Liverpool Environmental Engineering Consultants Limited

TOVIL QUARRY, NEAR MAIDSTONE

SITE SUB-SURFACE CONDITIONS AND RECLAMATION METHOD STATEMENT

MAY 2006

Abstract

1 Despite the known history of this land, there are now no indications that future residents could be at risk from landfill gas.

2 Variable and often poor ground bearing capacities will, instead, force remediation.

3 The preferred ground improvement strategy is to excavate (on average) the upper six metres of the quarry fills and sort these to remove non-compactable materials as well as fuel impacted soils and any more leachable contaminants.

4 This process is likely to allow the winning of a 600-mm thick clean soil cover which will be laid over the entire site.

5 Suitable soil arisings, after chemical confirmation, will be used to refill excavations and will be fully compacted. This compaction will restrict air entries into the site and so will minimise future emissions of carbon dioxide.

6 Shallow gas wells, and possibly flux box installations, will be employed post-remediation to demonstrate the land's freedom from gas hazards.

7 Off-site disposal of uncompactable waste residues (paper, plastic, metal scrap etc) is likely to amount to less than 15,000 cubic metres and fuel impacted soils (which may be biotreated on site prior to removal to landfill) are not expected to amount to more than 1,000 cubic metres.

8 A passive venting/barrier trench, on the land's south-western boundary, is proposed to remove any concerns that gases may, in future, enter the site from the adjacent closed landfill.

Tovil Quarry, near Maidstone

Site subsurface conditions

A} Location and current condition

1. The land lies some 1.9kms south-west of Maidstone, on the south-east of the B2010 at Farleigh Hill. National grid reference TQ 752 541 indicates the approximate centre of the site.
2. Other than for a construction plant storage area, immediately adjacent to the B2010, the land is currently derelict, and is locally covered with self seeded grasses and bushes. Ground levels are at approximately 43m AOD on the northern and southern sides but fall to 31m AOD in the central hollow in zone C (Fig 2).
3. The site lies on a north facing dip slope, into which the River Medway and the Loose Valley have cut their watercourse. In earlier times, a dry river valley also ran through the Tovil Quarry land (Fig1).

B} Earlier land usages

1. Ordnance Survey maps from 1868 to 1999 (Appendix 1) offer useful "snapshots" of the land usages at various times.
2. The earliest maps (till 1884) depict an entirely rural agricultural usage. Quarrying, for building stone, (1897 until prior to 1958) then took place, initially in the northern and north-eastern corners, and later this extended into the central and southern portions of the land.
3. Backfilling of quarried voids commenced in the 1950s and accelerated until the late 1970s. Incinerator ashes, from an adjacent works, were tipped adjacent to the

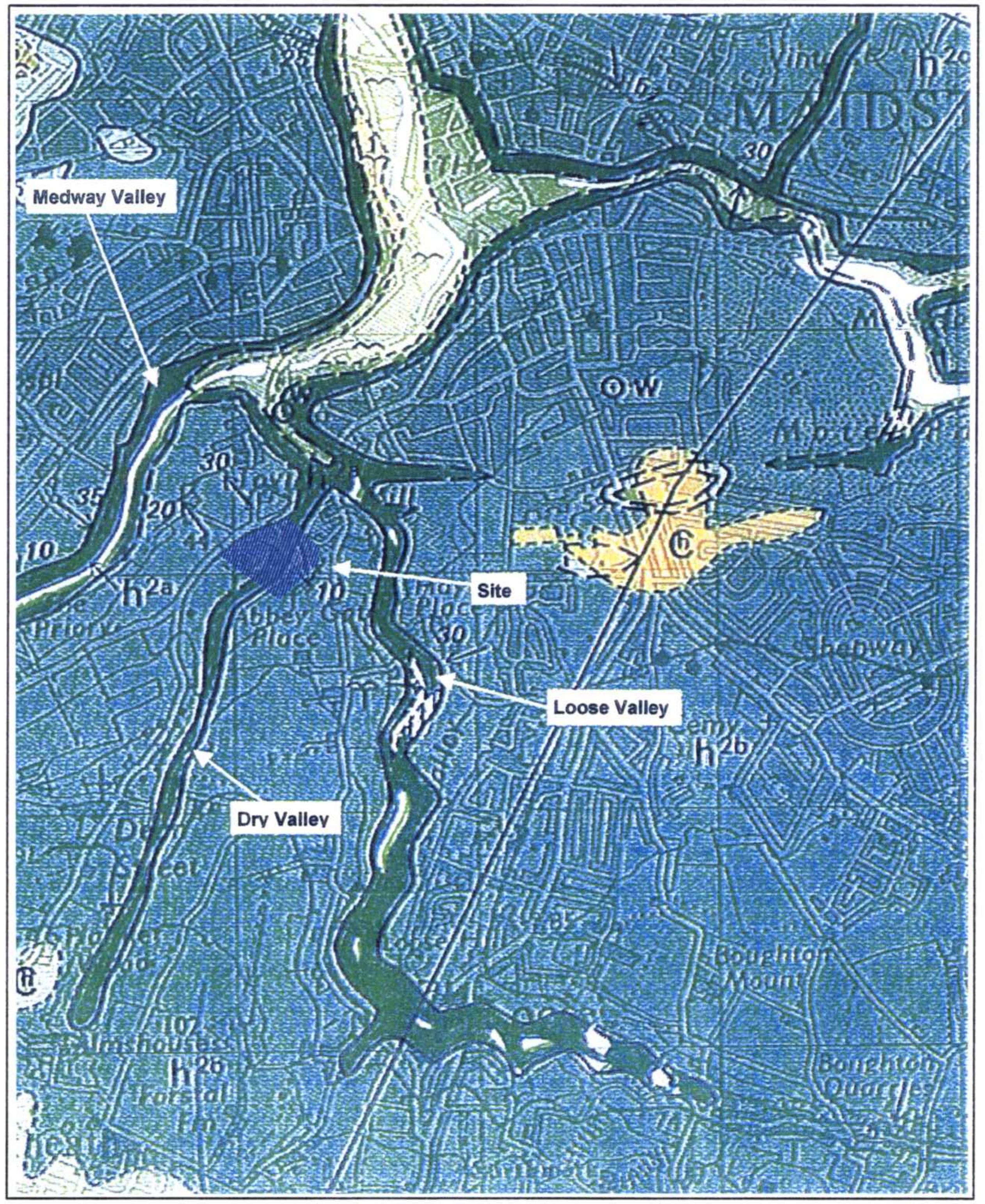

Fig. 1. TOVIL QUARRY - Topographic settings

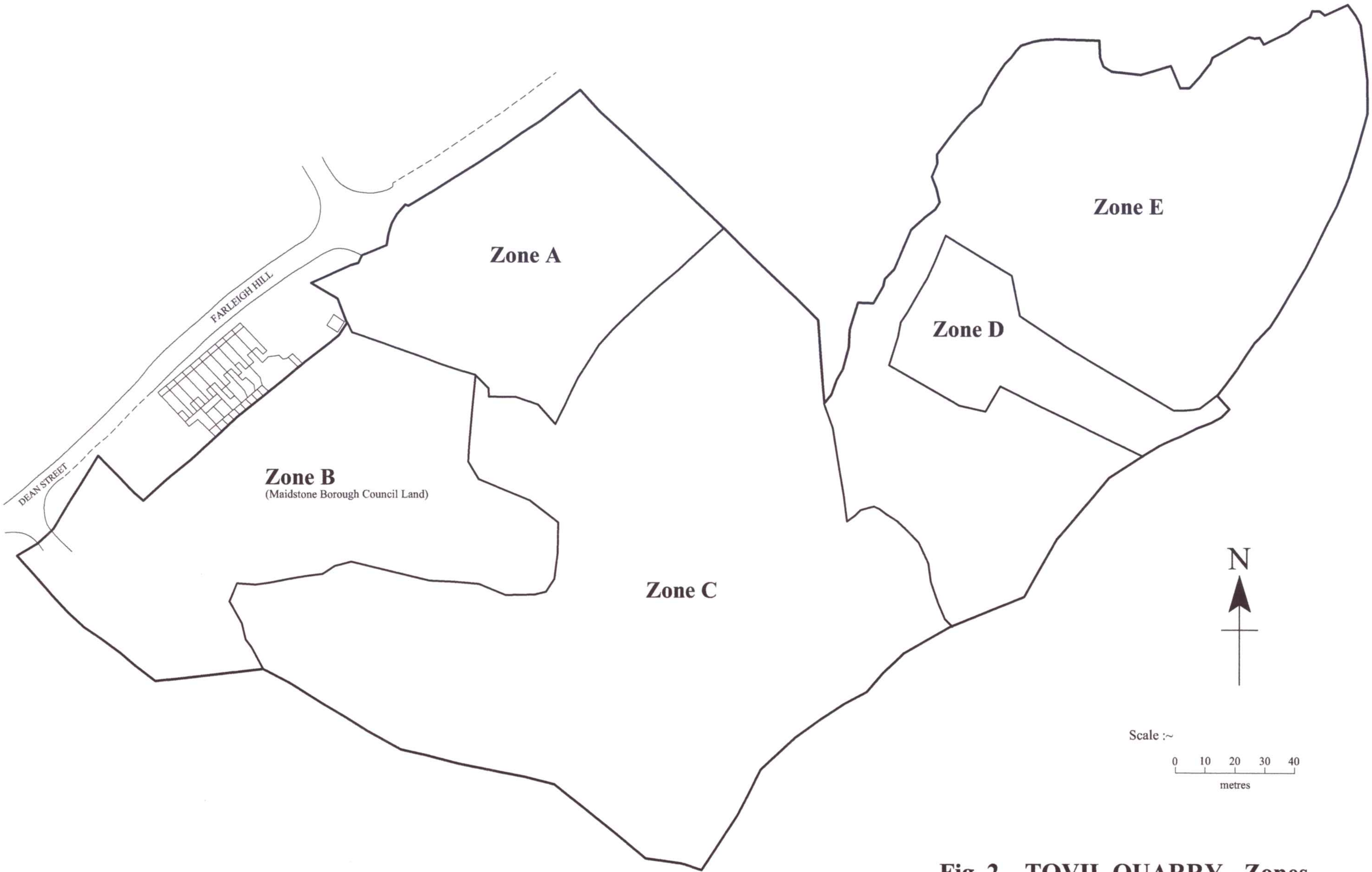

Fig. 2. TOVIL QUARRY - Zones

B2010 in the 1960s, and domestic refuse, from the Maidstone area, was tipped in the late 1960s to the mid 1970s in the central/western part of the site.

4. The main phase of backfilling appears to have ended by 1976, though unfilled quarry hollows still existed at this time.
5. As backfilling took place, areas of the land could be reused. A fuel depot existed, from about 1980 until the late 1990s, on the north-west corner adjacent to the B2010, and two effluent tanks (associated with an off-site print works) were in operation, from the late 1950s until the 1990s, on the north-eastern corner of the site.
6. Whilst the Ordnance Survey information suggests a relatively simple sequence of land usage, further unmapped complications did take place. In 1992, aerial photographs show that previously tipped soils, on the southern corner of the land, had been re-excavated, presumably for material recycling and recovery, and other aerial photographs, taken in March 2000 by the current landowner, show the land then lacked any vegetation cover and its surface was being extensively remodelled and excavated.
7. In a final alteration in 2002, a narrow strip on the eastern edge (zone "D") – where a depot and fuel tanks had existed within a steep sided hollow – was filled by the present landowner.
8. The available data indicates earlier and substantial quarrying was followed by the tipping of incinerator ashes, domestic refuse and waste paper pulp, and that the infilled quarry was then used for waste recycling and materials recover. As few specific details on the materials used as fills are available, it has to be concluded that both contaminated soils and materials prone to biodegradation are likely to have been incorporated, and that leakages of fuels (from the former fuel depot and from the

depot on the eastern edge of the land) could have further increased the probability of land contamination.

C} **Geological and hydrological setting**

1. The British Geological Survey sheet 288 (Maidstone) advised that the area's natural geological sequence consists of: - Hythe Beds (some 27m thick)
   Atherfield Clay (6 to 9m thick)

2 The Hythe Beds (alternating layers of sandy limestones and calcareous sandstones) existed below almost the entire Tovil Quarry site and were extensively quarried as a high quality building stone. Hydrologically these permeable Hythe Beds are classified as a Major Aquifer, whose groundwaters probably flow in a generally northwards directions towards the River Medway.

3 The underlying Atherfield Clay naturally outcropped in the earlier dry valley (Fig.1). These silty and sandy clays have low permeabilites and are classified as a non-aquifer.

4 Hydrologically, the Tovil Quarry site does not lie within any groundwater abstraction's source protection zone. However the Loose Valley is only 250m to the north of the site and its water quality could be impacted if mobile/soluble contaminants had been incorporated within the materials used to fill the former quarried voids.

5 It thus has to be concluded that the Tovil Quarry site is in a hydrologically sensitive area, though it is probable that more mobile/soluble contaminants have already migrated well off-site, as the bulk of the land filling took place some twenty-six years ago.

D} Site Investigations

1. Five separate phases of site investigation have taken place from 1989.
2. The earliest, in early 1989, occurred prior to the extensive remodelling and re-excavation of the filled quarries around March 2000. Thus its findings cannot be now accepted as still entirely valid.

E} First site investigation (1989)

1. Aspinwall and Co drilled ten boreholes (to depths of up to 21.5m) and eleven small diameter and shallower probeholes. Additionally forty-three trial pits (3m to 5m deep) were opened.
2. The work was primarily a landfill gas investigation, and monitoring took place on sixteen borehole installations (several boreholes had had both shallow and deeper gas piezometers installed) and the eleven probeholes on ten, or more, occasions from February to April 1989. The trial pits were opened only to allow physical examination of the near-surface fills. No chemical investigations of the fills were undertaken.
3. On the basis of fill types, fill depths and gas concentrations. Aspinall zoned the site. This practice was followed by later investigations (Fig 2), though Aspinall zone numbering has not been followed on Fig 2.
4. Aspinwall's work showed that: -

Zone A was then underlain by a thick (up to 13m) predominantly ash rich fill layer – believed to have come from the nearby incinerator off Burial Ground Lane - over a lesser thickness of quarry waste rock (up to 3.3m thick). No putrescible fills were found, and gas monitoring showed no enhanced landfill gas concentrations. Shallow fuel spillages were noted at some locations, and were interpreted as originating from the fuel depot which existed here in the 1980s and 1990s. Noticeably the ashy fills in two trial pits (Nos 19 and 32) were found to be "warm". On the evidence then available, Aspinwall and Co saw no reason why this zone should not be developed, if suitable gas controls were installed.

Zone B This area had been used for the disposal of both household wastes from Maidstone and also for shredded paper wastes from nearby paper manufacturers. The upper fill layer was found to contain high concentrations of undergraded remnants of refuse (cardboard, plastic, glass, cloth, wood) and, locally, shredded paper wastes also occurred. Newspapers found in the waste layers dated from 1974 and 1975, confirming the historical evidence that waste filling occurred primarily the mid 1970s. Some waste layers were noted to be "steaming". Despite the upper fill layer being of household waste remnants, some of which were very warm and so still decomposing, landfill gas monitoring failed to identify any instances of active gassing. The highest methane concentration (7% by volume in probehole 3) was not accompanied by any measurable positive gas pressure heads. As no boreholes were drilled by Aspinwall and Co. in this zone, the geological sequence, below 5.8m depths, was not established. Aspinwall and Co. regarded this zone as a considerable potential liability, which might generate methane in the future, and so did not advocate its development for housing.

Zone C This large central part of the site was found to be underlain by a layer of sandy clay with some inclusions of shredded plastic, paper, ash and brick particles (up to 15.3m thick) over waste quarry rock (locally some 13.2m thick). Some wastes were noted as being "warm", and newspaper within the fills dated to 1983. Aspinwall and Co proved that enhanced methane concentrations were widespread (up to 27% by volume as a known peak at borehole 6), though usually these concentrations were accompanied only by very low gas pressure heads, which suggested that active gassing was occurring only locally and at a limited rate. Despite the existence of putrescible wastes, (though only of not readily decayable paper and cardboard) Aspinwall and Co believed that the zone could be developed if gas control measures were installed in buildings, and if a vent/barrier trench were constructed along its southern boundary.

Zone D This, in 1989, was an unfilled narrow void surround by steep southern, western and northern slopes. An active depot then occupied the zone, which was not investigated by Aspinwall and Co.

Zone E This eastern edge of the site proved to be underlain by sandy clays (1.8m to in excess of 14.8m thick) overlying waste quarried rock. No degradable materials were encountered, nor were enhanced methane levels found. Aspinwall and Co concluded that the zone could be developed for domestic housing, if separated by barrier from Zone **C.**

5. The Aspinwall work is now only of historical interest, since

   a) the extensive surface remodelling and excavation, known to have occurred around March 2000, will have altered the recorded fill profiles to an unknown extent; and

   b) degradation of decayable materials will have progressed from 1989, and is likely to have diminished the recorded landfill gas concentrations.

For these reasons, the Aspinwall and Co results are not included in the appendices, though these will be forwarded if required.

F} <u>The second site investigation (Southern Testing Ltd 2005)</u>

1) Southern Testing opened fourteen boreholes (to depths of up to 22.5m) and fifty-three trial pits, up to 6.0m deep.

2) Although intended, primarily, as a landfill gas investigation, Southern Testing did include twelve complete analyses of fill samples plus ten further determinations of PCB and TPH concentrations, seven checks for the presence of asbestos and eight water leachability tests of chosen fill samples.

3) Southern Testing established that: -

   a) **<u>Zone A</u>** had similar ground conditions to those demonstrated by Aspinwall and Co, though the ground surface had been raised by tipping of demolition materials. The earlier fuel depot had been removed by the date of this investigation, and the fuel odours (which Aspinwall had recorded) had disappeared by December 2004. No enhanced methane concentrations were noted in Southern Testing's boreholes 13 and 14, though enhanced carbon dioxide levels (up to a known peak of 10% by volume) were found. These carbon dioxide concentrations were interpreted as due to the slow decomposition of incinerator ashes, which form the larger component of the upper layer of fills.

No "warm" or "steaming" fills were noted and the two samples of fill materials which were subjected to chemical analyses (Trial pit 18 (3.5m) and borehole 13 (8.5m)) were found to be uncontaminated, other than for a slight boron exceedance, which proved not to be measurably water leachable.

b) **Zone B** Again, ground conditions were found to be very similar to these reported by Aspinwall and Co, though the thicknesses of the remnants of undecomposed domestic wastes appeared to have reduced, possibly as a result of decomposition of the more readily decayable wastes.

Despite this zone having an upper fill layer of what was originally domestic wastes, methane levels proved to be low (nil to a known maximum of 1.8% by volume) and no measurable gas flow rates were observed. Carbon dioxide concentrations proved to be enhanced (up to 17.2% by volume at borehole 11, though at lesser levels in boreholes 10 and 12). One instance of "steaming" wood, cloth and paper wastes (trial pit 28 from 1.9m to 3.7m) was found. Soil analyses, by Southern Testing, were limited to three checks on the PCB and the TPH concentrations (Trial pits 26, 29 and 31) none of which proved to be enhanced, and to two water leachability tests (trial pits 28 and 31) which revealed no leachabilities of importance.

c) **Zone C** Ground levels appeared to have been altered significantly and raised over Zone C.

"Steaming" waster layers were noted in trial pits K and 15, where thicker layers of undecayed paper, wood and cloth occurred. Despite these indicators of on-going waste decomposition, high methane concentrations (up to 5.1% by volume) were found only in borehole 8, whereas boreholes 5, 6, 7, and 8 revealed either no measurable methane or (atypically) a 0.5% by volume level. Noticeably no positive gas flow rates were recorded, except in borehole 7's deeper gas piezometer where a peak value of 3.7LPH was noted. The validity of this distinctly atypical gas flow rate must be debatable as it was associated with a zero methane concentration on 24th January 2005. Carbon dioxide concentrations proved to be enhanced in boreholes 7 and 9.

Only three soil samples (from trial pits 21, 32 and 38) were fully analysed. One (TP38) was uncontaminated, whilst the ashy strata in TP21 gave rise to high levels of metals, which proved not to be significantly water leachable. Other, less complete, soil analyses showed the presence of asbestos in trial pit 21 and in borehole 5, and of a concentrated (3,900 mg/kg) lubricating oil spillage in trial pit L at 1.5m.

The asbestos proved in trial pit 21 and borehole 5 had been visible as asbestos scraps, when these holes were logged.

The extent of chemical investigation was obviously very much lower then is necessary in a zone where the upper sandy clay fill layer contains abundant inclusions of waste paper, plastic, shoes, tyres, metal, cloth, wood and tarmacadam fragments.

Natural rock, below the fill layers, was proved in zone C at boreholes 5, 6 and 7, where the Atherfield Clay, within the former dry river valley, was encountered. The presence of this impermeable floor allowed groundwaters to collect. Later sampling of these, in the third site investigation, revealed that these groundwaters are surprisingly unpolluted (See section G (b) – below) with only slight exceedances of the boron, nickel, ammonia and TPH concentrations, when compared to the U.K's Drinking Water Standards. Comparison to the more appropriate Environmental Quality Standards, for fresh waters, indicates that the water pollution is relatively trivial.

d) **Zone D** By December 2004, the earlier depot had been removed and the zone filled with more than a 14.6m thickness of predominantly sandy clay fills over redistributed quarry wastes.

Landfill gas monitoring showed methane on one occasion in borehole 3, though without any associated positive gas flow rates. No methane was found in borehole 4, and carbon dioxide levels were low in both these boreholes. Only two soil samples (from trial pit 9 and borehole 4) were chemically analysed and both proved to be uncontaminated. A water leachability test on a borehole 3 soil, which had not been subjected to solid analysis, revealed no polluting leachate.

e) **Zone E** Ground conditions were found to be very similar to those reported by Aspinwall and Co. A near surface cover of sandy clays, occasionally with inclusions of plastic, wood, ash and rubber fragments, is underlain by reworked quarry wastes. The uppermost fill layer appeared to be no more than 6.5m thick, and the underlying quarry wastes continue to depths in excess of 15.3m.

The few soils which Southern Testing had analysed proved to be uncontaminated except where an ashier band (trial pit B at 3.0) had been sampled. A high petroleum hydrocarbon concentration (720mg/kg) was also proved in this ashier sample.

Landfill gas monitoring showed no occurrences of enhanced methane or carbon dioxide.

4. Southern Testing's investigation is useful in that it confirms the local geological sequences, and highlights the physical changes which occurred from 1989. Its failures are: -
   a) inadequate landfill gas monitoring, on only two occasions when barometric pressures were high, and when soils were cooled by winter weather,
   b) inadequate chemical investigation of soil qualities. On the data Southern Testing obtained it cannot be decided whether the upper fill layers are/are not pervasively contaminated, and
   c) inadequate investigation of the site's groundwater qualities, though this was due to the impossibility of penetrating the site's lower (quarry waste) layer with a cable-percussion drilling rig.
5. Fig 3 locates the Southern Testing investigation locations and Appendix 2 contains the geological logs, gas monitoring data and chemical analytical results.
6. To supplement the two earlier investigations a fuller third investigation was undertaken in late 2005.

G} <u>The third site investigation</u> (Ground Investigation 2005/2006)

1. Seven boreholes (including two to replace holes drilled by Southern Testing Ltd.), one hundred and sixty-three gas spike holes, and fifty-one trial pits were constructed (Figs 4,5 and 6).
2. Five boreholes (to 23.5m depth) were sited to supplement Southern Testing's borehole coverage. Later, it proved necessary to add two shallower (7.0m) boreholes, as Nos 11 and 12 of the Southern Testing's set could not initially be relocated.

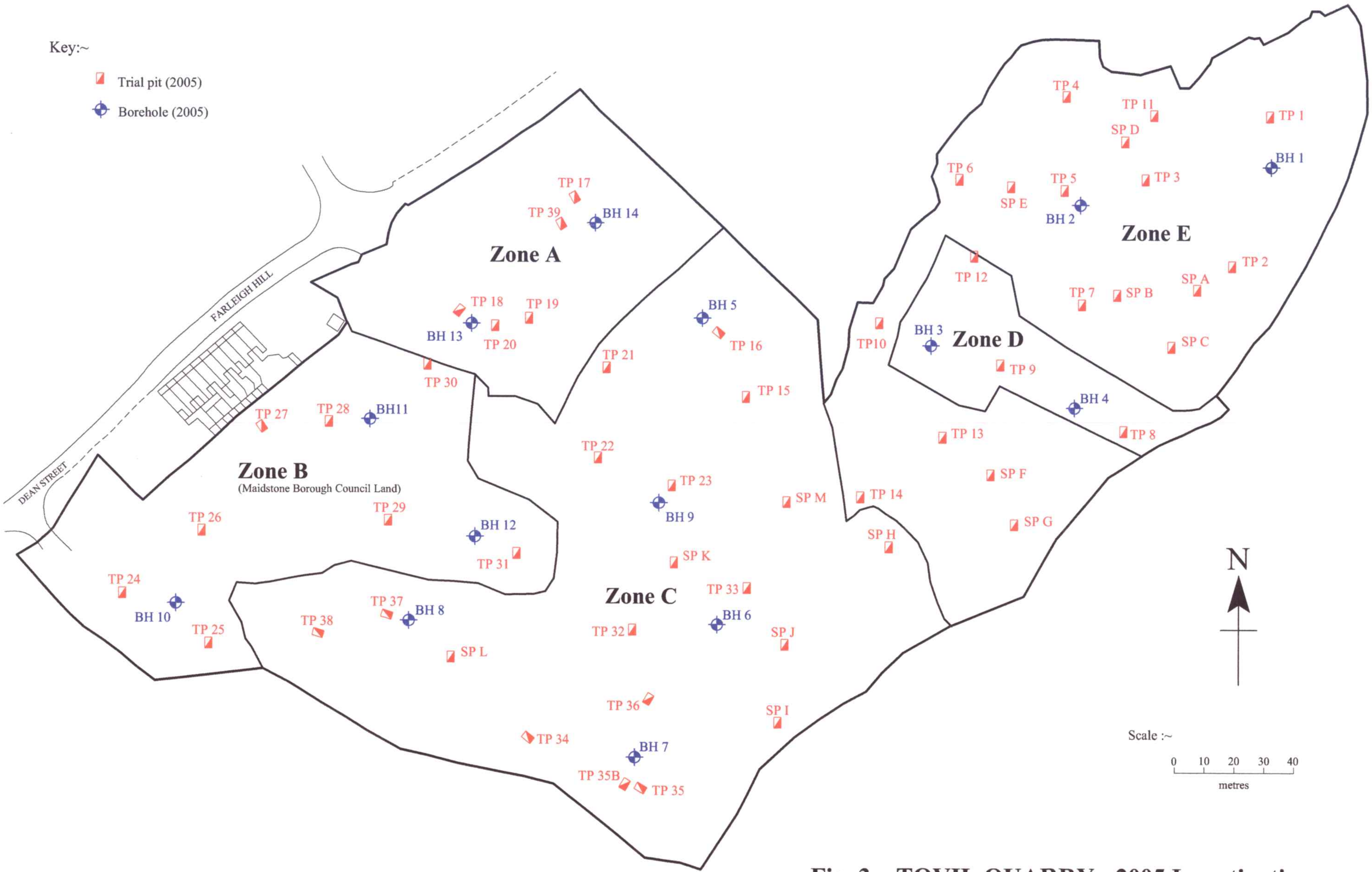

Fig. 3. TOVIL QUARRY - 2005 Investigations

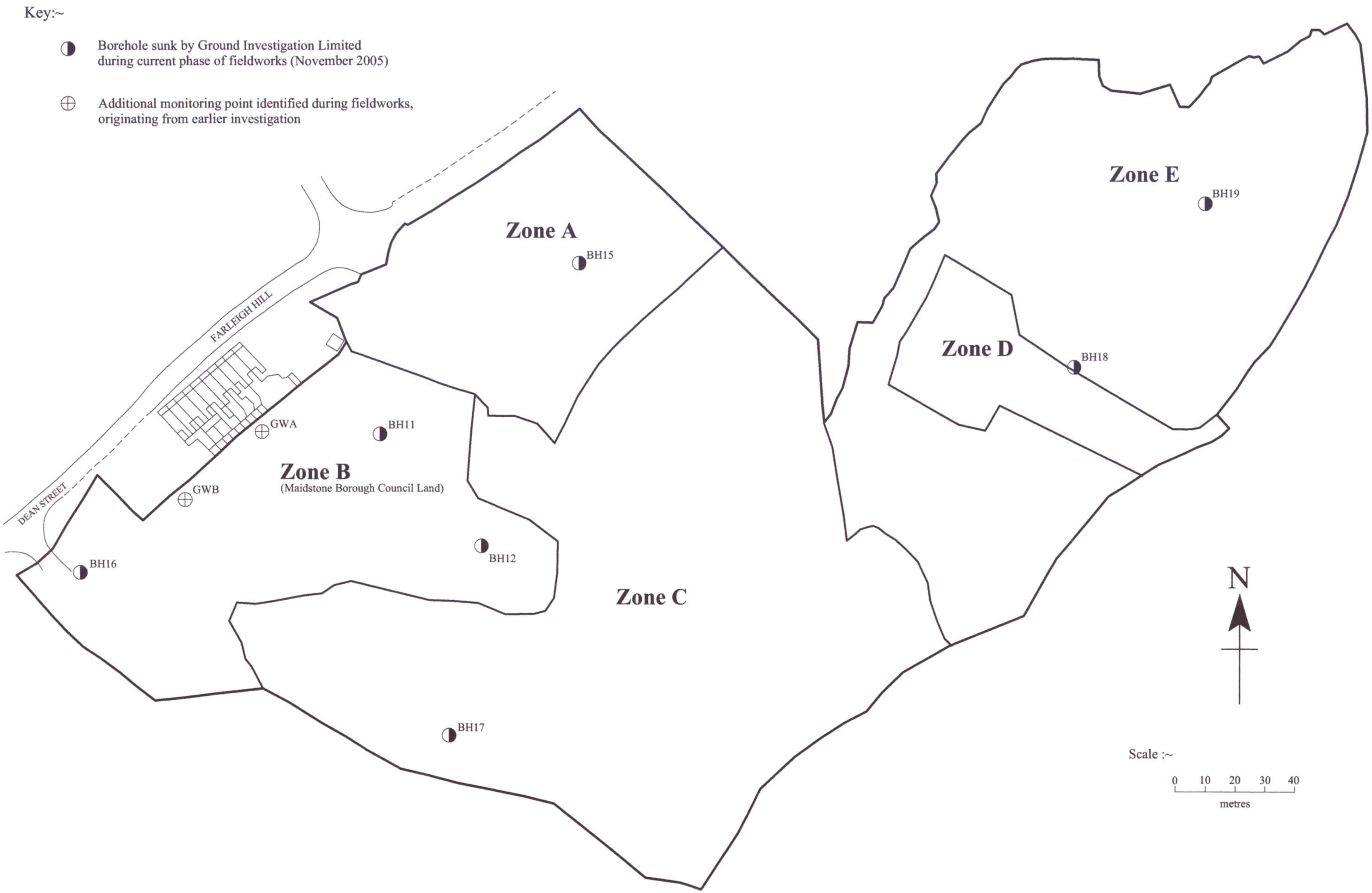

Fig. 4. TOVIL QUARRY - 2005/6 Investigation boreholes

Fig. 5. TOVIL QUARRY - 2005/6 Investigation - Trial pits

Fig. 6. TOVIL QUARRY - 2005/6 Investigation - Gas spike locations

3. The gas spike holes-each to 2m depths – were opened approximately twenty metres centres to identify any more actively gassing areas in the site. The known site history suggests that should any such areas exist these will be a result of unpredictable tipping of loads of more readily decayable wastes. Thus a regular grid spacing of gas monitoring points is more likely to locate any active gassing locations.
4. The trial pits – at some forty metres centres and to depths of 3.0m – were opened to provide representative soil quality samples, and to allow estimates of the proportion of wastes and non-compactable materials in the quarry's fills.
5. Ground Investigation showed that : -

   a) **Zone A** is underlain by an upper sandy ashy clay, with occasional brick inclusions, up to 13.9m thick. Below this are reworked quarry wastes which appear as very sandy gravels with cobbles and slabs of weakly cemented sandstones. Due to the loss of air drilling flush in the quarry wastes, the new borehole 15 could not be continued below 23.5m, and so failed to enter unquarried rock or to reach the local groundwater table. No degradable materials were encountered.

   Landfill gas monitoring at boreholes 13 shallow, 13 deep, 14 and 15 took place on four occasions, from 24th November 2005 to 15th February 2006. Barometric pressures had fallen to 984 mbars on 15th February 2006. This work revealed no methane occurrences, usually very low carbon dioxide levels, and no gas flow rates. Quite obvious gas density layering with depths down borehole tubes was apparent and confirmed that active gassing was not in progress (see section H – below - for the discussion on distinguishing active gassing from trapped gas conditions).

Monitoring of the eleven gas spike holes – on 28th November 2005 and 9th January 2006 – revealed a similar situation, no measurable methane was encountered, carbon dioxide levels were usually well below the 1.5% by volume concentration, and no gas flow rates could be established.

On the evidence of the borehole and spike test monitoring it is obvious that zone A poses no landfill gas hazard to future inhabitants.

Nine representative soil samples from borehole 15 and the seven trial pits showed that two were entirely uncontaminated (trial pits 39 and 44), whilst the others revealed medium to low levels of the heavy metals associated with ashy strata. Petroleum hydrocarbons were noted in borehole 15 (4.0) and trial pit 42 (2.0m), and are interpreted as fuel spillages from the former fuel storage depot.

Leachability tests then showed that most contaminants are very poorly water leachable; only the lead (in borehole 15) and the petroleum hydrocarbon (in trial pit 42) showed slight levels of water leachability.

No asbestos was found in the seven tested soil samples. On the evidence produced by Ground Investigation the re-use of zone A poses no significant problems, though a clean soil cover over soft cover areas is likely to be necessary.

b) **<u>Zone B</u>** The three Southern Testing boreholes, and the additional three drilled for Ground Investigation, showed that an upper layer of sandy clay and gravelly sand (some 5.0m thick) is underlain by quarry wastes (now a sandy gravel with cobbles of weakly cemented sandstone). The upper fill layer contains the undecayed residues of the original domestic refuse (i.e. paper, wood, glass, tins, ash and toy fragments).

Landfill gas monitoring at boreholes 10, 11, 12 original, 12 new, and 16 proved that methane levels were enhanced in boreholes 10 (to peak concentrations of 14.8% by volume), though usually absent elsewhere. Carbon dioxide concentrations proved to be high (to a known peak level of 18.8% by volume) at boreholes 10, 11 12 old and 12 new. Despite the occurrences of high landfill gas concentrations, no gas flow rates could be measured, and density gas stratification (see section (H) – below) was invariably present.

The large number (40 No.) of gas spike holes gave similar results. High methane concentrations were found in a few locations (e.g. GW 11, 13, 14, 15, 16 and 27) but were absent elsewhere. Carbon dioxide at enhanced concentrations (to a known peak value of 29.8% by volume at GW 16, though usually at far lower concentrations elsewhere) proved to be more widespread. Despite these localised occurrences of landfill gas concentrations, no gas flow rates were encountered. Thus no landfill gas hazard to future inhabitants is predictable.

Twelve representative samples of the upper fill layer were collected from boreholes 12 new and 16 and also from nine trial pits. All proved to be mildly contaminated by heavy metals, and petroleum hydrocarbon contamination was also proven in six of these sampled locations. All the contamination, however, was found to be essentially non-water leachable.

Asbestos determinations, on these soil samples, failed to identify any asbestos occurrences.

On the evidence produced by Ground Investigation, zone B's domestic housing re-use will pose no particular difficulties, provided that a clean soil cover (600mm thick) is laid over all garden and soft cover areas.

c) **Zone C** The four Southern Testing boreholes (Nos 5, 6, 7, and 8) and Ground Investigation's borehole 17 showed that an upper sandy gravelly clay layer, with inclusions of plastic, brick, glass and paper wastes, is underlain at a depths of 3.0m to 11.8m by quarry wastes. These deeper fills are up to sixteen metres thick. Natural rock was intersected in boreholes 5,6, and 7 (in the former dry valley) at depths of 7.9m to 17.2m. Borehole 17 also penetrated into the Hythe Beds at a depth of nineteen metres.

Borehole gas monitoring at seven installations (shallow and deep gas piezometers had been installed in Southern Testing's boreholes 6 and 7) revealed percentage levels of methane in both borehole 7's piezometers (to a peak level of 10.4% by volume), and also at borehole 17 on a single one of the three gas monitoring visits. Methane was not detected in the other installations, and carbon dioxide levels generally proved to be low. No gas flow rates were found and gas density stratification down borehole tubes was apparent. Thus active gassing was not occurring. It should be noted that Southern Testing had earlier recorded a positive gas flow rate at borehole 7, though this record's validity was questioned (see section {F} – Zone C – above.

The large number of spike test monitoring points produced similar results. Methane was absent at most locations and occurred atypically at only a few (e.g. GW7 where a 16% by volume concentration was found). Carbon dioxide levels, whilst often in excess of the 1.5% by volume threshold, seldom exceeded 8% values. No gas flow rates could be detected.

On this latest gas monitoring data no landfill gas risks to future inhabitants are predictable.

Eighteen soil samples from the upper fill layer were analysed. Six of these proved to be entirely clean, whilst the others contained low levels of heavy metals and benzo-a-pyrene. This contamination proved to be essentially non-leachable.

Tests for the presence of asbestos showed no occurrences of this contaminant.

On the available evidence, development of Zone C will prove no serious difficulties.

d) **Zone D** The three available boreholes show that an upper sandy gravelly clay fill, with inclusions of brick and some ash, is underlain at depths of 4.0 to 8.0m by quarry wastes. Those are thicker than 16.0m.

Gas monitoring at boreholes 3,4 and 18 revealed no methane occurrences, extremely low carbon dioxide concentrations and no gas flow rates. Density stratification of gases down the borehole tubes was far less marked than had been the case in zones A, B and C. This difference is believed to be due to the use of non-degradable soil fills, which had been unable to create trapped landfill gases (see section {H} – below).

The fifteen gas spike installations gave very similar results. Methane was not encountered (except at GW 122 where a 1.3% by volume concentration occurred), carbon dioxide levels were generally very low, and no gas flow rates were encountered.

Of the five soil samples collected from the quarry fills, three proved to be entirely uncontaminated, whilst the other two exhibited only slight contamination by either nickel or benzo-a-pyrene. No asbestos was demonstrated in theses soil samples.

The evidence is that a domestic housing re-use of Zone D will not experience environmental problems.

e) **Zone E**

The three boreholes (Nos 1,2 and 19) show that an upper sandy gravelly clay, with inclusions of brick, plastic and ash, is underlain by quarry wastes at depths of 4.0m to 8.0m. The quarry waste layer is thicker than 13.5m at borehole 19. Gas monitoring at the three boreholes showed no methane occurrences and generally very low carbon dioxide levels. Gas flow rates were not found and density stratification of gases down boreholes tubes was usually apparent. Thus no active gassing is occurring.

The much larger number of gas spike installations produced very similar results. Methane was never found and carbon dioxide was usually at very low concentrations. At a few locations (e.g. GW 135, 144, 150, 152) slightly enhanced carbon dioxide levels were encountered. In no instance were gas flow rates found.

On the available gas monitoring data no landfill gas hazards are likely to impact on future inhabitants.

Fourteen samples of the quarry fills were collected from borehole 19 and the trial pits within this zone. Eight of these were found to be entirely uncontaminated. Five others revealed only slight contamination by either nickel or arsenic and only one exhibited more extensive metallic and hydrocarbon contamination (TP38). In all cases the contamination proved to be very poorly water leachable. Fifteen asbestos determinations failed to find any asbestos contamination.

On the information now available the re-use of zone E for domestic housing is unlikely to encounter any environmental problems.

6. Groundwaters were encountered only in the boreholes 5, 6, and 7 drilled by Southern Testing Ltd. into the Atherfield Clay. These waters, whose chemistries reflect the

contamination of the overlying quarry fills, are only mildly polluted. Elsewhere the voided quarry waste layers acted as an underdrain and prevented groundwaters collecting within the depths possible with the rotary drilling rig which was used.

7. Appendices 3, 4 and 5 contain respectively the geological logs, chemical analyses and gas monitoring results obtained by Ground Investigation.
8. Ground Investigation's work did advance knowledge of the site in that : -
    (a) it showed that the "warm" and "steaming" layers noted in zones A, B and C had disappeared by late 2005,
    (b) no active gassing could be found at any investigated location,
    (c) the quarry fills were shown to be either mildly contaminated or clean. Where contamination did exist, this almost invariably proved to be very poorly water leachable.
    (d) no putrescible waste layers were found, though – on average – some 5% of remnants of wastes were found. These may have to be removed to allow proper compaction of the site's Made Ground layers,
    (e) a limited degree of groundwater depth and quality detail was produced.
9. The main failure of this investigation was to penetrate the compacted quarry waste layers to a depth enough to intersect groundwater outside of the dry valley feature.

H} <u>Active gassing and trapped landfill gas occurrences</u>

1. The presence of percentage concentrations of methane and/or carbon dioxide can either indicate a significant gas hazard or a complete absence of this.

2. In the first case, when active gassing is in progress percentage concentrations of methane and carbon dioxide will be monitored plus enhanced differential gas pressure heads and measurable positive gas flow rates. The cause of the differential pressures and the positive gas flows is that each cubic metre of decayable waste emits two to three hundred cubic metres of landfill gas (over the period of active decomposition). As no volumes exist in the tipped wastes, to accommodate these large gas emissions, the gases invariably become pressurised, and this pressure then powers gas outflows, usually towards the ground surface.
3. As the decomposition continues, the original atmospheric gases in the soil pores in the fills above and around the gassing source, are swept out and replaced by landfill gases.
4. When decomposition reduces, and finally ceases, the gas pressures at the decomposing source vanish and gas flow rates then cease. However the soil pores above and around the gassing source still remain filled with trapped landfill gases. This condition will continue until human intervention disturbs the soils and allows trapped gases to escape or be oxidised/dissolved.
5. Landfill gas monitoring, when the trapped gas condition prevails, will thus demonstrate the existence of enhanced level of methane and/or carbon dioxide but without any associated gas flow rates.
6. A further indication of the occurrence of trapped landfill gases is that density stratification will occur. Down a borehole tube the lighter oxygen levels will reduce with depth, whilst the denser carbon dioxide (1.5 times heavier than air) concentrations will increase with depths. Such stratification can only occur when no gas flow rates at all exist, since any flow – no matter how small – will mix the gas column and disrupt the gas density stratification.

7. Noticeably the Ground Investigation work showed that a consistent absence of measurable gas flow rates was almost invariably accompanied by visible gas density stratification.

I}`May 2006 site investigations

1 These final investigations focused on determining whether fuel spillages had created widespread soil contamination or groundwater pollution.

2 GeoTesting Services had three large diameter (127mm) rotary holes drilled in Zone E. These arose from an Environment Agency concern that the former fuel storage tanks, in Zone D, might have created fuel contaminated groundwaters which could have flowed towards the northern tip of Zone E. Boreholes reached depths of 34m to 42m, penetrated the unquarried base of the Hythe Beds and into the underlying Atherfield Clay, and all encountered groundwaters.

3 No signs of fuel contamination of the quarry fills were found and all the groundwaters proved to be extremely clean (Appendix 6). Only in the Southern Testing's borehole 7 was a degree of pollution (ammonia at a concentration of 36 mg/l) noted.

4 Whilst groundwater flows, in Southern Testing's boreholes 5, 6 and 7 (within the line of the former dry valley – Fig 1) had been directed to the north, these three new deep boreholes revealed a groundwater flow towards the east. The groundwater regime below Tovil Quarry is obviously more complex than had been believed, and cannot be typified by the six available groundwater boreholes.

5 GeoTesting Services logs and water chemistries are included at Appendix 6.

6 The other investigation of fuel contamination took place in Zone A, where the fuel depot had earlier existed. The Environment Agency expressed a concern that fuel

contamination of soils might be widespread here. To address this issue, RSK ENSR (acting for a possible purchaser of the land) opened four deep trial pits (Appendix 7). None of these exhibited fuel stainings or odours. Thus, whilst localised fuel contamination was noted in Zone A by Aspinwall & Co, and later by Southern Testing, it is apparent from the Ground Investigation and RSL ENSR work that this is neither pervasive or widespread.

J} Conclusions

1 The Tovil Quarry site has been very extensively investigated.

2 Despite a known history of waste tipping into quarried voids, investigations have shown the following.

a) There is now no on-going decomposition of tipped wastes. "Warm" and "steaming" waste deposits have not been found in the later investigations.

b) Active gassing has ceased. Locations where trapped landfill gases still exist are known, but none exhibits any signs of gas flows to pose future risks.

c) Groundwaters – at six known locations – are relatively unpolluted, so risks to nearby surface water qualities cannot reasonably be claimed.

d) Most of the upper quarry fill soils (some 67% of those analysed for Ground Investigation) are mildly contaminated, but with essentially non-water leachable contaminants.

e) The other upper quarry fill soils (some 33% of Ground Investigation's results) are chemically clean and will be enough to provide a clean soil cover over the site.

3 Thus, re-use of the land for domestic housing should neither expose future residents to gas or contamination hazards, or give rise to pollution of controlled waters.

4 The primary problem, which will compel site remediation, is geotechnical. "Loose" soils have been recorded locally by all the investigators to depths of up to five metres. Additionally, thicker deposits of undegraded paper, plastic and metal items are very likely to settle if loaded with buildings or roads. Ground Investigation occasionally found open voids (eg at trial pit 6 at 1.1m depth), where metal or scrap tyres are capping looser fills.

5 Resolving this inconsistent ground bearing capacity is thus compelled. The process of achieving this will also permit the removal of shallow fuel spillages and of thicker remnant waste collections which might give rise to continued low levels of groundwater pollution.

Tovil Quarry, near Maidstone

Reclamation Method Statement

A} Background

1 The land is surfaced by an upper fill layer which shows very variable ground bearing capacities and which also contains localised fuel contamination and some thicker collections of undegraded paper, plastic and other undegraded wastes.

2 These factors compel land remediation.

B} Reclamation outline

1 The above problems are restricted to the upper fill layer. Whilst this has known thicknesses from 3.0m (in Zone C) to 13.9m (in Zone A), examination of the twenty-one available borehole logs suggests that looser soils, and those with high contents of waste paper, plastic etc predominantly exist to depths of no more than 5.0m.

2 Excavation and sorting of the upper fill layer to an <u>average</u> depth of 6.0m is thus proposed. At most locations, adequately dense soils are anticipated by a depth of less than 5.0m. At locations where loose soils are thicker, or where deeper fuel spillages occur, excavation will be continued until firm strata without visible hydrocarbon contamination is found.

3 During excavation, thicker bands of undegraded waste paper, plastic, metal etc will be separated and, if appropriate, screened – to reduce waste volumes – prior to the off-site disposal of these unsuitable materials. All fuel stained soils, and those emitting fuel odours, will be segregated and <u>either</u> biotreated on site (if volumes are enough for a cost-effective scheme, prior to being taken off-site to a fully licensed landfill) <u>or</u> directly removed to a fully licensed landfill.

4 Excavations will be refilled with soil arisings shown to be chemically suitable and then fully compacted. Compaction and landfill gas testing will take place during and post refilling.

C} Reclamation Method Statement (detail)

1 The site will be sub-divided into separate blocks. Currently it is anticipated that ten such subdivisions (each of some 0.55ha in area) will be selected, though the appointed reclamation contractor may present a case for a smaller number, if this is operationally advantageous.

2 Each subdivision in turn will be treated as follows.

a) Quarry fills will be carefully excavated to limit the arisings, as far as is practically possible, to a single soil lithology. Deep excavations which will mix the various lithologies will not be permitted. Excavation will be ceased when either the quarry waste fills or denser strata are encountered.

b) Excavation arisings will then be stockpiled as heaps of the different soil types. It is anticipated that the main types of soil arisings will be

- sandy gravelly clays with a minimal waste content
- sandy gravelly clays with a high content of paper, plastic, metal, cloth etc
- localised collections of paper, plastic, metal and cloth etc wasteswithout a significant soil content
- fuel-stained or odorous soils.

Any asbestos board, or scrap, will be hand picked from the soil arisings and these arisings will then be stockpiled separately for asbestos fibres screening tests.

c) Stockpiles which contain high amounts of paper, plastic, metal, cloth etc will be screened to reduce their uncompactable contents. A magnetic head on the soil screen may be employed to recover metallic wastes, should this prove cost-effective. Those exhibiting fuel odours or staining will either be bio-treated on site, or (if volumes are too low for an effective scheme) be removed directly from the site.

d) Soil stockpiles intended for re-use to fill excavations, will be chemically analysed (ie both solid and leachable analyses). When re-use is permitted, chemically clean soils will be used to provide a 600mm thick clean soil cover over other marginally contaminated soils where the contamination is non-water leachable. Soils which prove to have any significantly high degree of water leachability (ie more than three times the Environmental Quality Standards for freshwaters) will not be re-used as fills.

Sampling of stockpiled soils will be at one truly representative sample per four hundred cubic metres of stockpile.

e) Stockpiles authorised for re-use will be used to fill excavations. The marginally contaminated soils will be laid and compacted in the lower part of the excavations and then covered with chemically clean soils to provide a 600mm thick clean soil capping. All compaction will be to Highways Sub-base Standards and this will be routinely checked by loading and laboratory tests.

f) When excavations have been refilled and shown to be fully compacted, shallow gas wells (3m deep) will be installed. It is currently anticipated that fourteen shallow gas observation wells will be drilled and monitored on at least three occasions, at one of which barometric pressures will be both low and falling. Flux box testing may be included if the gas well monitoring suggests that any minute gas flow rates might be present.

3 Work will, as far as is practically possible, be entirely completed on the first subdivision before remediation is commenced on the next. Each completed and validated subdivision will then be fenced off to prevent contractor entry. The completed and validated subdivisions will then be the responsibility of the landowner.

4 On currently available data, a total excavation of 330,000 cubic metres is expected. In this volume, up to 15,000 cubic metres of unsuitable waste materials are anticipated and will be removed from the site. Fuel impacted soil volumes may prove to be 1,000 cubic metres or less.

5 An application for a Soil Recovery Licence has earlier been made to the Environment Agency to authorise the soil excavation and re-use.

6 The intended work will provide about a further 825 soil analyses plus an unknown number of asbestos screening tests and routine soil loading tests to determine the compaction effectiveness.

D} Additional works

1 Another landfill – previously operated by Kent County Council – is immediately adjacent to the south-western boundary of the Tovil Quarry land.

2 Gas spike holes and boreholes monitored by Ground Investigation in this area, showed no indications of any gas migration into this south-western side of Tovil Quarry. However, the absence of gas migrations may be due to gas controls on the adjacent land which may become ineffective at some future time.

3 As a safeguard against any future gas inflows into Tovil Quarry land, a gas cut-off and passive venting trench will be constructed along the 240m long south-western boundary of the Tovil Quarry site.

4 This is planned as a six metre deep and one metre wide trench, infilled with gas permeable stone, which will be backed by an HDPE gas proof liner on the Tovil Quarry side. The stone filled vent trench will be capped with an HDPE liner and gas escapes will be permitted at twenty metre centres via gas permeable stone filled gabion boxes (1m x 1m x 2m) to minimise visual intrusion.

5 During the construction of this venting trench, excavations will reveal whether a six metre depth is adequate, or whether gas relief boreholes (drilled to penetrate into the quarry rock waste layer) are necessary at twenty metre centres. Available evidence, from Southern Testing's boreholes 7, 8 and 10 and their trial pits 24, 25, 34, 35 and 38 suggests that the 6m vent trench should intersect the quarry rock waste layer below the landfilled upper wastes.