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GEF/UNDP project Environmental Remediation of Dioxin Contaminated Hotspots in Viet Nam

Terminal Evaluation Report

Environmental Remediation of Dioxin Contaminated Hotspots in Viet Nam

GEF Project ID: 3032

UNDP PMIS ID: 3685

Terminal Evaluation Report - November 2014 / January 2015

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# Executive summary

## Project Summary Table

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| GEF Project ID | 3032 |
| UNDP PMIS ID | 3685 |
| Funding Source | GEF Trust Fund |
| Project Name | Environmental Remediation of Dioxin Contaminated Hotspots in Viet Nam  |
| Country | Vietnam |
| Region | Asia and the Pacific |
| Focal Area | POPs |
| Operational Program | 14 |
| Strategic Program | CB-1 |
| PIF Approval Date | 13/12/2007 |
| Approval Date | 22/02/2008 |
| CEO Endorsement Date | 15/09/2009 |
| Project Status | IA Approved  |
| Executing Agency | UNDP |
| Description | Several extensive and highly contaminated dioxin hotspots exist in Viet Nam. Several barriers (management, technical capacity, unavailability of data, institutional capacity, financial resources, communication and education) have limited Viet Nam in its ability to deal with these hotspots. Without the project, dioxins accumulated at hotspots will continue to become bio-available and dispersed in the local and global environment, through soil particles and organic materials that bind dioxin and are carried by water currents, wild life, and air. The project will address the barriers described above in order to effectively contain/remediate the highly dioxin contaminated material in the three main hotspots areas at Phu Cat, Bien Hoa and Da Nang as well as address the technical, institutional, financial as well as societal root causes for enabling Viet Nam to address additional sites of concern.  |
| PDF B Amount | 25,000 USD |
| Project Cost | 37,312,500 USD |
| GEF Agency Fees | 450,000 USD |
| GEF Project (CEO Endo.) | 4,977,000 USD |
| Co-financing Total (CEO Endo.) | 32,335,550 USD |
| Project Cost (CEO Endo.) | 37,312,550 USD |
| GEF Agency Fees (CEO Endo.) | 450,000 USD |

## Brief introduction to the project

The TCDD contamination in Viet Nam originated from the operations carried out by the US army during the armed conflict lasted from 1961 to 1971. The so-called Operation “Ranch-Hand” (May 1964 – January 1971) involved spraying an estimated 20 million U.S. gallons (76,000 m3) of defoliants and herbicides over rural areas of South Vietnam in an attempt to deprive the Viet Cong of food and vegetation cover. As the pesticides used for the Ranch Hand operation (and more specifically the so-called “Agent Orange”) were contaminated by TCDD, the operation resulted in an extensive contamination by TCDD of large part of the country. 40 years later, whilst the TCDD level in the sprayed area declined to lower levels, high level of contamination remained in a number of “hot spots”, among which the most severely contaminated are the three air bases where the Ranch Hand operation was based: the Bien Hoa Airbase, the Phu Cat Airbase, and the Da Nang Airbase.

As reported in the Project Document, the situation of TCDD contamination in the three air bases is as following:

* In the At Bien Hoa Airbase, there are at least three areas of very high contamination. The main area, a loading area (aka “Z1 area” – see Annex 1), has dioxin concentrations in the soil surface (0-30 cm layer) as high as 409,818ppt I-TEQ and an estimated average of over 15,864 ppt I-TEQ, with elevated dioxin concentrations found down to at least 1.5m depth; following the estimates provided by the inception report, the total amount of soil requiring decontamination / containment is from 195,500 to 235,000 m3, out of which still requiring containment from 101,500 to 141,500.
* In the Da Nang Airport and Airbase, there are three geographically proximate areas of very high contamination. This includes the former “mixing and loading areas”, where maximum dioxin levels reach 365,000ppt I-TEQ and the estimated average is well over 50,000ppt I-TEQ. The nearby storage/dumping area has a highest dioxin level of 134,802ppt I-TEQ with the average estimated as 39,883ppt I-TEQ.
* In the Phu Cat Airport and Airbase, dioxin concentration in the former herbicide storage area is very high, reaching up to 238,000ppt I-TEQ, and the average toxicity is estimated at 26,248ppt I-TEQ (over 97% of which is TCDD). The topography of the site suggests that water flow could have resulted in contamination of three nearby lakes, but samples taken from the drainage canal and lake sediment revealed comparatively low dioxin concentrations. The amount of soil to be contained, as revised at inception report, was of 12,000 m3
* The situation of PCDD/F contamination was updated with new monitoring data in the course of project implementation. The updated situation has been reported in the "Updated comprehensive report", released in 2014 (1)

The Project “Environmental Remediation of Dioxin Contaminated Hotspots in Viet Nam” (2) as originally approved has the objective to remove the barriers that limit Vietnam in dealing with the hotspot contaminated by Dioxin, namely:

* 1. The lack of an overall plan to deal with the hotspots and an overall regulatory framework regarding dioxin contamination;
	2. Limited availability of high quality data on site contamination and effects on environments and people;
	3. Technological capacities (access to technologies and essential equipment, knowledge, experience) for problem analysis and for remediation of dioxin contamination;
	4. Institutional capacities for coordination of national and international partners, and for planning and managing site remediation;
	5. Financial resources for remediation to internationally accepted norms;
	6. Capacities for public education and local land use planning to address the sensitive issue of highly toxic materials near populated areas.

The following assessments of dioxin contamination in the three areas were made prior to the project submission to GEF by the Vietnamese government, UNDP and donors:

* The Z1 (Bien Hoa airbase, 1994/1995), Z2 (Da Nang airbase, 1997/1998) and Z3 (Phu Cat airbase, 1999/2002) project by the Vietnamese Ministry of Defence;
* The collaboration between US EPA and VAST (Viet Nam Academy for Science and Technology) on sampling and contamination analysis;
* The project “*Assessment of Dioxin Contamination in the Environment and Human population in the vicinity of the Da Nang airbase, 2006/2007*” by Office 33 and Hatfield Consultants Limited (Vancouver, Canada), with funding from Ford Foundation;
* Soil and sediment samples taken and analyzed under the UNDP preparation project, by the Viet Nam - Russia Tropical Centre (VRTC) under the MOD and Hatfield Consultants.

The project built upon work conducted by international organizations or their contracted consultants in association with national partners, all of which are coordinated by the Office 33 of the Ministry of Natural Resources & Environment, which at the same time is the project implementation counterpart.

The project envisages the achievement of 3 outcomes:

* Outcome 1: Dioxin in core hotspot areas contained and remediated;
* Outcome 2: Land use on and around hotspots eliminates risks and contributes to environmental recovery;
* Outcome 3: Strengthened national regulations and institutional capacities.

## Evaluation Rating Table

The evaluating table below includes the additional outcomes achieved after mid-term evaluation and the updated scoring. Changes or new achievements after mid-term are reported in bold in Table 6 (Rating of the Relevance, Efficiency and Effectiveness of Project Outcome and Outputs.). Based on the available data and information, the "Satisfactory" scoring proposed at mid-term evaluation can be confirmed.

Table 1: Project overall rating

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| **Evaluation Ratings:** |
| **1. Monitoring and Evaluation** | ***rating*** | **2. IA& EA Execution** | ***rating*** |
| M&E design at entry | HS | Quality of UNDP Implementation | S |
| M&E Plan Implementation | S | Quality of Execution - Executing Agency | S |
| Overall quality of M&E | S | Overall quality of Implementation / Execution | S |
| **3. Assessment of Outcomes** | **rating** | **4. Sustainability (Risk)** | **rating** |
| Relevance | HS | Financial resources: | M |
| Effectiveness | S | Socio-political: | L |
| Efficiency | S | Institutional framework and governance: | L |
| Overall Project Outcome Rating | S | Environmental : | M |
|  |  | Overall risk for sustainability: | M/L |

### Summary of achievements.

**Component 1:** Dioxin in core hotspot areas contained and remediated.

**Indicator for Component 1**: Volume of contaminated soil and sediment contained and remediated. As a result of the GEF-project and leveraged funds / activities, all contaminated soil at concentrations greater than 1,000ppt and sediment at concentrations greater than 150ppt will have been treated adequately and residual contamination safely land-filled, and thereby 1,736 g I-TEQ dioxin release will be avoided: at Bien Hoa by the end of 2010; at Da Nang by the end of 2012; and at Phu Cat by the end of 2011.

This very ambitious indicator was partially revised at project inception as following: "*As a base target, an overall level of 1,700 g I-TEQ is recommended as a containment/remediation target such that this amount is eliminated as a near term ecological health threat and the amount actually eliminated (destroyed) be 1,000 g I-TEQ, all at Da Nang."*

**Achievements for component 1.** At midterm, the containment at Bien Hoa was partially completed; highly contaminated PCDD/F soil was disposed in a safe landfill for temporary containment; in Da Nang a turnkey remediation project based on thermal desorption is being carried out by USAID. In Phu Cat, 7500 m3 of PCDD/F contaminated soil where stored in a safe landfill. The level of contamination of the soil inside the landfill was from 600 ppt to around 250000 ppt.

In Bien Hoa, the infrastructures built with project funds (interim measures for runoff containment) concerned around 102000 m3 of soil with a contamination ranging from 1700 to around 2780 ppt, with a peak value of 962500 pptTe. It may be estimated that an amount of PCDD/F ranging from a minimum of 610 g I-TEq to a maximum of around 4000 g I-TEq have been contained by the interim measures in Bien Hoa and Phu Cat, although no information on the containment effectiveness in Bien Hoa is available. The amount of PCDD/F destroyed in Da Nang cannot be quantified yet as the remediation is still ongoing and data are not available yet. The exposure to PCDD/F was reduced for around 120,000 persons living nearby the Bien Hoa airbase and 47,000 living in the surrounding of the Phu Cat airbase.

**Component 2.** Land use on and around hotspots eliminates risks and contributes to environmental recovery

**Indicator for component 2.** Existence of action plan for each hotspot. By the end of the project, appropriate land uses have been introduced for at least 10ha at Bien Hoa; 8 ha at Da Nang, and 4ha at Phu Cat

**Achievement for component 2.** This outcome (outputs 2.1 and 2.2) has been partially achieved as the overall responsibility of the management of military areas falls under the MOD. Office 33 and MONRE had limited power to decide on land use of the three sites. After mid-term, two workshops (One in Hanoi on July 2014 and one in Bien Hoa in Oct. 2014) on land use of the contaminated sites was held with the purpose to share views on the issue. After implementing containment infrastructures in Bien Hoa and Phu Cat, these were handed over to MOD, which is now coordinating the Environmental Assessment for Bien Hoa. Da Nang was handed over to MOD at the beginning of the project as the remediation activity for that site was implemented by USAID under MOD coordination.

**Component 3.** National regulations and institutional capacities strengthened

**Indicator for component 3:** Assessment of capacity among government officials: By the end of the project, at least 70% of officials have received training or awareness raising on dioxin and less than 5% of officials are unable to access information on policies and laws related to dioxin Assessment of capacity among local communities. By the end of the project, less than 15% of respondents are unable to name agencies responsible for management of contaminated areas

**Achievements for component 3**. Standard on PCDD/F contaminated soil were implemented. Standard threshold for Industrial emission are under approval. A substantial number of trainings for officials and various stakeholder was carried out (see Annex I). At the baseline, 44% of local people in or near areas affected by dioxin do not know any agency undertaking treatment activities in the hotspots or surrounding area. For local awareness raising, the achievement is limited as by the end of the project, a survey in three communes reported 66.4% of residents in BH area 1 knowing about the communication activity of the project in general and 57.5% of residents in the surveyed area could name agencies responsible for management of contaminated areas.

# Summary of conclusions, recommendations and lessons

## PCDD/F destroyed or contained:

**PCDD/F destruction targets and indicators.** In the original project document, it was established as a target for component 1 that *"As a result of the GEF-project and leveraged funds / activities, all contaminated soil at concentrations greater than 1,000ppt and sediment at concentrations greater than 150ppt will have been treated adequately and residual contamination safely land-filled, and thereby 1,736 g I-TEQ dioxin release will be avoided: at Bien Hoa by the end of 2010; at Da Nang by the end of 2012; and at Phu Cat by the end of 2011."*

At inception report, however this target was modified as following: *"As a base target, an overall level of 1,700 g I-TEQ is recommended as a containment/remediation target such that this amount is eliminated as a near term ecological health threat and the amount actually eliminated (destroyed) be 1,000 g I-TEQ, all at Da Nang."*

Based on this refined target, it is understood that out of the 1,700 g I-TEQ to be destroyed or contained, a target of 1,000 g I-TEQ need to be actually eliminated by the ISTD destruction technology implemented in Da Nang, and the remaining 700 g I-TEq would be either destroyed or contained in Bien Hoa and Phu Cat

**Achievement.** The project was successful in building infrastructures for containing the release of PCDD/F from two hotspots (Phu Cat and Bien Hoa) to the environment, by means of the following actions:

1. Construction of an hydraulic barrier to prevent transport of PCDD/F contaminated soil and sediment by surface runoff following heavy rains events in Bien Hoa (completed in February Feb 2014 after project mid-term evaluation)
2. Establishment of a safe landfills containing around 7500 m3) of highly PCDD/F contaminated soil excavated from contaminated areas of the Phu Cat air bof Pase (completed in 2012, before project mid-term evaluation);

The activities in Da Nang, implemented by USAID, was since the second year of project implementation, being undertaken independently with USAID and MOD resources under a bilateral US-Vietnam cooperation, mostly under the coordination of MOD. In Danang a large amount of PCDD/F contaminated soil by means of on site thermal destruction is being remediating.

Except for one report (3) containing preliminary estimates based on data pertaining to the undisclosed Hatfield- USAID database, there were no attempts to monitor or assess the effectiveness of containment or destruction activities.

Under the evaluation, a simple formula to assess the potential amount of PCB contained or destroyed was therefore used, as following:

D = C x Q x E

Where:

* D is the amount of PCDD/F contained or destroyed
* C is the average concentration of PCDD/F in the soil treated or contained;
* Q is the estimated amount of soil treated / contained;
* E is the destruction or containment effectiveness of the specific technology (from 0 to 1, temporarily a value of 1 was adopted as maximum potential technology effectiveness)

Whilst under the project in general enough monitoring data were collected and made available to assess the value of the parameters C and Q, (1) no information concerning the technology effectiveness (the parameter E) was indeed available. The value of parameter E was therefore temporarily set at 1, which means that the implemented containment or destruction technologies are 100% effective. Therefore, the estimates represent currently the maximum potential amount of PCDD/F contained or destroyed achievable.

Some approximate estimations (chapter 7.3.6) on the PCDD/F release prevented were therefore attempted within the evaluation exercise based on general information made available under the project. Based on the few information available, the following estimates have been derived:

* Pacer Ivy area in Bien Hoa: the amount of PCDD/F currently being prevented to enter the environment thanks to the hydraulic barrier in Pacer Ivy is a range from 215 to 3690 g TEq, to which around 8.7 gTEq of dioxin contained in landfilled contaminated soil, plus 36 gTEq in the sediment trapped in the Pacer Ivy have to be added;
* Phu Cat landfill: around 7500 m3 of PCDD/F contaminated soil were placed in the safe landfill. Based on the average contamination of landfilled soil the amount of PCDD/F prevented to enter the environment has been estimated in around 395 gTE.

Therefore, summing up the average PCDD/F currently contained in Bien Hoa and Phu Cat, an overall amount ranging from 610 to around 4000 g I-TEQ have been contained by actions directly carried out with project funds, whether an additional unknown amount has been contained with governmental resources. Again, this is a very rough estimated based on the best data available, which need to be confirmed by a proper monitoring plan and environmental assessment to be carried out

There are no available data on the initial concentration of soil currently being treated in Da Nang (around 44,000 m3), therefore it is not possible to estimate the destruction of dioxin for that site. It has to be remembered that currently the project in Da Nang is being running independently by USAID under the coordination of MOD; with Office 33 only being informed of the status of the activities.

In any case, even without considering the amount destroyed in Da Nang, the amount of PCDD/F currently contained in Bien Hoa and Phu Cat still quite a huge amount of PCDD/F, comparable to the yearly emission of PCDD/F of a large country, representing a very large risk for the population and the environment, and therefore requiring that the remediation / containment actions are sustained after project ends.

## Exposure Reduction

Updated population estimates for the potential population at risk of dioxin exposure at Bien Hoa and Phu Cat Airbases were determined during the preparation of the "Evaluation of Dioxin Project Impact to Environment and People" (3), from interviews with Ward and District leaders. Based on current estimates provided in the report, over 120,000 people residing in wards near Bien Hoa Airbase and 47,000 persons near Phu Cat Airbase are potential beneficiaries of the reduced dioxin exposure achieved thanks to the activities conducted under the Dioxin Project. For further reducing exposure to PCDD/F of this population it is key to sustain the effort aimed at raising awareness on the food-chain related risk, and to sustain access restriction to contaminated areas.

## Technology testing

As already pointed out at mid-term, one of the result of the project was the testing of technologies for the destruction / treatment of PCDD/F contaminated soil.

Despite few uncertainties in the effectiveness of the tested technology in reaching the cleanup target when the contamination level is high, the project, by demonstrating a PCDD/F destruction technology and establishing containment infrastructures and safe landfills, contributed significantly to the knowledge and the increased technological capacity of the relevant stakeholders for problem analysis and remediation of dioxin contamination.

As a result of the mid-term evaluation, it was recommended to *"carry out additional tests aimed at a better understanding of the mass balance of the mechano-chemical process and at verifying the effective capability of the technology to remediate high contaminated soil should be carried out under this GEF project"*. These additional demonstration have been started at laboratory scale (biodegradation by HPC Envirotech (4)), full scale (thermal desorption by Thermodyne (5)) and semi-practical scale (Mechano-chemical destruction by EDL (6)).

The results of the technology testing were introduced during the workshop held in Hanoi on March 18-19 2015 (7)

Based on the technology report drafted by the international and national independent experts (8) there is quite a consensus that the mechano-chemical and the thermal desorption may be considered as technologies already in the commercial stage suitable for the treatment of PCDD/F contaminated soil in Vietnam, whereas the biodegradation technology still requires additional tests to prove its suitability.

The demonstration at pilot, full and large scale for the remediation of PCDD/F contaminated soil is one of the largest tests so far carried out and has to be considered a big achievement of this project. This resulted in data on technology performance made available either for Vietnam itself or for the remediation of sites contaminated by PCDD/F in other countries.

## Achievements after mid-term and fulfilment of MTE recommendations

The following recommendations were put forward at mid-term:

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| **Recommendation brought at MTE** | Status of compliance |
| **Timely Implementation of a monitoring plan for both Phu Cat and Bien Hoa to check and measure the effectiveness of the containment infrastructures and for the early identification of any residual risk.** | This recommendation has only partially fulfilled.The Czech Republic funded sampling equipment and infrastructures and developed a sampling plan for both the airbases. However, based on the available data and interviews carried out, it seems that, a monitoring plan is not implemented yet and most of the sampling equipment is still unused. The issue is that, whilst the project cooperates with MONRE, the equipment provided by the Czech Republic was eventually handed over to MOD, which is in charge of monitoring the hotspots, and which - based on interviews carried out in November 2014 in Bien Hoa - may have budgetary issues for implementing the monitoring plan. It has however to be mentioned that on Jan 2015, data was hand over to Dong Nai Province/Dong Nai DONRE for continuing monitor the area located outside of airbase since 2015. Provincial budget for external monitoring was allocated. for 2010 – 2015 following the Provincial Decision No. 1565/QĐ-UBND on the approval ofthe monitoring plan for Bien Hoa and the surrounding area dated June 21st 2010 and likely to be continued in the next term. USAID has recently started the environmental assessment in Bien Hoa, including monitoring activity (9). Hopefully, handover of operation from the project to the bilateral activity funded by USAID will ensure the proper transmission of information deriving from the monitoring carried out until now.  |
| **Extension of technology demonstration.** | This activity has been completed, resulting in extensive testing of three technologies, the Mechano Chemical Destruction (6), the batch thermal desorption (5) and the chemical-biological destruction (4).This has to be considered one of the biggest achievement of the project. The technology testing activity resulted in data on technology performance made available either for Vietnam itself or for the remediation of sites contaminated by PCDD/F in other countries. |
| **Securing necessary funds for the completion of containment measures in Bien Hoa as necessary** | The containment infrastructures in Bien Hoa were completed, therefore this recommendation has been accomplished. As a further recommendation it has to be considered that one of the biggest benefit of the project (the amount of dioxin contained in Bien Hoa and Phu Cat) represents also an outstanding environmental risk if continuation of activities is not ensured after project closure, The amount of dioxin contained by the hydraulic infrastructure and in Phu Cat is absolutely relevant (calculated as a lower-bound estimate in around 610 gTEq) therefore, if from one side this represent a significant benefit in term of risk reduction, from the other side it is crucial to establish a maintenance and monitoring plan for the infrastructure in Bien Hoa and to implement the existing monitoring plan exists for the Phu-Cat landfill. This is the main sustainability concern for the whole project after closure. As of now, GoV budget for the monitoring starting from 2015 outside the airbase by Dong Nai DONRE is confirmed, whereas no information for monitoring and maintenance of the containment infrastructures inside Bien Hoa airbase was provided by MOD. |
| **Report, by means of an approach as much as possible quantitative, project achievement particularly highlighting PCDD/F source reduction and the associated benefit for the human health and the environment.** | The report has been completed by Hatfield consultants. The report contain limited quantitative information related to PCDD/F source reduction - indeed the information provided is mostly based on undisclosed monitoring data stored in the Hatfield - USAID database.  |
| **Guidance document on the methodology for testing and procuring remediation technologies, to be compliant with the Stockholm Convention and the country environmental legislation** | The draft guidance document has been completed. |
| While the available timeframe is short (16 months), the communication plan with 67 activities seemed rather ambitious. The project should consider strategic activities for implementation, with proper attention on activities targeting local communities.  | Communication activities were implemented with a narrow budget, focusing in the population in Bien Hoa only. While more than 90% of the surveyed population reported a general understanding about the harmful impact of dioxin, the understanding on remedies for local population (including prevention of harmful exposure, policy for contaminated populations and governmental agencies in charge of the issue) varied. In Bien Hoa, were higher communication frequency was ensured, about 90% of the surveyed population showed awareness on prevention measures, 80-75% knew about relevant policies, and 30 – 45% was not aware of the agency in charge of the issues. In Binh Dinh where communication activities were limited, the level of unawareness among surveyed population was rather high: more than 90% did not know about prevention, 50% was not aware of relevant policies for people affected, and more than 90% did not aware about the agency in charge of dioxin remediation. |

# Acronyms and abbreviation

|  |  |
| --- | --- |
| CO | Country Office |
| DOH | Department of Health |
| DONRE | Department of Natural Resources and Environment |
| GEF | Global Environmental Facility |
| I-TEq | International Toxic Equivalent |
| M & E | Monitoring and Evaluation |
| MOD | Ministry of Defence |
| MONRE | Ministry of Natural Resource and Environment |
| MTE | Mid-term Evaluatio |
| PCDD/F | Polichloro Dibenzio para Dioxins and Furans |
| PMU | Project Management Unit |
| POPs | Persistent Organic Pollutants |
| TCDD | Tetrachloro Dibenzo para Dioxin |
| TOR | Term of Reference |
| UNDP | United Nations Development Programme |
| US EPA | United States Environmental Protection Agency |

# Conclusions, Recommendations & Lessons

## Actions to follow up or reinforce initial benefits from the project

### Actions aimed at ensuring sustainability of project infrastructures and monitoring.

Based on the outcomes of site visit and interviews, there are some risks for the sustainability and continuation of project benefits which should be properly addressed. As the project is completed, these recommendations are intended for the handing over step of the project to the government of Vietnam, and / or future partners

First of all, there is the need to ensure the maintenance of infrastructures for the containment of dioxin contamination. Although the containment measures implemented by the project are temporary, the time necessary for a complete decontamination of the site may be long: therefore proper efforts to ensure the functionality of these infrastructures are a key requirements for securing the continuation of project benefits.

In Bien Hoa the containment infrastructures are mostly hydraulic infrastructures aimed at preventing rainfall runoff water from flowing through the most contaminates area (the Pacer Ivy are), and small dams and catchments aimed at facilitating the settling of contaminated sediment whilst allowing water - purified from the sediment - to leave the area. The main risk for this infrastructure is the clogging of the channels due to deposition transportation of branches, leaves and bushes, and the gradual filling of the catchment basins due to the solid transport with water runoff. The channels should be cleaned after each rainfall period - at least 3 or 4 times per years; the level of sedimentation in the catchments should instead be measured regularly, and once a certain level is reached, the bottom sediment should be dragged out, measured for the content of PCDD/F, and stored - landfilled.

In Phu Cat, as the landfills is equipped with a system for sampling the leakage, periodical sampling and analysis of the leakage should be carried out. An increase in the dioxin level of the leakage (if any) should be interpreted as a symptom of breaking of one or more of the landfill impermeable layer, and in this case, confirmatory analysis and an emergency plan should be conducted. The sampling of the leakage is the most immediate measure for checking the integrity of the landfill: due to the extremely low mobility of PCDDF in soil, PCDD concentration in groundwater could build up very slowly after a breaking in the landfill and therefore, although necessary, it is not the most effective way to monitor landfill integrity.

Based on interviews, it seems that there may be a discontinuity on environmental sampling and analysis activity, due mainly to management issues and limitation of funds. This shortcoming should be addressed by the definition of new monitoring plan and the establishing of new partnerships if necessary. In this regard it should however mentioned that the DONRE of Dong Nai is implementing, starting from the year 2015, a specific activity aimed at the environmental monitoring outside the Bien Hoa airbase. If it is so, the sustainability issue only concerns monitoring inside the airbases.

### Actions aimed at ensuring the correct flow of information among partners.

One of the main project issues was the limited coordination between MONRE / Office 33 and USAID. As the Bien Hoa site is currently in the stage of handing over to USAID which will take the lead on future activities on the site, more focused effort should be dedicated to the collation and handing over of monitoring data and infrastructure design to MOD and USAID. Under the project some workshops were already held with the purpose to exchange information, however, based on the two meetings carried out by the evaluator with the USAID personnel in charge of Environmental Assessment and remediation activity, the lacking of exchanging of information emerged quite clearly.

Similarly, based on interviews with local stakeholders, emerged clearly that the information on the implementation of activities at Da Nang are insufficient. The USAID website on the Danang project provide very basic summaries on the activities being carried out, without any information on the monitoring data, dioxin level of the contaminated soil, Although is understandable that this kind of information need to be consolidated before its release, nevertheless the evaluator consider the level of information provided under the website not sufficient for communicating the remediation status and its benefits.

In addition, a specific action should be undertaken by GoV to ensure that the issues reported by the Czech government on the implementation of the monitoring plan are solved, and the sustainability of monitoring plans ensured.

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| E:\Pictures\Camera Roll\WP_20141110_029.jpg |
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| Figure 6: One of the monitoring wells provided by the Czech Republic cooperation and its position (Nov. 10, 2014) |

## Best and worst practices in addressing issues relating to relevance, performance and success

Again, it has to point out that addressing dioxin contamination is indubitably one of the most demanding activities from the point of view of environmental engineering. Worldwide, there are very few cases were dioxin contaminated soil has been effectively decontaminated, and in the large majority of cases the only viable solution has been landfilled: see for instance the case of Seveso. As pointed out by US EPA, *“Remediation technologies for the cleanup of dioxin-contaminated soils and sediments are still being developed, and many of the accepted techniques rely on thermal destruction, though physical, chemical and biological technologies show promise." (http://clu-in.org/contaminantfocus/default.focus/sec/dioxins/cat/overview/ last updated on Friday, August 1, 2014). The*

If we couple this difficulty with the fact that the three hotspots in Vietnam are by far the largest and heaviest sites contaminated by dioxin in the world, we can easily understand how huge has been the challenge.

The project should be therefore evaluated in the light of this challenge. It is evident that the project is unique and brought a number of global and local environmental benefits:

1. The spreading of PCDD/F to the environment from the Bien Hoa and Phu Cat sites was minimized and the Da Nang site is currently under remediation by the USAID project. The amount of dioxin contained in the two hotspot of Bien Hoa and Phu Cat has been conservatively estimated, based on the available soil monitoring data around 620gTEq against the 730 estimated at the beginning of the project. This is an enormous amount of Dioxin, which is comparable to overall yearly emission in the atmosphere of a mid-size country. In addition, although the remediation activity in Da Nang is not any more part of the project (being carried out independently by USAID under MOD coordination), in Da Nang 44000 m3 of contaminated soil are currently under treatment.
2. As already pointed out at mid-term, the project, which PMU was established at the Office 33,was effective in collecting and systematizing the documentation generated by the governments and international donors in the preceding years, and to the expand the database of environmental monitoring. By providing technical and financial support to the Office 33 the project acted as “catalyst” of the site characterization and cleanup efforts being carried out by the government and the international donors. This is well acknowledged in a report drafted by USAID (2), which stated *“UNDP's program also provides for an overarching umbrella framework that facilitates donor coordination among those working on environmental remediation of dioxin in Vietnam.”*
3. Although did not solve all the uncertainties related to the effectiveness of the treatment, the technology testing of the three technologies (mechano-chemical destruction, thermal desorption and bioremediation) carried out with the project technical and financial support represents a reference for the treatment of soil contaminated by dioxin and other POPs which expanded the available choices of disposal technologies for future treatment of POPs contaminated soil.
4. Under the project, important national and international initiatives for the exchange of know-how on the management of dioxin contaminated soil have been established. See for instance the "International Workshop on “Dioxin/POPs Pollution Assessment and Remediation in Viet Nam" and the newsletters "Environmental Remediation of Dioxin Contaminated Hotspots in Vietnam".
5. While international communications were made highly relevant and comprehensive, the need from the local population on continuous communication about their situation and risk reduction should be further addressed, using materials, tools and good practices produced by the project.

Obviously, due to the complexity of the project, there were difficulties and shortcomings, which however must be considered minor compared to the benefit achieved so far:

1. Interviews carried out in the course of the terminal evaluation confirmed some of the difficulties in communication, mostly between local institution and central institutions; coordination between MOD and MONRE especially on the side of land use of the hotspot after remediation (partially solved with two joint conferences on land use); information of some of the exposed population group, and specifically of the troops inside the airbase concerning their level of exposure. Although not anymore under the project responsibility, the level of detail of information released by the Da Nang remediation activity is insufficient.
2. Surprisingly, an objective risk-assessment approach for the before and after quantification of risk was not envisaged in the project design and not seriously attempted during project implementation. Even because of the limited scope of the TOR, the study assigned to an external consultant to carry out to a project impact evaluation resulted in interviews and further collection of existing data and did not provide quantitative information on the project impact.
3. The project seems to have lost some momentum in the second stage of implementation, after mid-term. Some activities like the completion of testing of cleanup technologies, monitoring, and drafting of guidance documents were still under completion when the terminal evaluation started. Partially this can be attributed to a progressive shifting of the team’s effort toward new activities, whilst the approaching of the project toward its closure stage was requiring an increasing level of effort on both on the administrative and technical side.
4. As already pointed out in this document, the lacking of a sound maintenance and monitoring plan for the hydraulic infrastructures in Bien Hoa and the landfill in Phu Cat represent the highest risk to be addressed with the effort of all the project stakeholders and the institutions which will be in charge of these sites after project closure.

## Proposals for future directions underlining main objectives

The project should be considered as successfully concluded, and the shortcomings identified, some of which indeed not attributable to the project itself, could be easily resolved with limited additional effort to be sustained by the beneficiaries.

One of the aspects that should be considered for future activities in the field of POPs, emerging as one of the lesson from this project, is to establish a *sound risk-based approach for the management of contaminated sites*. Risk based remediation is indeed the only approach which can help the quantification of cleanup target, design of cleanup activities, assessing its effectiveness, and identifying additional countermeasures. Other scientific tools - like epidemiological surveys - can only assess the residual risk "ex-post", when is too late.

This has been one of the outcome the GEF/UNDP project “Building Capacity to Eliminate POPs Pesticides Stockpiles" and is one of the core parts of the recently endorsed GEF/UNDP project "Vietnam POPS and Sound Harmful Chemicals Management Project". Considering that the issue of contaminated sites in Vietnam is very serious, *the implementation of a risk based approach, integrated with monitoring activities, and should be properly streamlined in the national regulation, official guidance, and demonstration*. It is likely and indeed should be advisable that further support is provided to the country on this area.

A second aspect concerns the cleanup technology issue. Beside the gigantic needs of the cleanup of dioxin hotspots, there are in Vietnam hundreds of small sites contaminated by POPs or other chemicals that would benefit from the *existence of medium/small scale cleanup facilities*. There are consolidated technologies (like the *indirect thermal desorption*) which proved effective in cleaning up soil contaminated by PCBs (see for instance the GEF/WB project "China PCB Management and Disposal Demonstration project"), PCDD/F, pesticides, hydrocarbons. Even the MCD technology may appear promising for soil contaminated by PCDD/F at a level <30,000 ppt TEQ provided that it is improved in term of air pollution control system and that it is integrated with sanitary landfills where the treated soil, which after treatment may still contain PCDD/F in the range of 100-1000 ppt TeQ, will be contained. The limitation of the technology to 30,000 ppt TEQ, as confirmed by the vendor itself,   makes that technology less suitable for other chlorinated POPs like PCBs considering that - assuming an equivalent level of chlorination -  PCB contaminated soil need to be treated with a destruction technology only when their concentration exceed 50,000,000 ppt. (50 ppm)." It seems that in Vietnam a *domestic capacity for site cleanup* has not yet been established. The establishment of *medium/small scale cleanup facilities based on consolidated technologies in Vietnam could be very beneficial for the country, and could represent an outstanding development opportunity.*

A third aspect that should be strengthened is environmental monitoring, and more specifically, the capacity to properly design and carry out *sampling plans* .aimed at characterizing the level of contamination of various environmental media and the release of dioxin in the environment. Thank to the joint efforts of the government of Vietnam and its partners like the bilateral donors mentioned in this document, there are now in Vietnam a number of laboratories which are equipped with up to date instrumentation for carrying out analysis of PCDD/F contaminated media (soil, plants, biota, and air). However one of the project lessons was that the analytical capacity is not properly integrated with a sound environmental sampling capacity. Environmental sampling indeed is very often the true bottleneck in any successful environmental monitoring and should be properly implemented to i. minimize sampling error and variability, ii. Ensure sampling significance, and iii. Minimize laboratory effort by the use of "smart" sampling strategies. This is a further area of development under which additional efforts would be very beneficial to ensure that a domestic capacity can be timely deployed when needed, considering also its key role in case of emergency response.

Last but not least*, the communication of environmental monitoring data* needs also to be strengthened. Monitoring and communication goes obviously hand in hand, as in the end the population is the key beneficiary of any monitoring activity. Nevertheless, the proper communication of environmental data is a sensitive issue and need to be properly designed, prepared, and undertaken. Environmental data should be communicated in a way which is comprehensible, useful, and timely, and which is target - specific. Unnecessarily alarming communication should be avoided, however any time a risk is identified it should be timely communicated together with the explanation related to all the necessary countermeasures to be adopted. This is for sure an additional area under which further efforts need to be carried out.