Assessment of Contaminated Soil and Groundwater

Soil samples were taken at multiple locations and at multiple depths and investigated for hydrocarbon contamination. Groundwater was studied where it was possible to reach the groundwater table

Assessment of Contaminated Soil and Groundwater

4.1 Field observations of the current situation on land

Though oil production in Ogoniland has ceased, the UNEP assessment team visited accessible oilfields and oil-related facilities in the region, including both pipeline and facility rights of way as well as decommissioned and abandoned facilities.

Rights of way consist of land along pipelines and around other oilfield infrastructure which are, by law, owned and managed by oil companies to facilitate easy access for routine maintenance as well as emergency response. SPDC practice is for rights of way around facilities to be fenced, while those along pipelines are kept clear of habitation and vegetation but not fenced. In most cases pipelines are buried. Rights of way act as buffer zones between oil facilities and local communities, so that any incident, such as an oil spill or fire, does not impinge directly upon areas of human habitation. In any well-functioning oil industry operation, maintaining rights of way is both essential to and indicative of good environmental management.

On the whole, maintenance of rights of way in Ogoniland is minimal, arising in part from the fact that the oilfield has been closed since 1993 and access for the operator is somewhat limited. The entire gamut of oil operations in Ogoniland took place on soil which is very productive. This means that, unless regularly maintained, the land on which oil facilities and rights of way are located can very quickly become overgrown with vegetation. There are several locations within rights of way where lack of maintenance is evident and of serious concern.

Habitation on or close to oilfield facilities

The UNEP team observed that the oilfield in Ogoniland is interwoven with the Ogoni community, with many families living close to oilfield facilities. In some cases it is unclear whether the settlements came before or after the oil installations. This is true for both pipeline rights of way and rights of way to facilities.

A house constructed on a well pad (Yorla 9, Khana LGA)

A traditional house, made from combustible material, adjacent to a pipeline (Ebubu Obolo, Eleme LGA)

In at least one instance, at Yorla 9, the assessment team came across a family that had built its house within metres of the oil well, on the well pad itself. The family, with very young children, was also using the land around the well pad, within the oil well right of way, for farming. This observation is disturbing in many ways. To begin with, from a safety point of view, especially where children are concerned, it is wholly inappropriate that the family home is located so close to the wellhead. An immediate hazard is that the children may fall and drown in the (currently unprotected) well pit around the wellhead. Moreover, surrounding the well site are a number of other mud and water pits which, even if uncontaminated, are also potential hazards to both children and adults. In addition, the family is unprotected from fire, which is not unusual at disused oil wells in Ogoniland.

In some locations the project team observed buildings very close to rights of way; indeed in extreme cases the right of way itself had ceased to exist owing to the construction of farms and houses along it. An entire village of the Hausa community, for instance, lies along what appears to be a flare pipeline next to a flow station. Furthermore, the Hausa houses are made of readily combustible materials.

With respect to pipeline rights of way, three concerns arise:

- Communities living very close to or on rights of way are at personal risk from pipelines which are operational. While there is no obvious day-to-day danger from buried pipelines, where there are open well pads the potential for oil spillages and associated fire could put vulnerable communities at risk, both physically and legally

- As communities along rights of way go about their daily lives, the possibility that some of their activities may inadvertently cause an accident cannot be ruled out. Drilling of a well for drinking water or digging out a septic tank, for example, can both cause damage to a pipeline which may result in a leak, leading to a fire and possible explosion, endangering workers as well as the neighbouring community

- The establishment of a community or individual homes on or close to a right of way defeats the very object of the right of way and prevents rapid access to the facility should an accident needing specialist intervention occur

Chief Vincent Kamanu at part of an SPDC facility overgrown with vegetation (Gio, Tai LGA)

That communities have been able to set up houses and farms along pipeline rights of way is a clear indication of the loss of control on the part of both the pipeline operator and the government regulator. This is a serious safety breach. In addition, other poor and marginalized families may follow suit and construct their own houses within rights of way of other oilfield facilities.

Unmanaged vegetation

The project team observed overgrown wellheads and pipeline rights of way at several sites. In some cases, excessive vegetation growth prevented access by the UNEP team.

While overgrown vegetation does not cause an immediate danger to the facilities, there are concerns. Firstly, a small spill around the facility or on the right of way may not be noticed as quickly as it would be in a cleared area. This may, in turn, lead to a fire, causing damage to the facility, the vegetation and the local community.

Dense vegetation at these sites also indicates a lack of regular attention from the operator. This in turn will encourage encroachment by individuals wishing either to make use of the site for building or farming, or to tap into the facility. Consultations with SPDC on this matter revealed that in a number of situations where there appeared to be a lack of control, the pipelines were listed as "abandoned" and no longer operational. However, no information was available on whether these facilities were decommissioned following international best practice in terms of site remediation or, literally, abandoned. It is not uncommon in many pipeline abandonments for oil to remain in the pipeline. Until such time that pipelines – and associated rights of way – are closed down in a professional manner, they will continue to pose potential risks to the community.

Facilities not in operation

Some oil facilities that are no longer in operation have never been formally decommissioned and abandoned. Left without maintenance and exposed to the elements in a coastal region these facilities are vulnerable to corrosion. In the specific context of Ogoniland, where site security is at best irregular and unauthorized access commonplace, such facilities are highly prone to damage.

Visits to a number of facilities confirmed this understanding. Most alarming was the situation at Bomu flow station in K-Dere. When the UNEP team first visited this location, the fences (since fixed) were broken and oil contamination was visible within the site. Given that the area around this facility is densely populated, this is a very serious situation from the point of view of both community safety and security of the facility.

Conditions such as these at oilfield facilities indicate a lack of control on the part of the operators. In a properly maintained facility, a flow station should be secure, with no oil on the ground and minimal fugitive emissions.

Decommissioned and abandoned facilities

In any oilfield operation some assets are routinely decommissioned when they no longer serve a productive purpose, or are no longer economically viable. Typically, such assets are first operationally abandoned by decoupling them from the main infrastructure, mothballed (left without maintenance) and at an appropriate time properly decommissioned. SPDC has internal guidelines on 'Well and Field Assets Abandonment Standards and Strategy'.

In the case of Ogoniland, the situation is rather more complex. Because SPDC departed the Ogoni oilfield in an abrupt and unplanned manner, within a volatile security context, a number of resources were left abandoned even though that was not the intention. Decisions were taken subsequently to abandon other facilities. In fact, records show that a number of facilities were abandoned prior to the 1993 close-down.

While the SPDC database shows a number of pipelines and assets referenced as "abandoned" or "decommissioned", the way in which some facilities were left does not seem to have adhered to SPDC's own standards. UNEP's reconnaissance routinely came across oilfield resources which had evidently been abandoned in an uncontrolled fashion. This varied from pipelines left open and lying in trenches (possibly deserted midway through pipe-laying operations), to oil facilities left standing but without subsequent maintenance. The bottom line is that the current state of the abandoned facilities of oil field structure in Ogoniland do not meet with international best practices.

A view of the Bomu flow station (K-Dere, Gokana LGA)

Abandoned oil field infrastructure (Bodo West, Bonny LGA)

The abandoned facilities in Ogoniland pose both environmental and safety risks. From an environmental point of view, there is no indication as to whether the various containers lying around are full or empty, or what they contain(ed). Corrosion of metallic objects leads to ground contamination by heavy metals. Attempts by criminal elements to recover objects for sale as scrap may lead to safety risks, both on and off oilfield sites, while children playing on these facilities also face health risks.

Well blowouts

'Blowout' is oil industry terminology for a situation in which control of a well is lost during drilling or operation. More frequent during drilling, blowouts lead to the release of hydrocarbons (crude oil, produced water and associated gas) into the environment. Often, the mixture will catch fire and burn until such time as the well is brought back under control – a process which may take weeks or even months if control is to be achieved by the drilling of a relief well. Although the Ogoniland oilfield has been closed since 1993, formation pressure, corrosion and illegal tapping can cause wells to blow out, leading to oil spills and fires.

The UNEP team witnessed one such incident in 2006 during aerial reconnaissance of Ogoniland. A massive fire was raging at the Yorla 13 oil well and apparently continued burning for over a month. Such fires cause damage to the vegetation immediately around the well site and can produce partly burned hydrocarbons that may be carried for considerable distances before falling on farmland or housing.

No blowouts were reported during the main field period of UNEP's assessment in 2009 and 2010.

The control and maintenance of oilfield infrastructure in Ogoniland is clearly inadequate. Industry best practice and SPDC's own documented procedures have not been applied and as a result, local communities are vulnerable to the dangers posed by unsafe oilfield installations. The oil facilities themselves are vulnerable to accidental or deliberate tampering. Such a situation can lead to accidents, with potentially disastrous environmental consequences.

An oil well on fire (Yorla 13, Khana LGA)

The cumulative impact of artisanal refining puts significant environmental pressure on Ogoniland

4.2 Field observations concerning illegal oil-related activities

Illegal tapping of oil wells and pipelines

Bunkering is an oil industry term for supplying oil to a ship for its own use. In Ogoniland (and the wider Niger Delta) this term refers to the illegal tapping of oil industry infrastructure with a view to procuring oil illegally.

A number of defunct SPDC oil wells are located in the Ogoniland creeks. However, the wells still contain oil and are self-flowing, such that by operating the well valves, crude oil (along with gas and water) can be produced. During one visit the assessment team observed a group of people tapping into these wells and transferring oil to small boats. This happened in broad daylight, without any apparent hesitation, even in the presence of the UNEP team. The oil collected was either transferred to larger boats for onward shipment or used locally for illegal artisanal refining (see following section).

SPDC informed UNEP that by November 2010 all the wells had been sealed and capped. No further tapping was observed by the UNEP team during subsequent visits.

Similarly, there are SPDC and NNPC pipelines through Ogoniland that still carry crude oil. There are frequent reports of these pipelines being tapped illegally, in some cases leading to spills and fires. Though UNEP did not directly observe such incidents on the ground, this does not mean that such incidents did not take place during UNEP's fieldwork period. As there are no externally visible signs while pipelines are being tapped for oil (unlike the highly visible artisanal refining – see next section) and access to sites always had to be negotiated days in advance, only with precise intelligence and community support would it be possible to observe live operations.

Artisanal refining

The process of artisanal refining typically involves primitive illegal stills – often metal pipes and drums welded together – in which crude oil is boiled and the resultant fumes are collected, cooled and condensed in tanks to be used locally for lighting, energy or transport. The distilleries are heated on open fires fed by crude oil that is tipped into pits in the ground. As part of the oil burns away, some seeps into the ground. A typical artisanal refinery may comprise just one operating still and the entire refinery may be no more than 100 square metres in area. Others, however, are much bigger, containing multiple stills operating simultaneously. Stills are always located at the water's edge, primarily to facilitate the transportation of both the crude oil and refined products. The crude is usually stored in open containers or open pits, increasing the risk of fire.

Artisanal refining of crude oil has a tradition reaching back to the Biafran War, when the Biafran Government advocated the development of low-tech refineries in Biafra to make up for the loss of refining capacity during the course of the conflict. The same low-tech methods of refining continue in the Niger Delta to the present day and hundreds of artisanal refineries are to be found along the creeks. Their presence is obvious, even from a distance, marked by dark plumes of smoke rising from the fires. The practice represents a huge environmental, health and safety problem.

Owing to security constraints, UNEP could only observe live refining operations from the air. Once refining operations are complete, those taking part usually leave their tools on site, presumably with the intention of returning at a later date. It was evident to the UNEP surveyors that the operation is run on a very small scale, with minimal investment.

For reasons that could not be determined, the number of artisanal refineries has proliferated in Ogoniland since January 2009. Satellite images of the region taken in January 2009 and again in January 2011 show the increase in this activity (Map 10).

Aerial view of artisanal refining site (Bodo West, Bonny LGA)

Map 10. Satellite images give evidence of the increase in artisanal refining between January 2009 (left) and January 2011 (right)

Aerial view of a typical artisanal refining site in operation (Bodo West, Bonny LGA)

UNEP is fully aware that unemployment and the absence of new job opportunities in the region may drive some of the local community members to take up this occupation. There is a high risk of self-harm from artisanal refining – a large number of accidents, fires and explosions on refining sites claim dozens of lives every year, quite apart from the longer-term health effects of ingestion, absorption and inhalation of hydrocarbons. Given the circumstances under which these refineries operate (regularity of the practice; dozens of workers to be transported in and out, accommodated and fed; huge smoke plumes above the distilleries all day indicating the locations even from a distance, etc.), it is hard to understand why no action is taken by the local and regional authorities, police, army or navy to stop the practice.

While the footprint of individual artisanal refining operations is localized, the cumulative impact exerts a significant environmental stress on Ogoniland. The main problems are:

- clearance of coastal vegetation when setting up an illegal artisanal refinery, leaving land vulnerable to erosion
- contamination of soil and groundwater in the immediate vicinity
- damage to surrounding vegetation from fire and smoke
- spread of pollution beyond the refinery area – any crude left behind after the refining process can be picked up by higher tides and transported over a wider area
- contamination of water in the creeks and coastal and mangrove vegetation, as well as soil exposed to layers of oil at low tide
- air pollution – those involved in the artisanal refining process are at high risk of exposure to extreme levels of hydrocarbons, which can have both acute and chronic impacts, while the smoke blowing from the area can adversely affect entire communities

Although the impacts of each illegal refinery are small, the cumulative effect risks an environmental catastrophe, the costs of which would far outweigh the short-term economic benefits derived. Unless artisanal refining of crude oil is brought to a swift end through effective regulatory action, in conjunction with developmental and educational initiatives, it has the capacity to cause further serious damage to the ecosystem and livelihoods of the coastal communities in Ogoniland and beyond.

The fact that these operations are ongoing and proliferating in full view of the enforcement agencies is indicative, at best, of a lack of effective preventive measures and, at worst, of collusion.

4.3 Geological observations

The geological profile of Ogoniland, including the depth and quality of groundwater, is a key factor when assessing contaminated sites. Soil type and grain-size distribution are crucial to the mobility of crude oil in soils and to the groundwater conditions that determine the spread of contamination plumes.

Soil

For soil sampling, UNEP drilled some 780 boreholes to depths of up to 5 metres, along with a further 180 boreholes down to a maximum of 14 metres for groundwater monitoring. In addition, UNEP had access to one deeper borehole of 50 metres, drilled by a local contractor. Based on the data from approximately 960 boreholes, the soil properties in Ogoniland can be described reasonably well.

Figure 7 presents a number of logs of soil sectioned from north to south in Ogoniland. The southernmost point lies on the edge of the creeks at an elevation of 1.5 metres above sea level, while the northernmost point lies 20.6 metres above sea level.

Three observations are evident from this profile: (i) the shallow geology of Ogoniland is highly variable with wide variations over short distances; (ii) the shallow formations range from gravelly sand to clay and everything in between; and (iii) there is no continuous clay layer across Ogoniland. This information itself is not surprising. No uniform layering can be assumed for Delta sediments, as erosion and deposition from the rivers' side arms cause vertical and lateral discontinuities that provide pathways for the migration of liquid hydrocarbons and contaminated groundwater. The diversity of soil types and the extent of sedimentary layers on drilling sites showed little lateral correlation.

Groundwater

Of the 180 groundwater monitoring wells drilled by UNEP in Ogoniland, a topographic survey was conducted for 142. The shallowest observed water

Figure 7. Soil logs from across Ogoniland, along with groundwater depths

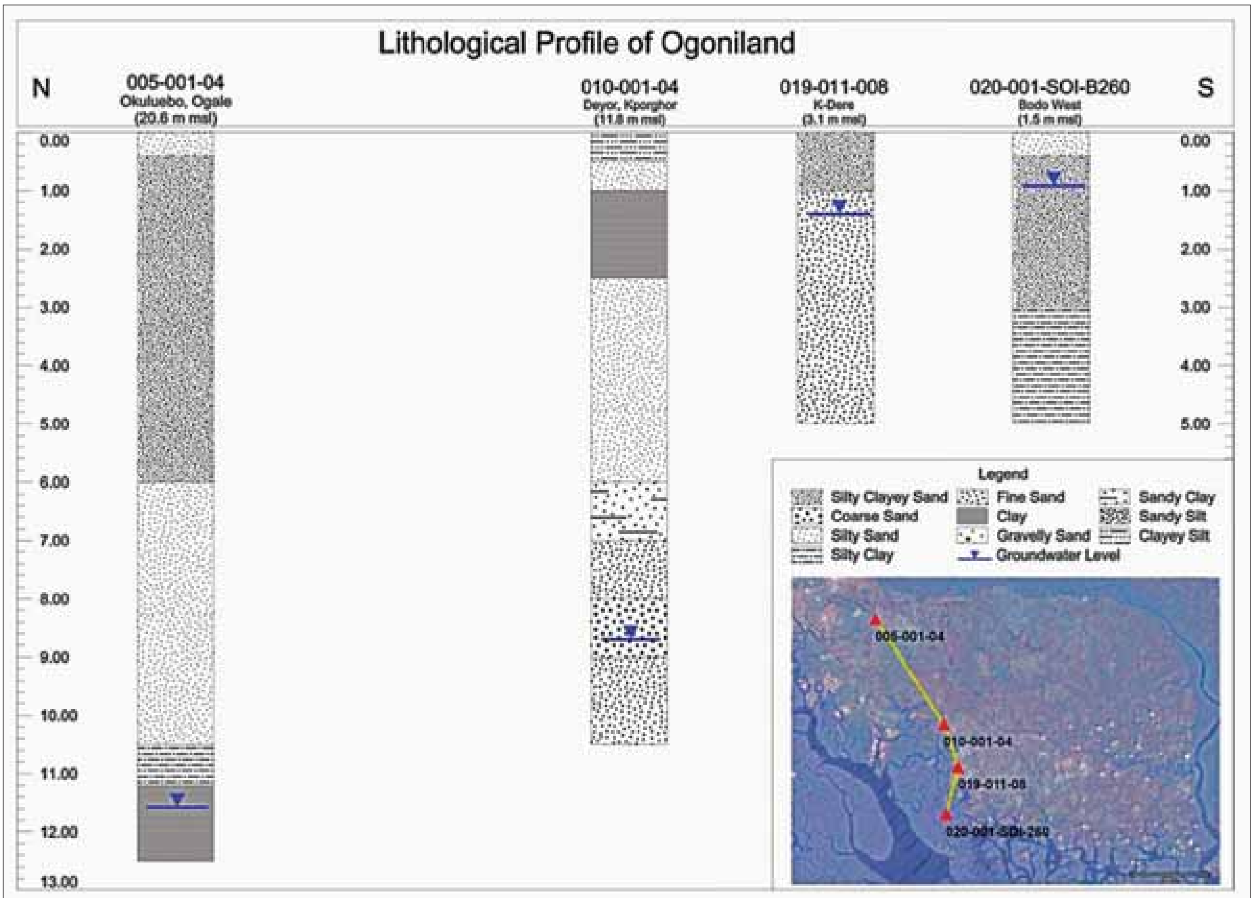
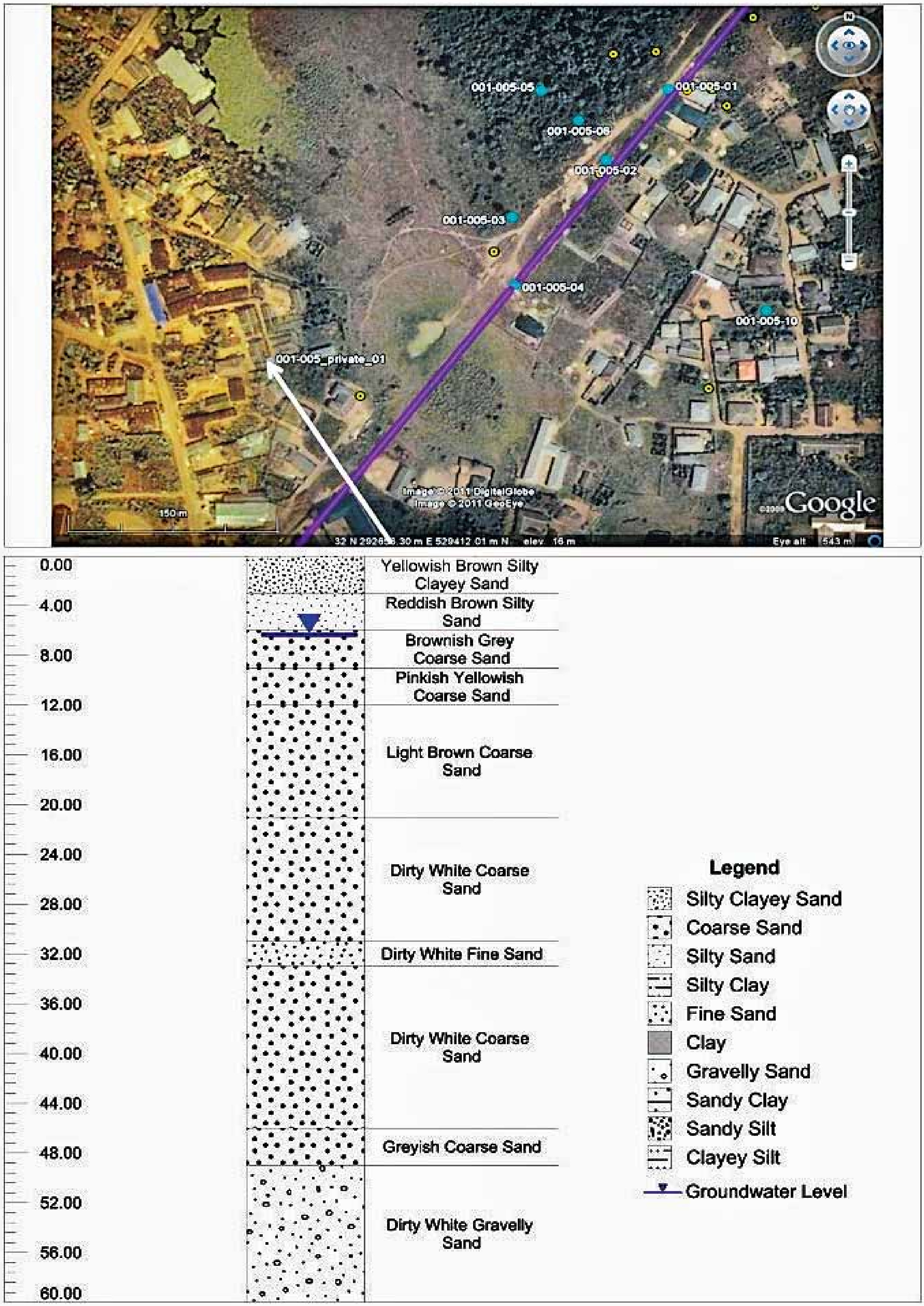


Figure 8. Soil logs from Nsioken Agbi Ogale, Eleme LGA



level was 0.7 metres below ground level while the deepest was 14 metres below ground level.

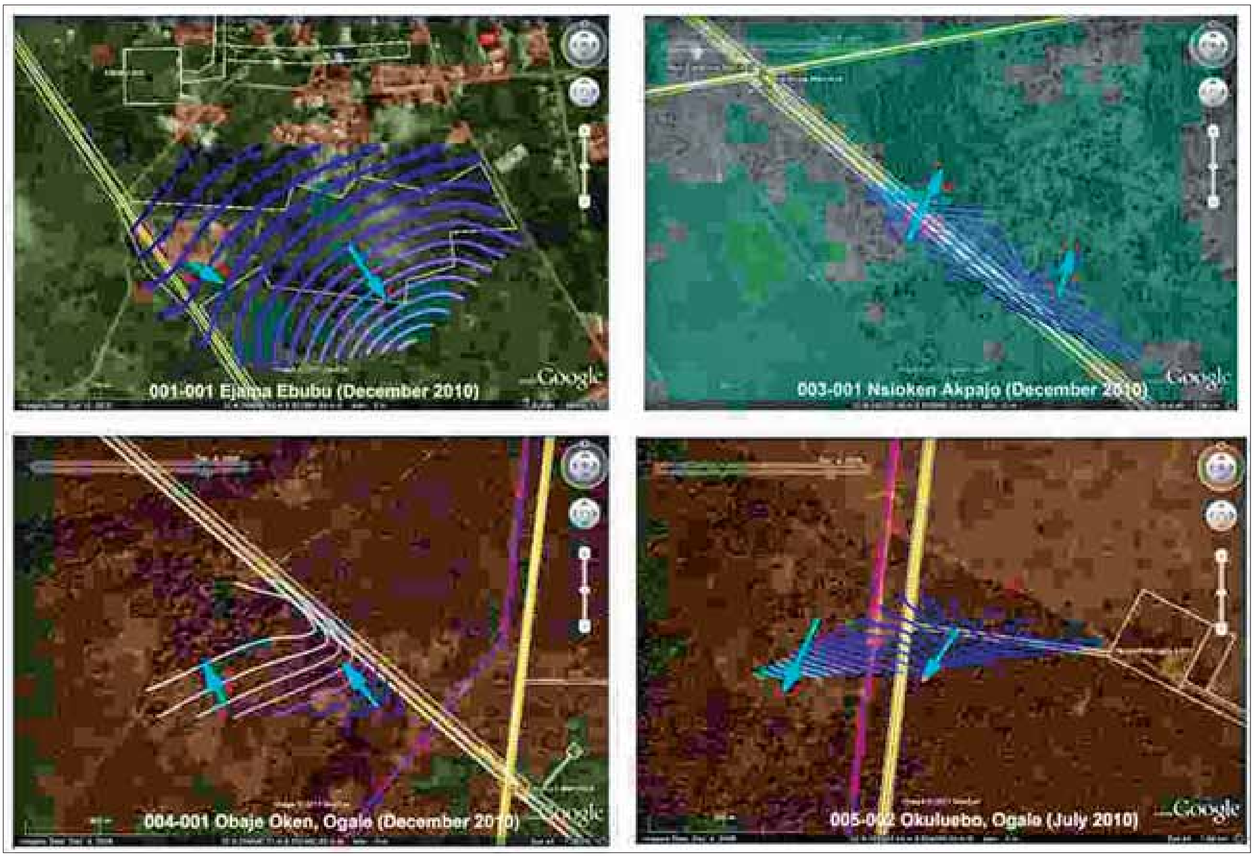
Figure 7 shows the profile of groundwater on a north-south cross section, in which the depth of the water table varies with the prevailing land profile. The groundwater situation in Ogoniland is typical of a delta environment. In areas close to the creeks, the water table lies close to surface. In intertidal areas in the mangrove zones, the groundwater level rises and falls with the tidal rhythm, while in the interior there are localized swamps into which groundwater drains. The water table fluctuated seasonally in all wells, especially those furthest from the coast.

UNEP technical assistant and Rivers State university students collecting groundwater samples

While investigating groundwater contamination at one site, UNEP came across a family drilling deeper boreholes to obtain clean water. Here, the opportunity was taken to obtain a deeper geological profile of the area (Figure 8). The geological profile indicated that there is indeed only one aquifer, which is being tapped by both shallow wells and deeper boreholes. As impermeable layers of clay are highly localized in Ogoniland, interconnectivity with underlying aquifers could not be excluded any of the sites investigated.

While no general flow direction was detected of groundwater in Ogoniland, the flow was typically directed towards the nearest creek or swamp (Figure 9).

Figure 9. Variable groundwater flow direction in Ogoniland (blue arrows indicate flow direction)



4.4 Contamination assessments

Soil and groundwater contamination

As discussed in Chapter 3, the study investigated 69 different sites for contamination of soil and, where possible, groundwater. Samples of soil were taken at multiple locations within each site, and at each sampling location within a site, samples were taken at multiple depths. Groundwater samples were taken either from dedicated wells drilled for that purpose or from boreholes made to take soil samples.

The sites investigated fall into the following groups:

- SPDC pipeline rights of way
- SPDC legacy sites (e.g. abandoned facilities)
- Suspended SPDC facilities (e.g. wells, flow stations and manifolds never formally abandoned)
- NNPC crude oil pipelines
- NNPC product lines

Table 16 provides a summary of the sites investigated, categorized into the above groupings. At a number of locations within Ogoniland, NNPC pipelines and SPDC pipelines share rights of way. In such instances these were classified as SPDC pipelines, though it was not evident if the spill investigated originated from an SPDC or NNPC crude pipeline.

Table 16. Summary of sites investigated in the various categories

Site classification	Number
SPDC pipeline rights of way	34
SDPC legacy sites	6
Suspended SPDC facilities	22
NNPC crude oil pipelines	2
NNPC product line	3

Two further sites were investigated in detail: an artisanal refinery site and a 'fly-tipping' site (i.e. where waste of unknown origin was being disposed of within Ogoniland).

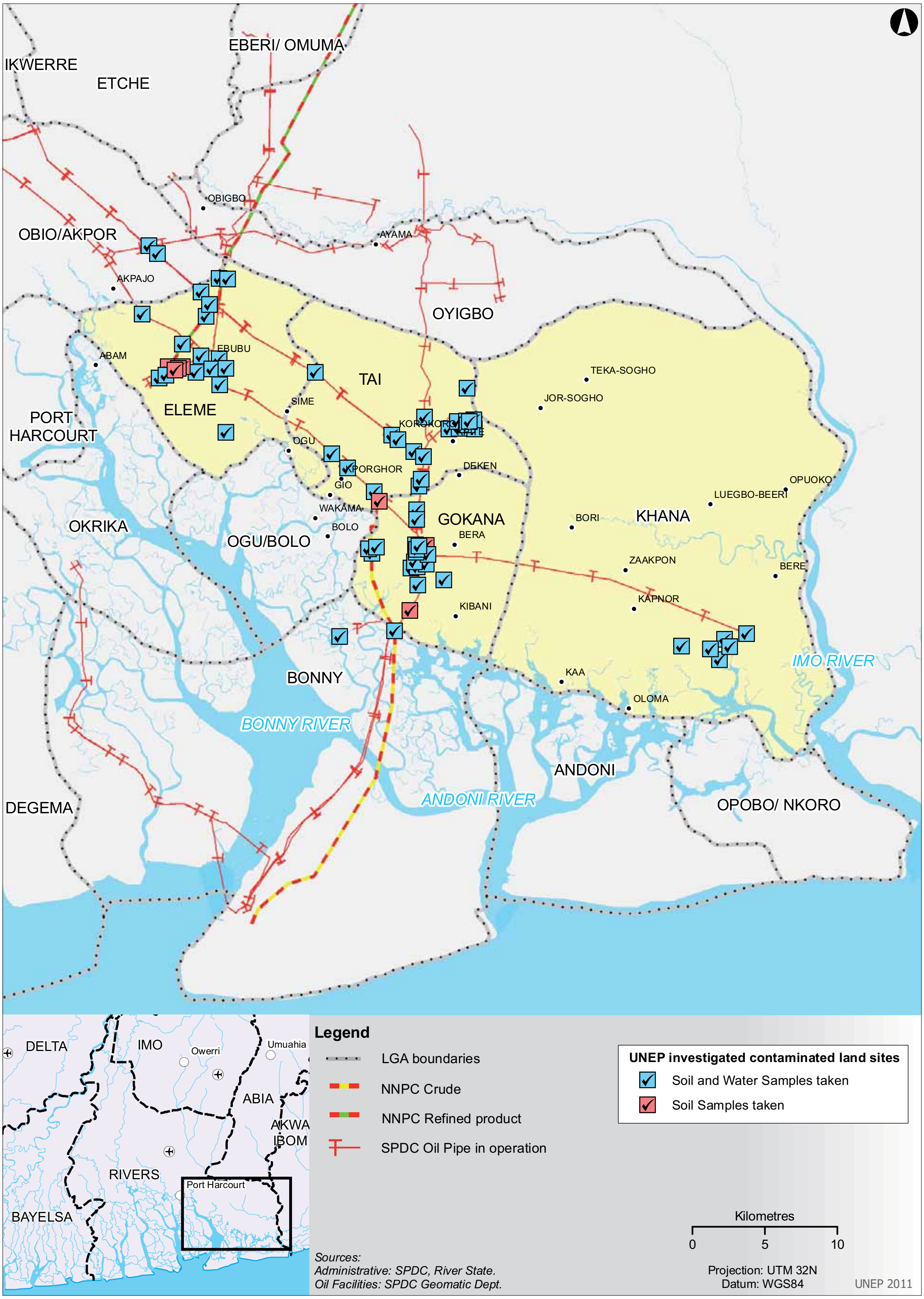
The locations of the sites investigated are presented in Map 11. All sites were investigated for hydrocarbon contamination in soil, while groundwater was investigated where it was possible to reach the groundwater table.

In the following section, findings from representative sites in each of the above categories are presented as case studies. The studies serve to illustrate the prevailing environmental situation in Ogoniland. For each of the sites, site-specific observations, results and conclusions are given, along with site-specific recommendations. Information on all other sites is then presented in tabular form. Taken together, this information provides an overview of the nature and extent of hydrocarbon contamination in Ogoniland.

To accompany this summary report, individual reports for 67 of the sites investigated have been prepared. Each report contains site-specific information on soil profiles, soil and groundwater contamination, proximity to community and depth of penetration of hydrocarbon contamination, concluding with site-specific recommendations. Together, the reports amount to more than 1,000 pages. They will be submitted to both SPDC and the Government of Nigeria and will be available online to interested stakeholders. The supporting database, complete with the analytical data, will also be made publicly available.

The recommendations given in this report are meant to achieve immediate risk reduction. However, prior to initiating comprehensive clean-up, consultation with the regulators, risk assessments and community consultations need to be undertaken during the next phase of the project.

Map 11. Location of soil investigations site along with groundwater sampling



Case study 1 SPDC pipeline right of way – 001-001 Ejama-Ebubu, Eleme LGA

Site description. Ejama-Ebubu is probably the most infamous of the oil spill locations in Ogoniland, the original spill occurring here during the Biafran War more than 40 years ago. There have been multiple spills and clean-up attempts since.

The Ejama-Ebubu spill site is situated in the Ejama-Ebubu community, Eleme LGA. Here, the 20-inch Rumuekpe manifold to Bomu manifold trunk line and the 28-inch Rumuekpe to Bomu trunk line run parallel from north-west to south-east. The initial pipeline right of way had a width of 25 metres. After the original spill and the ensuing fire, an area of 85,000 square metres was surrounded by a concrete block wall to the east of the pipeline. Although the contaminated area has been secured, much of the wall has collapsed and, with no guards present, uncontrolled access is possible at all times.

Land use. Prior to the oil installation the land appears to have been a combination of agricultural holdings and swamps. The nearest housing areas are approximately 300 metres east of the 1970 spill point and less than 20 metres north of the compound wall. The areas to the west and south are currently used for plantations of cassava (*Manihot esculenta*) and other crops. The swamp drains into a lagoon lined by trees with thick undergrowth to the west. The stream leaving the lagoon is still used by community members for washing, swimming and other purposes.

Spill and remediation history. During the Biafran War in 1970, the now abandoned Rumuekpe manifold to Bomu manifold trunk line was damaged. Crude oil spilled flowed downwards in an easterly direction into a lagoon approximately 200 metres east of the pipeline. From the lagoon the oil washed further into creeks, leading to contamination of downstream areas. Part of the area caught fire, evidenced by crusts of ash and tar or bitumen over the main contaminated area.

Community guide at Ejama-Ebubu, Eleme LGA

Table 17. Summary of results of soil and groundwater investigations at the Ejama-Ebubu site

UNEP site code	qc_001-001
Site name	**Ejama-Ebubu**
LGA	Eleme
Site description	SPDC pipeline right of way
Total Investigated Area (m^2)	169,712
Number of soil samples	92
Number of groundwater samples	15
Number of drinking water samples	2
Number of surface water samples	1
Deepest investigation (m)	6.00
Maximum soil TPH (mg/kg)	49,800
Number of soil measurements greater than EGASPIN intervention value	36
Deepest sample greater than EGASPIN intervention value (m)	6.00
Number of wells where free-phase hydrocarbon was observed	1
Maximum water TPH (µg/l)	485,000
Number of water measurements greater than EGASPIN intervention value	8
Presence of hydrocarbons in drinking water	No
Number of soil measurements below 1 metre	62
Number of soil measurements below 1 metre greater than EGASPIN intervention value	23
Total volume of soil above intervention value (m^3)	105,302
Total volume of soil above target value (m^3)	236,077

SDPC records show that other spills took place in 1992 and in November 2009. Multiple attempts at remediation have taken place. A mobile thermal desorption unit (TDU) was brought to the site but, according to anecdotal information from the community, it was never used. In 2006, a remediation contract was awarded and some excavation took place. Burnt and highly contaminated soil was moved to the sides of the area and deposited in two large piles, each of approximately 5,000 cubic metres, near the northern and southern walls of the site. The work was abandoned midway through, though no consistent explanation for this has been forthcoming from SPDC or the community. Apart from the measures described, no significant remediation activities have been undertaken, even though the spill is now over four decades old.

Visual observations on site. Preliminary site visits were carried out by UNEP in late 2009.

In the central and more heavily contaminated areas, large lumps of ash and tar are still present. In other places the soil is caked into crusts of dried crude oil. The heavily contaminated soil deposited at opposite ends of the site are not covered, allowing rainwater to infiltrate. Contaminants leaching from piles of soil form oily sheens and slicks on pools of water and on flowing water, which eventually ends up in the lagoon.

On dry days, the sun heats up the piles of contaminated sand, liquefying the oily and asphalt components, thus remobilizing them into the underlying soil.

During the rainy season, the water level of the lagoon rises by more than 1 metre, washing the oily residues further downstream.

There is no control of surface water runoff, so that contaminated leachate is able to enter and pollute surface waters leaving the area.

Sample analysis. A number of soil and groundwater samples were collected. A summary of the contamination detected is presented in Table 17. Results of soil analyses are presented in Map 12. Where a number of samples were taken at a given location (at multiple depths), the weighted average of the contamination is used. The higher values along the north-west edge are from the contaminated soil that was dug and piled up in that area during an earlier clean up attempt.

Conclusions. Although the spill is over 40 years old and repeated clean-up attempts have been made, contamination is still present at the site. The observed levels of contamination are higher than Nigerian Government standards and SPDC's specifications. Natural attenuation processes have not reduced pollution to acceptable levels. There are two possible reasons for this. Firstly, the area is so heavily contaminated that biological processes alone have not been able to break down the hydrocarbons without active human intervention. Secondly, the presence of a surface crust from burning and/or the piling up of the most contaminated spoils have prevented biodegradation.

In addition to spreading laterally, pollution has spread vertically, contaminating more soil and reaching the groundwater.

Considering the size of the area, the quantity of pollution remaining and the fact that it is very close to human habitation, urgent intervention is warranted with respect to remediation of soil, groundwater and the creeks. Moreover, given the gravity of the pollution and the fact that contamination extends to a ground depth of more than 5 metres, the standard SPDC approach of *in situ* remediation by enhanced natural attenuation (RENA) will not be appropriate at this location.

Site-specific recommendations:

1. The impacted area should be demarcated and appropriate signage erected to indicate that the site is heavily polluted; similar signage should be placed in affected swamps and creeks
2. Where community land is impacted, inhabitants should be informed
3. A community-based security and surveillance system should be put in place to ensure compliance with the restrictions introduced to protect public health
4. The site should be reworked to prevent runoff from the area reaching downstream swamps
5. Runoff from the area should be monitored and if necessary treated while the clean-up initiative is being developed
6. Monitoring of well water should be introduced to act as early warning for surrounding communities not yet impacted by groundwater pollution emanating from the site
7. Prior to site clean-up, additional soil sampling, along with the excavation of trial pits, should be carried out to delineate the area requiring treatment
8. A detailed plan should be prepared for (i) clean up of the contaminated soil and (ii) risk reduction at the site. Additional guidance on clean-up of contaminated soil is provided in Chapter 6.
9. A detailed plan should be prepared for (i) clean up of the contaminated water and (ii) risk reduction in the community. Additional guidance on clean-up of contaminated water is provided in Chapter 6.
10. During the clean-up, excavation water should be carefully managed to ensure that pollutants do not escape into the environment.

A summary table of contamination at other sites investigated along the SPDC pipeline right of way is presented in Table 17. From the summary presented in the table, the following key observations can be made:

1. At 22 of the 33 investigated sites along SPDC pipeline rights of way, soil contamination exceeded the limits set by Nigerian national legislation
2. At 19 of these 22 locations, contamination extended deeper than 1 metre (i.e. below the area reached by RENA treatment)
3. At 19 of the 33 sites, groundwater pollution exceeded the intervention values set in Nigerian legislation (EGASPIN)
4. At five of the investigated sites hydrocarbons were detected in the drinking water used by neighbouring communities

Detailed results from the investigation at these sites, including spill history, contamination contours and presence of sensitive receptors, along with site-specific recommendations, are presented in the site fact-sheet available online.

Map 12. Contamination values for Total Petroleum Hydrocarbons at Ebubu-Ejama site, Eleme LGA

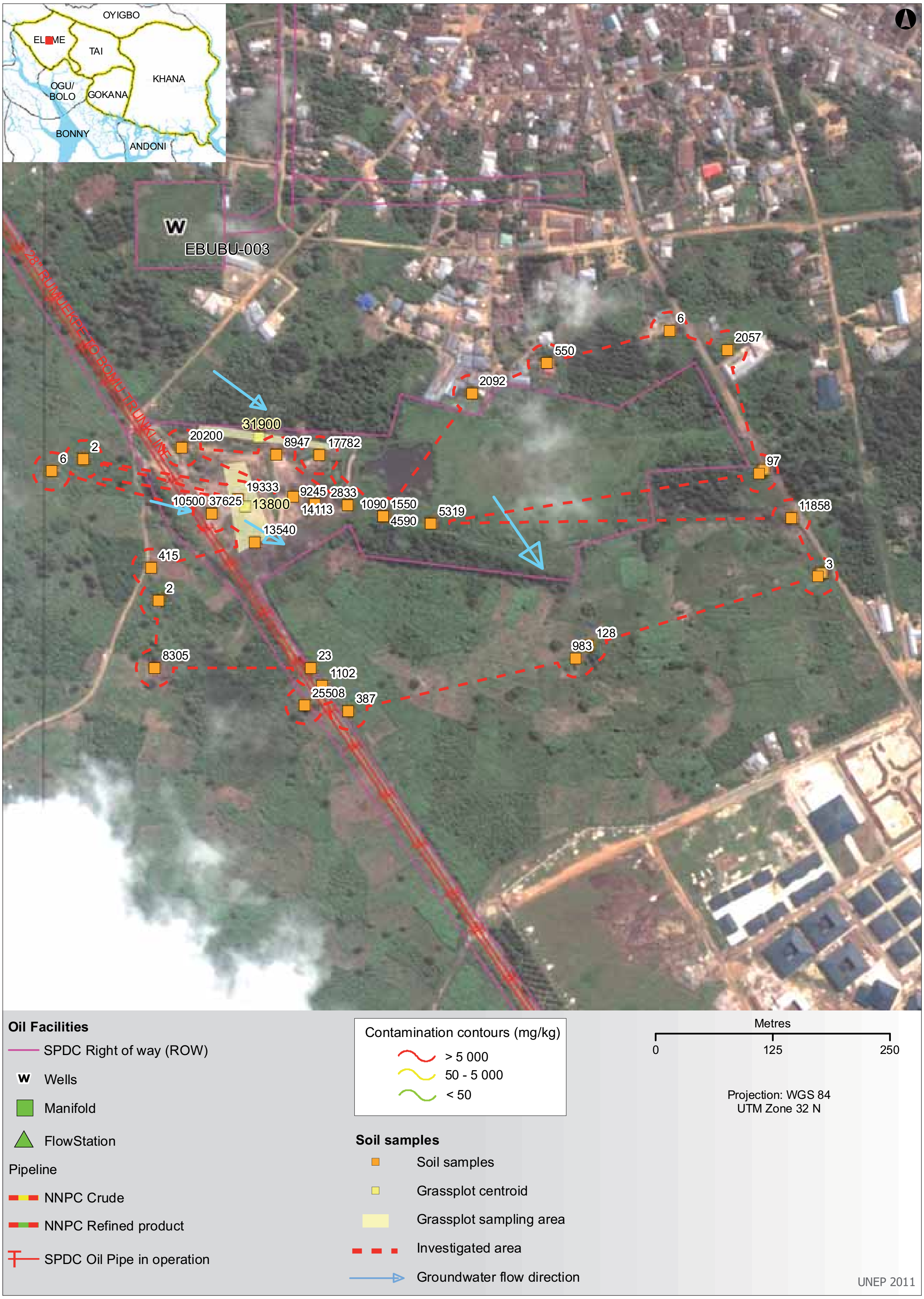


Table 18. Summary of contamination of investigated sites along SPDC pipeline rights of way

UNEP site code	LGA	Number of soil samples	Number of groundwater samples	Deepest soil investigation (m)	Maximum soil TPH (mg/kg)	Number of soil measurements >EGASPIN	Deepest soil sample >EGASPIN (m)	Maximum water TPH (ug/l) (CL samples)	Hydrocarbons in community wells	Number of water TPH measurements >EGASPIN	Number of samples with TPH >EGASPIN below 1 m
qc_013-002	Tai	48	10	5	9,200	7	5	1760000		5	6
qc_012-001	Eleme	132	10	5	36,900	17	5	133000		5	14
qc_009-006	Tai	62	2	5	12,300	4	3	162000		1	3
qc_009-003	Tai	1	1	8.5	645			53.1	yes		
qc_005-009	Tai	68	5	6.5	2,930			26900	yes	2	
qc_003-005	Obio/Akpor	13	1	5	629			9540		1	
qc_002-002	Eleme	43	4	3.8	4,220			16500		4	
qc_019-045	Bonny	11	3	3.4	1,400			277000		1	
qc_019-044	Gokana	30	4	5	9,990	1	2	109000		3	1
qc_019-020	Gokana	70	7	5	52,200	18	5	29600	yes	7	13
qc_019-002	Gokana	27	5	5	34,500	10	4	32000		2	7
qc_019-001	Gokana	18	8	2.5	10,400	1	2.5	116000		6	1
qc_010-009	Tai	9	1	2	5,620	1	1.2				1
qc_010-004	Tai	38	8	5	36,200	4	4	543			2
qc_009-010	Tai	274	4	5	34,100	63	5	1140000		3	48
qc_005-002	Eleme	42	7	11.8	8,580	11	3.08	2740000		3	9
qc_004-004	Eleme	6	1	2.58	3,740						
qc_003-002	Eleme	23		3	13,400	3	3	91.7			2
qc_003-001	Obio/Akpor	77	13	8	3,680			427			
qc_002-004	Eleme	4	3	2.32	126			11600		1	
qc_002-003	Eleme	7	2	9	15,300	1		25100		1	
qc_008-008	Tai	45	4	5	567			10			
qc_009-004	Tai	125	5	5	23,100	51	5	74700		2	45
qc_019-006	Gokana	46		5	2,640			10			
qc_010-005	Gokana	18		5.2	10,500	5	4.6				4
qc_010-001	Tai	58	5	10	6,210	3	5	130000		2	2
qc_019-009	Gokana	27		5	43,600	10	5	15	yes		7
qc_019-007	Gokana	4		5.1	14,600	4	5.1	43900		2	4
qc_004-001	Eleme	151	16	5.2	7,570	2	2.6	1720000		9	2
qc_002-009	Eleme	7		2	7,370	1	0.5				
qc_002-007	Eleme	16		3	5,810	1					
qc_002-006	Eleme	46		5.2	11,100	5	4				4
qc_001-009	Eleme	51	4	5	841			12	yes		

Case study 2 SPDC suspended facilities – Bomu Manifold, K-Dere, Gokana LGA

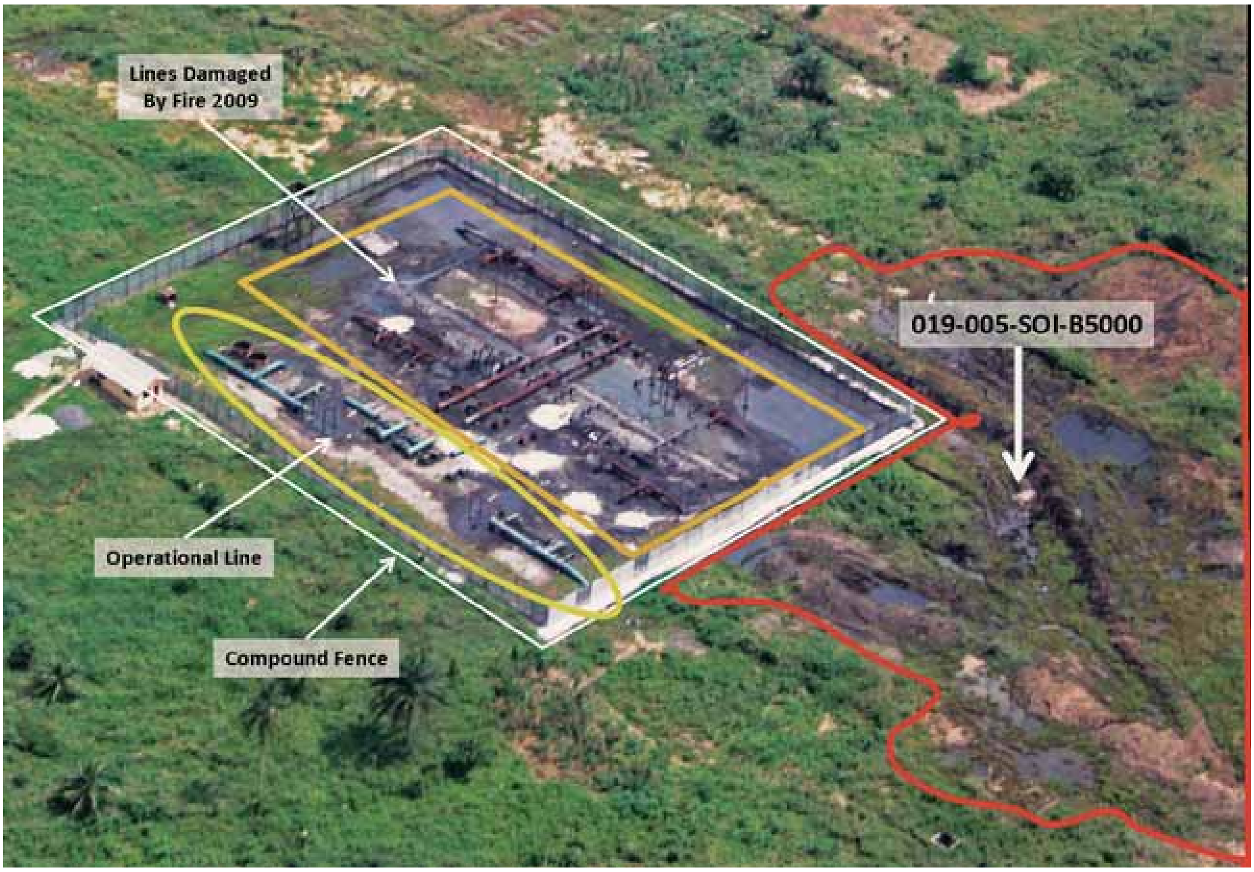
Site description. The Bomu manifold is situated to the east of K-Dere and Kpor in Gokana LGA. It connects five northbound pipelines (28-inch Rumuekpe to Bomu trunk line; 20-inch Rumuekpe manifold to Bomu manifold trunk line; 24-inch Nkpoku to Bomu trunk line; 12-inch Egberu manifold to Bomu trunk line; 36-inch Rumuekpe to Nkpoku trunk line) to four southbound pipelines (disused 6-inch Yorla to Bomu trunk line; 10-inch Bomu flow station to Bomu tie-in manifold delivery line; 24-inch Bomu to Bonny trunk line; 28-inch Bomu to Bonny trunk line).

The manifold covers an area of 5,000 square metres. It is surrounded by a 3-metre high wire-mesh fence with two separate gates, both of which are wide enough to provide access for heavy machinery. The site is currently guarded by SPDC staff and armed army personnel. Access is possible only with a permit issued by SPDC.[3]

Most of the pipes and manifold infrastructure are above ground. Outside the manifold area, pipes run below ground.

The area inside the fence is visibly heavily polluted with crude oil, which is seeping through the fence and contaminating several thousand square metres of soil outside the complex. There is no trench or perimeter drain system around the manifold.

Land use. The nearest inhabited houses are approximately 220-250 metres to the west in K-Dere. A primary school and a local community health-care centre are located some 300 metres to the north-west of the manifold and an abandoned house lies about 100 metres to the south. The area immediately bordering the manifold to the north and east is covered by a cassava plantation. No grazing animals were observed on the site. An old flow station, reportedly damaged during the Biafran War and later decommissioned, is located 150 metres to the east, while a



Arial view of the Bomu manifold (K-Dere, Gokana LGA)

3 The fence was mended and security provided after the initial UNEP site visit.

newer flow station, also inoperative but only partly decommissioned, lies 90 metres to the west. The Bomu 1 and Bomu 24 wellheads are situated 80 metres to the north-west and 160 metres to the south-west, respectively.

Spill history. At the time of the sampling visits, in August and December 2010, half of the infrastructure was scorched and inoperative. Local community members reported that a fire had occurred in April 2009 following an oil spill on the Trans-Niger Pipeline, which transports 120,000-150,000 barrels per day through Ogoniland. Information about the amount of oil spilled, the duration of the leakage and the duration of the fire were not available; local community members mentioned that the fire lasted "several days". Workers on the manifold stated that since the fire only one of the two pipelines leading into and out of the manifold was operating.

Other spills in the manifold occurred in October 1990 (twice), February and March 2001 and January and October 2003.

According to SPDC information, two remediation projects have been completed in the Bomu manifold area in the past, while for the latest spill a two-tier assessment and contracting process were under way.

Visual observations on site. Most of the manifold area inside the fence is covered in oily residues, soot and ash. Oil is seeping from the concrete seal through the fence into the surrounding area. The extent of the contamination covers the manifold area itself and an additional 19,000 square metres of land outside the manifold. Of this, some 9,000 square metres are heavily polluted, the concentration of oil on the surface being above saturation, resulting in an oily sheen on pools of standing water and a strong oily smell. Some of the still operational pipes are leaking and the oil collected from them is stored in an open container with a volume of approximately 10 cubic metres.

A small trench leading south from the manifold is heavily contaminated with oil. It leads into a small collection pond covering an area of approximately 600 square metres adjacent to the abandoned house south of the manifold, before continuing to connect with a small creek that flows south towards Bodo. Next to the abandoned house the sampling team found an open, hand-dug well in which the groundwater was approximately 1 metre below surface level, the same level as groundwater found in the monitoring wells on the site.

In the cassava plantation to the east, the plants appear to be somewhat inhibited in their growth and overall health.

Sample analysis. A summary of the soil and groundwater investigations is presented in Table 19.

The highest soil contaminations, at 63,600 mg/kg TPH, were found in the top 0.60 metres of a borehole in the most heavily contaminated area directly bordering the southernmost part of the manifold (019-005-SOI-B5000). This is extremely high and is far above the EGASPIN intervention value of 5,000 mg/kg. Contamination gradually decreased with depth until at 4-5 metres below ground surface (bgs) concentrations fell below 20,000 mg/kg (Figure 10).

Conclusions. While the site is currently fenced, environmental contamination is migrating both laterally and vertically. The measured hydrocarbon values significantly exceed the EGASPIN intervention values for both soil and groundwater and therefore intervention and risk reduction measures are needed for both.

A small portion of crude oil has gathered in a collection pond, with runoff seeping from the site via a trench leading southwards into the creeks. The trench is heavily contaminated and will need to be excavated and cleaned up.

Free phase oil and contaminated soil should have been removed in the days immediately after the spill and fire, as this would have prevented the lateral and vertical spread of the pollution. Nearly two years after the incident, still nothing appears to have been done, enabling the contamination to spread further, thereby increasing the extent and cost of the remediation effort.

There are definite signs of crude oil-related groundwater contamination in the whole manifold area. Continued emission of petroleum-related contaminants needs to be halted immediately to reduce risks to the surrounding communities.

Since there is no systematic drainage collection system in place around the manifold, crude oil is being washed off into the surrounding fields. At the time of UNEP's field visits, fresh crude oil was found in a trench leading southwards. During the rainy season in particular, runoff from the manifold is contaminating surrounding areas. Considering the seriousness of the pollution and the fact that contaminants have penetrated to a depth of 5 metres or more below ground surface, the standard SPDC approach of *in situ* RENA will not be appropriate at this location.

Table 19. Summary of results of soil and groundwater investigations at the Bomu Manifold site, Gokana LGA

UNEP site code	qc_019-005
Site name	Bomo Manifold
LGA	Gokana
Site description	SPDC operating site
Area Investigated (m^2)	37,988
Number of soil samples	56
Number of groundwater samples	5
Deepest investigation (m)	5.00
Maximum soil TPH (mg/kg)	63,600
Number of soil measurements greater than EGASPIN intervention value	21
Deepest sample greater than EGASPIN intervention value (m)	5.00
Maximum water TPH (µg/l)	3,410
Number of water measurements greater than EGASPIN intervention value	1
Presence of hydrocarbons in surface water	yes
Number of soil measurements below 1 m	38
Number of soil measurements below 1 m greater than EGASPIN intervention value	17
Total volume of soil above intervention value (m^3)	38,257
Total volume of soil above target value (m^3)	62,775

Site-specific recommendations:

1. The impacted area should be demarcated and appropriate signage erected to indicate that the site is heavily polluted; similar signage should be placed in the impacted drains
2. Where community land is impacted, inhabitants should be informed
3. The site should be reworked to prevent runoff from the area into downstream areas
4. Runoff should be monitored and if necessary treated while the clean-up plan is being developed
5. Monitoring of well water should be introduced to provide an early warning mechanism for surrounding communities not yet impacted by groundwater pollution emanating from the site
6. Prior to site clean-up, additional soil sampling, along with excavation of trial pits, should be carried out to delineate the area requiring treatment
7. A detailed plan should be prepared for (i) clean up of the contaminated soil and (ii) risk reduction at the site. Additional guidance on clean up of contaminated soil is provided in Chapter 6
8. A detailed plan should be prepared for (i) clean up of contaminated water and (ii) risk reduction at the site. Additional guidance on clean-up of contaminated water is provided in Chapter 6
9. During the clean-up, excavation water should be carefully managed to ensure that pollutants do not escape into the environment

Figure 10. Vertical profile of contamination at 019-005-SOI-B5000

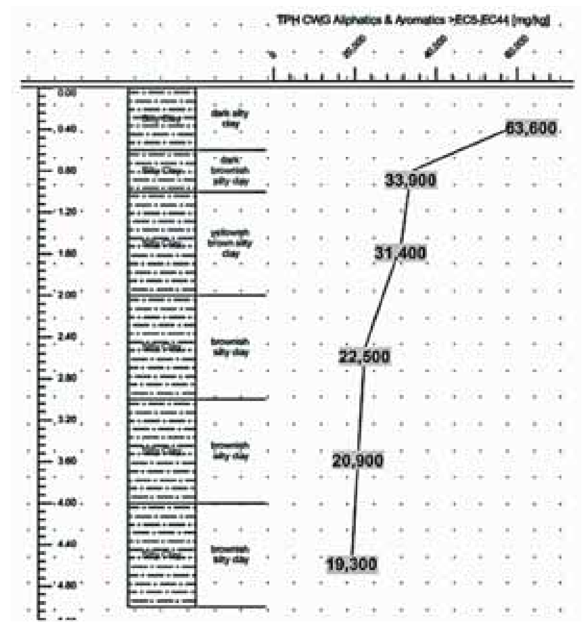


Table 20. Summary of contamination of investigated SPDC suspended facilities

UNEP site code	LGA	Number of soil samples	Number of groundwater samples	Deepest soil investigation (m)	Maximum soil TPH (mg/kg)	Number of soil measurements >EGASPIN	Deepest soil sample >EGASPIN (m)	Maximum water TPH (ug/l) (CL samples)	Hydrocarbons in community wells	Number of water TPH measurements >EGASPIN	Number of samples with TPH >EGASPIN below 1 m
qc_019-014	Gokana	16	2	3.2	389			11,500	yes	2	
qc_019-021	Gokana	26		5	7,620	2	3				2
qc_009-002	Tai	44	2	5	1,040			10,900		1	
qc_008-002	Tai	58	2	5	1,880			42,800	yes	1	
qc_007-001	Eleme	58	3	6	442			10			
qc_019-035	Gokana	16	1	2.6	3,480			10,300	yes	1	
qc_019-032	Gokana	21	2	2.2	1,220			49			
qc_019-010	Gokana	32	5	5.2	139,000	5	2	172,000		5	1
qc_019-004	Gokana	18	1	5	23,200	8	2.6	32			4
qc_015-003	Khana	36		3	8,830	1	1.5	10			1
qc_015-002	Khana	45	2	5	20,400	3	3.5	288			3
qc_015-001	Khana	42	2	3.5	8,200	5	3	358,000		1	2
qc_014-004	Khana	18	3	2.6	198			519			
qc_014-001	Khana	24	2	2.6	157			2,140		1	
qc_008-007	Tai	75	1	7.4	11,200	25	5.6				22
qc_008-004	Tai	72	2	5	4,860			47			
qc_008-003	Tai	127	2	5.2	10,800	9	5	22,600		2	9
qc_001-002	Eleme	25	4	3	10,400	6	3	1,980	yes	3	3
qc_001-004	Eleme	8	4	6.5	533			13,200		2	
qc_008-010	Tai	60	3	5	6,700	5	5	360			5
qc_008-009	Tai	53	2	5	4,030			1,180,000		1	

A summary of contamination at other SPDC suspended facilities investigated by UNEP is presented in Table 20. From the summary presented in the table, the following key observations can be made:

1. At 10 of the 21 UNEP-investigated sites along SPDC suspended facilities, soil contamination exceeded the limits set by Nigerian national legislation
2. At all 10 of these locations, contamination penetrated deeper than 1 metre below the surface (i.e. below the area targeted by RENA)
3. At 11 of the 21 sites, groundwater pollution exceeded the intervention value set in Nigerian legislation
4. At four of the investigated sites, hydrocarbons were detected in drinking water used by neighbouring communities

Case study 3 SPDC legacy site – 008-010 Korokoro flow station

Site description. Korokoro flow station is situated in Bue Mene community, Korokoro, less than 100 metres from the nearest inhabited houses, less than 250 metres from a school and within 500 metres of a fish farm. There are two wellheads (Korokoro 4 and Korokoro 8) immediately adjacent to the flow station, which is surrounded by a mostly damaged fence. Access control is non-existent, such that both wellheads are unsecured and easily accessible.

Land use. The flow station covers approximately 7,000 square metres. Parts of the site are used for cassava plantations. Approximately 50 per cent of the surrounding neighbourhood consists of housing with fruit and vegetable gardens. The rest of the surrounding area is covered by about 20,000 square metres of bush and forest, as well as plantations of cassava and other crops.

Spill history. Five oil spills at the flow station were recorded by SPDC: in July 1986, in August, September and December 1989 and in January 1990. No spills were reported at the wellheads.

Visual observations on site. The area of the flow station is overgrown with small trees, shrubs and undergrowth. The infrastructure, including gas-liquid separators and oil-water separators, is still in place. All technical installations appear not to have been cleaned before the station was shut down. Outside the flow station, approximately 100 metres to the east, a rectangular depression of some 200 square metres indicates the area formerly used for gas flaring. Superficial soil contamination could be seen here, as well as in the cassava plantation about 100 metres to the north-east, where three of the spill incidents were reported.

Sample analysis. A summary of the soil and groundwater investigations is presented in Table 21.

The soil contamination data are presented in contour form in Map 13.

Investigation of the soil and groundwater showed evidence of significant soil contamination in the flow station area, with the wellhead areas also contaminated by TPH. Soil TPH concentrations reached a maximum of >14,000 mg/kg in the topsoil, with concentrations of 5,000-6,000 mg/kg found at 4-5 metres depth in the centre of the contaminated area, where three of the spills were reported; sampling from two boreholes demonstrates how variably contamination is distributed in the soil in this area (Table 22).

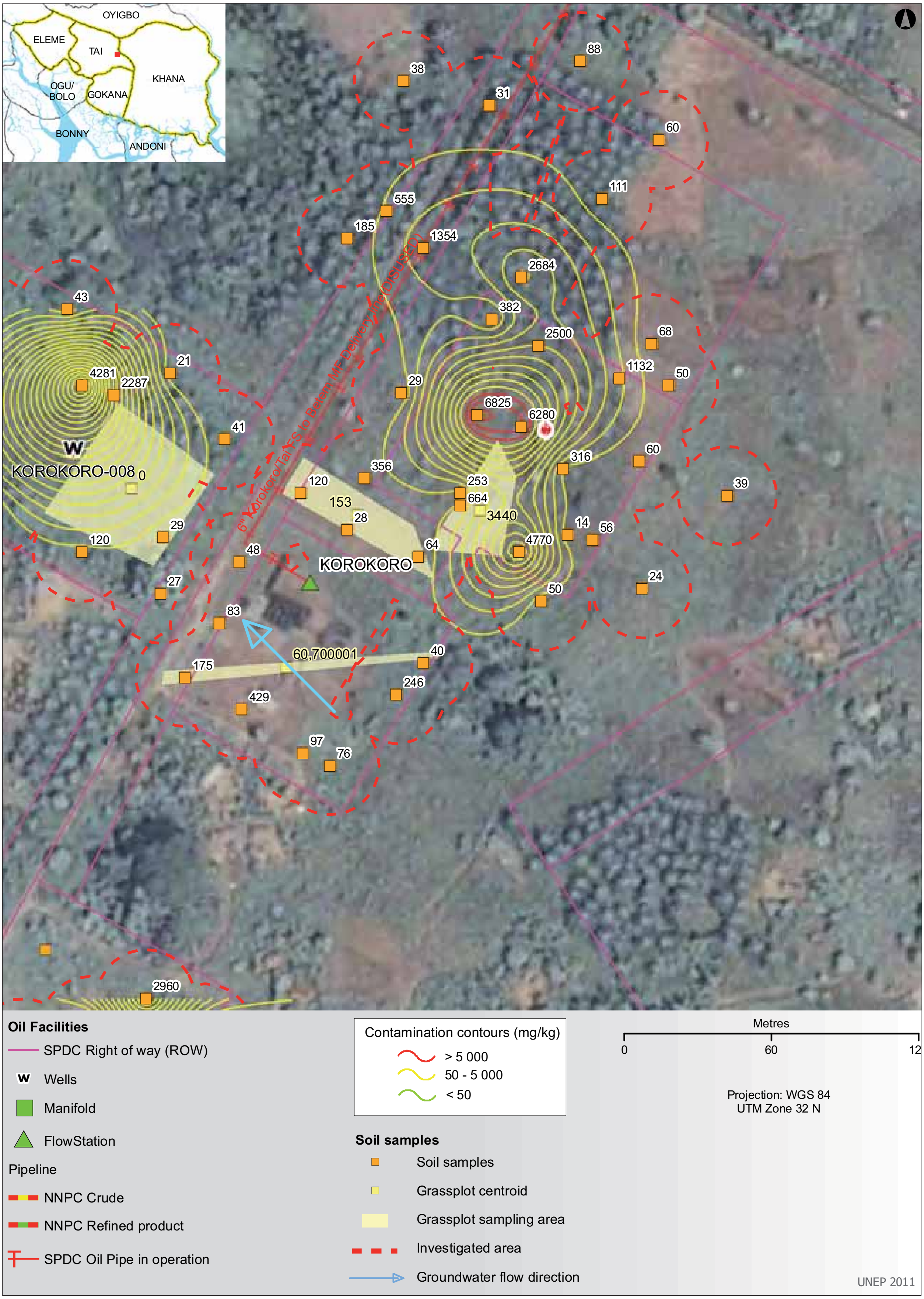
Borehole B180 was drilled in an area where oil had spilled onto the ground and seeped down to the maximum sampling depth of 5 metres, at which depth the concentration of TPH was 6,530 mg/kg. Borehole B600, drilled 20 metres away from B180, showed no detectable contamination down to 1 metre deep. Below one metre, TPH contamination reached 13,500 mg/kg, slowly decreasing to 5,430 mg/kg at a depth of 5 metres.

The high level of TPH at 5 metres shows not only that the upper soil profile does not retain contamination, thus facilitating vertical migration, but also that crude oil is able to reach greater depths. Sample B600 thus demonstrates how deceptive uncontaminated surface soil can be in relation to contamination at greater depths.

Table 21. Summary of results of soil and groundwater investigations at the Korokoro flow station, Tai LGA

UNEP site code	qc_008-001
Site name	**Korokoro flow station**
LGA	Tai
Site description	SPDC legacy site
Investigated area (m^2)	41,052
Number of soil samples	204
Number of groundwater samples	4
Number of drinking water samples	4
Deepest investigation (m)	5.20
Maximum soil TPH (mg/kg)	14,200
Number of soil measurements greater than EGASPIN intervention value	13
Deepest sample greater than EGASPIN intervention value (m)	5.00
Maximum water TPH (µg/l)	769
Number of water measurements greater than EGASPIN intervention value	2
Presence of hydrocarbons in drinking water	no
Number of soil measurements below 1 m	171
Number of soil measurements below 1 m greater than EGASPIN intervention value	12
Total volume of soil above intervention value (m^3)	3,390
Total volume of soil above target value (m^3)	48,501

Map 13. Contamination contours at Korokoro Well 8, Tai LGA



Given human smell detection levels for petroleum hydrocarbons of between 200 and 500 mg/kg, the average human being would probably not notice the contamination in the top 1 metre of soil around the B600 sampling location.

General conclusions. Considering that the oil spills took place between 1986 and 1990, natural attenuation, or biodegradation of contaminants, has not proven effective in reducing contaminant concentrations to safe levels in the affected area. Remediation of the whole area is advisable but this has apparently never been carried out, even though pipeline rights of way on the site are currently being used for agricultural purposes. Superficial decontamination by enhanced natural attenuation – so far the only remediation method observed by UNEP in Ogoniland – will not solve the environmental problems at this site. Contamination reaches to a depth of at least 5 metres below ground surface, and areas that are apparently uncontaminated at the surface may be highly contaminated underground.

Table 22. Vertical Profiling of TPH concentrations in Korokoro flow station, Tai LGA

Soil sampling borehole	Depth interval (m)	TPH (mg/kg)
008-010 B180	0.0-0.4	14,200
	0.4-1.4	6,810
	1.4-2.6	6,020
	2.6-4.0	5,630
	4.0-5.0	6,530
008-010 B600	0.0-0.7	433
	0.7-1.0	285
	1.0-2.0	13,500
	2.0-3.0	6,460
	3.0-4.0	5,620
	4.0-5.0	5,430

Site-specific recommendations:

1. The impacted area should be demarcated and appropriate signage erected to indicate that the site is heavily polluted
2. The site should be reworked to prevent water from pooling and infiltrating downwards, carrying oil with it
3. Monitoring of well water should be introduced to provide an early warning for surrounding communities not yet impacted by groundwater pollution emanating from the site
4. The flow station should be decommissioned following industry best practice
5. Prior to site clean-up, additional soil sampling, along with excavation of trial pits, should be carried out to delineate the area to be treated
6. A detailed plan should be prepared for (i) clean up of the contaminated soil and (ii) risk reduction at the site. Additional guidance on contaminated soil clean-up is provided in Chapter 6
7. A detailed plan should be prepared for (i) clean-up of the contaminated water and (ii) risk reduction at the site. Additional guidance on contaminated soil clean-up is provided in Chapter 6
8. During the clean-up, excavation water should be carefully managed to ensure that pollutants do not escape into the environment

A summary of contamination in the SPDC legacy sites investigated by UNEP is presented in Table 23. From the summary presented in the table, the following key observations can be made:

1. At four of the five SPDC legacy sites investigated by UNEP, soil contamination exceeds the limits set in Nigerian national legislation
2. At three of these locations, contamination has penetrated more than 1 metre below the ground surface (i.e. below the area targeted for treatment by SPDC)
3. At four of the five sites, groundwater pollution exceeded the intervention values set in Nigerian legislation

Table 23. Summary of contamination of investigated SPDC legacy sites

UNEP site code	LGA	Number of soil samples	Number of groundwater samples	Deepest soil investigation (m)	Maximum soil TPH (mg/kg)	Number of soil measurements >EGASPIN	Deepest soil sample >EGASPIN (m)	Maximum water TPH (ug/l) (CL samples)	Hydrocarbons in community wells	Number of water TPH measurements >EGASPIN	Number of samples with TPH >EGASPIN below 1 m
qc_016-001	Khana	85	13	5.2	8,820	2	0.4	77,000		3	
qc_019-033	Gokana	6		2	331			10			
qc_009-001	Tai	21	6	3	9,030	2	2	213,000		4	1
qc_005-001	Eleme	35	3	9	9,220	6	3	3,590		2	6
qc_019-012	Gokana	49	3	5	29,600	11	5	588,000		4	11

Case study 4 NNPC trunk line spill – 019-013 1990 pipeline leak in K-Dere

Site description. Approximately 2 km west of K-Dere in Gokana LGA, the 24-inch NNPC Bonny to Port Harcourt Refinery trunk line runs in a north-south direction transporting crude oil from Bonny Terminal to the Port Harcourt Refinery. The pipeline right of way is neither secured nor guarded and is easily accessible via a 150-metre dirt track off the main tarmac road leading out of K-Dere to the west.

Land use. To the west of the spill site is a forest area of approximately 60,000 square metres. The areas to the east and south are used for cassava and palm tree plantations.

Spill history. The pressurized pipeline ruptured catastrophically in 1990, killing three workers at the site. Local community members accompanying UNEP reported that oil from the pipeline was sprayed high into the air, contaminating many tens of thousands of square metres. Aside from the 1990 incident, no other spills have been reported from this site.

Visual observations on site. The spill site itself, extending over approximately 1,000 square metres, is obvious from the covering of ash and slag generated by the ensuing fire. An area of some 5,000 square metres immediately around the spill point is devoid of all vegetation. Oil crusts can be seen on the soil surface in the surrounding areas. The soil is hydrophobic, such that rain falling onto the ground hardly infiltrates.

The bare soil is prone to erosion and this has carved out gullies leading into a nearby small tidal creek north-west of the blowout point. The assessment team estimated that sediment in the creek is highly contaminated over an area of 20,000 square metres.

The contamination in the immediate vicinity of the spill was never remediated, as suggested by the soil sampling results.

NNPC trunk line spill (K-Dere, Gokana LGA)

Table 24. Summary of results of soil and groundwater investigations at the K-Dere NNPC pipeline rupture site, Gokana LGA

UNEP site code	qc_019-013
Site name	**NNPC pipeline rupture**
LGA	Gokana
Site description	NNPC crude pipeline
Investigated area (m^2)	40,348
Number of soil samples	52
Number of groundwater samples	4
Number of surface water samples	1
Number of free-phase water samples	1
Number of CL sediment samples	1
Deepest investigation (m)	5.50
Maximum soil TPH (mg/kg)	32,600
Number of soil measurements greater than EGASPIN intervention value	13
Deepest sample greater than EGASPIN intervention value (m)	5.00
Maximum water TPH (µg/l) (CL samples)	5,650
Number of water measurements greater than EGASPIN intervention value	2
Presence of hydrocarbons in sediment (CL) above EGASPIN intervention value	yes
Total volume of soil above intervention value (m^3)	4,818
Total volume of soil above target value (m^3)	26,843

Sample analysis. A summary of the investigations is shown in Table 24.

Soil contamination data are presented in contour form in Map 14.

The vertical profile of contamination is also of interest (Table 25). The main contaminants were TPH, with maximum concentrations of 32,600 mg/kg at a depth of 0-0.10 metre in sample B5000 and 28,300 mg/kg at a depth of 2-3 metres in sample B5010.

Table 25. Vertical profiling of contamination at the NNPC pipeline rupture site, Gokana LGA

Soil sampling borehole	Depth interval (m)	TPH (mg/kg)
019-011-SOI-B5000	0-0.10	32,600
	0.10-0.50	20,200
	0.50-1.00	11,000
	1-2	7,060
	2-3	10,300
	3-4	10,400
	4-5	10,100
019-011-SOI-B5010	0-0.40	16,900
	0.40-1	12,900
	1-2	9,720
	2-3	28,300
	3-4	21,300
	4-5	12,600

The sediment sample 019-011-SED-5000, taken from the creek, proved to be highly contaminated, laboratory results showing TPH at 32,600 mg/kg. The gas chromatography (GC) fingerprint of the oil at a depth of 2-3 metres was identical with that found in the sediment from the creek, proving the linkage between source and impact (Figure 11a and 11b). The hydraulic connection between contaminated land and creeks will have important implications for the sequence of remediation to be carried out. Until the land-based contamination has been dealt with, it will be futile to begin clean-up of the creek as pollutants will continue to migrate towards the creek, re-contaminating water, sediments and vegetation.

Groundwater in this area has been impacted with TPH concentrations near the contamination centre reached 1,360 µg/l and 2,800 µg/l. However, the fact that this area is remote from nearby communities and the water is currently not used for irrigation give an opportunity to contain and clean up the contamination before potential receptors are reached through this pathway.

Map 14. Contamination contours at NNPC spill, K-Dere Gokana LGA

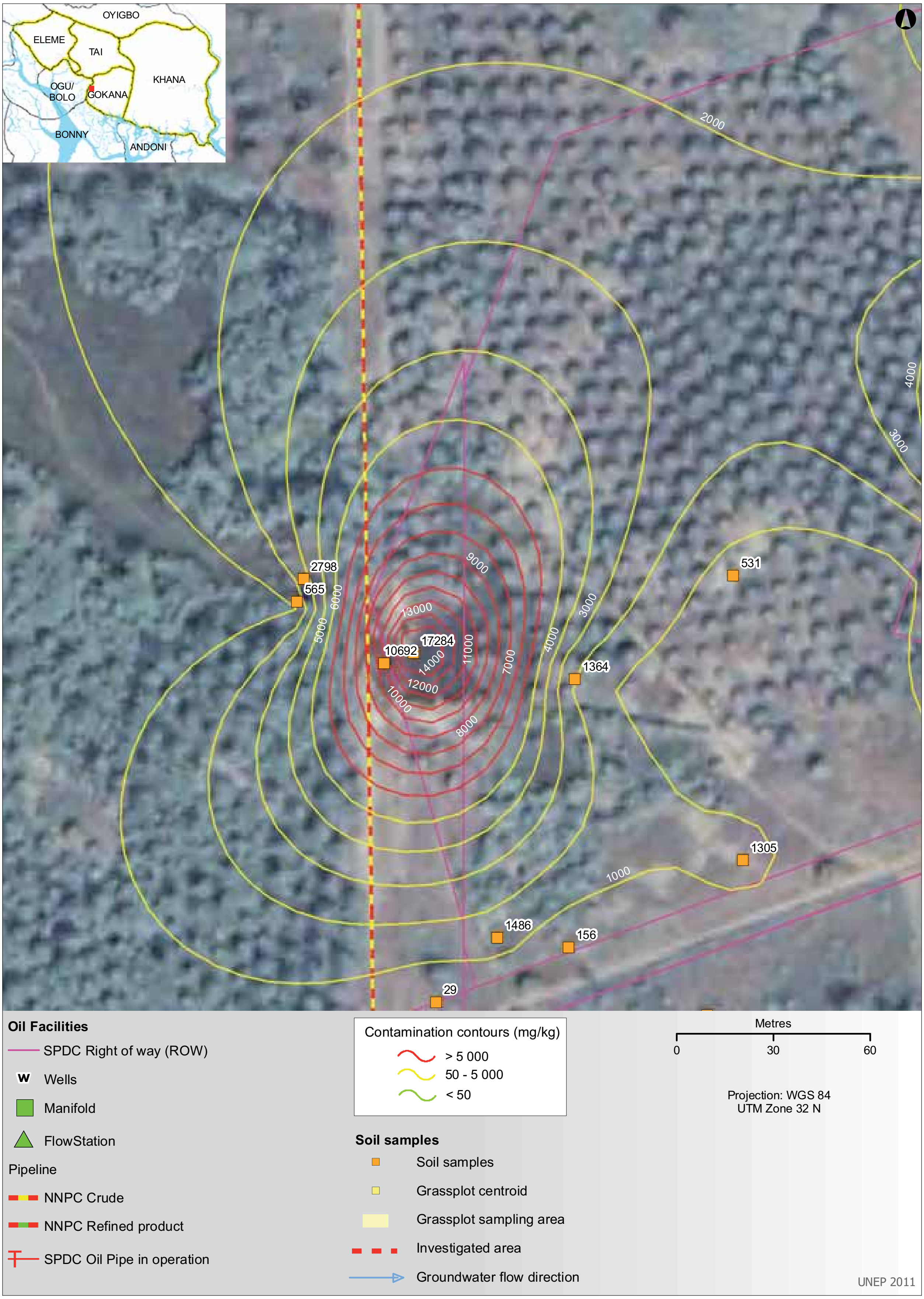
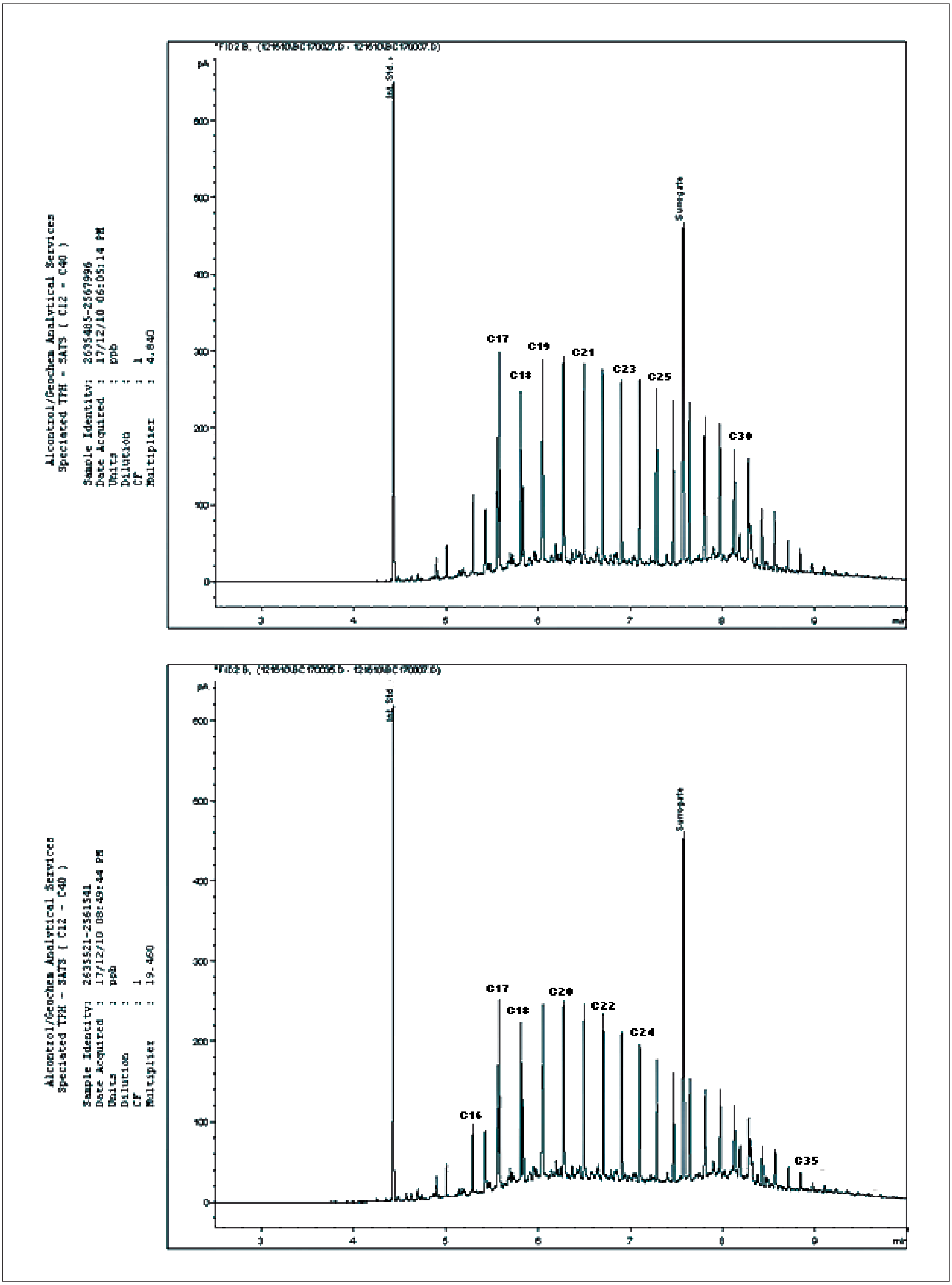


Figure 11a and 11b. Gas chromatography (GC) fingerprint of sample 019-011-SED-5000 at 0-0.1 metre depth (top) and sample 019-011-SOI-B5000 at 2-3 metres depth (bottom)



General conclusions. Soil contamination arising from the 1990 NNPC pipeline blowout impacted an extensive area. No effective remediation has taken place at either site, such that an area of approximately 5,000 square metres has been impacted and is devoid of any vegetation. Soil contamination extends to a depth of at least 5 metres.

The soil in the core affected area must be considered highly contaminated, based on the concentrations of hydrocarbons, and is currently unfit for any further use. The absence of any protective vegetation has led to soil erosion and heavy contamination – via transport and deposition of contaminated particles – of the adjacent creek and possibly the surrounding agricultural land. Direct runoff of oil for the duration of the rupture, and subsequent sub-surface transfer of contamination, also cannot be ruled out. Since the waters in the creek are tidal, the hydrocarbon coating of the sediment grains will be washed off or dissolved, or the sediment itself may be transported, leading to further downstream contamination.

UNEP investigations have shown that 20 years after the oil spill on this site, natural attenuation has not been effective.

Site-specific recommendations:

1. The impacted area should be demarcated and appropriate signage erected to indicate that the site is heavily polluted
2. The site should be reworked to prevent runoff from the area into the nearby creek
3. A leachate monitoring system and, if necessary, leachate treatment should be established
4. Monitoring of well water should be introduced to provide an early warning for communities not yet impacted by groundwater pollution emanating from the site
5. Prior to site clean-up, additional soil sampling, along with excavation of trial pits, should be carried out to delineate the area to be treated
6. A detailed plan should be prepared for (i) clean up of the contaminated soil and (ii) risk reduction at the site. Additional guidance on clean up of contaminated soil is provided in Chapter 6
7. A detailed plan should be prepared for (i) clean up of the contaminated water and (ii) risk reduction at the site. Additional guidance on clean-up of contaminated water is provided in Chapter 6
8. Further assessment of the creek should be carried out to map the extent of pollution and to decide whether it would be appropriate to undertake dredging at a later stage, once the contaminated land has been treated
9. During the clean-up, excavation water should be carefully managed to ensure that pollutants do not escape into the environment

A summary of contamination at the investigated NNPC pipeline site at K-Dere is presented in Table 26.

Table 26. Summary of contamination on the NNPC pipeline site

UNEP site code	LGA	Number of soil samples	Number of groundwater samples	Deepest soil investigation (m)	Maximum soil TPH (mg/kg)	Number of soil measurements >EGASPIN	Deepest soil sample >EGASPIN (m)	Maximum water TPH (ug/l) (CL samples)	Hydrocarbons in community wells	Number of water TPH measurements >EGASPIN	Number of samples with TPH >EGASPIN below 1 m
qc_019-046	Gokana	72	3	5	2,900			2,320		2	

Case study 5 NNPC product line spill – 001-005 Nsisioken Agbi, Eleme LGA

Site description. An NNPC product pipeline from Port Harcourt refinery runs to Umu Nwa Nwa through Nsisioken Agbi in Eleme LGA. The pipeline crosses a number of other pipelines at Nsisioken Agbi, including the SPDC-owned 28-inch Rumuekpe to Bomu trunk line, the 36-inch Nkpoku to New Ebubu (Oghale) trunk line and the abandoned 20-inch Rumuekpe manifold to Bomu manifold trunk line. The pipeline runs underground but is otherwise not secured and there are no signs or fences to indicate the route of the pipeline.

Land use. A number of houses have been built next to the pipeline over a linear distance of approximately 500 metres, the closest house being approximately 10-15 metres from the pipeline. All the houses in this area have fruit and vegetable gardens and water is taken from hand-dug wells or deeper boreholes. A sacred forest is located west of the spill site, covering approximately 45,000 square metres. An area of wetlands lies downhill to the south-west of the spill site, the water surface covering some 20,000 square metres in the dry season, rising to 100,000 square metres during the rainy season. A small cassava plantation is situated between the sacred forest and the wetland.

Spill history. The NNPC trunk line transports refined products, including gasoline and diesel or kerosene. No data on spills on NNPC pipelines were made available to the UNEP team. The spill investigated by UNEP was found during reconnaissance visits, together with community representatives, along known pipeline rights of way. According to local anecdotal information, the spill occurred around 2005 close to the area of housing, some 300 metres uphill from the wetland. Groundwater was contaminated to a distance of at least 600 metres from the source of the spill. A few residents claimed to have smelt oil in their drinking water.

Other spill incidents on this site have not been reported by local representatives. No additional data were available from NNPC.

Visual observations on site. A dirt road follows the trunk line downhill. Visible signs of spilled oil could be seen, such as dark crusts on the soil surface, as well as oily sheens on standing pools of water.

During test borehole drilling, especially close to the pipeline, an intense kerosene smell could be detected. Free-phase hydrocarbon was recovered from the drilled well.

Sample analysis. A summary analysis of the contamination is presented in Table 27.

Given that the nearby community draws water for drinking, cooking and washing from the area, the most important observation at this site was the presence of free-phase hydrocarbon on water at the source of the leak and the presence of dissolved hydrocarbons in the area. Most worrying, the water had very high concentration of benzene, a known carcinogen. In addition to methane, the samples also revealed the presence of methyl tertiary butyl ether (MTBE). MTBE is not a part of crude oil but an additive added to refined products at the refinery, so its presence proved that the spill was indeed that of a refined product (e.g. gasoline) rather than crude oil.

Soil contamination at the site is presented in contour form in Map 15.

General conclusions. Contamination of soil on the spill site extends over a wide area. Contaminants are being leached from the soil to the groundwater and transported over a distance of more than half a kilometre to community drinking water wells. Severe contamination of drinking water by toxic and carcinogenic substances presents an acute health hazard.

Site-specific recommendations:

1. The acute health risks to the surrounding community make it essential that clean-up of the site be treated as highest priority
2. An alternative water supply should be made available immediately. All community wells in which

Field work in Nsisioken Agbi, Eleme LGA benzene and/or MTBE have been detected should be marked and the community requested not to consume any further water from these wells

3. Comprehensive monitoring of drinking water quality in all household and public drinking-water wells should be carried out within a radius of 1 km of the spill location
4. The impacted area should be demarcated and appropriate signage erected to indicate that the site is impacted
5. Prior to site clean-up, additional soil sampling, along with excavation of trial pits, should be carried out to delineate the area to be treated
8. The initiation of clean-up at this site is made more complex by the presence of swampland and a sacred forest. In preparing detailed clean-up plans, community consultation will be needed. Innovative technological options which can achieve pollutant removal without disturbing the sacred forest may have to be employed

A summary of contamination in the investigated NNPC pipeline rupture site at Nsisioken Agbi is presented in Table 28.

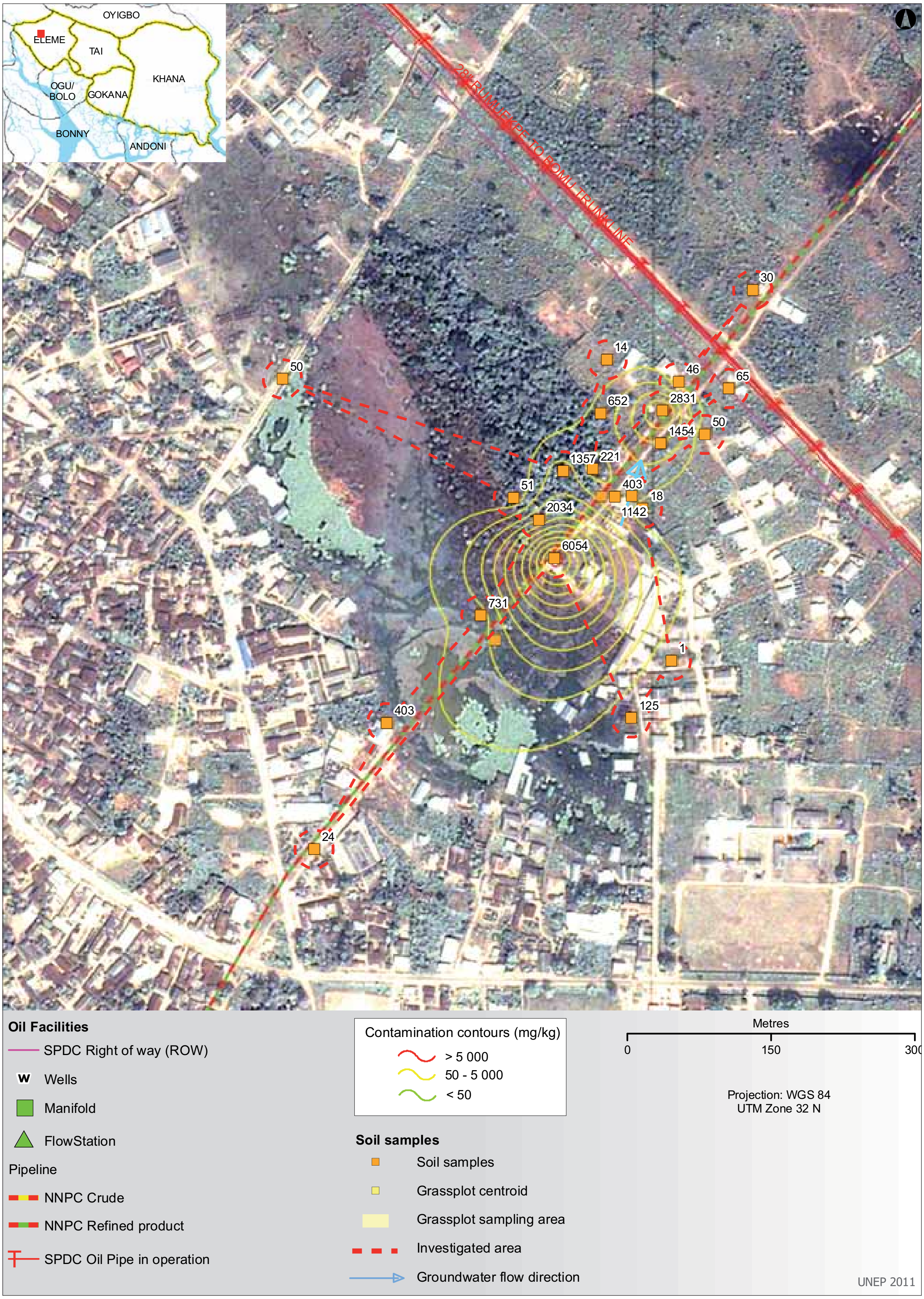
Table 27. *Summary of investigation of soil and groundwater at the Nsisioken Agbi Ogale NNPC pipeline rupture site, Eleme LGA*

UNEP site code	**qc_001-005**
Site name	**Nsisioken Agbi**
LGA	Eleme
Site description	NNPC product pipeline
Investigated area (m^2)	26,995
Number of soil samples	66
Number of groundwater samples	7
Number of drinking water samples	20
Number of surface water samples	2
Number of free-phase water samples	2
Number of sediment samples	2
Deepest investigation (m)	6
Maximum soil TPH (mg/kg)	7,310
Number of soil measurements greater than EGASPIN intervention value	2
Deepest sample greater than EGASPIN intervention value (m)	2
Maximum water TPH (μg/l) (samples)	86,100
Number of water measurements greater than EGASPIN intervention value	5
Presence of hydrocarbons in drinking water	yes
Presence of hydrocarbons in surface water (CL)	yes
Presence of hydrocarbons in sediment (CL) above EGASPIN intervention value	yes
Number of soil measurements below 1 m	48
Number of soil measurements below 1 m greater than EGASPIN intervention value	2
Total volume of soil above intervention value (m^3)	10,025
Total volume of soil above target value (m^3)	38,366

Table 28. Summary of contamination at the investigated NNPC product line

UNEP site code	LGA	Number of soil samples	Number of groundwater samples	Deepest soil investigation (m)	Maximum soil TPH (mg/kg)	Number of soil measurements >EGASPIN	Deepest soil sample >EGASPIN (m)	Maximum water TPH (ug/l) (CL samples)	Hydrocarbons in community wells	Number of water TPH measurements >EGASPIN	Number of samples with TPH >EGASPIN below 1 m
qc_002-008	Eleme	13		3	2,950						
qc_004-006	Eleme	38		5	13,200	6	2	181			3

Map 15. Contamination contours at Nsioken, Agbi, Ogale, Eleme LGA



Case study 6 Fly tipping of oilfield waste - 001-022 – oil waste dump site

Site description. Site 001-022 is located in Oken Oyaa, Ejama, approximately 700 metres west of Ejama Farming Camp, 1.2 km south-east of Ejama-Ebubu and 4 km north of Onne. It lies in the bend of SPDC's 28-inch Rumuekpe-Bomu trunk line and the 20-inch Rumuekpe manifold to Bomu manifold right of way and is located inside a borrow pit belonging to a local landowner. It is outside the SPCD right of way and is freely accessible. According to anecdotal evidence, the landowner has leased the area to an unknown waste management company. The borrow pit does not comply with EGASPIN regulations in that it is neither lined with 1 metre of re-compacted or natural clay/cement with a hydraulic conductivity ≤1 x 10-9 m/s, nor sealed in an equivalent manner. The site is not an authorized disposal site.

Land use. The area was formerly used for sand mining, apparently for construction purposes. There is some agriculture, and private and commercial housing is concentrated along a nearby expressway and in a new real estate project some 500 metres north of the site.

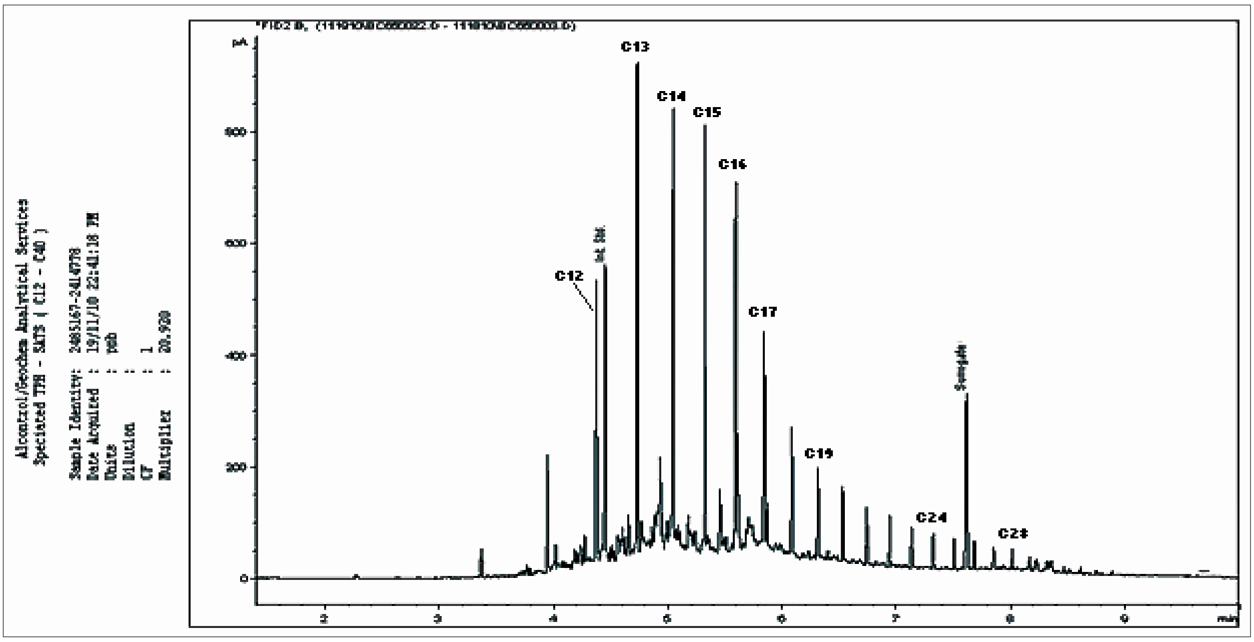
Spill history. There is no spill history as such, as it is not physically related or connected to any oilfield infrastructure in the vicinity. The waste observed by the UNEP assessment team had evidently been dumped a few days, or weeks at the most, prior to the site visit, as a satellite image dated 12 June 2010 does not show any waste at the location. The waste, disposed of in several hundred 'Big Bags' (1 cubic metre reinforced plastic transport bags), amounted to 1,000-1,500 cubic metres of oil mixed with grey clay containing small rock fragments. Oil was seeping from the bags, forming puddles in the ground.

Sample analysis. Samples taken directly from the waste bags had 54,300 mg/kg TPH. This is clearly above the EGASPIN intervention value of 5,000 mg/kg.

Some of the bags were broken and oil had already leached into the soil. Most of the 31 soil samples collected from around the waste were only slightly contaminated, with TPH concentrations below 500 mg/kg in 28 samples and below 50 mg/kg in 10 samples. Some of the samples had elevated levels of barium (maximum 2,630 mg/kg), which raises the possibility that the waste may have come from drilling operations (in which barium is used as a weighting agent).

Fly tipping of oilfield waste in Ogoniland (Oken Oyaa, Eleme LGA)

Figure 12. GC fingerprint of the oil phase sample 001-022-X-100 from a Big Bag



Gas chromatograph-flame ionization detector (GC-FID) fingerprints of the aliphatics fraction (C12-C40, see Figure 12) revealed that the oil was a fresh and unweathered crude oil. An analogous series of n-alkanes are clearly visible, indicating relatively fresh oil. Below this a small unresolved complex mixture can be seen, indicating the presence of some weathered material.

General conclusions. Examination of the site and subsequent laboratory analysis revealed the likely source of the material to be cuttings from oil drilling operations. It falls to the responsible authorities to monitor the movements of hazardous waste from source to end point under a duty of care. The fact that waste of this type is being disposed of in an open and unlined pit proves that the chain of custody between waste generator, waste transporter and waste disposal facility in the region is not being adhered to. The local environmental authority, lacking a proactive support network, is obviously not in a position to monitor instances like this. The case also demonstrates a lack of control by the operator of the site from where the material originated.

As there are currently no oil drilling operations in Ogoniland and the oil was relatively unweathered, the source of the dumped waste must lie outside Ogoniland. Whatever the case, the EGASPIN requires that an operator take care of “the containment and recovery of any spill discovered within his operational area, whether or not its source is known. The operator shall take prompt and adequate steps to contain, remove and dispose of the spill”. Furthermore, each oilfield operator is required to identify the oil produced by gas chromatograph-mass spectroscopy (GC-MS) fingerprinting on a field-by-field basis. Whether this provision is applicable for disposal of solid hydrocarbon wastes is for the Government of Nigeria to decide.

Site-specific recommendations:

1. The dumped waste material should immediately be removed to a landfill with proper containment
2. Appropriate action should be taken against the operator of the facility and use of the borrow pit at Oken Oyaa for disposal of waste must cease immediately
3. Additional monitoring should be carried out at the site after the waste material has been removed and while clean-up plans are in preparation

Case study 7 SPDC remediation site 008-002 – Korokoro Well 3, Korokoro, Tai LGA

Site description. The site is located approximately 500 metres north-east of Korokoro, Tai LGA, and is part of the Aabue community lands. The site itself consists of Korokoro Well 3 and the surrounding rights of way, the latter covering an area of 7,900 square metres. The wellhead area, accessible via a tarmac road, is not fenced or guarded and is therefore freely accessible. The average height of the ground surface is 17-18 metres amsl.

The well was drilled and completed in March 1963 but has not been producing oil since the early 1990s. During drilling operations, groundwater was found at 2.56 metres bgs.

SPDC provided no information about maintenance cycles.

Land use. A small household is situated approximately 10 metres to the north of the right of way. A hand-dug well serves as the water supply. The wellhead area is surrounded by cassava fields. The soil consists of yellowish-brown silty or sandy clay.

Spill history. Spills reported by SPDC took place in 1992 (Incident No. 1992-00119), 1993 (Incident No. 1993-00299), 2000 (Incident No. 2000-00230) and 2003 (Incident No. 2003-00149). According to SPDC, the cause of the spill was sabotage each time, though UNEP was unable to verify this. An area of 12,000 square metres was contaminated and remediation was completed. No information was available as to the delimitation of the remediated area, the form of remediation, or the year in which remediation took place.

Visual observations on site. The site was overgrown with elephant grass at the time of the sampling field visit. Along the south-eastern boundary, distinct signs of soil contamination by crude oil were found, covering an area of approximately 800 square metres inside and outside the right of way. The contamination had a visible impact on the size and health of the cassava plants.

The former tailings pit was easily identifiable as a rectangular, shallow, dry depression in the ground next to the wellhead. Sampling revealed that oil-based muds had been used for drilling. Except for the tailings pits, all the soil profiles on the site revealed soil in natural bedding, indicating that the SPDC remediation attempt had consisted of enhanced natural attenuation.

Korokoro Well 3 (Tai, LGA)

Table 29. Summary of soil and groundwater investigations at Korokoro Well 3

UNEP site code	qc-008-007
Site name	**Korokoro Well 3**
LGA	Khana
Investigated area (m^2)	
Number of soil samples	74
Deepest investigation (m)	7.6
Maximum soil TPH (mg/kg)	11,200
Number of soil measurements greater than EGASPIN intervention value	25
Deepest sample greater than EGASPIN intervention value (m)	5.6
Number of soil measurements below 1 m	57
Number of soil measurements below 1 m greater than EGASPIN intervention value	22
Volume of soil exceeding the EGASPIN intervention value (m^3)	
Volume of soil exceeding the EGASPIN target value (m^3)	

Although the visible impact of contamination on the site was limited to an area of approximately 800 square metres, the contamination was far more extensive below ground. Mobile phase hydrocarbons were found at a depth of 5 metres, even beyond the right of way. In all, the contamination footprint covered some 20,000 square metres.

A summary of the chemical investigations carried out at the site is presented in Table 29.

A groundwater monitoring well (008-002-01) was constructed next to the former tailings pit but sampling was not possible as crude oil phase on the groundwater surface was present at a depth of 6 metres.

Vertical profiling of some of the sampling locations is presented in Table 30. This demonstrates not only that contamination has migrated vertically, but also that SPDC's clean-up activities, confined to the surface, failed to meet the EGASPIN intervention value (5,000 mg/kg), despite remediation of the site being declared complete.

Table 30. Vertical profiling of contamination at Korokoro Well 3

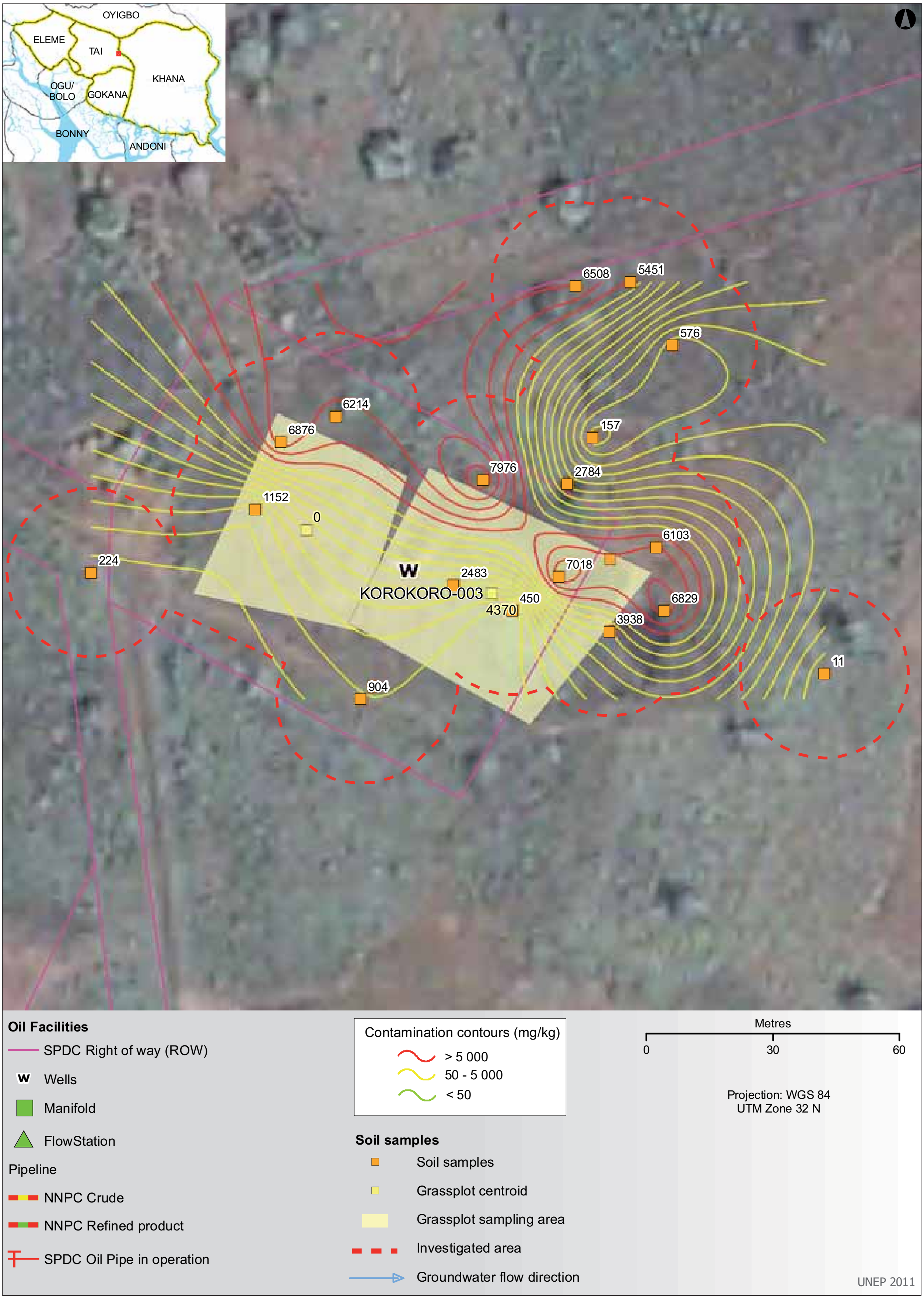
Sampling station	Depth from (m)	Depth to (m)	TPH (mg/kg)
008-002-SOI-B210	0	0.4	10,600
	0.4	1.0	4,830
	1	1.5	6,210
	1.5	2.0	11.1
008-002-SOI-B250	0	0.6	2,240
	0.6	1.0	4,300
	1.0	3.0	7,340
	3.0	4.0	5,880
	4.0	5.0	6,890
008-002-SOI-B350	0	0.8	2,060
	0.8	1.5	3,260
	1.5	2.3	2,850
	2.3	4.2	5,280
	4.2	5.0	4,310
008-002-SOI-B450	0	0.4	8,310
	0.4	1.2	9,050
	1.2	2.4	10,700
	2.4	4.6	4,200
	4.6	5.0	6,120
008-002-SOI-B252	0	1.0	2,330
	1.0	2.0	2,920
	2.0	3.0	6,990
	3.0	4.6	8,060
	4.6	5.0	9,510

General conclusions. Past remediation efforts cannot be considered either effective or successful. Concentrations of TPH still exceed EGASPIN intervention values, even in the surface soil (Map 16). Contamination extending to 5 metres bgs has not been affected by any remediation attempts. Pollution has migrated to the groundwater, as evidenced by the free-phase hydrocarbon found in the UNEP monitoring well.

Site-specific recommendations:

1. The impacted area should be demarcated and appropriate signage erected to indicate that the site is heavily polluted
2. The site should be reworked to prevent runoff from the area entering the nearby creek
3. Monitoring of well water should be introduced to provide an early warning for communities not yet impacted by groundwater pollution emanating from the site
5. Prior to site clean-up, additional soil sampling, along with excavation of trial pits, should be carried out to delineate the area to be treated

Map 16. Contamination contours at Korokoro Well 3, Tai LGA



6. A detailed plan should be prepared for (i) clean up of the contaminated soil and (ii) risk reduction at the site. Additional guidance on clean up of contaminated soil is provided in Chapter 6
7. A detailed plan should be prepared for (i) clean up of the contaminated water and (ii) risk reduction at the site. Additional guidance on clean-up of contaminated water is provided in Chapter 6
8. During the clean-up, excavation water should be carefully managed to ensure that pollutants do not escape into the environment

A summary of the locations in Ogoniland that have been classified by SPDC as "remediation completed" is presented in Table 31. The following key observations can be made from the information presented in the table.

1. At 10 of the 15 sites classified by SPDC as "remediation completed", hydrocarbon contamination exceeding SPDC's own site closure criteria was detected
2. At nine of these 10 locations, pollution has migrated below 1 metre, an area not targeted by SPDC for remediation
3. At eight of the 15 locations, the groundwater had TPH values exceeding the EGASPIN intervention value, but no clean-up attempt has yet been made
4. At two of the 15 sites, hydrocarbon contamination was detected in nearby community wells

Clean-up efforts by SPDC in Ogoniland are not leading to environmental restoration nor legislative compliance, nor even compliance with its own internal procedures.

Table 31. Summary of contamination of investigated SPDC remediated sites

UNEP site code	LGA	Site category	Number of soil samples	Number of groundwater samples	Deepest soil investigation (m)	Maximum soil TPH (mg/kg)	Number of soil measurements >EGASPIN	Deepest soil sample >EGASPIN (m)	Maximum water TPH (ug/l) (CL samples)	Number of water samples >EGASPIN	Number of community wells with TPH	Number of soil measurements below 1 m >EGASPIN
qc_009-006	Tai	SPDC right of way	62	2	5	12,300	4	3	162,000	1		3
qc_019-002	Gokana	SPDC right of way	27	5	5	34,500	10	4	32,000	2		7
qc_010-004	Tai	SPDC right of way	38	8	5	36,200	4	4	543			2
qc_003-002	Eleme	SPDC right of way	23		3	13,400	3	3	91.7			2
qc_019-021	Gokana	SPDC suspended facility	26		5	7,620	2	3				2
qc_008-002	Tai	SPDC suspended facility	58	2	5	1,880			42,800	1	yes	
qc_019-035	Gokana	SPDC suspended facility	16	1	2.6	3,480			10,300	1	yes	
qc_019-032	Gokana	SPDC suspended facility	21	2	2.2	1,220			49			
qc_019-010	Gokana	SPDC suspended facility	32	5	5.2	139,000	5	2	172,000	5		1
qc_019-004	Gokana	SPDC suspended facility	18	1	5	23,200	8	2.6	32			4
qc_015-003	Khana	SPDC suspended facility	36		3	8,830	1	1.5	10			1
qc_015-001	Khana	SPDC suspended facility	42	2	3.5	8,200	5	3	358,000	1		2
qc_014-004	Khana	SPDC suspended facility	18	3	2.6	198			519			
qc_014-001	Khana	SPDC suspended facility	24	2	2.6	157			2,140	1		
qc_016-001	Khana	SPDC legacy site	85	13	5.2	8,820	2	0.4	77,000	3		

Table 32. Location and Concentration of Hydrocarbons in Background Locations in Ogoniland

Community/LGA	Closest Contminated Site	Distance to Contaminated Site (m)	Cobalt mg/kg	Arsenic mg/kg	Barium mg/kg	TPH mg/kg
AKPAJO, ELEME	qc_003-001	322	0.92	0.3	9.8	Not Detected
OKULUEBO, ELEME	qc_005-006	444	2.12	1.54	21.9	Not Detected
KPITE, TAI	qc_009-001	425	0.72	1.07	13	Not Detected
NWIKARA-AGU, KHANA	qc_014-001	180	0.59	1.99	166	95.300
GBE, GOKANA	qc_019-034	168	0.21	0.3	1.25	4.140

Background concentration of hydrocarbons

Even though hydrocarbons are natural organic substances, unlike heavymetals, hydrocarbons are not generally present in the surface soil. A number of soil samples were taken during the assessment from locations away from areas contaminated by hydrocarbons and the results are presented in Table 32. While in most locations there is no presence of hydrocarbons, in two of the locations hydrocarbon is observed even 100 metres beyond the spill site. This could be symptomatic of the situation in Ogoniland where after oil spills, the hydrocarbon spread laterally by runoff contaminates soil much beyond the original perimeter of the spill. This value has particular importance while discussing the target value for clean-up.

Barium pollution

In extracting oil from the ground in Ogoniland, as elsewhere, the oil industry used barium sulphate to increase the density of the fluid used in drilling operations. During the drilling process, the cuttings which come up with the drilling fluid are separated and often disposed of in a pit next to the wellhead. Historically, these pits were unlined and, on close inspection, it is not uncommon to find a range of contaminants in them, including barium and hydrocarbons. Barium was therefore a subject of limited investigations during the UNEP assessment.

Barium (chemical element Ba), a soft silvery metallic alkaline earth metal, was detected in all the collected samples. However, this is not surprising since most heavy metals occur naturally and the presence of barium, does not, in itself, denote oilfield contamination or obvious harm. The Nigerian intervention value for barium is 625 mg/kg, a value that was exceeded in five samples in two locations examined during the UNEP study. Values at these sites ranged from 1,000 mg/kg to 3,050 mg/kg.

Since barium is not a pollutant that can be visually observed on the ground like hydrocarbon, these values represent individual sampling locations only and no conclusions can be drawn as to the full extent of the contamination problem. Thus, additional investigation is needed to discover if there is indeed extensive contamination by barium. Based on the results, a risk reduction strategy – possibly involving local containment, or excavation and transport – should be developed.

Naturally occurring radioactive material (NORM) results

On-site measurements. The ambient dose rates at all sites investigated, even at 'worst case' sites with fresh spillages of oil, was always found to be within the natural background level of 80±40 nanosievert per hour (nSv/h).

On-site measurements confirmed that NORM is present in very low concentrations in Ogoni crude oil and that it makes no detectable additional contribution to the ambient dose rate, within measurement uncertainties. An ambient dose rate in the range of about 100 nSv/h is of no radiological concern. As a reference, the annual dose limit – above background – for human beings is 1,000,000 nSv per year. Surface contamination measurements at all investigated sites were all within the natural background level of 3±2 counts per second (cps); this result is similar to the ambient dose rate finding.

Laboratory measurements. Uranium-235, Thorium-234, Actinium-228, Radium-226, Bismuth-214, Bismuth-212, Lead-212, Lead-214, Lead-210, Thallium-208 and Potassium-40 activity concentrations, measured by gamma spectrometry, were all above detection limits for soil samples but not for liquid samples. Radium-226 and Uranium-235 activities were calculated from the peak at 186 kilo-electron volts (keV) assuming radioactive equilibrium of Radium-226 with its parent Uranium-238 and of natural Uranium-235/Uranium-238 ratio. Liquid samples were measured by ICP-MS expressed in activity concentrations of Uranium-238, Uranium-235, Uranium-234, Thalium-232, Thalium-230 and Radium-226.

These results confirm the on-site findings: NORM is present in the environments assessed by UNEP in concentrations – in the low parts per million range – that would be expected for the geology of the region. Soil samples heavily contaminated with old spilled crude match the zero blank/reference sample and are within analytical or expected natural uncertainties. The conclusion of the laboratory analysis therefore is that NORM is by factors lower in crude oil than it is in the soil. This is confirmed by measurements of the liquids using ICP-MS. Uranium and measured daughter product concentrations in crude oil are lower – by a factor of 1,000 or more – than in local soil.

Visible hydrocarbon pollution on surface water and vessel used to transport oil

4.5 Discussion of institutional issues

UNEP's review of institutional issues in Nigeria led to a series of observations that have a direct bearing on the current environmental situation in the country. There are also implications for how jurisdictional gaps and overlaps between institutions can be improved so that sustainable environmental improvements can be achieved in Ogoniland. Some of the key observations are detailed below.

Multiple institutions with unclear mandates

Nigeria has a three-tier administration: federal, state and local government. Both the federal and state governments have ministries of environment but the Department of Petroleum Resources (DPR) – the 'technical arm' of the Ministry of Petroleum Resources – continues to have a role in regulating environmental issues as well.

The most important piece of legislation on environmental management in Nigeria is the 1992 Environmental Guidelines and Standards for Petroleum Industries in Nigeria (EGASPIN). This confers a statutory role on the DPR to manage all environmental issues arising from oil industry activities, including clean-up of contaminated sites. However, the National Oil Spill Detection and Response Agency (NOSDRA), created in 2006, has since also assumed responsibility for the latter role, though NOSDRA's mandate does not cover supervision of contaminated site remediation. More importantly, the two agencies have differing interpretations of EGASPIN, which further undermines clean-up operations in Ogoniland.

The overlap of authorities and responsibilities between state ministries and federal ministries is another issue which has an impact on environmental management on-the-ground. In the Nigerian system, central government agencies also have state or regional administrative offices. Separate state government agencies, which sometimes have similar mandates, often end up doing the same work. These overlapping efforts are not always coordinated and can lead to suboptimal environmental management.

Undergrowth shrouds a warning sign at Ogale, Eleme LGA

NOSDRA mandate and resources are not aligned

The National Oil Spill Detection and Response Agency came into being under the National Oil Spill Detection and Response Agency (Establishment) Act, 2006. The Act states that the organization's mandate "shall be to coordinate and implement the National Oil Spill Contingency Plan for Nigeria" [39]. The main focus of the Contingency Plan is on emergency response in the event of an oil spill. The NOSDRA Act also legislates for emergency response systems and capacity.

However, in the five years since its establishment, very few resources have been allocated to NOSDRA, such that the agency has no proactive capacity for oil-spill detection and has to rely on reports from oil companies or civil society concerning the incidence of a spill. It also has very little reactive capacity – even to send staff to a spill location once an incident is reported. In the Niger Delta, helicopters or boats are needed to reach many of the spill locations and NOSDRA has no access to such forms of transport other than through the oil companies themselves. Consequently, in planning their inspection visits, the regulatory authority is wholly reliant on the oil company. Such an arrangement is inherently inappropriate.

Equally important is the question of mandate when it comes to cleaning up a contaminated site. NOSDRA undertakes supervision of contaminated site assessment based on EGASPIN provisions. However, since the agency did not exist at the time EGASPIN was formulated in 1992 and reissued in 2002, the Act itself does not empower NOSDRA. Consequently, little training and few resources have been provided to enable NOSDRA to carry out this task.

At the time that NOSDRA was created, a clear directive should have been issued delineating the operational boundaries between NOSDRA and the DPR. In the absence of such clarification, both bodies continue to deal with contaminated site clean-up, coordination between the two is poor, and in extreme cases they take differing approaches to interpreting the rules.

Conflict of interest

Petroleum resources account for 80 per cent of national revenue and 95 per cent of export earnings, making the Ministry of Petroleum Resources, which licenses and regulates oil industry operations, a key ministry in Nigeria. In 1990, when the ministry, through its Department of Petroleum Resources (DPR), developed the EGASPIN, there was no federal Ministry of Environment (environment is currently part of the Federal Ministry of Environment, Housing and Urban Development). Moreover, it seemed logical at that time for the Ministry of Petroleum Resources to oversee the oil industry because of the strategic nature of the country's oil reserves as well as the technical nature of the industry and the specialized skills therefore needed to regulate it.

However, there is clearly a conflict of interest in a ministry which, on one hand, has to maximize revenue by increasing production and, on the other, ensure environmental compliance. Most countries around the world, including in the Middle East where oil is the mainstay of the regional economy, have placed environmental regulation within the Ministry of Environment or equivalent. It is noteworthy to mention in this context that after the 2010 *Deepwater Horizon* incident, it came to light that the US Offshore Energy & Minerals Management Office (under the Bureau of Ocean Energy Management, Regulation and Enforcement) responsible for the development of the offshore oilfield was also the body that issued environmental approvals. Even though other federal and local agencies had commented on the industry plans, President Obama called this a "cosy relationship between the oil companies and the federal agency that permits them to drill" [40]. Consequently, a new Bureau of Safety and Environmental Enforcement, under the US Department of the Interior, has been created, which is independent from the Department of Energy Resources.

Lack of resources

Resource limitations, both physical and human, are a feature of all Nigerian ministries. There are also other issues at play, involving various ministries at federal level as well as the contrasts between ministries at federal and state level. For example:

- Both DPR and NOSDRA suffer from a shortage of senior and experienced staff who understand the oil industry and can exercise effective technical oversight. The main reason for this is that individuals with technical knowledge in the field of petroleum engineering or science find substantially more rewarding opportunities in the oil industry

Inadequate regulatory requirements and enforcement are leaving communities exposed

- A typical pattern in Nigeria (as in other countries) is that offices in the federal capital of Abuja are better equipped with staff and resources than regional offices. This may not be a financial issue but staff may be reluctant to serve in the regions owing to poorer working conditions and opportunities, ranging from security to schooling for children and career advancement prospects. This is certainly an issue impacting both DPR and NOSDRA

- All government departments, both federal and state, lack office equipment and vehicles. Even when such resources are allocated there is often a shortage of funds for maintenance (e.g. maintaining vehicles and buying fuel for generators)

- State ministries of environment are even less well provided for in terms of human resources, equipment and infrastructure, and attracting quality staff is especially difficult

- Shortage of equipment is particularly troublesome for agencies having to respond to oil spills, which are often in areas inaccessible by road. In the absence of such resources, government agencies are at the mercy of oil companies when it comes to conducting site inspections.

Inadequate regulatory requirements and enforcement

The oil and gas sector in Nigeria is subject to comprehensive legislation which includes detailed environmental and technical norms. The most detailed and exhaustive standards and guidelines – the EGASPIN – were issued by the DPR in 1992 and reissued in 2002. However, the original Act dealing with the oil industry in Nigeria is the Petroleum Act, 1969, which empowers the Minister of Petroleum Resources to regulate for the prevention of pollution of water courses and the atmosphere. It is not entirely clear from reading EGASPIN if it was issued under the 1969 Act. Consequently, whether EGASPIN is a legally enforceable instrument or a non-enforceable guideline is also unclear. This issue was discussed with both DPR and NOSDRA officials, who all have varying interpretations on the legislative status of EGASPIN. UNEP's institutional assessment was not able to verify whether EGASPIN's legislative standing has been tested in the Nigerian courts.

Regardless of its formal status, for all practical purposes EGASPIN currently forms the basis for environmental management of the oil industry in Nigeria. It is a substantial document running to 361 pages divided into eight sections dealing with all aspects of environmental management of oil activities ranging from exploration to terminal operations.

UNEP's review examined two specific elements of EGASPIN:

- Part VIIIB, contingency planning for the prevention, control and combating of spills of oil and hazardous substances, and
- Part VIIIF, management and remediation of contaminated land.

For the purposes of this study, the most important aspect is the approach EGASPIN takes with regard to the criteria for clean-up operations following an oil spill.

EGASPIN recommends the use of the Risk-Based Corrective Action (RBCA) approach pioneered in the United States. However, section 8.1 of Part VIIIF states: "In the interim period whilst suitable parameters are being developed, the guidelines on remediation of contaminated land shall make use of two parameters, i.e. intervention values and target values (Table VIII F1)." Even though EGASPIN was first issued in 1992, the required guidance for a risk-based approach has not yet been developed and the 'intervention and target values' approach remains the operating principle in Nigeria today.

EGASPIN defines 'intervention value' (8.1.1) as indicating "the quality for which the functionality of soil for human, animal and plant life are, or threatened with being seriously impaired. Concentration in excess of the intervention values correspond to serious contamination". 'Target value' (8.1.2.1) is defined as indicating "the soil quality required for sustainability or expressed in terms of remedial policy, the soil quality required for the full restoration of the soils functionality for human, animal and plant life. The target values therefore indicate the soil quality levels ultimately aimed for". A list of intervention and target values is provided in Appendix VIII F1 of the EGASPIN.

While in the provisions discussed above EGASPIN is clear and in line with the terminology as applied elsewhere (e.g. in the Dutch Soil Act of 1987 which pioneered the use of intervention and target values), there is internal contradiction elsewhere. The more stringent part of the provision states, in section 2.11.3 of Part VIII:

"Any operator or owner of a facility that is responsible for a spill that results to (sic) impact of the environment shall be required to monitor the impacted environment alongside the restorative activities. The restorative process shall attempt to achieve the minimum oil content and other **target values (**quality levels ultimately aimed for) for BTEX, metals and polycyclic aromatic hydrocarbons (PAHS) in the impacted environment (also See Part VIII F).

(i) For all waters, there shall be no visible oil sheen after the first 30 days of the occurrence of the spill no matter the extent of the spill

(ii) For swamp areas, there shall not be any sign of oil stain within the first 60 days of occurrence of the incidence

(iii) For land/sediment, the quality levels ultimately aimed for (target value) is 50 mg/kg of oil content (See part VIII F)."

However, section 6.6 of Part VIII of the EGASPIN states:

"Remedial Action Closure. When Remedial Action Treatment has been undertaken and the **intervention values** (Risk Based Screening Levels (RBSLs) or Site Specific Target Levels (SSTLs) if RBCS (Risk Based Corrective System) is used) have been demonstrated to be achieved at the point of compliance, or containment or institution controls have been installed and monitoring and site maintenance are no longer required to ensure that conditions persist, then no further action shall be necessary, except to ensure that suitable institutional controls (if any) remain in place."

This latter section is an incorrect interpretation of the 'intervention value' and 'target value' approach to contaminated site management. Intervention value is not expected to be the point of compliance for close out of remedial action. The triviality of the above-quoted interpretation can be explained by taking as an example a site that has been contaminated with 5,001 mg/kg of hydrocarbons. Since it is above the intervention value of 5,000 mg/kg, a treatment plan has to be prepared and implemented. However, remediation work at the site can stop when the value has reached 4,999 mg/kg – in effect, by achieving just a 2 mg/kg reduction of hydrocarbons. In other words, the site can be considered to have moved from a situation where "the functionality of soil for human, animal and plant life are, or threatened with being seriously impaired" to a situation where it is legally acceptable to stop the treatment and even stop monitoring.

Discussions with the DPR clarified that they indeed expect the operator to achieve the target levels at which a remediated spill site can be closed. On the other hand, discussions with NOSDRA confirmed that they use the intervention values as the closure criteria for sign-off. NOSDRA also mentioned that, in their judgement, 5,000 mg/kg is a high target and that in their new legislation, currently in preparation, this will be lowered to 2,500 mg/kg.

Resolving the issue

It is evident from the above that Nigerian legislation is internally inconsistent with regard to one of the most important criteria for oil spill and contaminated site management; specifically the criteria triggering or permitting remediation closure. This is enabling the oil industry to legally close down the remediation process well before contamination has been fully eliminated and soil quality has been restored to achieve full functionality for human, animal and plant life.

This situation needs to be resolved for the whole of Nigeria, and in particular prior to initiation of the clean-up in Ogoniland. It should be mentioned in this context that the Government of The Netherlands, which pioneered the intervention and target value approach, has discontinued setting a target value for soil. Since both DPR and NOSDRA mentioned that they are working on new legislation, it may be opportune to make fundamental changes.

International best practice on contaminated site remediation currently depends on development of site-specific clean-up targets based on a robust source, pathway and receptor model. However, application of this model has to be done in a transparent manner so that the regulators fully comprehend what input data are used to obtain the clean-up targets and the sensitivity of each of these parameters. It has also been accepted internationally that health is just one of the risks to be managed through contaminated site remediation. Situations could arise where non-health risks, such as commercial reputation or community perception, would require the government and oil operator to agree on more stringent targets than would strictly be necessary from a health-risk management point of view.

Making legislation accessible

Another problem with current Nigerian legislation is its inaccessibility. Few texts are available online and many are not easily available even in paper form. In addition, printed copies of legislation, such as the 'Laws of the Federation of Nigeria', are extremely expensive and therefore limited to those able to bear the costs. Moreover, many secondary or very recent texts are available only at the issuing agency or from the government printing house in Lagos. Inaccessibility of legislation leads not only to a lack of transparency, but also to a loss of trust in the legal system. Making legislation readily accessible, cheaply and in a variety of forms, will help build confidence at all levels.

Review of SPDC's practices and performance

As an oil company with decades of experience in Nigeria, and as part of a larger, international organization with global reach, it is not surprising that the Shell Petroleum Development Company has established procedures for the range of environmental issues resulting from its oil exploration and production. SPDC is also backed up technically by Shell which provides a broad policy framework with corporate guidelines and specific technical assistance through Shell Global Solutions.

SPDC procedures

SPDC has documented procedures on all aspects of its business management. It was not the objective of the current study to undertake a systematic audit of all SPDC procedures and their implementation on the ground. However, in matters where there is a direct interface with the environmental contamination of Ogoniland, it was important first to identify the situation on the ground and then to verify whether that situation was a consequence of lack or deficiency of procedures, or laxity in enforcement of those procedures.

Of the three SPDC procedures dealing with environmental issues – oil spill response, oil spill clean-up and abandonment – quantitative assessment was only possible regarding site clean-up. A review of SPDC's performance in cleaning up contaminated sites is given below.

In undertaking this review, UNEP did not proactively look for SPDC-contaminated sites for assessment. Rather, once the on-the-ground assessment of contaminated sites had been completed, the team checked SPDC records to see how many of the sites were classified as 'remediation completed'. Where this was the case the site was assessed as to whether (i) it was still contaminated according to Nigerian legislation and (ii) the site met with SPDC's own internally set standards.

SPDC's approach to remediation

The SPDC Oil Spill Clean-up and Remediation Procedure (SPDC-2005-005716), the company's main operating document in guiding clean-up activities, was subjected to examination by UNEP. This procedure is based on a Shell Global Solutions report, 'Framework for Risk Management of Historically Contaminated Land for SPDC Operations in the Niger Delta (OG.02.47028)'. The report states:

"As the crude ages the lighter end will be lost through natural attenuation processes and as a result the viscosity will increase and vertical migration will further decrease. The high water table in many locations will also prevent deep infiltration of free product. It is expected therefore that any spills within the Niger Delta will migrate predominantly along the ground surface from areas of high topography to areas of low topography. *Trial pits have confirmed the shallow extent of soil contamination in many SPDC sites.*"

The report was based on a desk study and no field work was undertaken. So the trial pits, underlined in the above statement, refer to those excavated by SPDC as part of its own vertical delineation

Easily accessible disused wellhead (Bomu 27, Gokana LGA)

An Ogoniland site showing remediation by enhanced natural attenuation (RENA)

of contamination. It is useful to note that SPDC's internal procedures for vertical delineation of contamination state:

"*...trial pit should be excavated to at least 0.5 metres and no more than 1.5 metres below ground level (bgl)*"

"...hand augering should be down to at least 1 metres bgl and preferably to 2 metres bgl"

As already seen from UNEP's field sampling, contamination of hydrocarbons has migrated to depths of more than 5 metres in some instances. Hence, Shell Global Solutions' guidance note and the SPDC procedure for vertical delineation need to be revised to incorporate this new information.

Three points of particular interest in the SPDC document are:

1. Remediation by enhanced natural attenuation (RENA) is given as the primary method of remediation of oil-impacted sites

2. Soil remediation criteria are defined and, though the document makes provisions for using risk-based screening levels to indicate satisfactory completion of remedial activities to acceptable risk levels, a TPH value of 5,000 mg/kg (same as the EGASPIN intervention value) was validated as the end point

3. For groundwater the document states that "remediation of impacted potable (usable) groundwater shall be undertaken in conformity to the EGASPIN recommended **target** level of 10 ppm of dissolved TPH". However, there is no location in Ogoniland where groundwater remediation has been attempted

A number of criticisms can be made of the above approach:

The RENA approach to remediation. Hydrocarbons, once released to land, can be transferred and degraded through a number of natural processes, including:

- evaporation to the atmosphere
- combustion
- infiltration, alone or along with rainwater, to soil and eventually to groundwater
- overflow into swamps and water bodies
- runoff with rainwater to swamps and water bodies
- microbial degradation on the ground surface, or in soil, swamps, water or groundwater

The principle of enhanced natural attenuation for clean up of contaminated land is to augment one or more of the above processes so that the concentration of contaminants can be reduced.

After reviewing contaminated land clean-up issues in Nigeria, Shell Global Solutions endorsed the RENA approach. Hence it is SPDC's preferred procedure and 100 per cent of oil spill remediation in Ogoniland has been undertaken using the RENA approach.

Under RENA, contaminated land (topsoil) is initially ploughed over, either mechanically or manually, to increase aeration. Fertilizer is added to supplement the nutrient requirements of the bacteria as they break down the pollutants. The ploughed soil is then piled into neat windrows to further enhance the aeration process. Samples are taken from the windrows every quarter and once the SPDC specification of 5,000 mg/kg of TPH is reached, the windrows are levelled.

The implicit assumption in the RENA approach applied by SPDC is that the natural process being enhanced is bioremediation. All enhancing actions, whether ploughing, adding nutrients or windrowing, are applied to further natural biodegrading processes. In an ideal situation this approach is scientifically defendable. However, the reality on the ground in Ogoniland speaks otherwise. The RENA process is failing to achieve either environmental clean-up or legislative compliance. As seen in the analyses and case studies presented in this report, it is also failing to achieve compliance with SPDC's own procedures.

The case against RENA in Ogoniland. The following arguments could be made for discontinuing the use of RENA as an approach to remediation in Ogoniland:

1. The effects of temperature, rainfall and topography hamper the RENA approach at oil-impacted sites because no controls are in place to manage the following processes:

   (i) Oil-impacted sites are open and exposed to sun and air, leading to hydrocarbons evaporating and being carried away, risking exposure to on-site workers, neighbouring communities and nearby agricultural workers. No air monitoring, on-site or off-site, is undertaken

   (ii) They are continually exposed to rain, which falls on the windrows, leaching out hydrocarbon, which can then run off into nearby farms, communities, swamps or streams, contaminating a much wider area. Rain falling up-slope can also run off through the windrows. No measures are taken to prevent rainwater from reaching windrows, directly or through runoff, and no systems exist to collect runoff before it escapes from the site. Moreover, no system is in place even to monitor whether this is happening

   (iii) Soil remediation occurs *in situ* with no impermeable layer to prevent infiltration of oil, either by itself or with water, into the subsoil and then into the groundwater. There is no monitoring of this issue

2. Not all hydrocarbons are amenable to bacterial biodegradation, rendering the process unfeasible in situations where:

   (i) hydrocarbons are too toxic for the bacteria, and/or too recalcitrant for biodegradation and/or present in too high a concentration

   (ii) fire has occurred on the ground and the hydrocarbons have been burnt into a crust, mixing bituminous hydrocarbons with clayey soil

   (iii) the soil is very clayey in nature, making oxygen transfer difficult

3. Currently, SPDC undertakes RENA on the land surface layer only, based on the assumption that given the nature of the oil, temperature and an underlying layer of clay, hydrocarbons will not move deeper. However, this basic premise of limiting remediation to the surface soil is not sustainable since observations made by UNEP show that contamination can often penetrate deeper than 5 metres. The RENA approach, if using bioremediation as the primary process to be enhanced, will not work at depths below 1 metre due to difficulties with oxygen transfer

In addition, the UNEP team also noted the following on-site practices which further argue the case against RENA as an appropriate choice for site remediation:

4. Trenches cut from RENA sites to nearby water courses preferentially channel away spilled oil and runoff

5. In practice the top 1 metre of topsoil is not being tilled and mixed properly. Only the top 15-20 cm of soil is dug out and piled onto unploughed soil, so while the windrow may appear to be 30-40 cm high (i.e. the top of the windrow is 30-40 cm above the bottom of the excavated area), the depth of soil that has been broken down is, in fact, only 15-20 cm, thus also limiting any bioremediation to those 15-20 cm.

There are enough theoretical and practical reasons to recommend discontinuation of the RENA approach in Ogoniland for cleaning up contaminated land. While bioremediation or enhancing natural processes are workable approaches to achieving clean-up, they should only be adopted after proper characterization of affected sites, with adequate provision made for (i) controlling transfers of oil off-site due to runoff, infiltration and other processes, and (ii) monitoring and supervision.

SPDC clean-up specifications

The second most important element of SPDC procedures, after the primacy given to RENA, is the recommended values for clean-up.

SPDC uses 5,000 mg/kg TPH as its remediation criterion for soil. While no specific reason has been given for choosing this value, it was the assumption of NOSDRA that the value was taken from the EGASPIN intervention value of 5,000 mg/kg.

As discussed previously, the EGASPIN document, which forms the basis for the SPDC procedure, suffers from issues of internal inconsistency. In one section the legislation defines a 'target value' of 50 mg/kg TPH as the desired end point for restoration after oil spill, while in a section on remediation of contaminated land an 'intervention value' of 5,000 mg/kg TPH is given for remediation closure.

A trench made from a RENA site to a nearby watercourse (Bodo West, Bonny LGA). The fluid in the channel is degraded crude oil

During the early phase of discussions with SPDC, UNEP was informed that the remediation close-out value of 5,000 mg/kg TPH set by SPDC was not drawn from the EGASPIN but was based on a risk assessment. If this was a corporate decision, it is not stated as such in the SPDC documentation, nor is it communicated to the authorities as required by EGASPIN. However, the SPDC procedure does mention the guidance provided by the Shell Global Solutions document mentioned above.

Development of contaminated site clean-up criteria based on health risk assessment was first proposed by the American Society for Testing of Materials (ASTM) 'Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites' [41]. The basic philosophy of this approach is to model potential exposure of a sensitive receptor to hydrocarbon contamination through viable pathways. A target level of contamination in the environment is set based on acceptable exposure of the receptor. This approach has many merits as it makes the decision more objective and more resource efficient. However, in developing a risk-based screening level of 5,000 mg/kg TPH, applicable to all sites in the Niger Delta, the following key issues have been overlooked:

1. The varied geology of the Niger Delta differs significantly over short distances. Applying a uniform set of input data parameters (e.g. soil organic matter) across all sites is therefore not appropriate unless the sensitivity of clean-up levels to such generic inputs is properly considered.

2. Different countries have different thresholds for policy-driven parameters, such as acceptable additional cancer risk. Thresholds ranging from 1 per 10,000, to 1 per 1,000,000 people have been used. WHO guidelines are based on 1 per 100,000. Shell Global Solutions has used the acceptable risk threshold of 1 per 10,000 as there was no applicable national legislation. However, this was done without consulting the national authorities and explaining the likely impact on clean-up criteria. For example, using a risk threshold of 1 per 100,000, as used by WHO, would have resulted in a clean-up threshold of 500 mg/kg in some instances. This lower threshold would have needed a different technological approach to clean-up and would have significantly increased the costs of clean-up to the company.

Table 33. SPDC selection criteria for appointing remediation contractors

Description	Maximum score (%)	Minimum score (%)
Past performance		
Regulatory certification of completed site	10	6
HSE performance or (HSE plan in case of new vendors)	6	3
Managerial competence	4	2
Nigerian content development	5	3
HSE record		
Leadership and commitment	8	5
Toolbox documentation	5	3
Manpower resources & competence assurance	7	4
Hazards & effects management	10	6
Timely service delivery		
Adequate manpower	10	6
Financial capability	8	6
Technical competence	5	2
Management of community issues		
Evidence of previous work in the community/a community	5	3
Knowledge of community sensitivities	7	4
Evidence of successful completion	10	7
Total	**100**	**60**

3. There are scientific uncertainties as to what constitutes a reasonable health criteria value for a pollutant. A decision on what is appropriate for Nigeria should not be taken in isolation, without consultation, and without explaining what impact it may have on the clean-up criteria.

It is recommended that SPDC works with the Nigerian regulators to clarify the paradox of remedial intervention and target values being the same. They should also agree on a consultative approach to setting site-specific clean-up values.

The final point of interest concerning the SPDC documentation is their selection criteria matrix for appointing contractors to undertake remediation work (see Table 33).

Flare arrangements at disused flow station

Two issues are instructive here: (i) 'technical competence' in the table represents just 5 per cent of the potential score allocated; and (ii) the relative importance assigned to past performance in obtaining a 'regulatory certification of completed site' compliance versus technical competence.

In its 'Execution Strategy for Oil Spill Response, Clean-up and Remediation of Impacted Sites in East and West', SPDC identifies some of the major weaknesses of its old strategy [42]. The following were some of the observations made in 2007:

- Lack of timely and effective oil-spill containment and recovery were identified as the major causes of escalated spread of spills in the environment and consequently higher clean-up costs

- Clean-up cost estimates were based on the estimated volume of a spill and the estimated area of impact prior to recovery of the free-phase product. Thus the actual area requiring clean-up was often exaggerated, which translated into exaggerated cost estimates

- No process was put in place to ensure that resources paid for in contracts were actually provided and utilized

- Incidences of poor clean-up leading to secondary clean-up before remediation were prevalent (meaning that the first clean-up after the oil spill was not appropriate or adequate and necessitated a second clean-up before the RENA approach could be initiated at the site)

SPDC Remediation Management System. In January 2010, a new document, 'Remediation Management System' (RMS), was adopted by all Shell Exploration and Production Companies in Nigeria (SEPCiN) [43]. A revised version of this document was made available to UNEP in January 2011. As the document only came into force recently, the SPDC sites assessed by UNEP were not managed according to the RMS and no direct comparisons between the previous and new system have therefore been possible. However, the document is reviewed here with a view to understanding the key changes and to consider, if the new system were to be implemented, whether past attempts at remediation would have been different and whether the new procedure would improve things in the future.

The following are the key changes from the previous remediation procedure:

- The RMS has set a TPH value of 3,000 mg/kg as the cut-off value for completion of remediation work, as against the former value of 5,000 mg/kg
- An *ex situ* RENA approach has been proposed, making use of a high-density polyethylene (HDPE) membrane to prevent contamination of the location where the *ex situ* remediation is undertaken. The previous document had no provision for *ex situ* RENA and the possibility that hydrocarbons may infiltrate to lower layers was not considered a process risk
- A leachate collection system has been proposed in the *ex situ* RENA process. In the previous system no cognizance was given to the possibility of leaching of hydrocarbons through runoff
- The RMS brings sediments and groundwater into the purview of the materials to be remediated.

It is clear that SPDC has been learning internal lessons regarding clean-up. The changes proposed in the RMS are certainly an improvement on the existing situation. However, they do not meet the local regulatory requirement or international best practices, as elaborated below.

Remediation close-out value. The RMS sets a new remediation intervention value of 3,000 mg/kg TPH to demonstrate commitment to remediation excellence. This compares to the EGASPIN intervention value of 5,000 mg/kg TPH and is presented as the company doing "more than" the legislation requires. However, as elaborated in earlier sections, the use of an 'intervention value' as the 'target value' for remediation close-out is not in line with EGASPIN philosophy and its interpretation by DPR. The proposed SEPCiN value, while certainly an improvement on the previous value, does not represent full compliance. Expert-level discussions are needed between DPR, NOSDRA and the oil companies to arrive at a technologically feasible target value. These discussions should include post-clean-up use of the remediated site (e.g. human use, wildlife site, linkages to wetland) – in other words, a risk-based approach.

***Ex situ* RENA approach.** Conceptually, the *ex situ* RENA approach is an improvement over *in situ* RENA as it recognizes both infiltration and runoff from contaminated soil as issues to be addressed. However, the new approach still has major limitations that are not acknowledged in the document. Since no practical application of the RMS has been observed in Ogoniland, the conformity of provisions in the RMS with situations on the ground could not be verified.

In the *ex situ* RENA approach (Figure 13), a 400-mm thick layer of clean sand (or clay/lateritic layer) is placed over the HDPE liner as a treatment layer (prescribed in a cross-sectional diagram in the RMS document). This layer will invariably become contaminated either through infiltration of leachates or during mixing of the contaminated soil for aeration. It is not evident from the procedure if, at the end of the treatment cycle, this layer will stay in place or be removed and disposed of along with the contaminated soil. If the treatment bed is removed with every cycle (which will be necessary with a sand base), the volume of contaminated material will increase during the treatment process, diluting the actual contaminant and making it possible to achieve the clean-up target value without having achieved full clean-up. On the other hand, if the layer of sand is left in place for multiple cycles, quite how the layer will be treated once the site clean-up is over is not elaborated. In both cases, further refinement and clarifications are needed.

Leachate management. The *ex situ* RENA approach has a leachate collection system, but the approach taken to managing the collected leachate is to put it back on the treatment bed. Since Nigeria experiences heavy rainfall, relying solely on the treatment bed to manage leachate will be hampered by flooding of the treatment area, thus jeopardizing the treatment itself and causing runoff into adjoining areas, and negating the benefit of introducing a leachate collection system. In order to achieve the desired objectives, a separate leachate monitoring, treatment and disposal system integral to the treatment unit is needed.

Management of sediments and groundwater. While the opening part of the RMS mentions that the document covers treatment of sediments and groundwater, these topics are not in fact elaborated.

It clear from the review of the new RMS that SPDC has been trying to address some of the limitations of the previous clean-up system. However, the proposed modifications alone are incapable of fully resolving the limitations of the current approach identified by UNEP. SPDC procedures for oil spill clean-up and remediation need to be fully reviewed and overhauled so as to achieve the desired level of environmental restoration. In addition to procedures and clean-up methods, contracting and supervision also need to be improved.

SPDC operational practice at oil spill sites

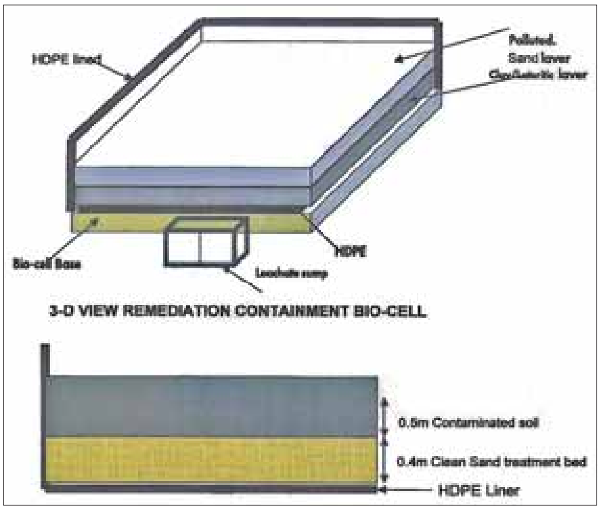
It is evident from the UNEP field assessment that SPDC's post-oil spill clean-up of contamination does not achieve environmental standards according with Nigerian legislation, or indeed with SPDC's own standards. During its reconnaissance survey, UNEP came across dozens of locations where oil spill incidents had occurred in the past. The spills may have happened decades ago or weeks ago, with multiple spills at some locations. Some of these locations had actually been documented by the operator as assessed and cleaned up, while others were still to be cleaned up. The difference between a cleaned-up site and a site awaiting clean-up was not always obvious. Results from the sites that were studied in detail are presented in case studies 1 to 7; however, there are a few general observations that merit attention.

Poor due diligence. An oil spill is one of the possible technical risks anticipated by an oil company. All oil industry operators have systems and resources in place to deal diligently with spills within the shortest possible time. In Nigeria, both SPDC and NNPC have their own dedicated resources to deal with smaller oil spills (referred to by the oil industry as Tier 1). PPMC has its own Pollution Control Centre to deal with bigger spills. Together, the oil industry operators in Nigeria have set up a consortium called 'Clean Nigeria Associates' to deal with larger (Tier 2) oil spills. Truly large (Tier 3) spills will need international assistance from specialized oil spill response agencies.

In summary, there are systems and resources in place in Nigeria to deal with most oil spills, small and large. Even though the oil industry is no longer active in Ogoniland, oil spills continue to happen with alarming regularity. Three minimal operational interventions are absolutely necessary in the event of an oil spill:

1. Ensure that the source of the spillage is shut off by closing the valves on the facility
2. Contain the oil within the spill site to prevent runoff by blocking culverts and digging interceptor gullies
3. Clean up pooled or standing oil which presents a safety hazard

Figure 13. Proposed cross section of a containment bio-cell (Ref SPDC remediation management system) cell [43]



SPDC procedures for oil spill clean-up and remediation need to be fully reviewed and overhauled

A typical spill site within Ogoniland, many of which remain unaddressed for long periods of time

Once these actions have been achieved, contamination of the site should be assessed and the clean-up process initiated.

The UNEP project team visited a number of locations with recent spills. One observation made consistently through the entire survey was that there was always a time-lag between the spillage being observed and dealt with. In the worst case situations, standing oil left on the ground posed an imminent safety hazard and an ongoing environmental hazard. It was not possible at these locations to say how long these pools had been standing. Nor was it possible to ascertain whether the source of the spill had been shut off or was continuing to leak oil. All these factors increase percolation of hydrocarbons into permeable ground surfaces.

Where the oil operator appeared to have taken intervention measures, such as laying a skirt boom or absorbent boom to contain the spill, the equipment used was often observed to be in poor condition, rendering it ineffective. In such cases, pollution continued to spread well past containment points.

The oil industry often cites access restrictions placed by the community as reason for the delay between the reporting of an incident and addressing it. While this may be true in the early days of the spill, the time-lag between the spill event and the site being comprehensively cleaned up shows that issues of access are not the sole cause of delays. In addition, the substandard approach to containment and the unethical action of channelling oil into creeks cannot be laid at the door of community.

Loss of control. Various factors at a spill location, if not properly attended to by the oil operator, can lead to loss of control. Ogoniland has very high rainfall and though there is a so-called rainy season, it rains virtually every month. Any delay in cleaning up an oil spill will lead to oil being washed away by rainwater, traversing communities and farmland and almost always ending up in the creeks. At a number of locations it was evident that fire had broken out following the oil spill. Where oil is standing, it evaporates, creating a flammable mixture that can easily ignite. Standing oil also percolates into soil and kills vegetation, which itself becomes a combustible fuel, further increasing the risk of fire.