost system.

Both bulking and green materials need to be as fresh as practical for an effective composting process.

Compared to material suitable for providing bulk, 'green' materials have a large amount of readily biodegradable constituents and a higher proportion of nitrogen. Nitrogen is the major element in amino acids and proteins, and acts as a nutrient for the microorganisms in the compost.

'Green' materials suitable for soil composting include;

- mulched tree prunings, 'green' woody material, leaves and ("yard wastes"),
- fresh cow, sheep or horse manure,
- fresh grass clipplings,
- fresh hay,
- tree prunings, leaves, and a small proportion of grass clippings (must be well dispersed),

Inoculum can include horse or cow manure. Treated sewage sludge (as long as metals and other contaminants are at acceptable concentrations), can also be used.

There are also materials not suitable for addition to the composting pile:

- chemically treated wood products (woodchips, sawdust, wood),
- human waste,
- piggery waste, and
- meat, bones, milk products and fatty food waste.

Approximately equal proportions of 'green' and bulking material, with a small proportion of inoculum, is the best nutritional balance for microorganisms. The mix should also promote aeration, moisture retention (and movement) within the windrows.

It is important that the mix contains both 'green' and bulking materials, as too much of either will adversely affect the rate of the composting. A higher proportion of 'green' material *may* be required to balance out the moisture levels if the bulking materials selected are very dry.

The nominal composition of the soil composting treatment will be approximately 70% v/v soil and 30% v/v total (applied) organic amendment (prior to mixing). This is estimated to correspond to approximately 90% w/w (wet) soil and 10% w/w (wet) mulch.

Table 2 summarises the amounts of 'green' and bulking materials required for the composting of a total of 2000 m^3 of contaminated soil. Once the excavation commences, it may be evident that there is either more or less than 2000 m^3.

Table 2. Proposed volumes of materials for soil composting

Constituents	**Volume (m^3)**	**Bulk Density (t/m^3)**	**Mass (wet t)**	**Ratio (% total wet mass)**
contaminated soil	2000	1.7	3400	90
bulking agent eg. green tree waste (leaf mulch)	835	0.17	142	4.2
inoculum eg. Horse or cow manure	140	0.4	56	1.6
'green' material eg. grass clippings	947	0.15	142	4.2
Total	**3922**		**3740**	**100**
Total (when mixed)	2490-3110	1.2 - 1.5		

4.4.2. Other Soil Amendments

The soil compost will also be supplemented with a commercial controlled release nutrient formulation, to be supplied by Rio Tinto R&TD.

This nutrient will be blended with the soil compost at the final mixing stage.

The soil compost should be dosed with nutrients at a rate of approximately 50 g/m^3. This will be confirmed once the concentrations of petroleum hydrocarbons are determined.

4.5. Soil Processing

This has been detailed in Appendix 1. In summary, this approach has been employed by Rio Tinto R&TD in similar full-scale remediation projects utilising thermophilic composting.

4.5.1. Objectives

The primary objective of the soil processing and treatment process is to change the physical and chemical properties of the soil by addition of gypsum ($CaSO_4$) and organic material. The aim of these additions is to:

- stimulate microbial activity present in the contaminated soils
- introduce a wide spectrum of (compost) microorganisms to support degradation of organic contaminants
- reduce the inherent cohesive characteristic of the soil
- optimise the soil aggregate size (particularly to breakdown large clay aggregates)
- create an environment where the mobilisation and bioavailability of the organic contaminants within the soil mass is maximised.

The overall effect will be to introduce and stimulate biodegradation activity for hydrocarbons in the contaminated soil.

4.6. Treatment Operations

4.6.1. Watering

This will be done on an as required basis. The rate of watering will be dependent on the characteristics of the final compost mixture. Rio Tinto R&TD will assess the water holding capacity of the final mixture and this will *assist* in determining the optimum rate and frequency of water application.

4.6.2. Mixing

Effective mixing is necessary for an efficient composting process. Although the specific regime to be used will, to an extent, be controlled by the type of equipment available, mixing guidelines have been provided in Appendix 1.

4.7. Monitoring

4.7.1. Field Observation and Testing

Selected measurements can be made in the field. These include on-line temperature logging, measurement and visual appraisal of the soil moisture, and effectiveness of the mixing.

4.7.2. Soil Sampling

This will be conducted using a hand held soil auger. Samples will be collected according to a standard protocol and will be conducted by Rio Tinto R&TD, or by on-site personnel under Rio Tinto R&TD's instruction. A protocol is detailed in

Appendix 1. All samples will need to be despatched with correctly completed Chain of Custody documents.

Rio Tinto will prepare batch check standards to be used at each of the sampling times, to ensure any analytical variations are controlled.

4.7.3. Analysis

Rio Tinto R&TD will co-ordinate the dispatch of soil samples for chemical analyses, once microbial analyses have been conducted.

4.8. Treatment Time

Treatment time will largely be dictated by the factors impacting on the effectiveness of the composting process. Process monitoring will assist in predicting the endpoint for the treatment process. Composting of soil typically takes 2-3 months with approximately 1 turn of the compost windrow per week. Such a regime should ensure that all the composting mass reaches the temperature/time conditions of 55°C for approximately 4-8 weeks.

4.9. Reuse of Treated Soil

Procedures for final sampling and validation of the composted soil are given in Section 6.

Previous experience with composting of clay soils shows that as well as reducing concentrations of chemical contaminants, visual characteristics and physical properties are generally improved.

Two options will be available for final disposition of the soil on the Fiskville site:

- use as fill to create a new training pad, immediately east of University Road. This would involve relocating and compacting the soil, and then sealing with a new concrete surface.
- use as landscaping material.

5. Health, Safety and Environment Site Management Plans

5.1. Health and Safety

5.1.1. General Issues

All activities for the remediation and soil treatment will be conducted in accordance with a site Health and Safety plan (Appendix 2).

5.2. Dust Suppression

The excavation and removal of soil from the FLP, and old fire training pits, as well as preparation of the hardstand area, all (potentially) involve the generation of dust. Activities should be carried out in a manner which avoids the creation of dust. Methods of avoiding dust pollution include;

- periodically dampening down unsurfaced working areas that are constantly used by machinery,
- placing a thin layer of gravel over exposed haul routes,
- loading and unloading material as close as possible to the composting facility to prevent the spread of loose material around the site,
- reducing cleared land to a minimum around clean fill borrow area, with reseeding of the grass cover, and
- ensuring windrows are wetted during periods of high wind.

5.3. Stormwater and Leachate Control

An earthen bund is to be constructed around the perimeter of the treatment facility, and the use of a compacted clay layer, as the base of the treatment facility, will minimise leaching of contaminants into the soil profile.

5.4. Sediment Control

Overflow from and onto the treatment area, and subsequent transport of soil, will be minimised by the earthen bund.

5.5. Odour

Excavation of soil contaminated by petroleum hydrocarbons may initially produce odours for a short time, due to volatilisation of the lighter, lower boiling point fractions. These odours are usually short lived, but where odours exceed levels considered safe by the Site Supervisor, works should cease until odours have reduced.

5.6. Noise Control

Care will be taken during the excavations and processing operations so as not to cause excessive noise to the surrounding community and environment.

6. Validation Procedures

6.1. Excavations

The Site Supervisor will need to prepare appropriate validation procedures to ensure that all contaminated soil (exceeding EPA limits) is excavated properly.

6.2. Treated Soil

Rio Tinto R&TD will prepare validation procedures for ensuring the processed soil is effectively remediated.

7. Accountabilities

An accountability matrix has been prepared, outlining the key tasks for each of the parties involved, for the remediation process. The matrix is presented in Appendix 3.

8. Documentation

A field log book should be kept on site for use by the site operators (CFA personnel, the Contractor, and Site Supervisor).

Chain of custody documents should be used for the dispatch of samples to Rio Tinto R&TD (or to other laboratories). Examples of chain of custody documents are are provided in Appendix 4. It should be noted that all pre-processing (soil) samples and process (compost) samples should be sent to Rio Tinto R&TD. Rio Tinto R&TD will forward samples for chemical analyses to AMDEL.

Where sample are dispatched from site by personnel other than from Rio Tinto R&TD, the sections on the chain of custody called "Sampled (or sent) by __________" and "Relinquished by, Date, Time, and Organisation", MUST be completed.

Appendix 1

Work Plan for Soil Preparation and Set-Up

WORK PLAN FOR SOIL PREPARATION AND SET-UP

1. Scope

The process described here is for bioremediation of hydrocarbon contaminated soil excavated from the CFA Fiskville site. The protocol describes procedures to be adopted for the implementation of a soil composting treatment and includes instructions for the amendment of the soil and execution of the composting treatment. A description of the operations required for maintenance and monitoring of the process are also included.

3. Description of Treatment Area

A flat hardstand area will be prepared to the east of the FLP. Uncontaminated clay soil on the site will be used as a base. This base should be compacted prior to placement of contaminated soil.

4. Treatment Design

Rio Tinto R&TD will be responsible for sampling of the excavated soil and the transfer of samples to the approved laboratories for analysis. A total of 30 soil samples will be collected during the excavation phase for analysis of baseline concentrations of contaminants identified at Fiskville: total petroleum hydrocarbons, phenols, BTEX, lead.

Once all contaminated soil is stockpiled in the treatment area, it will be blended with suitable organic materials (as specified by Rio Tinto R&TD, and to be supplied by CFA), and supplemented with selected controlled release nutrients to form a soil compost. The blending operation will be undertaken in accordance with a detailed specification to be prepared by Rio Tinto R&TD. The blended compost will be layed out in 5 windrows, approximately 70 m x 5 m x 2.5 m.

5. Soil Processing Operations

5.1. Equipment Required

Excavation, soil handling, and soil mixing is to be performed using the Contractor's equipment. Equipment should be selected at the Contractor's discretion after consultation with Rio Tinto R&TD. It is envisaged that the following equipment will be required;

Excavator and truck - excavation of soil and transport to contaminated soil stockpile (adjacent to the treatment pad)

Front end loader - for borrow and placement of stockpile soil and organic material for process mixing. Loader(s) may also be used to turn the soil mix during the composting process.

Agricultural fertiliser spreader or lime/cement spreader - for gypsum spreading on soil prior to addition of organic amendments (if gypsum is found to be necessary).

Compost mixer (eg. pavement stabilisation mixer) - initial process mixing and blending.

5.2. Amendments

5.2.1. Organic Amendments (Leaf Mulch)

The organic material recommended for use in the treatment is **green tree waste or mulch** (yard waste, or similar) - freshly produced from lopping, pruning etc. It is necessary that the material have a reasonable proportion of 'green' material (ie. sufficiently high in a readily biodegradable fraction). The presence of significant quantities of eucalyptus tree waste in the mulch waste is preferred.

The mulch will be obtained by CFA and delivered to site prior to commencement of soil mixing operations.

The volumes of organic materials for soil amendment are calculated assuming a total undisturbed soil volume of 2000 m^3 at an *in situ* (bank) bulk density of 2.0 t/m^3. If the final volume of the excavated soil is significantly different (±20%) from this, advice should be sought from Rio Tinto R&TD, prior to commencing the treatment.

The materials will be obtained on a volume basis, and the volumes required are calculated according to estimated bulk densities (from the literature, commercial suppliers and previous experience).

The nominal composition of the soil composting treatment will be approximately 70% (v/v) soil and 30% (v/v) bulking material and green material, prior to mixing. This is estimated to correspond to 90% w/w (wet) soil and 10% w/w (wet) mulch.

5.2.3 Mineral Nutrients

These will be provided by Rio Tinto R&TD at recommended rates (based on previous studies conducted by Rio Tinto R&TD and depending on the quantity of petroleum hydrocarbons present in the soil.

5.3. Soil Preparation and Processing

The soil preparation and processing should be performed as a staged operation.
Transfer the hydrocarbon contaminated soil from the stockpile to the main treatment area for processing.

Spread the soil in a layer approximately 300 mm thick (or as required to suit the mixing equipment) and examine the material for large items of rubble. Items (if any) such as bricks, timber, steel, drums and other non-organic wastes should be removed.

Amend the contaminated soil piles with gypsum at a rate of approximately 1-5% (w/w) (pending advice from Rio Tinto R&TD's testwork).

Add controlled release nutrients at a dosing rate of approximately 50 g/m^3 of contaminated soil (pending advice from AMDEL's testwork).

Spread the 'green' material in a layer approximately 100 mm thick upon the gypsum-applied soil layer.

Turn and mix the material using the compost mixer. This operation should be repeated as required to ensure thorough blending of the compost mix.

This preparation process is designed to generate a soil compost of uniform consistency (principally with respect to aggregate size, amendment and contaminant distribution) and should be carried out thoroughly. The operations will be supervised and documented (including photographically) by Rio Tinto R&TD personnel. Any proposed variations from the procedure given above must be noted, and confirmed with Rio Tinto R&TD, to ensure the process is optimised.

5.4. Materials Handling

The processing operations should be carried out in daily batch operations that match the excavation production. An excavation production rate of approximately 300-350 m^3 per day has been anticipated. For the 2000 m^3 volume to be excavated, a total processing time has been estimated at 1.5-2 working weeks.

5.5. Moisture Addition

The soil being excavated from the site is likely to be moist. Additional moisture is not likely to be required during the blending operation.

If, however, volumes of dry soil are encountered, the soil and composting mixes may need to be watered (with mains water) during the blending operation.

Excessive application of water should be avoided particularly since the soil may become sticky and difficult to handle, and oxygen may become limiting.

5.6. Layout of Treatment Facility

It is expected that some volume reduction (approximately 25-30%) will occur when the raw materials are blended together to form the composting soil. The final volume of the freshly mixed material should be approximately 2,500-3,500 m^3.

The composting soil should be formed into 5 windrows with dimensions approximately 70 m x 5 m wide x 2.5 m high.

7. Process Monitoring & Control

7.1. Monitoring of Operating Temperatures.

Frequency : Continuously logged
Performed by: Rio Tinto R&TD

The operating temperature of the compost pile and soil beds is a significant factor in the successful operation of the process. The rate of heat generation in the compost windrow is the clearest indicator of the progress and intensity of composting action.

A Datataker DT50 data logging unit (supplied and programmed by Rio Tinto R&TD) shall be used for on-line data collection. The temperature of the soils will be monitored and recorded using 5 probes (1 per windrow). The temperature of the windrows will be monitored continuously over the period of the treatment. The ambient temperature will also be monitored.

7.2. Mixing of Compost Materials

Frequency : Weekly
Performed by : Contractor

Mixing of the soil and compost should be performed on a weekly basis until advised otherwise by Rio Tinto R&TD. The compost should be mixed with a loader or similar machine by lifting compost from the end face of the row, turning the machine, and then emptying the bucket contents upon the top and end face of a new pile forming upon the opposite side of the machine.

Temperature monitoring probes MUST be removed prior to mixing of the pile near the temperature monitoring locations.

7.3. Irrigation & Moisture Control

Frequency : As required
Performed by: Rio Tinto R&TD and CFA

The moisture content will be assessed qualitatively at each sampling. In general the materials need to be kept visibly moist, but *not saturated*. Quantitative assessment of the moisture content of the material will be included in each laboratory analysis. An automatic sprinkler system may be required to maintain the moisture content in the later stages of the treatment.

During the treatment phase, CFA will be responsible for maintaining moisture levels within limits to be set by Rio Tinto R&TD. Soil compost windrows will be mixed according to a schedule to be specified by Rio Tinto R&TD.

7.4. Leachate

The generation of leachate is **not** anticipated. If leachate is generated by the windrows, it is likely to be a transient effect. Any leachate will be contained.

7.5. Soil Sampling

Frequency : Weekly
Performed by : Rio Tinto R&TD

Soil sampling for testing of contaminant concentrations and microbiological parameters will be conducted by Rio Tinto R&TD to a standard Rio Tinto R&TD protocol. Soil samples will be dispatched to laboratories by Rio Tinto R&TD.

This is highlighted in the following sections.

Introduction

During the commissioning and operation of a soil treatment landfarm, soil or groundwater samples are taken for the following purposes:

- to validate the residual soil in an excavation,
- to monitor the progress of the biotreatment process,
- to monitor the impact of the landfarm on the local groundwater, and
- to validate the treated soil.

Each of these sampling activities will have its own set of objectives, constraints and protocols. In particular, local authorities are likely to have specific requirements for the validation of treated soil.

Scope

Sampling and analysis for process monitoring purposes need only be sufficient to allow Rio Tinto R&TD to provide advice on the continuing operation of the landfarm. This sampling protocol applies to the collection of this process monitoring data only.

The protocol has been prepared for typical Australian site conditions, and in accordance with established standard procedures for collection of soil samples for chemical and microbiological testing.

Objective:

The objective is to obtain representative soil samples to determine:

- the initial condition of the soil, including the initial concentration of hydrocarbons
- changes in hydrocarbon concentrations and other soil properties during treatment, to allow appropriate adjustments to process conditions, and also to indicate when the remediation has been completed

Preparation:

The number of soil samples required to provide the required level of confidence will vary depending on the volume of soil in the facility.

The layout of sample locations should be recorded on a suitable drawing of the site.

A photographic record of the sampling sites (at the time of sampling) should be obtained.

Baseline samples should also be collected, either before transport of excavated soil to the landfarm facility, or from intermediate stockpiles of excavated soil.

If the sample protocol to be employed is to vary significantly from that described herein, the revised protocol should be adequately documented.

Equipment required:

Clean hand auger

Clean 5 L bucket

Clean 1000 mL glass jars with air tight lids

Polythene bags

Clean mixing board and spatula or trowel

Sampling Procedure

Equipment Decontamination: All equipment to come in contact with sampled soil should be kept as clean as possible and must be decontaminated prior to use. The decontamination procedure is simply to wash the equipment in sequence as follows

- detergent solution (eg DECON-90 or similar)
- clean tap water rinse.

Sampling: Typically, the landfarm can be divided several smaller sub- plots. One composite sample should be collected from each of the sub-plots. Composite sampling should only be used for process monitoring purposes.

Select, at random, a number of grid squares from which to collect soil samples. Then select sampling locations at a different location within each of the grid squares.

At each sample location in the landfarm, use the hand auger to collect a soil core to the base of the contaminated soil layer ie a depth of 25-30 cm (about 1 kg of soil). Transfer the soil core to the clean bucket.

The samples from each plot should be mixed and cone-and-quartered to provide one composite sample to be transferred to a glass jar and one composite sample to be transferred to a polythene bag.

The sample jars should be completely filled with the sample material, covered with a piece of washed aluminium foil and then sealed with a Teflon lined lid.

The polythene bag should be packed loosely with soil, loosely tied and placed into a glass jar which can then be sealed.

Sample Identification: The glass jar must be appropriately labelled at the time of sampling by the person responsible for sampling.

Use a non-water soluble permanent marker, preferably on adhesive labels or tape. The jars must be clearly and unambiguously labelled, including the following details:

- **Date of sampling** eg. 20/12/97
- **Project/site identification** eg. CFA, FV
- **Sample Number** a unique identifying number
- **Sample Description** origin and type (compost/soil)
- **Sample Taken By** person's initial taking sample.

Packaging should minimise drying of the soil, prevent extremes of temperature, and allowing exchange of air between the jars.

The sample should be kept cool (refrigerated if possible, but **not** frozen), or packaged in insulated cool box with cooling blocks.

Samples for analysis of hydrocarbons should be placed in a cooler box along with ice packs and padding so that no one sample is free to move within the box and so that there is no contact allowed between glass surfaces. Shredded paper is **not** a suitable material for packing as it is affected by water from melting ice. Plastic bubble wrap is an ideal material for padding and polystyrene foam can also be used.

Sample Transport: The cooler box should be clearly labelled **'REFRIGERATE'** and addressed to:

Rio Tinto R&TD, 1 Research Avenue, Bundoora 3083.

Arrangements should be made for dispatch of the samples to the analytical laboratory as soon as possible after packing, preferably within 24 hours of the samples being taken.

Chain-of-Custody Procedures

Chain of Custody Forms Details of the samples sent for analysis **must** be recorded on an appropriate *Chain of Custody Form*, which must be sent to the laboratory with the samples.

A Chain of Custody form is to be filled out prior to packing and dispatch for every set or shipment of samples.

An original chain of custody form **must** be enclosed with each container used.

File Copies of the CoC are to be taken by the party relinquishing the sample and included in the job file.

The form MUST be signed and dated by both the relinquishing party and the receiving party each time it is shipped. Upon receipt of the samples the laboratory will cross check the samples against the chain of custody form and report any discrepancies.

Each Chain of Custody form clearly identifies each sample in the sample shipment, all analyses required for each sample, any special comments and lists the number of samples in the shipment. The form requires documentation of the following details:

- **Client name**
- **Site**
- **Project Code/Reference**
- **Sample type**
- **Sample Location**
- **Sample number**
- **Date and time of sampling.**
- **Chemical Analysis**

7.6. Chemical Analyses

Frequency : As sampled
Performed by: AMDEL and Rio Tinto R&TD

AMDEL will perform analyses for assessment of concentrations of hydrocarbons in soil. Samples will be sent to AMDEL's laboratory by Rio Tinto R&TD.

7.7. Assessment of Microbiological & Physical Parameters

Frequency : As sampled
Performed by: Rio Tinto R&TD

Rio Tinto R&TD will perform analyses to assess microbiological and physical parameters in the compost soil. Analyses will include assessment of total heterotrophic populations (THP), total hydrocarbon degraders (diesel:lube oil MPN), pH and moisture. Analyses will be performed at Rio Tinto R&TD's laboratories in Bundoora, Victoria.

Appendix 2

Health and Safety Plan

1. INTRODUCTION

1.1. PURPOSE AND SCOPE

This Health and Safety Plan (HSP) describes the health and safety requirements for Rio Tinto R&TD, the Site Supervisor, Contractors and other working on the remediation program at CFA, Fiskville.

The site investigation consists of a program of excavating and sampling soils from various locations across the site.

The following procedures have been designed to minimise the risks of accident and injury and minimise exposure to toxic contaminants that may be present on the site. This plan also contains procedures to be followed in the event of an accident or emergency.

1.2. APPLICABILITY

1.2.1. Rio Tinto R&TD Personnel

Compliance with this plan is **mandatory** for all Rio Tinto R&TD Personnel, who must be familiar with its details and implications.

1.2.2. Contractors

Contractors will be undertaking site works (such as excavations) that are required for the investigation. The Contractors should be aware of this plan and any other health and safety requirements stipulated by CFA.

Contractors performing work activities as part of a Rio Tinto R&TD contract are expected to meet all applicable Commonwealth and New South Wales requirements for employee health and safety. Contractors are responsible for supervising their employees and maintaining safe working conditions at the work site.

2. INDUCTION

The Site Supervisor should conduct a site safety orientation/training meeting to:

- review the HSP, and
- obtain personnel signatures acknowledging their receipt and understanding of the HSP.

Additional on-site health and safety meetings will be conducted by the Site Supervisor as needed.

3. HAZARD EVALUATION

3.1. CONTAMINATION

3.1.1. Suspected Contaminants

The major contaminants present at the site are;

- Petroleum hydrocarbons
- Phenols
- Lead

3.2. Exposure Pathways

The principal exposure pathways to these contaminants are:

- Absorption through the skin,
- Inhalation, and
- Ingestion.

Prolonged exposure to any of these contaminants, by direct contact, will eventually result in absorption through the skin. This is most likely to occur during sampling and subsampling, where the actual contaminated soil materials are being handled. Absorption through skin is fastest when the soil is wet or damp, but prolonged exposure to dry dust will also result in absorption. Wearing appropriate clothes and gloves effectively minimises skin absorption of contaminants.

Inhalation is the primary exposure pathway for volatile contaminants such as organics, and also for airborne particulates (i.e. fine dust). Organic contaminants are not expected to be encountered very often during the investigation, and can be dealt with by means of respirators where they are present. Inhalation of fine airborne dusts can also be prevented by the use of respirators or breathing masks. Inhalation of contaminants is not a great risk with wet or damp soils.

Ingestion of contaminants results from airborne particulates and poor personal decontamination procedures. This is prevented by not eating, drinking or smoking while working and washing up thoroughly (hands and face) before eating etc.

3.3. OTHER HAZARDS

3.3.1. Heat Stress

Extreme temperatures could occur during the course of the field work, but heat stress can be aggravated by the prevailing work conditions. Specifically, this is a potential problem when protective suits (such as Tyvek) are being worn. These suits are non-breathing and decrease the rate of body heat dissipation, particularly during periods of high activity. Dehydration also becomes a possibility when working in these conditions. It is the responsibility of each team leader to ensure that personnel wearing protective suits take regular breaks (not more than two hours apart) and drink plenty of water.

3.3.2. Noise

The use of backhoes to excavate the test pits represents the major noise source during the investigation. The noise level produced by these machines will not generally be sufficient to require hearing protection. Exceptions to this will be during periods of hard digging, such as rock or concrete breaking. During noisy operations, all staff should stand sufficiently clear of the machine that they do not need to raise their voices to be heard. If this is found to be unacceptable or not possible, then hearing protection must be worn.

3.3.3. Heavy Equipment

Operation of heavy equipment (i.e. backhoes) presents a source of possible striking/crushing/falling injuries to the staff working with the equipment. All staff are to stand clear of the backhoes' swing circle during excavation work. Whenever sampling or pit inspection is required, the operator is to place the bucket on the ground, at least two metres from the excavation, before any sampling or inspection takes place.

3.3.4. Open Excavations

Open excavations present a hazard to both people and vehicle movement, and can collapse, without warning, if left open for extended periods. To minimise the risk associated with open excavations, each test pit is to be immediately backfilled after completion, unless special circumstances warrant the pit being left open for further inspection or sampling. Where the pit is to be left open, it must be immediately barricaded or roped/taped off to warn people and vehicles of an open excavation. The pit should then be backfilled as soon as it is no longer required.

Entry into open excavations is permitted for unsupported excavations up to 1.2m deep, but only when there is another person to act as a "spotter" from the surface. Entry into deeper excavations is considered a confined space entry and also requires shoring of the excavation.

3.3.5. Confined Spaces

Confined space work will not be required as a part of this workplan.

3.3.6. Engine Exhaust

- Exhaust from diesel powered engines (eg. backhoe) can contain significant quantities of aldehydes, polynuclear aromatic hydrocarbons and particulates. For normal outdoor working conditions this will not pose a problem for anyone involved.

3.3.7. Underground Utilities

There is a variety of underground services present at the site. While every effort has been made to locate services, it is still possible that they may be encountered during excavation. This is particularly applicable to non-metallic structures such as old stormwater/wastewater drains. If an underground service is encountered during excavation, the excavation should be stopped immediately and the Site Supervisor informed.

3.3.8. Above Ground Electrical Hazards

At some parts of the site there are overhead structures. The sampling team leader will ensure that the backhoe boom and bucket does not come within five metres of overhead structures at any time during excavation operations.

4. SITE CONTROL MEASURES

4.1. SITE ENTRY

All visitors to the site must check in with the CFA administration.

4.2. COMMUNICATION

Each work team on site will carry a mobile phone at all times, and a list of the phone numbers of:

- The other work teams,
- The Site Safety Officer,
- The Site Supervisor, and
- Emergency services.

Additionally, at the start of each day, the Site Supervisor will confirm the excavations to be completed that day, and record this.

5. PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) is used to allow staff to work in environments that are not safe for unprotected people. The level of PPE required is determined by the known or expected hazards on the site. The equipment that should be used is as follows:

- Steel toe capped boots with chemical resistant soles,
- Hard hat, and
- Safety glasses or goggles.

Additionally, for the sampling teams working with the backhoes, the following additional requirements apply:

- Long trousers and long sleeved shirts and/or Kleenguard coveralls or Tyvek overalls (in dusty conditions, coveralls are mandatory).
- Nitrile gloves for the person handling the samples.
- Breathing mask if working in dusty conditions (3M 8710 paper facemask for toxic particulates is recommended, or a half face respirator with a particulate filter can be used).

For the sample preparation, when working with dried samples inside a building, all of the above requirements apply at all times (i.e, coveralls and a face mask or respirator at all times).

If strong organic odours are encountered and do not dissipate, then a half face respirator with an organic vapour filter cartridge is to be used, in conjunction with all other PPE requirements.

Male personnel are required to be cleanly shaven and all personnel are required to perform positive and negative pressure fit tests prior to entering a contaminated area requiring respiratory protection.

Other safety equipment will be available on site, including:

- first-aid kit and manual,
- hearing protection,
- 9 kg ABE fire extinguishers (if flammable environments are expected),
- eye wash bottle, and
- orange safety vest.

6. DECONTAMINATION

6.1. PERSONAL DECONTAMINATION

Personal decontamination procedures are required to ensure that staff do not ingest contaminated materials while eating or drinking and do not carry contaminated materials into offices or off the site. All staff **must** observe the following procedures

- Upon leaving the work area for a break, lunch or at the end of the day, personnel will remove all contaminated protective clothing/equipment.
- Contaminated PPE to be disposed of, ie. suits, gloves, tape, respirator cartridges, etc, will be placed into plastic bags and/or barrels for disposal by CFA. It is not necessary to dispose of PPE after one use (i.e. after each break), and staff should reuse items such as gloves, coveralls and masks/respirator cartridges as long as they remain serviceable
- Gloves and respirators, if used, will be washed with a detergent and water solution and then rinsed with fresh water.
- Equipment wash and rinse waters will be considered contaminated and placed into CFA's waste water system.
- Personnel will thoroughly wash and dry hands and face before eating, drinking or smoking following field activities.

6.2. DECONTAMINATION - MEDICAL EMERGENCIES

The contaminants of concern do not pose an immediate threat to life or health if inhaled or when in contact with unprotected skin. In the event of physical injury or other serious medical concerns, immediate first-aid is to be administered in lieu of further decontamination efforts.

7. UNSUSPECTED SITUATIONS

In the event site conditions are discovered which were not anticipated during the preparation of this Health & Safety Plan, site activities must stop immediately and the work area vacated. The Site Supervisor will specify appropriate precautions necessary for continued field activities.

8. STANDARD SAFE WORK PRACTICES

In addition to the procedures described previously, the following standard safe work practices apply:

- Eating, drinking, smoking, and chewing gum are strictly prohibited during work in any exclusion zone
- Unnecessary contact with contaminated surfaces or waste materials is to be avoided.
- Medicine and alcohol can exaggerate the effects of some chemical and physical agents. Any staff on prescribed medication must inform the Site Supervisor before commencing work. Alcoholic beverage or unauthorised drug intake is strictly forbidden during work operations.
- All personnel should be familiar with standard safety procedures and additional instructions contained in CFA documentation.
- No one may work alone in the field, ie. out of earshot or visual contact with other workers. The use of the 'buddy system' is mandatory. For field sampling teams, work may continue with only one of the team present provided the backhoe operator is there.
- All employees have the obligation to correct or report unsafe work conditions.

9. EMERGENCY RESPONSE

9.1. EMERGENCIES

If any emergency situation occurs on the site, all work is to stop and the Site Supervisor is to be contacted immediately. The Site Supervisor will decide the appropriate response and evacuate personnel in accordance with CFA procedures. The Site Supervisor will be in charge of verbally alerting personnel and summoning outside assistance.

9.2. FIRST AID AND EMERGENCY PROCEDURES

All normal first aid and emergency procedures apply, as directed by the Site Supervisor.

The following items will be located on site at all times:

- first-aid kit and first-aid manual, and
- emergency phone list.

In the event of serious trauma or unknown chemical exposure, the employee should be stabilised and the emergency telephone list used to call for an ambulance and any other emergency support providers considered necessary. Workers with suspected back or neck injuries are **NOT** to be moved until professional emergency assistance arrives.

All injuries, accidents and incidents must be reported to the Site Supervisor as described in CFA's procedures.

9.3. FIRE OR EXPLOSION

All staff must immediately evacuate the area and inform the Site Supervisor and CFA.

9.4. EMERGENCY INFORMATION

Fire Department		000
Ambulance		000
Police Department	Emergency	000
Rio Tinto R&TD		03 9242 3111
Local Electrical Utility		132 412
Local Gas Utility		Elgas 03 275 8444
Local Telephone Utility		132 255
Local Water/Sewer Utility		Central Highland Water 03 5320 3100
Poisons Information Centre		131 128
Name of Nearest Hospital		Ballan

Please Note
Sewage - self contained unit on the property.

Appendix 3

Accountability Matrix

Accountability Matrix for CFA Fiskville Remediation Project

Organisation	Activity											
	RAP Preparation	Excavation Sample Design	Excavation	Excavation Validation	Excavation Validation Reporting	Replacement of Soil[1]	Soil Placement	Soil Mixing	Procure Inputs	Compost Mix Preparation	Baseline Sampling	Processing/ Soil Mixing
CFA	✓					-		✓	✓	✓		✓
Rio Tinto	✓					-		✓			✓	
Site Supervisor		✓		✓	✓	-	✓					
Contractor			✓			-	✓					
AMDEL						-						

1. not to be conducted as part of current project.

Accountability Matrix for CFA Fiskville Remediation Project (Continued)

Organisation	Activity									
	Maintain Moisture	Soil Sampling	Chemical Analyses	Microbial Analyses	Field Analyses (water/temp.)	Process Validation	Project Manage/ Reporting			
CFA	✓	✓			✓					
Rio Tinto		✓		✓	✓	✓	✓			
Site Supervisor		✓								
Contractor										
AMDEL			✓							

Appendix 4

Documentation

CFA, Chemical Analyses (to be conducted by AMDEL via RT R&TD) CHAIN OF CUSTODY FORM

Client Name: CFA
Site: Fiskville
Project Code: A912B (RT R&TD No.)
Sample Type (s): Soil/Compost

Send Invoice: T.F. Guerin, Rio Tinto R&TD, 1 Research Avenue BUNDOORA 3083
Send Report: T.F. Guerin, Rio Tinto R&TD, 1 Research Avenue BUNDOORA 3083

CHEMICAL ANALYSIS REQUIRED (analyses section to be completed by Rio Tinto R&TD)

Test Pit/ Borehole/Site Location No	Laboratory Number (if necessary)	Other Sample Number	ATD Sample Number	Date/Time Sampled from field or trial	Date Sample Sent from ATD for External Analyses	TPH/ BTEX (EO-82)*	C17:Pristane/ C18: Phytane	phenols	Pb	pH (1:5 soil in water)	Av.P	Av.N	H_2O (dry wt.)	

Notes:

*Please unsure chromatograms for TPH/BTEX and PAHs are send with final report.

Sampled (or sent) by ____________________

Total No of Containers [ ]

NB: The following MUST ALWAYS be Completed

Relinquished By:__________ **Organisation:**__________
Date:________ **Time:**________
Relinquished By:__________ **Organisation:**__________
Date:________ **Time:**________

Received by:__________ **Organisation:**__________
Date:________ **Time:**________
Received by:__________ **Organisation:**__________
Date:________ **Time:**________

Delivery Method:____________ **(attach shipping bill, if any)**

Shipping Container ID____________

CHAIN OF CUSTODY FORM

Client Name: CFA
Site: CFA, Fiskville
Project Code: A912B (RT R&TD No.)
Sample Type (s): Soil/Compost

Send Invoice: T.F. Guerin, Rio Tinto R&TD, 1 Research Avenue BUNDOORA 3083
Send Report: T.F. Guerin, Rio Tinto R&TD, 1 Research Avenue BUNDOORA 3083

ANALYSIS REQUIRED

Test Pit/ Borehole/Site Location No	Laboratory Number (if necessary)	Other Sample Number	RT R&TD Sample Number	Date/Time Sampled from field or trial	Date Sample Sent from ATD for External Analyses	Total Heterotrophic Populations (THP) by MPN	Hydrocarbon Degrading Populations by MPN	Remarks

Notes: Ensure samples are kept cool

Sampled (or sent) by ______________________

Total No of Containers

NB: The following MUST ALWAYS be Completed

Relinquished By:__________ Organisation:__________ Received by:__________ Organisation:__________
Date:________ Time:________ Date:________ Time:________
Relinquished By:__________ Organisation:__________ Received by:__________ Organisation:__________
Date:________ Time:________ Date:________ Time:________
Delivery Method:__________________(attach shipping bill, if any) Shipping Container ID__________________


COFFEY

12/1966

CFA Training College

SOIL REMEDIATION
AND VALIDATION PROGRAM
FISKVILLE NEAR BALLAN, VIC

Report E3523/3-AI March 1998

Coffey Partners International Pty Ltd
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Telephone (03) 9853 3396

E3523/3-AI MKSP:MKSP
18 March 1998

CFA Training College
RMB 300
BALLAN VIC 3342

Attention: Mr Roger Kershaw

Dear Sir

RE: SOIL REMEDIATION AND VALIDATION PROGRAM
CFA TRAINING COLLEGE-FISKVILLE, NEAR BALLAN, VIC

We have pleasure in forwarding our draft report for the above site. Two copies of the report are provided for your information. One copy has been dispatched direct to Mr T Guerin of Rio Tinto Research and Technology. Your attention is drawn to the enclosed sheet "*Important Information About Your Environmental Assessment Report*".

Should you have any queries or require further information, please contact Mr Grant Eggleston or the undersigned.

For and on behalf of
COFFEY PARTNERS INTERNATIONAL PTY LTD

Michael Probert

M K S PROBERT

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