Joint UNEP/OCHA Environment Unit

UN expert assessment mission to Kenya, 7th-16th March 1999

JET FUEL A-1 SPILL FROM AN AVIATION SERVICES DEPOT IN LOKICHOKIO

Findings

Assessment of mitigation works

Assessment of environmental risk

Recommendations

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The UN – Expert Mission to Lokichokio Kenya wants to thank Mr. Christian Lambrecht of the UNEP – Nairobi for his assistance. Without his help many obstacles could not have been overcome. For kind assistance and important contribution to our findings, we thank the Basecamp manager WFP Mr. Ben Martinson and his staff in Lokichokio for their assistance and willingness to contribute to this mission's findings. To all others who made our mission and this report possible we are sincerely grateful.
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SUMMARY

Acute pollution - Jet fuel spill:
After the spill of jet fuel at the Caltex Kenya Ltd. (Caltex) aviation services depot at Lokichokio had occurred, a request for assistance was at the 21st January send to UNEP in Nairobi. The United Nations World Food Programme (WFP) expressed their concern that the jet fuel spill may cause

serious environmental damage to the scarce water supply in Lokichokio. After a request from UNEP/OCHA to various nations, Austria and Norway responded positively, and experts from OMV Proterra Vienna Austria and Norwegian Pollution Control Authority composed the UN Expert Mission team. The team carried out their assessment between the 7th to the 16th of March 1999.

Environmental risk:

Protection of aquifer: The probability that jet fuel A-1 components could reach the ground water and consequently pollute the ground water at a significant level is medium. The negative consequence of an introduction of jet fuel components in ground water could be very significant both on long and short terms. The negative consequence is determined very high. The environmental risk is unacceptable. Actions are needed.

Soil at the Caltex site

The probability that jet fuel A-1 components left in the soil could further contaminate soil at a significant level is very high. The negative consequence of an introduction of jet fuel components could be very significant and is determined high. The environmental risk is unacceptably high. Actions are needed.

Residential areas/offices and camp sites

The probability that jet fuel A-1 components left in the soil could create significant concentration in such areas, is low. The consequence of such introduction of jet fuel components (vapour) in residential areas is determined high. The environmental risk is within acceptable range. No action is needed

Soil at the dump site

The probability that jet fuel A-1 components could reach the ground water and consequently pollute the ground water at a significant level is low. The consequence of such an introduction of jet fuel components could be very negative and is determined high. The environmental risk is acceptable, provided remediation continues.

Guidelines for recommended remediation:

1. Caltex must comply with Kenyan laws and regulations and manage the acute spill accordingly
2. The Kenyan authorities should within the legal framework enforce Caltex to take proper action.
3. Correct remediation must have basis in Caltex' environmental risk assessment which is actually based on the actual concentration of contaminants in the various recipients.
4. The Kenyan authorities should ensure that proper action is taken and that the site is remediated to an acceptable level of environmental risk

LIST OF CONTENT

1. UN EXPERT MISSION TO LOKICHOKIO – SCOPE OF WORK

The scope of work is based on the instructions given from UNEP/OCHA and comprises the "Mission's aim" and "Requested output". The itinerary, confer appendix 12 gives some indications on the executed work and on how aims have been achieved.

1.1 Mission's aims

1. To carry out an examination of the spill
2. Assess the environmental significance of the spill and its possible impact on ground water
3. Collaborate with WFP/UNICEF and UNEP representatives as well as relevant national- and local authorities
4. Inform and give parties involved on the risk of the spill as well as on long and short terms appropriate mitigation (options on cleaning up and rehabilitation) of the spill

1.2 Mission's output

1. Preliminary conclusions on the, findings, risk assessment, possible mitigation, clean up and restoration

Present a report on the conclusions and the recommendations forwarded by the expert mission. The report is available for WFP, OCHA, UNEP and relevant national and local authorities.

2. CONDITIONS

2.1 Expert mission to Lokichokio

After the spill of jet fuel at the Caltex Kenya Ltd aviation services depot at Lokichokio had occurred a request for assistance was on the 21st January send to UNEP in Nairobi. The aviation services depot is provided for and operated by Caltex Kenya Ltd. (Caltex) under a WFP contract. The WFP expressed their concern that the jet fuel spill may cause serious environmental damage to the scarce water supply in Lokichokio. It appeared that Caltex was addressing the problem, but WFP hoped that this is done by the UN standards and guidelines.

A formal request to the joint UNEP/OCHA Environment Unit, Disaster Response Branch from UNEP, to give expert assistance was send on the 25th January. After a request to various nations, Austria and Norway responded positively, and experts from OMV Proterra Vienna Austria Mr Rupprecht Berger and Norwegian Pollution Control Authority Mr. Geir Lenes composed the UN Expert Mission team (UN-M).

The UNICEF/WFP carries out a large food distribution programme in south Sudan. The food is dropped by a major air lift operation from Lokichokio, which started in 1989. The use of jet fuel A-1 has been in the order of 120 m3/day, possibly at a maximum of 250 m3/day and could within 6 months decrease to about 50 m3/day.

The UN-M carried out their assessment between the 7th to the 16th of March 1999.

2.2 Climate and physiography

Lokichokio is a small border town in the northern part of Kenya in Turkana district, confer general overview map appendix 1.1 for exact location. The town is situated on the western fringe of the Lotikipi plain, between the Mogila Range and the Songot Mountain close to the major Nanam River. Location

co-ordinates are N: 4°12’ E:34°22’. The approximate altitude at Lokichokio is 640 m.a.s.l.

The climate in the north of Kenya can be classified as semi arid to sub humid /1,2,3,4/. Low total annual rainfall, low reliability and an extremely high order of variability dominate the rainfall features. The rain falls in periods of several wet days in March – June and October - December. Mean annual rainfall in Lokichokio is approximately 535 mm. Potential annual evapotranspiration is about 2000 mm. The maximum temperature is likely to vary between 25 – 40 °C.

2.3 Hydrogeological basis

Lokochokio is within the Nanam River catchment area that belongs to the Lotikipi basin. The catchment is composed of four different units that are;

1. Uganda escarpment
2. A gently dipping plain between the escarpment and the ranges
3. The ranges
4. 4. Lotikipi plain - a "no outlet depression"

The drainage pattern is partly governed by the tectonically features, and the tributaries flowing in the depressions between lava ridges indicate a SW-NE lineament pattern. At Lokichokio the density of lineaments (possibly fractures and joints) are relatively high, indicating a higher probability of finding ground water in the volcanic rock (aquifer in consolidated materials). The main river follows a depression most likely caused by faulting. The main fault is very distinct at Lokichokio and Nanam River bends here 90° when passing through the outlet between Songot Mountain and Mogila Range.

Basically, rainfall on the Uganda escarpment contributes to the flow of water in Nanam River and hence, also dominates the recharge of the shallow ground water. No records on surface water flow in Nanam River exists, the river is defined intermittent and carries water irregularly and only for a short time.

Recharge of the aquifers in the fractured and jointed rhyolite and basalt is mainly taking place at the major hills and ranges. It is also believed that the recharge at the Uganda escarpment contributes to the relatively abundant

ground water at Lokichokio. Recharge to rock aquifers through the soil, on the plains area, is probably minor due to the very high evapotranspiration, low rainfall and thick silty clayey soil (vertisole and red soil), which restricts percolation and facilitates surface flow.

Water is a scarce resource in this area. During rain the availability is usually far better. As the dry period extends surface water can be found in pools, depressions and cavities in rock. Ground water is located in the shallow dry riverbed aquifers and in rock aquifers. The portion of consumed ground water is increased as the dry period is prolonged. Such water is drawn from numerous ground water wells within and in the vicinity of the town. For residents in Lokichokio the dependence of ground water is distinct and prominent. Basically such water is only provided from drilled ground water wells in rock. For the nomadic Turkanas shallow ground water in the sandy riverbed of Nanam River system is a crucial resource.

Hydrogeological investigations at Lokichokio to serve road construction purposes as well as for supplying the residents and the nomadic Turkanas, have proven the potential of the aquifers /2/. There is ground water both in the shallow sand beds of the Nanam River as well as in the fractured rhyolite and basalt. The ground water in the sandy riverbed of Nanam River is for a major part of the year confined in many small and shallow sub surface basins, which do not necessarily communicate. Losses are mainly due to vertical percolation. The aquifers in the fractured rhyolite and basalt are only accessible from drilled wells. In general, aquifers in such rock are confined and isolated, however, in Lokichokio it is anticipated that such aquifers communicate both due to the nature of stratification and the dense joint and fracture pattern.

The rock is very stratified due to separate incidents of eruption and subsequent lava flows. In between the more competent basalt and rhyolite layers are distinct ash layers. They can be thick and extensive and are incompetent (flexible). Hence they can constitute major horizontal barriers for downward percolation of water. Due to proper soil barrier and also the presence of such barriers in rock, the ground water quality is mainly acceptable in Lokichokio. Information with respect to geology and the aquifers

in fractured rock, on the southern side of Nanam River and within the premises of Lokichokio is listed in appendix 1.2 and 2. The overburden is poorly characterised and mapped, however, it has been established that it is relatively thick (6-28 m), stratified and composed of silt and clay materials. Water rest level in the rock aquifer is shallow (13 – 30 m) and the aquifer yield is high (1,8 – 10 m^3/h).

3. FINDINGS OF THE ASSESSMENT MISSIONS

3.1 Findings of the assessment mission on the 29th January 1999

A preliminary mission was send to Lokichokio to assess the jet fuel A-1 spill. The conclusions of that mission are as follows:

- Caltex operates a depot consisting of five large bladders each having storage capacity of 180 m^3 of jet fuel
- One bladder burst on the 19th January releasing approximately 156 m^3 of jet fuel into the bladder compartment
- Combating the spill resulted in a total recovery of 12 m^3 of jet fuel
- Approximately 136 m^3 of jet fuel had infiltrated the ground
- The jet fuel had percolated at least 2.5 m into the soil, the horizontal transport and spreading had not been identified
- Excavation was carried out to a maximum depth of 1-2 m
- Excavated soil had been deposed of some few hundred meters away from the Nanam River. The local chief and the DO recommended the disposal site on the basis that the pastoral communities do not use the area.
- Soil samples from the disposal site have been sent for chemical analysis
- Unacceptable high environmental risk has been identified with respect to the deeper laying ground water. Risks along possible transport and spreading route has not been addressed
- Some recommendations on recovery measures, assessment/monitoring measures, preventive measures and deepening the excavation down to at least 2.5 m have been given.

The report is enclosed in appendix 3.

3.2 Findings of the UN- Expert mission 7th-16th March 1999

3.2.1 Aviation services depot and the surroundings

The Caltex aviation services depot is locate in the middle of the Lokichokio town ((N:04°12'16,7'',E:34°21'50,9''). The Caltex facility is composed as follows (confer appendix 1.3):

- Office block
- Loading/Off loading area for truck tankers
- Fire equipment shed and an alarm
- Six large settling tanks for jet fuel
- One compartments with 3 bladders (compartment area A), each of a capacity of 50.000 gallons (180 m^3)
- One compartment with 2 bladders (compartment area B) of similar capacity
- Pumps and connecting piping net work
- Compartment area A has a concrete slab, a roof protecting against sun radiation, and a permanent brick wall surrounding the 3 bladders (bladder 1,2 and 3). The bladders rest on a sand cushion. There are open holes through the wall for piping net work
- Compartment area B was established at a later stage due to a higher demand for jet fuel A-1, and does not have a concrete slab, no protecting roof and the 2 bladders (4 and 5) are placed directly on the pre-prepared ground. A major opening in the wall is located in the north west corner and smaller holes let piping net work through the brick wall
- None of the compartments can completely retain large volumes of jet fuel A-1 for a long time, the compartment area B being the poorest with leakage also into ground and out to the surroundings via holes and not confining dikes

Next to the Caltex premises is the Godown compound – relief supplies warehouse, a UNICEF filling station, Kate camp, WFP compound and NGO camps. Residential areas and various stores, main roads etc. are enclosed in a circle with radius at some few hundred meters. Many wells are close to the site, confer appendix 1.2.

3.2.2 Examination of the spill

The incident in chronological order as has been identified by the UN - M does in general comply with the chronology described by Caltex, confer appendix 4 and 11:

- A minor leak was observed in the dorsal top seam in bladder no. 4 at 12:30. On the 19.01.99
- Jet fuel were immediately being pumped from the leaking bladder into another bladder and altogether 11 m^3 were recovered
- The bladder no. 4 burst completely at about 13:30 along the dorsal top seam and the jet fuel A-1 splashed into the compartment B, as well as into the area in front of the Caltex office and the Godown store area
- WFP and Caltex started combating the spill and recovered 10,7 m^3 jet fuel. The jet fuel contained in the ruptured bladder was recovered in drums, which eventually were provided by the WFP
- UN security and the DO acted to minimise hazard and explosion to the people being close the site
- The remaining volume of jet fuel evaporated, infiltrated the ground and percolated further into the soil within approximately 30 minutes
- At about 14:00 only minor volume of jet fuel remained on the surface and within relatively short time, all the jet fuel A-1 had disappeared from the surface

3.2.3 Accounting the jet fuel A-1 spill

Based on the review of the incident and a practical evaporation test carried out in Lokichokio, the following jet fuel A-1 budget has been established confer appendix 5 for more details. According to UN - M the total area that received jet fuel A-1 is about 1400 m^2. The temperature at the time was about 40 ^oC with wind and low humidity.

Volume of jet fuel A-1 in the bladder no. 4 158 m^3

Recovered volume of jet fuel A-1 (retained in drums and bladder) 22 m^3

Evaporated volume of jet fuel A-1 21 m^3

Infiltrated volume of jet fuel A-1 **115 m^3**

The accuracy of the estimated volume of infiltrated jet fuel A-1 into the ground is according to the UN – M reasonable. The budget accounts for the various jet fuel "flows". The evaporated jet fuel A-1 caused high concentrations in the air in a large area. The plume moved with the wind towards the airport.
The infiltration of the jet fuel was rather fast. Unfortunately, none precise and concrete characteristics on the soil parameters are available (composition, thickness, stratification, porosity, water content in porous matrix, grainsize analysis, fraction of organic carbon etc). However, such information will be reported in the final Caltex report. At 10.03.99 three pits were dug in the vicinity of the spill area to reveal soil conditions and basically the soil seems to be unstratified and homogenous to about 1,5 m depth, confer appendix 1.3 and 6. Below this depth, it must be anticipated a higher degree of stratification. The soil at the location is compacted silt and clay. The presence of permeable soil, which possibly could conduct jet fuel out of the site, and into vulnerable recipients has not been revealed. Caltex must however, address this issue in particular.
Based on the soil parameter assumptions and the jet fuel A-1 specification presented in appendix 7, it is possible to estimate the percolation of the jet fuel A-1 in the ground, confer appendix 5.The velocity of the downward moving saturated jet fuel front is in the range of $v = 10^{-5}$ m/s. Hence possible vertical transport distance could be in the order of 1 m for a time span of 24 hours (excavation and removal of major part of the source was done the day after the incident took place). Based on the volume percolating, the soil parameters and given spill area the possible depth to which the jet fuel can percolate will be in the order of 3,2 m. An estimated average percolation depth is then in the range of (3,2 m + 1)/2; 2 m.
3.2.4 Status on the contaminated recipients
Contaminated soil at the Caltex aviation services depot
Caltex was confident that the spill had been remediated adequately. Remaining fuel in the soil close to the Caltex office and north of the building will, according to Caltex be removed later. The remaining jet fuel does not represent any major risk to the ground water or to the health of the people in Lokichokio. The UN - M would like to draw the attention on the following:

Caltex started excavation of the second compartment (where the bladder burst) the day after the incident took place. Based on the general assumptions made in chapter 3.2.3 it is not likely that the jet fuel did percolate deeper than approximately 3 m. Excavation of contaminated soil was carried out in two separate phases. On the advice of Mr. Lambrecht UNEP, the last excavation continued deeper than 2 m, and in parts of the compartment even down to 2,5 m. Criteria to terminate excavation were restricted to a possible lack of smell or visible traces of hydrocarbons. This indicates at least, that a major part of the source has been removed.

The bottom of the excavated area was inspected by Mr. Peter Grayson UNICEF on the 11-12 February 1999, confer appendix 8 and 9. He reported that the bottom was dry and had no signs of hydrocarbons. At some few places along the walls, signs of jet fuel could be seen. The excavated hole was later backfilled on the 11th of February. Unfortunately soil samples to document hydrocarbons in the soil at the time of terminating the excavation work have not been analysed. Only new soil sampling and chemical analysis can give accurate concentrations on retained hydrocarbons in the soil. Caltex will, however, address this issue in their final report. Totally, about 2000 m^3 of soil (given as an undisturbed volume) has been removed. Sand was used to cover other areas that were flooded by spilt jet fuel.

Based on the volume of soil excavated and a possible retention capacity of jet fuel A-1 in such soil (5% by volume, 30 ltrs/m^3 soil), it is anticipated that this could represent 90m^3 jet fuel A-1. Deducting this volume from the infiltrated volume (115 m^3) gives a deficit of **25 m^3, that could still remain in the soil. This indicates that approximately 500 m^3 contaminated soil sub surface at the site.** This volume can partly and most likely be accounted for, as remaining jet fuel in not excavated areas such as:

1. at the Godown compound
2. underneath the Godown store building
3. in soil in front of the Caltex office
4. as residuals in the walls and bottom of the excavated area

Rock aquifers

The most likely ground water wells to be affected by the spill given an introduction of jet fuel in the rock aquifer is presented in the appendix 1.2. No taste or smell of hydrocarbons in the ground water was reported to the UN – Mission. Some of these wells are pumped at a high discharge rate and given the time elapsed, one should expect that jet fuel components would have appeared in some of these wells. It is never the less necessary to monitor the ground water and analyse water samples (THC and individual chemical parameters) to be able to be conclusive on this issue. The fact that recharges could take place now, due to the rains with consequent washing out of hydrocarbons, emphasis this.

The dumping site

The dumping site for contaminated soil is located about 2,3 km north of the Nanam River crossing following the gravel road to Sudan (N:04°13'45'', E:34°20'38''), confer appendix 1.4. In general the thickness of deposited soil varied between 0,2 m and 0,5 m. At some places the depth was more than 1 m. The soil at the dump site was silt and clay, which confirms the findings in the excavated pits. It was estimated that the dump covered about 3000 m^2. Prior to dumping the contaminated soil, the site was evened out, however, large boulders that were ripped loose are still present in the contaminated soil matrix. No geoliner was installed to impede percolation of jet fuel A-1. Totally, the soil volume confined in the waste dump was verified at about 2000 m^3 . Unfortunately, Caltex did not take any soil samples for analysis to be able to conclude on the actual concentration of jet fuel in the soil at the time of excavation, nor at the time of placing the materials in the dump. Caltex has not taken samples afterwards to be able to establish the rate of evaporation and biodegradation of hydrocarbons in such soil.

The dumping site is somewhat elevated above the main plain and no major stream is in the vicinity of the site. According to an evaluation of the site, the in situ soil is characterised as silt and clay, however, some sands and large boulders are also present. The soil is basically weathered volcanic materials with low hydraulic conductivity (10^{-6} m/s).

The excavated contaminated soil could be prone to erosion (rain), however subsequently transport of contaminants into the Nanam River is not likely to occur. This is hence not considered to be a major risk to the Lokichokio community. Some 4 pits were dug in the dumping area. The contaminated soil still smelled hydrocarbons, but not saturated with hydrocarbons. Percolation into the in situ soil at the time of inspection was in the order of 0,05 m. The contaminated soil were obviously tilled, however, the soil were not as evenly distributed within the site as has earlier been pointed out to Caltex Kenya Ltd. At some positions the thickness of the contaminated soil were in excess of 1 m and it should not exceed 0,3 m. This is a major constraint to the rehabilitation of the soil, basically a prerequisite for not to install protecting liner and must be corrected soonest.

3.3 Evaluation of mitigation work and soil and contaminant survey

Excavation works

- The excavation works started with in a reasonable time
- The excavation could have been carried out more thoroughly at the beginning (depth, areas excavated etc)
- The documentation of the jet fuel concentration in the excavated soil is lacking
- The documentation of the remaining jet fuel in soil in the walls and bottom of the excavation pit is lacking
- Criteria for terminating excavation was not appropriate

Dumping site for contaminated soil

- The selection of dumping site is not based on sound judgement
- The arguments and the final conclusions being basis for the decision on not to install liner is lacking (UN – M estimates that there is no instant need of liner)
- The risk imposed due to the dumping of contaminated soil is not established
- The spreading and tilling of the contaminated soil are not according to given recommendations

Caltex aviation services depot

- Risk analysis has not been executed
- A thorough assessment of the hydrogeological conditions are lacking
- No ground water sampling for hydrocarbon analysis has been performed
- A complete assessment of remaining jet fuel in soil is lacking
- The soil composition, stratification and thickness above the rock surface is lacking
- Recharge potential is not defined
- The effectiveness of soil and rock barriers have not been established
- Expected concentration of hydrocarbons in eluded water is not defined

Evaluation of the soil and contaminant survey

The Caltex survey was carried out on the 24th of February 1999. Preliminary conclusions on the findings of the soil and contaminant survey were presented to the UN – M in Nairobi. In general and to our knowledge, the concentration of hydrocarbons referred to in soils (SGS Kenya sampling) represent concentrations at the time of sampling and do not adequately describe concentrations in soil at the time of the incident. Hence, it is difficult to interpret such findings. The findings of the survey on the 24th February are based on soil coring and subsequently PID measurements and the need for accurate results are pertinent. In general the concentrations were low, apart from samples in areas not excavated. The conclusion on the hydrogeological conditions at Lokichokio is basically wrong and needs to be corrected prior to risk analysis.

4. RISK ASSESSMENT

4.1 Introduction

Caltex has presented a basis for the remediation works. The company policy document, confer appendix 10 and international standards should compose such basis. Caltex has said that no source of danger should remain, identifying a limit of 500 ppm total hydrocarbons in soil as guideline. It is expected that Caltex must be more specific on this issue and the actual acceptance criteria must be based on a) risk analysis or b) precise rest level

of hydrocarbons in the recipients based on the combination of total hydrocarbons and the individual chemical components according to the following:

- Level of contamination in soil
- Level of contaminants in eluded water
- Level of contamination in exposed aquifers

It is expected that Caltex either carries out a risk analysis to establish such criteria or presents concrete values on contaminants in soil, elude soil water and ground water. Eventually the actual findings of contaminants in the recipients must comply with such selected concentrations, to prove that the remediation works have gone far enough and that the imposed risks involved are acceptable.

4.2 Consequences of the spill of jet fuel A-1

The consequences of introducing jet fuel A-1 in recipients at Lokichokio are basically linked to:

1. deterioration of major ground water recipients (short term)
2. evaporation and subsequently high concentrations of hydrocarbons in "in door" air
3. mobilisation of hydrocarbons over long time and subsequently deteriorating ground water resources
4. impact on plant growth due to high concentrations of hydrocarbons in soil

The general characteristics of a jet fuel A-1 are presented in appendix 7. The Jet fuel A-1 belongs to kerosene and aviation fuels. Jet fuel A-1 is characterised by content of alkanes (C9-C16) and cycloalkanes. The aromatic hydrocarbons 1-2 rings (benzene 0,05 %, naphthalene, n-hexane < 1 %) are also percent at a significant percentage (17 – 25 %). In general such fuels are added antioxidants to minimise oxidation of hydrocarbons and bacterial growth. The consequences of such additives must also in this context be

elaborated. It is obvious that the individual chemical components must be addressed to be conclusive on the imposed risk.
The biodegradation of hydrocarbons varies according to respective components. In general the relative resistance to such biodegradation is as follows:
alkanes > branched alkanes > low molecular aromatics > cykloalkanes (naftalenes) > poly aromatic and polar hydrocarbons. It is expected that the natural degradation in soil (intrinsic bioremediation/natural attenuation) and in ground water and soil could take long time, due to partially lack of nutrients and water.

4.3 Probability of an identified vulnerable recipient being contaminated

Probability of an identified vulnerable recipient being contaminated is related to the transport and spreading of contaminants. According to our evaluation of the site based on soil, rock and aquifer information it is likely that a major spill of jet fuel A-1 being left unattended in soil eventually could contaminate vulnerable recipients.

4.4 Environmental risks

To establish the environmental risk imposed the following has been the basis:
-remaining jet fuel A-1 sub surface and in excavated soil
-transport and spreading of contaminants in the in situ soil and aquifers
-identified vulnerable recipients
-potential of natural attenuation of contaminants in sub surface
Aquifer
The probability that jet fuel A-1 components could reach the ground water and consequently pollute the ground water at a significant level is **medium.** The negative consequence of an introduction of jet fuel components in ground water could be very significant both on long and short terms. The negative consequence is determined **very high.**

The environmental risk is unacceptable. Actions are needed.

Probability						
Ext high						
Very high						

High						
Medium						
Low						
	Low	Medium	High	Very high	Ext.high	Consequence

Soil at Caltex site

The probability that jet fuel A-1 components left in the soil could further contaminate soil at a significant level is **very high.** The negative consequence of an introduction of jet fuel components in such soil could be very significant and is determined **high.**

The environmental risk is unacceptably high. Actions are needed.

Probability						
Ext high						
Very high						
High						
Medium						
Low						
	Low	Medium	High	Very high	Ext.high	Consequence

Residential areas/offices and camp sites

The probability that jet fuel A-1 components left in the soil could create significant in door concentration in residential areas is **low.** The negative consequence of such introduction of jet fuel components (vapour) is determined **high.**

The environmental risk is within acceptable range. No action is needed

Probability						
Ext high						
Very high						
High						

Medium						
Low						
	Low	Medium	High	Very high	Ext.high	Consequence

Soil at the dumping site

The probability that jet fuel A-1 components could reach the ground water and consequently pollute the ground water at a significant level is **low.** The negative consequence of such an introduction of jet fuel components could be very significant and is determined **high**.

The environmental risk is acceptable provided remediation continues.

Probability						
Ext high						
Very high						
High						
Medium						
Low						
	Low	Medium	High	Very high	Ext.high	Consequence

5. REDUCTION OF IMPOSED ENVIRONMENTAL RISKS

The representatives of Caltex stress the already imposed costs and they have been reluctant to proceed on with other necessary investigations and analysis (hydrologeological study and risk analysis). It is, however, pertinent that environmental risk analysis is the platform for deciding on further remediation work. The UN – M has identified a need for further works and recommends that Caltex follow up on the conclusions.

5.1 Acute jet fuel A-1 pollution - Responsibilities

5.1.1 Responsibilities

WFP is the owner of the jet fuel A-1 and the fuel is bought from the Caltex fuels store in Eldoret and hauled (contracted by WFP) by trucks to Lokichokio. Caltex is responsible for the complete management of the jet fuel aviation

services comprising the storage facility and the tanking operation at the airport. It is therefor with out doubt, the sole responsibility of Caltex to address the spill and initiate work to minimise the environmental effects of the jet fuel A-1 spill. This is also recognised by the Caltex and they have acted accordingly.

According to Caltex they have combated the acute jet fuel spill and mitigation works have basically comprised excavation of a large volume of contaminated soil. Caltex has also initiated a soil and contaminant survey and within two weeks a final report on the jet fuel spill will be presented to parties involved. It is expected that the report will address the findings on the soil and contamination survey with emphases on risk and possibly further works to be executed. Caltex has assured the UN-Mission that the conclusions will guide Caltex with respect to further remediation works.

5.1.2 Caltex environment, health, and safety policy

Caltex recognises the importance of protecting and preserving the environment and of the caring for the health and safety of their employees, contractors, customers and communities in which they operate. To manage that Caltex has established an Environment, Health and Safety policy EHS, confer appendix 10. This implicates among others, compliance with law and regulations, conduct audits and promote awareness of EHS, concerns regarding product storage, and to establish and maintain emergency preparedness plans for EHS incidents which may involve the company.

Some expensive, operative, environmental, health and safety lessons have been learnt at Lokichokio. In the discussions with the Caltex representatives the following emerged:

1. Caltex has not executed any analysis to define risks involved in operating an emergency jet fuel aviation services depot within Lokichokio town.
2. Caltex do not have any emergency preparedness and response plan to be able to manage such incidents as occurred in Lokichokio on the 19. January 1999.

3. Caltex agreed to that the facility at Lokichokio was not properly constructed both with respect to the compartments, surrounding dikes as well as to the lack of concrete slab in the compartment hosting the burst bladder.
4. Caltex was aware that the burst of the jet fuel bladder most probably was caused by a combination of factors listed as follows; 1). Reuse of old bladders, 2). Exposure of bladders to continuos UV-radiation, 3). Large temperature variations. Such management is not according to the manufactures specifications.
5. Possible malpractice with respect to the filling operation of the bladders.

An international expert from the Caltex Company had inspected the facilities in Lokichokio on the October 1998. The report with conclusions has not been available to UN-M.

There are many explanations to the current situation, however, this cannot be an excuse to continue such malpractice. Caltex promised to address these issues and soonest establish a safe and properly operated jet fuel aviation services depot. Caltex indicated also the possibility of moving the depot to a safer area at the airport. Proposed corrective actions be also forwarded in the Caltex preliminary report chapter 6, confer appendix 4.

5.1.3 Legal framework

In Kenya, both the Water Control Act (Ministry of Water - MOW) and the Environmental Protection Act (Ministry of Environment - MOE) could be applicable to enforce and regulate the Caltex Ltd. remediation works to mitigate such jet fuel A-1 pollution in Lokichokio. In general, the representative of the Ministry of Water proposed that Caltex must apply Kenyan standards with respect to establishes acceptance criteria for remediating contaminated water and soil. Such standards will comply with similar European standards. It is recommended to monitor Caltex closely on this issue.

Caltex did not notify central authorities about the incident in Lokichokio on the 19th January 1999. Local authorities in Lokichokio have been notified according to Caltex saying. The District Officer (DO) in Lokichokio was aware

of the incident and the DO had actually participated in the first phase of the spill to guideline residents with respect to the health hazard. The police participated also in this phase of the emergency operation. It is not known how or when the DO informed the central authorities in Nairobi.
National authorities have according to the UN - M not been notified, and MOW representatives were not aware of the incident prior to the meeting with UN - M on the 12.03.99. It is not known how such emergency pollution incidents should be notified with respect to the juridical framework. It is strongly felt that Caltex should immediately have informed the national authorities on the incident, its implications and the approach Caltex would apply to hinder and mitigate adverse environmental effects.

5.1.4 Improvements

The aviation services depot is provided for and operated by Caltex under a WFP contract. This is basically an emergency operation to aid the malfed people of south Sudan. However, with respect to the size of the operation and the time frame it has worked within (since 1989), it is pertinent to expect that the operation and provided facilities in Lokichokio would have been of a more permanent status.
The incident in Lokichokio and the risk imposed could have been very high. The reason for a hopefully limited environmental impact is not due to considerate planning, but solely based on coincidence and relatively efficient natural geological barriers on site. This should be of major concern for all parties involved and must be adequately addressed at all levels. It is also proposed that the WFP/UNICEF, when engaged in an emergency operation, should carry out analysis to reveal environmental risks imposed by such operations, ensure that contractors work within recognised EHS standards and that such EHS policy is implement in practise.
Several different parties and organisations are engaged in Lokichokio and they manage petroleum products in relatively large quantities within the town premises. It is possible that such storage and handling represents an unwanted environmental risk. It is the responsibility of the authorities to ensure that such activities are acceptable with respect to environment, health and safety. However, it is in principal, the different organisations and

companies that must comply with the Kenyan law and regulations in such a way that the vulnerable environment and the residents of Lokichokio are not exposed.

5.2 Guidelines for further works

The remediation works in Lokichokio is, due to the identified environmental risk recommended to be within the framework as follows:

1. Caltex must comply with Kenyan laws and regulations and manage the acute spill accordingly
2. The Kenyan authorities should within the legal framework enforce Caltex to take proper action.
3. Correct remediation must have basis in Caltex' environmental risk assessment which is actually based on the actual concentration of contaminants in the various recipients.
4. The Kenyan authorities should ensure that proper action is taken and that the site is remediated to an acceptable level of environmental risk

5.2.1 Remediation works at the Caltex site

- Carry out environmental risk analysis
- Establish exact level of contaminants in soil and ground water
- Excavate contaminated locations still not cleaned up
- Execute deep soil coring (at least 15- 20 m) down to rock surface to reveal stratigraphy and soil composition
- Evaluate and model efficiency of soil an rock barriers
- Compare result of the risk analysis and accept criteria with respect to actual rest contamination
- Execute remediation to reach acceptable level of environmental risk

5.2.2 Remediation works at the soil dump

- Carry out environmental risk analysis
- Establish a more even spreading of the contaminated soil – depth must not exceed 0.3 m

- Continue intensive tilling (Once every week for one month, then once a moth until further analysis shows acceptable rest concentration of hydrocarbons in soil)

5.2.3 Further investigations and analysis on ground water aquifers

- Execute environmental risk analysis
- Assess vulnerable resources – initiate hydrogeological investigations
- Monitor the ground water at relevant wells on THC and Aromatic components
- According to findings simulate transport and spreading of contaminates in aquifers
- If needed, initiate appropriate remediation work

5.2.4 Other actions

- Notify national authorities – Ministry of water and Ministry of Environment
- Report to the national and local authorities
- Report to WFP

LIST OF REFERENCES

1. Hydrogeological report. Drilling of water wells in Kenya. Kenya Sudan Road Link. Norconsult A.S Kenya, June 1981.
2. Assessment of water resources in Turkana district. Norconsult A.S Kenya, July 1983.
3. Environmental study of Turkana district. Norconsult Nairobi 7. of June 1990
4. Hydrogeological survey. Kenya Sudan road link Lodwar – Juba. Norconsult AS December 1981

APPENDICES

1. Overview - Lokichokio
    1. General overview map

2. Ground water wells - locations
3. Caltex site map
4. Dumping site

2. Ground water wells - details
3. Report on Fuel spill at Lokichokio, Kenya Assessment mission 29. January 1999, Christian Lambrechts – UNEP
4. Caltex preliminary report on the Jet fuel A-1 spill on the Tuesday, January 19, 1999 at the Caltex aviation services depot Lokichokio Kenya 11.march 1999
5. Transport and spreading of jet fuel - calculations
6. Results of pit digging
7. Specifications on the Jet A-1 fuel
8. Subject – Caltex Fuel spill, Lokichokio – letter to MB, dated 30.01.99, Peter Grayson UNICEF
9. Subject – Caltex Fuel spillage – letter to MF, dated 15.02.99, Peter Grayson UNICEF
10. Caltex Environment, Health and Safety policy
11. Incident report of jet A1 spill at Caltex 19.01.99 from Tarek Keshavjee. To Rajab Mohammed and Rhoda Asewa both WFP.
12. Itinerary

APPENDIX 5

TRANSPORT AND SPREADING OF JET FUEL A-1 AT CALTEX LTD. PREMISES LOKICHOKIO.

CALCULATIONS.

1. Jet fuel A-1 spill budget

A. Volume of spill V1 = 158 m^3
B. Recovered volume V2 = (In drums; 10,7 m^3, in the bladder; 11 m^3) = 22 m^3
C. Volume of oil on the ground (V1-V2) = 136 m^3
D. Evaporation rate (from test in Lokichokio); 1. First hour 3mm/h, 2. Remaining hours 1 mm/h.

E. Spill area A (A1=inside compound; 30m*30m = 900m^2, A2 = Outside into bladder area 100 m^2 and out in Godown area = 400 m^2) = 1400 m2
F. Excavated soil E1 = (depth 2 m * A1) = 1800 m^3
G. Average volume of jet fuel in soil = (E1*(concentration of jet fuel in soil;5% i.e. 30 ltr/m^3))=90m^3
H. Evaporated volume EP = 1400m^2(3*1h+1*12h) = 21 m^3
I. Jet fuel balance = 136-21-90 m^3 = **25 m^3 left in soil: 500 m^3 of soil could still be contaminated.** This can partly and most likely be accounted for by the remaining jet fuel in the soil at the Godown compound, underneath the storage building, in soil in front of the Caltex office and possibly residuals in the walls and bottom of the excavated pit.

2. Evaporation rate

Evaporation test (Jet fuel A-1) was started at lunchtime 10.03.99. Approximately 20 litres of Jet Fuel A-1 was placed in an open plastic container Ø 40 cm near by the airport in an open and wind exposed location. The final reading showed an evaporation rate of 6 mm in 4,5 hour. Temperature was 28 ^oC and the humidity was relative high. To relate this find to the situation at the time of the incident (40 ^oC) we have applied a doubled evaporation value in our Jet fuel budgeting (calculations of the jet fuel mass balance).

3. Movement of saturated Jet fuel A-1 in the soil at Caltex

Velocity of the downward moving saturated Jet fuel front v = 2*K*Cst^{-1} = 2*5*10^{-6}*1^{-1} = 10^{-5} m/s

Distance percolated (in 24 h) = 10^{-5} m/s*24*3600 s = **0.86m, say 1 m**

*Anticipated average d**epth of** intruded **Jet fuel A-**1 at the Caltex site*

D=1000*V1(A*R*f) $^{-1}$ = 1000*136(1400*30*1) $^{-1}$ = **3.2m**

Estimated average percolation depth is (3.2 m + 1.0)/2 = **2m**

APPENDIX 6

DIGGING OF PITS AT CALTEX SITE

Pit A. In front of the Caltex office next to the retaining wall

0-1,5 m. Red brownish soil. Silt, some fine sand an clay, homogeneous, not stratified. Some smell of hydrocarbons down 1,5 m.

Pit B. Back side of the bladder compound, approximately outside bladder 5. 0-1,5 m. Red brownish soil. Disturbed. Fine sand, some silt and gravel. Very little smell of hydrocarbons down to 1,5 m.

Pit C. Back side of the bladder compound, approximately outside bladder 4. 0-1,0 m. Silt, some fine sand and clay, homogeneous, not stratified. No smell of hydrocarbons.

APPENDIX 12

ITINERARY.

OCHA MISSION 07-15.03.99. ACUTE POLLUTION - LOKICHOKIO

DAY 07.03. G. Lenes leaves Norway and arrives in Nairobi at 22.25.

DAY 08.03 Collected by the UNEP representative Christian Lambrecht.

Meeting with Mr Donald Kaniaru Chief, Law unit UNEP on the issue of legal framework and enforcement.

Meeting with Rob Postma FAO with respect to maps, satellite imagery, aerial photos.

Meeting with Luka A. Isavwa Director Regional centre for services in surveying Mapping and Remote Sensing.

Meeting with prof. Charles Okidi – legal Office of UNEP on the legal frame work with respect to enforces polluter to take appropriate action. The legal framework was in place and both the Water Control Act and the Public Health Act could be applicable.

Contacted Norconsult Nairobi, the managing director Bruno Illi on the issue of having access to their aerial photos covering Lokichokio.

DAY 09.03 Tried to set up a meeting with Dr. Morris Ndege. He is a specialist in water and could contribute to the findings.

Mr Rupprecht Berger arrives in Nairobi

Meeting with Till Dornhofer. Ph.D. Deputy director Drylands Ecosystems and Desertification Control. UNEP. Mr. Tiller advised the expert team to set up a meeting with Ministry of Environment – Permanent representative to UNEP in Kenya and the Ministry of Water Development – Water control office.

The UN Mission participants arrive in Lokichokio.

Meeting with Ben Martinson Base camp manager Lokichokio. He was informed about the missions mandate and duties to be carried out. He provided the assistance the team required and gave access to whatever people the team would like to interview in this respect.

DAY 10.03 Visited Caltex facilities (N:04°12'16,7'',E:34°21'50,9'') and initiated pit excavations. Discussed with Mr McPhearson with respect to such digging. The Caltex staff informed us about the Panafcon ltd Nairobi investigations on the 24. February 1999.

The UN Mission visited the dumping site of contaminated soil. It is located about 2,3 km north from the Nanam river crossing along the gravel road to Sudan (N:04°13'45'',E:34°20'38'').

In the meeting with the assisting DO, administrative police cpt. Sylvester Ekomsa he said he were given a report on the incident which he later forwarded to the DO.

Meeting with Felix Edwards, Rajab Mohammed and Rhoda Asewa all from the WFP at Lokichokio. The mission were given information regarding the incident, spill volume, the emergency situation, health hazard, the combating phase where especially the WFP-staff were essential to manage and handle the acute pollution.

The findings at the excavated pits at Caltex very duly registered.

Evaporation test (Jet fuel A-1) was started at lunchtime.

The UN team visited the Alan Pake Drilling company, which provided well logs from some the wells nearby the Caltex site. We also discussed some details with respect to the conditions of the overburden in the same area.

DAY 11.03 Assessing high priority wells in the vicinity of the Caltex spill site and wells possibly being in the direction of a possibly migrating jet fuel plume.

Meeting with the DO in Lokichokio Mr. I. A. Nakoru. He was aware of the incident and the DO had actually participated in the first phase of the spill to avoid health hazard to people. The DO and the local Chief had also given instruction to Caltex on the location suitable to receive jet fuel contaminated soil.

The UN – Mission returned in the evening to Nairobi

DAY 12.03 Meeting at WFP with Caltex. Ian McPherson Director, Julian Baker Manger Panafcon Ltd, William Otieno Otuka Regional manager Operation Caltex, Saovjey Gandhi Regional Environmental Safety Co-ordinator Caltex, Juha Rauhalahti WFP, John Muhoho WFP, Tabeth Ngugu WFP, Stephen Nsubuga WFP, Christian Lambrecht UNEP,Tarek Keshavjee WFP, Rupprecht Berger UN, Geir Lenes UN on the Lokichokio jetfuel spill.

Meeting with Dr. Maurice M. Ndege. University of Nairobi. He promised to facilitate the mission representatives with Kenya standards on threshold limits of various compounds in soil and water.

Meeting at the Ministry of water with Mr John M. Omwenga Leader of the Water quality and water control division. The UN – mission presented the mandate and gave information on the incident. Mr. J. M. Omwenga was not aware of the incident and was grateful for the information given to the authorities. Mr. Simeon Ochieng Deputy director was also given the same information. The UN-mission stressed that the Ministry of water should approach Caltex for details on the incident.

Mr Till Dournhoffer, Land UNICEF was given a short and condensed debriefing on the UN- Mission findings.

It has due to foreseen reasons, not been possible to meet with Peter Greyson, UNICEF. In charge of drilling programme – Turkana, whom has first hand information on the excavation works executed by Caltex.

Day 13.03 Compilation and collation of information. Report writing.

Day 14.03 Compilation and collation of information. Report writing. Mr Lenes returns late night to Norway. Mr Berger will return to Austria on Tuesday the 16.03.99.

APPENDIX 2

GROUNDWATER WELLS

LOKICHOKIO

Well no.	Well Owner	Location	Co-ordinates	Thickness of over-burden (m)	Barriers	W.S.L (m)	W.R.L (m)	Trans-missivity m^2/s	Actual pumpin rate (m^3/h)

B - 8	UNICEF	UN-1 WFP camp		28	Silt and clay	54	30		3,1
C-10653	*UNICEF*	**UN-2** **WFP camp**	N: 4° 12,394' E: 34° 21,905'	26	Silty sand	50	29		3,1
C-9985	Interreact Ltd		(N: 4° 10' 0'') (E: 34° 20')	16	Silt and clay	66	31		
	Mr Patel	**Kate camp**	N: 4° 12,260' E: 34° 22,055'	6	Clay	52	31		2,1
	Trackmark Ltd	**Trackmark Camp**	N: 4° 12,572' E: 34° 22,096'						1,8
C-10917	Trackmark Ltd	Trackmark Camp		18	Silt and clay	34	18		
C-10916	NPAid	Intereact Complex		12	Silt	47	28		
NC-36A **C-5087**	**MOTC**	**Nanam River**	N: 4° 12,625' E: 34° 20,720'	16	fine sand	31	13	$1,5*10^{-5}$	
NC-36B C-5100	MOTC	Nanam River	N:639102,969 E:470026,231	8,5	Silty and clayey sand	28	13	$3,3*10^{-4}$	

Bold letters show wells visited by the UN - mission