REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
25-05-1999

2. REPORT TYPE
Technical

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Cleanup Plan for Fuel Spills at Air Operations Ramp, Diego Garcia, British Indian Ocean Territory

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Mr. Jerry Hansen

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

AFCEE

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Center for
Environmental Excellence
3300 Sidney Brooks
Brooks City-Base, TX 78235

10. SPONSOR/MONITOR'S ACRONYM(S)
AFCEE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This Cleanup Plan (Final) outlines the cleanup requirements for three JP-5 fuel-contaminated sites located on the Air Operations ramp. The plan describes how to efficiently and effectively clean the sites, provides estimates of cleanup duration and cost. The plan is based on Bioslurper fuel recovery efforts that have been underway at the ramp since 1996. The design of the Bioslurper accommodates rapid takedown of fuel recovery system to clear the aircraft ramp. Natural Attenuation processes will be monitored for cleanup of residual fuel in soils and the small amount of fuel constituents that dissolve into the groundwater.

15. SUBJECT TERMS
bioslurper, fuel recovery, product recovery, dual-phase extraction, remediation, natural attenuation, JP-5

16. SECURITY CLASSIFICATION OF: UNCLASSIFIED			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Mr. Jerry Hansen
U	U	U	UU	17	**19b. TELEPHONE NUMBER** *(include area code)* 210-536-4353

Cleanup Plan
For Fuel Spills at Air Operations Ramp
Diego Garcia, British Indian Ocean Territory

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25 May 99

EXECUTIVE SUMMARY

The purpose of this cleanup plan is to outline cleanup requirements for three JP-5 fuel contaminated sites located on the Air Operations ramp at Diego Garcia. This plan describes how to efficiently and effectively clean the sites, gives an estimate on how long the cleanup will take, and estimates the cost to cleanup.

This plan is based on very successful fuel recovery operations that have been underway at Diego Garcia since early 1996. Over 70,000 gallons (500,000 pounds) of JP-5 fuel has been recovered using "Bioslurper" technology. Additionally, it is estimated that the Bioslurpers have enabled the natural microbes in the soils to aerobically degrade over 200,000 pounds of fuel in the soils at the site. Very few sites anywhere have experienced this magnitude of fuel removal success.

The design of the current Bioslurpers has successfully accommodated several lengthy contingency operations requiring rapid takedown of fuel recovery hardware on the aircraft ramp. Real world mission requirements have been maintained with the current Bioslurper design. Operation of the Bioslurpers is simple and reliable and the Bioslurpers have not required any additional personnel to be stationed on the island.

Natural Attenuation processes will be monitored for cleanup of residual fuel in the soils and the small amount of fuel constituents that dissolve into the groundwater. Natural Attenuation is well accepted by the US regulatory community and DOD components, especially for cleanup of fuels. JP-5 fuel is one of the more environmentally safe fuels, as there is very little mass of JP-5 fuel that is soluble in water. Natural process will easily destroy any JP-5 components that dissolve into the groundwater.

The cleanup will be accomplished using a teaming arrangement between HQ PACAF, HQ AFCEE, and Det 1, 613 ASUS (on Diego Garcia). Overall project management will be provided by HQ PACAF. HQ AFCEE will provide technical guidance and assistance in obtaining equipment and materials. Det 1, 613 ASUS will manage Bioslurper operation and maintenance and arrange for equipment installation, operation, and maintenance through on-island public works resources.

Total cost of active cleanup over a three-year period is estimated at $380,000.

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SECTION 1

PROJECT DESCRIPTION

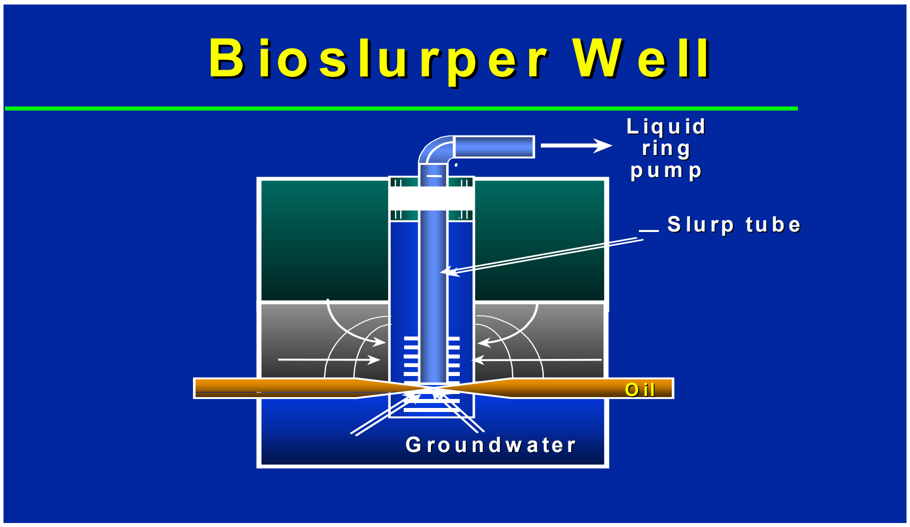
There are three known areas in the vicinity of the Air Operations ramp that is contaminated with JP-5 fuel. The largest contaminated area is in the vicinity of a pipeline split that occurred near refueling pit 49. This spill area was discovered in 1991. The second most significant area is in the area of refueling pits 30 and 32 where HQ PACAF and AFCEE identified the source of fuel in the subsurface in August 1997. The third area is in the fuel storage yard adjacent to the ramp where fuel contamination was first found in 1998. All three areas are similar in subsurface characteristics and type of fuel contamination. The same technologies can be used to remediate all three sites. Recoverable fuel will be removed with vacuum enhanced recovery using "Bioslurping". Additionally, Bioslurping will enhance aerobic biodegradation of fuel (Bioventing) in the unsaturated soils. Natural attenuation processes including tidal mediated Bioventing will be allowed to degrade residual fuel remaining in the soils and to degrade the small quantities of fuel constituents that dissolve into groundwater. The current efforts at the pit 49 site have been managed by HQ PACAF with AFCEE and USEPA providing technical assistance. The Det. 1, 613 ASUS (Air Force) at Diego Garcia manages Bioslurper operation and maintenance and arranges for equipment and well installation through on-island public works resources. AFCEE has provided equipment and materials needed for the Bioslurpers and for installation of wells.

1.1 Bioslurping

Bioslurping is a form of vacuum enhanced skimming of fuel floating on the water table. A typical Bioslurper system [4. 5.] consists of a vacuum pump that is piped to fuel recovery wells. The recovery wells are standard wells with the well screen area placed across the water table. A dip tube or "straw" is placed on the inside of the well with the inlet of the "straw" placed at or into the water/floating fuel. The well is sealed at the top so that no atmospheric air can be directly drawn into the well. The top of the "straw" is connected to the piping going to the vacuum pump. The vacuum pump draws fuel and soil gas up through the "straw" and to the vacuum pump. Soil gas enters the well through the well screen that is exposed above the water table. This has the effect of drawing oxygen rich atmospheric air from the ground surface into the unsaturated soils. This "biovents" any contaminated unsaturated soils resulting in aerobic biological degradation of fuel contaminants. From the vacuum pump, the fuel -water mixture is piped to an oil-water separator where the fuel is removed and collected for recycling. The vapors are discharged directly to the atmosphere or treated if needed and then discharged. Overall the Bioslurper technology is simple and easy to maintain. These characteristics make bioslurping a technology of choice especially for a location as remote as Diego Garcia.

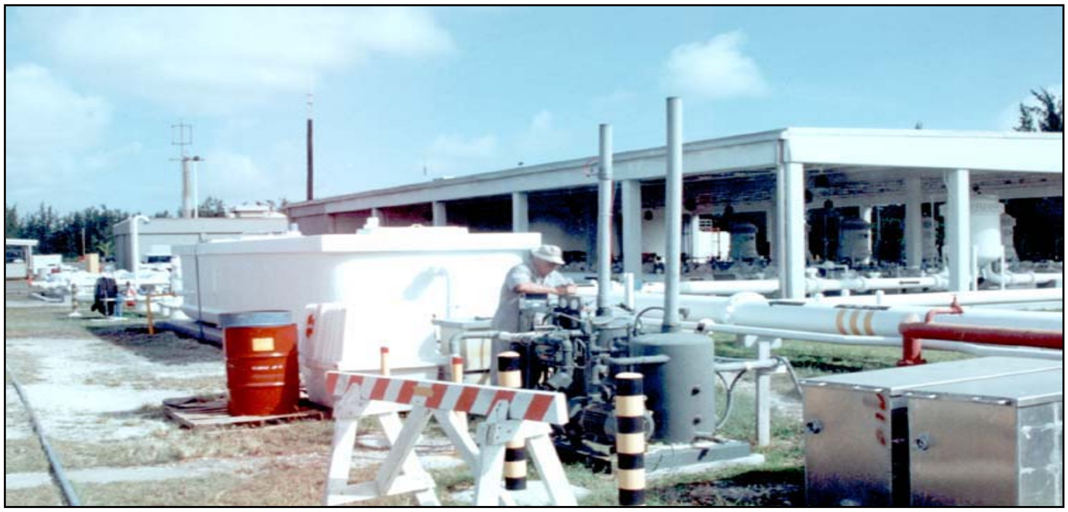
1.1.1 Bioslurping systems at Diego Garcia.

The first Bioslurper system was installed at Diego Garcia in March 1996. The vacuum pump is a 10-hp liquid ring pump that is located adjacent to an existing oil-water separator in the fuel storage yard. The piping from the vacuum pump to the recovery wells is 1,100 feet of 4-inch diameter PVC. The recovery wells are located in the downgradient portion (grass area) of the



free product area. Six wells are connected to the first Bioslurper. The "straws" were placed about 1 foot into the water/fuel at low tide. During April 1996, 2,000 gallons of fuel were recovered. Fuel recovery rates have averaged about 1,000 gallons per month from May 1996 until January 1997. The recovered fuel is being used as fuel at the Diego Garcia diesel powered electric generating plant.

Bioslurper Wells in Grass Area



Two Bioslurper Pumps in Fuel Storage Yard

The second Bioslurper system was installed at Diego Garcia in January 1997. This installation was originally planned for November 1996, but operation “Desert Strike” resulted in a three month delay. The second vacuum pump is identical to the first and is manifolded together with the first Bioslurper vacuum pump. Ten additional recovery wells were installed in the concrete ramp in the vicinity of the pipe split near refueling pit 49. Four-inch diameter PVC piping was laid on the concrete ramp from the recovery wells towards the vacuum pump. The piping from the additional recovery wells was connected into the existing 4 inch PVC piping system. The PVC piping on the ramp is connected together with hose clamps and elastic couplers. This assembly method was selected so that the piping can be quickly removed if the ramp area is needed for military operations. The two Bioslurper systems are connected together to form a common piping system. During the month of January 1997, 8,000 gallons of fuel was recovered. The recovery rate since then has averaged 5,000 gallons per month until Oct 97 when contingency operations (“Southern Watch”) required that the system on the ramp be removed to allow for aircraft operations. In less than four hours, the Bioslurper piping was removed and the ramp was ready for air operations.

Bioslurper Piping on Ramp

Bioventing effects from Bioslurper operation can result in considerable degradation of fuel hydrocarbons that are in the unsaturated soil. Introduction of atmospheric air into contaminated soils promotes degradation of hydrocarbons [7.]. Degradation usually occurs at a rate of 1 pound of hydrocarbon degraded from 13 pounds of air introduced into the soil. Each Bioslurper system has a vapor flow rate averaging 50 cubic feet per minute. The oxygen content of the Bioslurper discharge has varied from 7.3 to 8.1 % with atmospheric air at 20-21 % oxygen content. This flow is composed of two sources. One is a volatile fuel vapor. The second is soil gas that is replenished by atmospheric air. The JP-5 fuel has insignificant amounts of volatile vapors. The amount of oxygen consumed by the aerobic fuel degradation processes in the soil can be calculated and used to determine the mass of fuel degraded by the "Bioventing" effects. Fuel "bioventing" degradation amounts to over 150,000 pounds of fuel degraded per year for the Bioslurper system.

Bioslurper Piping on Ramp

Connection to Bioslurper Well on Ramp

Drilling Bioslurper Well on Ramp

1.1.2 Planned Bioslurping Activities

Pit 49 Area (1991 Spill). The current array of recovery wells covers about 40 % of the extent of the fuel floating on the water. Currently an additional 15 recovery wells are being installed to increase the coverage. Additionally, the Bioslurper system capacity is being expanded by adding one 15 horsepower vacuum pump to the two existing 10 horsepower vacuum pumps. The new wells will be connected to the expanded Bioslurper system. It is estimated that an additional 24 recovery wells may be required to complete coverage of this site. All recovery wells are equipped with valves on the dip tube ("straw"). Various wells will be valved off as levels of fuel in the well drops. Wells with the most fuel will be valved on. The wells will be cycled on and off as the fuel levels recover and drop and as the Bioslurper system capacity allows. Monthly measurements of fuel in wells will be taken as the wells are cycled off. The groundwater will continue to be monitored at six-month intervals. Monitoring will include analysis for dissolved fuel contaminants and indicators of natural degradation processes. Soil gas will be field tested at some locations to track degradation of contamination smeared in the unsaturated soils.

Bioslurper will continue to operate until fuel recovery has become nonproductive. At that time the Bioslurper system will continue to operate in the Bioventing mode to aerobically degrade fuel that remains in the unsaturated soil. Bioventing operation will continue until soil gas tests indicate that aerobic degradation has been completed. Natural attenuation processes will be monitored as the dissolved fuel components degrade. Natural tidal mediated Bioventing will be relied on to degrade fuel smeared in soils that are outside the influence of Bioslurping/Bioventing.

Pits 30, 32 Area (1997 Spill). No active cleanup is currently underway. The major contamination is the fuel free product near the old leaks at refueling pits 30 and 32. The fuel free product in this area can be removed using Bioslurper technology. It is estimated that 20 recovery wells would be required. These wells would be connected using PVC piping laid on the ramp and running over towards the "Chute Tower". Bioslurper vacuum pumps, oil-water separator, and a recovered fuel storage tank would be located at the Chute Tower. Electrical power is available at the Chute Tower for powering the Bioslurper equipment. Between the taxiway and the runway, in the grass area near water production well AO-15, a small fractional horsepower Bioventing blower would be connected to the AO-15 electrical supply. Approximately 9 injection wells would be installed in the grass area between well AO-15 and the taxiway. Bioventing air would be blown into these injection wells to increase the aerobic degradation of the fuel contamination in this area.

Fuel Storage Yard (1998 Spill). Currently, there is no active cleanup of this contamination. However, the Bioslurper equipment for the 1991 Spill is located in the fuel storage yard. Additional Bioslurper recovery wells could be installed in the yard and easily connected to the existing Bioslurper system. Additional Bioslurper vacuum pumps may be needed, but installation would be easy.

1.2 Natural Attenuation

1.2.1 Overview of fuels natural attenuation. Over the past ten years' natural attenuation of fuel components has become a widely accepted cleanup process. USEPA has recently issued policy [12.] regarding the use of natural attenuation for the cleanup of contaminated soil and groundwater.

Petroleum spill sites will naturally attenuate given enough space and time. Some heavily contaminated fuel sites require source reduction activities such as free product removal in order to shorten the cleanup timeframes. AFCEE and EPA researchers started collecting and analyzing data from fuel contaminated sites in 1993. Since then over 50 Air Force fuel sites [10.] have been evaluated. Water samples were analyzed for microbial respiratory substrates such as dissolved oxygen, nitrate, sulfate, carbon dioxide (producing methane), and ferrous iron. The sites were characterized to determine the extent of the source areas and fuel constituents dissolved in groundwater. All sites exhibited evidence of natural biodegradation of fuel components dissolved in the groundwater. Typically, sulfate reduction and methanogenesis are the primary mechanisms. Most contamination plumes are not migrating. Natural attenuation alone is protective at a majority of the sites. Some sites require some source reduction activities, such as bioventing or bioslurping, to remove free product or cleanup fuel contaminated soils.

Other studies of fuel-contaminated sites have produced some interesting data. In 1995 the California State Water Resources Control Board had Lawrence Livermore Laboratories conduct the "LUFT Historical Case Analysis"[3.]. Historical data on over 1,000 fuel spills was evaluated. For fuel plumes, 33 % of plumes are shrinking, 59 % of plumes are stable, and 8 % of plumes are growing. 85 % of plumes are less than 250 feet in length. Similar data was obtained in a 1997 Texas study "Characterization of Benzene Plumes at Leaking Petroleum Storage Tank Sites in Texas"[2.]. The Texas data indicated that 75 % of benzene (10 ppb) plumes are less than 250 feet in length and impact an area of less than 100,000 sq. ft. Even without cleanup, plume mass increases, stabilizes, and rapidly declines over time. Most Texas plumes are stable or declining. Only 14 % of plumes in the Texas study are increasing in concentration, whereas only 3 % are increasing in length.

Several studies [9. 10.] have indicated that JP-5 fuel has few soluble components, typically well below 1 % by weight. The relatively low concentrations of BTEX [10.] in fresh JP-5 will likely to result in minimal environmental threats from JP-5 releases, especially in comparison to gasoline and JP-4 releases. Investigations [13. 14.] at Site 2 located at Naval Air Station Fallon, Fallon, Nevada have identified a large free product plume that contains compounds typical for diesel and jet fuel JP-5. In general, very few compounds are present in the groundwater at Site 2, and those compounds that are present occur in low concentrations.

1.2.2 Evidence of Natural Attenuation at Diego Garcia. Three lines of evidence [1.] are used to evaluate the effectiveness of natural attenuation:

a. Historical loss of contaminants
b. Geochemical evidence of attenuation processes
c. Direct microbiological evidence

Historical loss of contaminants: Groundwater samples from Diego Garcia have been analyzed for dissolved hydrocarbon contamination since 1993. Additionally, several free product samples have been analyzed by the USEPA. None of the free product samples had measurable concentrations of more soluble benzene or toluene. Concentrations of fuel components dissolved in groundwater have consistently remained at relatively low levels (see Table 1). This can be attributed to the low concentrations of soluble constituents present in the JP-5 fuel and to active degradation processes in the subsurface. Typically, total BTEX dissolved in groundwater at gasoline spill sites have been measured [10.] at 40,000 – 90,000 ug/L. For JP-4 spill sites, total BTEX dissolved in groundwater has been measured [10.] at 20,000 – 29,000 ug/L.

Table 1. Total BTEX (ug/L)

	Well				
Date	**S1-20**	**S1-30**	**S2-20**	**S2-30**	**WP-4**
Aug 93	45.5	40.5	54.3	47.2	-
May 94	47.0	44.7	85.0	87.3	-
Oct 95	55.5	36.4	64.2	58.9	-
Mar 96	61.3	55.1	65.6	76.5	16.5
Jan 97	60.0	57.3	63.9	60.6	9.5
Sep 98	63.2	62.1	No sample	No sample	19.7

Note: Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)

Geochemical evidence: This line of evidence includes evaluation of natural degradation processes to include: utilization of electron acceptors, production of indicators of electron acceptor usage, and production of products of the degradation processes. Biodegradation of fuel is determined by looking for the electron acceptors that are used by microbes in degrading fuel [1.]. Dissolved oxygen is the most thermodynamically favored electron acceptor used in the biodegradation of fuel hydrocarbons. After dissolved oxygen has been depleted in the microbiological treatment zone, nitrate may be used as an electron acceptor for anaerobic biodegradation via denitrification. Iron reduction, sulfate reduction, and methanogenesis are other electron acceptor mechanisms that are often present at a fuel-contaminated site.

USGS investigations at Diego Garcia found elevated levels of carbon dioxide and methane in vadose zone soil gas at locations near the leak. Carbon dioxide and methane in soil gas are products of biodegradation. This finding has been confirmed during soil gas sampling by the USEPA. Additionally, USGS data indicate by the presence of sulfides that sulfate reduction was occurring. The recent sampling events (1995, 1996, 1997, and 1998) by the USEPA determined that sulfate reduction and methanogenisis are active processes degrading dissolved hydrocarbons (see Table 2). There is no indication of iron reduction or nitrate reduction. Background levels of dissolved oxygen vary considerably. However, at locations where dissolved contamination is present, dissolved oxygen was not present. Aerobic degradation is occurring, but the rate is difficult to determine. For dissolved fuel contaminants, sulfate reduction and methanogenisis are the primary degradation processes that are active at Diego Garcia.

Sulfate may be used as an electron acceptor for anaerobic degradation of fuel compounds. Each 1.0 mg/L of sulfate consumed by microbe's results in the destruction of approximately 0.21 mg/L of BTEX. The highest sulfate concentrations were measured at well C3-1. This sulfate concentration is above 20-mg/L indicating that background sulfate concentrations may be above 20 mg/L. This concentration of sulfate could result in the destruction of 4,200 ug/L of BTEX.

During methanogenesis, carbon dioxide is used as an electron acceptor, and methane is produced. The degradation of 1 mg/L of BTEX results in the production of approximately 0.78 mg/L of methane during methanogenesis. The highest methane level was measured at well S1-20 where methane was measured at 11.6 mg/L. This level of methane could result from the degradation of 13,500 ug/L of BTEX.

The degradation processes of sulfate reduction and methanogenesis are more than adequate to degrade the small quantities of JP-5 fuel constituents that dissolve into the groundwater. The expected degradation capacity of sulfate reduction and methanogenesis totals 17,700 ug/L of fuel. This degradation capacity is much greater than the measured BTEX levels that are well under 100 ug/L, or the total fuel carbon levels that have not exceeded 1,500 ug/L.

Table 2. Water Quality Analysis.							
Back-ground wells	Dissolved Oxygen mg/L	Fuel Carbon ug/L	Methane mg/L	Sulfate mg/L	Nitrate mg/L	Sulfide mg/L	Redox Potential mV
C3-4	5.2	<1	<0.01	20.5	0.1	<0.1	+23
C3-1	4.5	<1	0.8	5.1	<0.05	0.1	+3
Plume of Contaminated Wells							
S1-20	0.0	781	11.6	9.7	<0.05	2.0	-108
S1-30	0.0	528	11.0	18.6	<0.05	5.0	-137
S2-20	0.1	725	10.7	11.5	<0.05	2.0	-135

Direct Microbiological Evidence. A number of samples of contaminated groundwater have been analyzed by the USEPA for the presence of volatile fatty acids. These acids are intermediate byproducts and indicate if current active microbial degradation is occurring. Measurable levels of fatty organic acids are present in groundwater at the site, which is evidence that microbial degradation processes are actively occurring.

1.2.3 Tidal Mediated Bioventing

The island of Diego Garcia experiences twice daily tidal variations of up to 5 feet. The magnitudes of these tidal variations vary from day to day. The tidal variations are reflected in variations in the observed depths to water in the monitoring wells. The water levels in the wells vary by 60-80% of the tidal variations. These variations in the water table appear to be pumping atmospheric air into, and soil gas out of, the unsaturated soils. This process results in increased aerobic degradation of fuel components that are smeared into the unsaturated soils. Soil gas measurements taken at various depths in the unsaturated soil indicate that as the water level drops, oxygen levels in the soil gas increase. When the water level rises, oxygen levels drop and methane and carbon dioxide levels rise. These measurements, as shown in Table 3, indicate that oxygen is being consumed by microbial activity and that carbon dioxide and methane are being produced by the microbial activity.

EPA Taking Soil Gas Samples

Table 3. Soil Gas Components as Related To Water Table Fluctuations.

Water Level (bgs, ft)	Time	Oxygen (%)	Carbon Dioxide (%)	Methane (%)
2.0	0800	3.1	10.1	10.0
0.9	1000	6.2	1.9	2.0
0.7	1200	8.6	1.0	1.0
1.1	1400	1.7	8.8	8.9
2.1	1600	1.6	11.5	12.2
2.4	1800	1.8	11.0	11.4
1.9	2000	3.9	9.0	8.9

1.2.4 Planned Natural Attenuation of the Three Spill Sites. Natural Attenuation will be monitored for progress in containing and shrinking the dissolved fuel in the groundwater at the sites. In 1997 HQ/PACAF and AFCEE installed a number of groundwater monitoring wells in the grass area between the Air Force ramp and the water production wells located along the runway. These wells will be monitored for fuel contamination in order to insure that the groundwater near water production wells meets water quality requirements.

SECTION 2

PROJECT DURATION

1.1 Bioslurping Duration. Bioslurping has been underway at Diego Garcia since March 1996. The fuel recovery trends since March 1996 can be used to estimate how long Bioslurping will take to remove the recoverable fuel.

Bioslurping started at the pit 49-grass area in March 1996. In March 1996 approximately 2,000 gallons of fuel was recovered. The fuel recovery rate dropped to about 1,000 gallons a month from April 1996 to January 1997. Recovery of fuel from the grass area continued after January 1997. However, additional wells in the ramp area were connected in January 1997 and the fuel recovery from the grass area was combined into a common piping system with the fuel recovery from the additional ramp wells. In November 1997 “Southern Watch” air operations required that the wells in the ramp area be disconnected. From November 1997 until July 1998 the ramp wells were not connected and the original wells in the grass area were the only Bioslurper recovery wells in operation. During this period fuel recovery from the grass area averaged about 120 gallons per month. The grass area is adjacent to the ramp. It appears that the Bioslurper had recovered most of the fuel originally in the grass area and that the quantities being recovered in 1998 were most likely from seepage from the ramp area. The period of major fuel recovery from the grass area was March 1996 to at most November 1997, a period of 21 months.

It is estimated that for the pit 49 spill site (1991 Spill) Bioslurper technology applied to the entire site and operated continuously can remove the recoverable fuel within a 24-month period.

The pit 49 site appears to be the largest of the three sites. It is expected that at the other two sites the fuel can be recovered in less time and that a 24-month period for recovery of recoverable fuel is a conservative estimate.

The Bioslurper systems will be converted to a Bioventing system when fuel recovery ends. The Bioventing system will use the same wells and piping to inject air into the subsurface to increase the aerobic degradation of residual fuel. Bioventing studies at multiple sites [8.] have found that at most sites the BTEX components are degraded within one year. Based on this data, Bioventing for one year following fuel removal should remove the BTEX components. BTEX components are the primary soluble contaminants of concern in fuel.

1.2 Natural Attenuation monitoring. Monitoring of the site will continue after the estimated three-year duration of active fuel cleanup. It is anticipated that about 30 wells will be included in long term monitoring. Water samples will be taken on an annual basis and analyzed for fuel constituents and indicators of natural attenuation. It is estimated that monitoring will be required for 6-10 years.

SECTION 3

PROJECT COSTS

Costs: Bioslurper components are not a major cost item. The most expensive component is the liquid ring pump skid which costs about $10,000 each. Cost to operate and maintain the current Bioslurper system has been less than $20,000 per year. Total cost of active cleanup over a three-year period is estimated at $380,000. Following is a breakdown of the estimated costs. The estimated costs are based on experience at Diego Garcia with the current Bioslurper system, which has recovered over 70,000 gallons of JP-5 fuel and aerobically degraded several hundred thousand pounds of fuel in the soils.

ITEM	COST EACH	QUANTITY FOR 1991 SITE	COST FOR 1991 SITE
Well material, 15 ft deep well	90	24	2160
2 inch PVC pipe (ft)	0.32	0	0
4 in PVC pipe (ft)	0.89	1000	890
2 inch rubber couplers (ea)	1.47	0	0
4 inch rubber couplers (ea)	2.5	100	250
misc fittings (ls)	1500	1	1500
1 inch vacuum hose (ft)	4	600	2400
15 horsepower vacuum pump (ea)	12000	0	0
10 horsepower vacuum pump (ea)	10000	1	10000
bioventing blower (ea)	1000	1	1000
misc repair parts (ls)	5000	1	5000
CONUS shipping (ls)	1000	3	3000
drilling of wells (on-island) (ea)	70	24	1680
piping connections (on-island) (ls)	5,000	1	5000
one year operation (on-island) (ls)	20,000	3	60000
monitoring - analytical, 1 yr (ls)	6,000	3	18000
reports (ls)	15,000	1	15000
travel to sites (each trip per person)	4,000	8	32000
TOTAL COST FOR SITE			157880

ITEM	COST EACH	QUANTITY FOR 1997 SITE	COST FOR 1997 SITE
Well material, 15 ft deep well	90	30	2700
2 inch PVC pipe (ft)	0.32	1700	544
4 in PVC pipe (ft)	0.89	1000	890
2 inch rubber couplers (ea)	1.47	50	73.5
4 inch rubber couplers (ea)	2.5	100	250
misc fittings (ls)	1500	1	1500
1 inch vacuum hose (ft)	4	300	1200
15 horsepower vacuum pump (ea)	12000	1	12000
10 horsepower vacuum pump (ea)	10000	0	0
bioventing blower (ea)	1000	1	1000
misc repair parts (ls)	5000	1	5000
CONUS shipping (ls)	1000	2	2000
drilling of wells (on-island) (ea)	70	30	2100
piping connections (on-island) (ls)	5,000	1	5000
one year operation (on-island) (ls)	20,000	3	60000
monitoring - analytical, 1 yr (ls)	3,000	3	9000
reports (ls)	10,000	1	10000
TOTAL COST FOR SITE			113257.5

ITEM	COST EACH	QUANTITY FOR 1998 SITE	COST FOR 1998 SITE
Well material, 15 ft deep well	90	24	2160
2 inch PVC pipe (ft)	0.32	0	0
4 in PVC pipe (ft)	0.89	1000	890
2 inch rubber couplers (ea)	1.47	0	0
4 inch rubber couplers (ea)	2.5	100	250
misc fittings (ls)	1500	1	1500
1 inch vacuum hose (ft)	4	400	1600
15 horsepower vacuum pump (ea)	12000	0	0
10 horsepower vacuum pump (ea)	10000	1	10000
bioventing blower (ea)	1000	1	1000
misc repair parts (ls)	5000	1	5000
CONUS shipping (ls)	1000	2	2000
drilling of wells (on-island) (ea)	70	24	1680
piping connections (on-island) (ls)	5,000	1	5000
one year operation (on-island) (ls)	20,000	3	60000
monitoring - analytical, 1 yr (ls)	3,000	3	9000
reports (ls)	10,000	1	10000
TOTAL COST FOR SITE			110080
TOTAL COST FOR ALL SITES	**381217.5**		

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