BHP Diamonds Inc.

Boston Gold Project,
Aimaoktak Lake, N.T.

Sewage Effluent Remediation of Hydrocarbon Stained Soils BHP - Boston Gold Project

Spill NWT 98-115

Prepared for:

Nunavut Water Board
Gjoa Haven, N.T.

Prepared by:

BHP Diamonds Inc.
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21 September, 1998

BHP

Background

A cache containing 4,000 drums of low sulfur diesel and turbo-B fuel was placed on the tundra next to the Boston Gold Bulk Sample Site during March of 1997. The fuel was removed from the tundra over the 1997 and 1998 seasons, as it was required by the ongoing operations at Boston.

Hydrocarbon staining was detected and reported during a Kitikmeot Inuit Association Land Use Inspection in June of 1997. Several very small stains caused by weeping barrel bungs were found and listed in the inspection report. At that time, the land use inspector requested that BHP excavate the stained soil and replace it with clean crushed rock to re-insulate the continuous permafrost under the cache. This was done progressively throughout the 1997 as spots were discovered. The excavated soil was placed in 45-gallon drums and airlifted to the Ekati Diamond Mine for treatment during the winter of 1997/98.

When the remaining drums were removed and placed on the Boston pad in July of 1998, BHP staff found further staining. The amount of hydrocarbon represented by each individual stain was minor. Collectively there were numerous small hydrocarbon stains dispersed over an area of 35 by 90 meters. A spill report was filed with the NWT Spill Line on July 15, 1998 (see enclosed).

An internal BHP evaluation of spill NWT 98-115 concluded that continued spot excavation of stains would be more harmful to the re-vegetation of the tundra then would *in situ* bioremediation and/or phytoremediation. This conclusion was based on several factors. Inspection indicated that there is not a significant amount of hydrocarbon saturated soil. The organic soils that overlay the glacial till are very thin (3-6 cm). An active layer of 30 to 40 cm exists around the Boston Gold Project. Protection of the organic soil horizon and maintenance of the underlying permafrost are important considerations of the treatment proposal.

Excavation of stained soil in 1997 not only removed the organic horizon but also created a substantial waste management problem, in the form of containerized soil. At the present time BHP does not have the capacity at Boston to treat large amounts of excavated hydrocarbon stained soil. Given these factors, an *in situ* solution is a logical choice.

Treatment Proposal

Land treatment has been successfully used to remove petroleum hydrocarbon from contaminated soils in high latitude climates (Wardell 1995). Numerous factors effect the rate and extent of hydrocarbon degradation in soil. Some of these include pH (6 –8), temperature, moisture, aeration, nutrient status (e.g., nitrogen, potassium, and phosphorus), petroleum product characteristics, and the ecology of the microbial populations present in the soil (Huesemann 1994: 1).

Previous Arctic reclamation experiences of the Homestake Mining Company at the Cullaton Lake Gold Mine and BHP Diamonds Inc. at the Ekati Diamond Mine have shown primary treated sewage effluent promotes the re-growth of the Arctic tundra and may facilitate the breakdown of hydrocarbons. Land treatment of domestic and commercial wastes is currently being reviewed in the Arctic at several Hudson Bay communities in Nunavut. Based on these experiences, *in situ* treatment using primary treated black water as a medium was considered a viable option by BHP for soil remediation at Boston. This approach is particularly appropriate as the area identified in spill report NWT 98-115 had prior to 1997, been used as the discharge point for treated sewage at the Boston. The plan does not introduce treated sewage to a new area where it has not been released in the past.

Black water treatment elevates soil moisture, adds nitrogen, potassium and phosphorous and increases the numbers of microbes in the soil. This meets four of Huesmann's basic criteria (1994). Increased soil aeration will be mechanically provided without significant disturbance to the root mat.

Work in Antarctica suggests that bacteria in low-nutrient environments are capable of using a greater diversity of organic material at lower concentrations. Further bacteria in low-nutrient media are known to adapt and develop the ability to degrade anthropogenic compounds. Once bacterial populations adapt the rate of degradation increases (Wardell 1995: 4). Wardell's work further suggests that microbes present in virgin high latitude soils and many of the broad range of microbes found in black water, will adapt to feed on hydrocarbons.

To start the process, for 1 week in early August 1998, a small amount of black water was placed on the spill. The puddles created by the effluent contained petroleum sheens. These were removed with absorbent pads. Fertilizer (16-16-16) was hand broadcast on to the site to provide additional nutrients to aid the revival of established plant colonies and to promote germination in the spring of 1999. During early September 1998, local sedges were harvested at Boston and used to seed the site. These measures will help to expedite re-vegetation of barren patches in 1999. The rest of the plan is contingent upon BHP opening the Boston Camp in 1999.

If after a relatively passive soil remediation/-monitoring programme, test results do not indicate a significant drop in hydrocarbons; BHP will consider a more interventionist approach. Subsequent measures might include increased Phytoremediation with native plant species and / or the inoculation of the site with bacteria that has been demonstrated to be effective in the biodegradation of hydrocarbons (Ecological – Engineering Nd, Lee and Cutright Nd).

Regulatory Considerations

Moving the Boston sewage discharge point (SNP #3) on to the spill area required a revision of the Boston Water Licence SNP Plan. Run off from the discharge placed on the spill will eventually enter Aimaoktak (Spyder Lake) north of SNP #4. A new SNP station was added to the Boston Water Licence to capture the point of run off entry into Aimaoktak Lake (SNP# 5 - see enclosed map). The end of pipe (SNP #3) will be rotated between the SNP # 4 and 5 drainages so that the effluent can be used to water the spill but will not saturate it by continuous discharge. Both SNP # 4 and #5 will be active in 1999 and 2000.

For the plan to be successful, it is necessary to discontinue chlorination of the effluent to increase microbial survival. Depending on the size of the Boston camp population over the next two years, it may be necessary to resume chlorination to meet present water licence requirement thresholds. If this is necessary, the bioremediation will be suspended until the population of the camp is reduced and discharge levels can be met without chlorination. During periods of chlorination SNP #4 will be used as the point of discharge into Aimaoktak Lake. To increase the chance for this approach to succeed BHP is under separate cover, requesting the NWB to amend the threshold levels for fecal coliform in Bostons Type B Water Licence (NWB1BOS9801).

A request for the changes to the SNP was made to the Nunavut Water Board in a letter dated July 17, 1998. The Nunavut Water Board approved the necessary changes in the new Boston Water Licence (NWB Licence No. NWB1BOS9801, Section G-1) signed on July 31, 1998. The board made their approval contingent upon the submission by BHP of a monitoring plan (Section G-1). This submission is designed to fulfills the requirements of section G-1.

Monitoring Plan

The effectiveness of sewage in the clean up of Spill NWT 98-115 will be evaluated based on the following:

- the remediation/-monitoring plan will be conducted for two seasons,
- photographs were taken of the spill area in July of 1998 as a baseline,
  - re-growth will be monitored in 1999 and 2000 by re-photographing the site at the beginning and the end of each season (same day as soil samples),
- the addition of the black water to the dry tundra, will float hydrocarbons on puddles,
  - puddles will be monitored for sheens,
  - hydrocarbons will be collected from puddles using spragsorb pads and booms. The frequency that spragsorb needs to be changed will provide a

heuristic measure of the rate at which the hydrocarbons are being cleaned from the surface,

- to provide a control on hydrocarbon degradation in the affected area and to monitor any hydrocarbons that might migrate down slope with the discharge water, BHP will:
  - establish five sampling points on the spill site covering a range of dense, medium and light hydrocarbon stains. A control site will be established in similar but virgin soil away from the immediate impact of the Boston site. BHP is willing to consider a second control point with in the spill area that will go untreated. The small internal control could provide valuable information on the of success of the sewage treatment compared with the natural dissipation of hydrocarbons. This will only be done however, if there is agreement from the regulators that it will not alter the overall timing of closing the spill.
    - soil samples will have the root mass removed, the remaining material will be treated as a composite,
    - during 1999 and 2000 – immediately after run off and at the end of the growing season, soil samples will be taken for analysis. These samples will be collected in late June and late August at the same time that monthly SNP samples are taken. The first set of samples will be used to determine the average level of hydrocarbons in the soil,
    - the soil samples will be tested for Total Petroleum Hydrocarbons (TPH). TPH incorporates the components of Diesel Range Petroleum Hydrocarbons (DRPH) which cover diesel fuel and turbo - B. TPH will be used to estimate biodegradation of hydrocarbon components (Huesumann 1994). The rate of hydrocarbon breakdown will be monitored against standard TPH benchmarks (Heath, Koblis and Sager 1993). The current Government of the Northwest Territories standard allows a TPH of 2,500 ppm in soils associated with industrial sites (Environmental Guidelines for Site Remediation 1998).
    - a Fertility for Oil Spill Analysis (FOSA) will be done with the first sample in 1999 to guide remediation,
    - tests for Hydrocarbon Utilizing Organisms (HUO) will be conducted on the first sample in 1999 and the last sample in 2000 to evaluate changes in the population of beneficial microbes over the treatment period.
  - an intermediate water sampling point will be selected down slope from the spill. It will be sampled on a month basis, when water is found down slope from the spill. The sample will be taken at the same time SNP samples are collected so that the data is comparable. If a sheen is present absorbents will be installed to collect it.
    - these samples will be evaluated against the water discharge criteria in NWB Licence No. NWB1BOS9801 – BOD, Fecal Coliform, Total Suspended Solids, and pH. In addition to the regulated criteria in NWB Licence No. NWB1BOS9801, BHP proposes to add a test for TPH to

the suite of tests done at the intermediate water sampling point and at SNP #5.

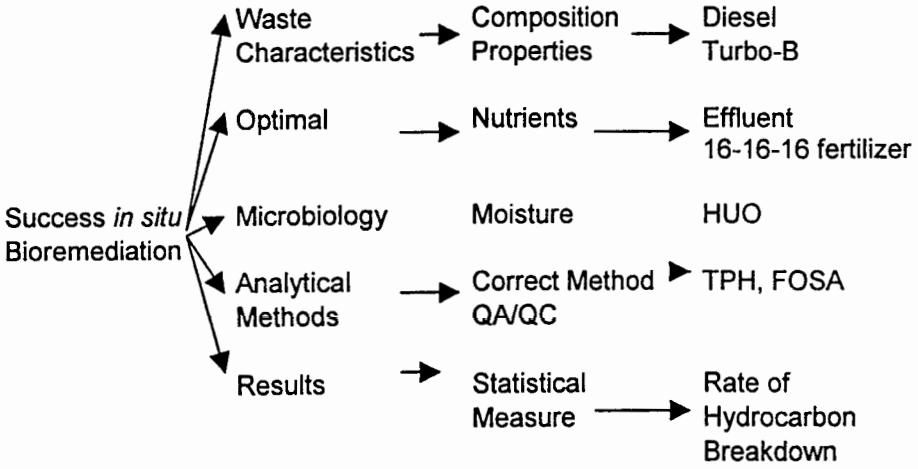
- if test results at the intermediate point exceed allowable discharge levels, BHP will monitor and mitigate as necessary to ensure that the run off that does not meet the release criteria will not enter the lake at SNP # 5. It is not anticipated, however, that any further remedial action will be required. The low flow of water from the sewage line must trickle through 200 meters of tundra after it passes the spill on its way to Aimaoktak Lake. This will allow adequate time for biological action to remove residual nutrients, for fecael coliforms to die off and for the attenuation of water within the tundra vegetation.

The results will be reported in monthly water reports throughout the 1999 and 2000 seasons and summarized in the annual reports. The treatment will be evaluated against Huesemann's criteria (see Table 1).

Spill Closure

If in August of 2000 the average of the soil samples from the spill area meet or are less than the TPH guideline of 2,500 ppm established by the Government of the Northwest Territories, the remediation will be considered complete. At that time BHP will request the KIA Land Use inspector to close the spill. If the level remains above the 1998 GNWT guideline, BHP will continue treatment for an additional year.

Table 1 – Factors affecting success in bioredíation



(after Huesemann 1994)

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1998 Environmental Guidelines for Site Remediation. Resources Wildlife and Economic Development. Government of the Northwest Territories.

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Lee, S. and T. Cutright
Nd Bioremediation of Polycyclic Aromatic Hydrocarbon Contaminated Soil. Temarex.com/biorem.htm.

Wardell, L.J.
1995 Potential for Bioremediation of Fuel-Contaminated Soil in Antarctica. Journal of Soil Contamination 4(2): 1-11.

Northwest Territories

N.W.T. SPILL REPORT (Oil, Gas, Hazardous Chemicals or other Materials)

24-hr Report Line
Phone (403) 920-8130
Fax (403) 873-6924

A Report date and time	B Date and time of spill (if known)	C	Spill number
July 15, 1998	UNKNOWN	☑ Original report ☐ Update no.	98-115

D Location and map coordinates (if known) and direction (if moving)

BHP BOSTON CAMP, BHP MINERALS CANADA

E Party responsible for spill

BHP MINERALS

F Product(s) spilled and estimated quantities (provide metric volumes/weights if possible)

DIESEL FUEL & JET-B, QUANTITY UNKNOWN.

G Cause of spill

LEAKING BARRELS

H Is spill terminated?	I If spill is continuing, give estimated rate	J Is further spillage possible?	K Extent of contaminated area (in square metres-if possible)
☑ yes ☐ no		☐ yes ☑ no	35m x 90m

L Factors affecting spill or recovery (weather conditions, terrain, snow cover, etc.)

M Containment (natural depression, dykes, etc.)

NONE

N Action, if any, taken or proposed to contain, recover, clean up or dispose of product(s) and contaminated materials

PLANS TO MONITOR SITE. FUTURE PLANS INCLUDE APPLYING FERTILIZER AND INDIGENIOUS GRASS SEED.

O Do you require assistance?	P Possible hazards to persons, property, or environment: eg: fire, drinking water, fish or wildlife
☑ no ☐ yes, describe:	NONE.

Q Comments and/or recommendations

AREA WAS USED AS A STORAGE SITE FOR APPROX 4000 BARRELS OF BOTH JET-B AND DISEL FUEL. THIS FUEL CACHE WAS THE ORIGINAL LOCATION FOR BARREL STORAGE WHILE A CRUSHED GRAVEL PAD WAS CONSTRUCTED AT BHP BOSTON CAMP. ALL BARRELS HAVE RECENTLY BEEN MOVED FROM THE TUNDRA AND ONTO THE GRAVEL PAD. WHILE THE (DRUMS) BARRELS WERE IN STORAGE, SMALL LEAKS OCCURED OVER TIME. TO AVOID FURTHER DAMAGE TO THE SITE, BHP PLANS TO MONITOR THE SITE, AND APPLY FERTILIZER AND INDEGENIOUS GRASS SEED TO AID IN THE RECOVERY.

FOR SPILL LINE USE ONLY

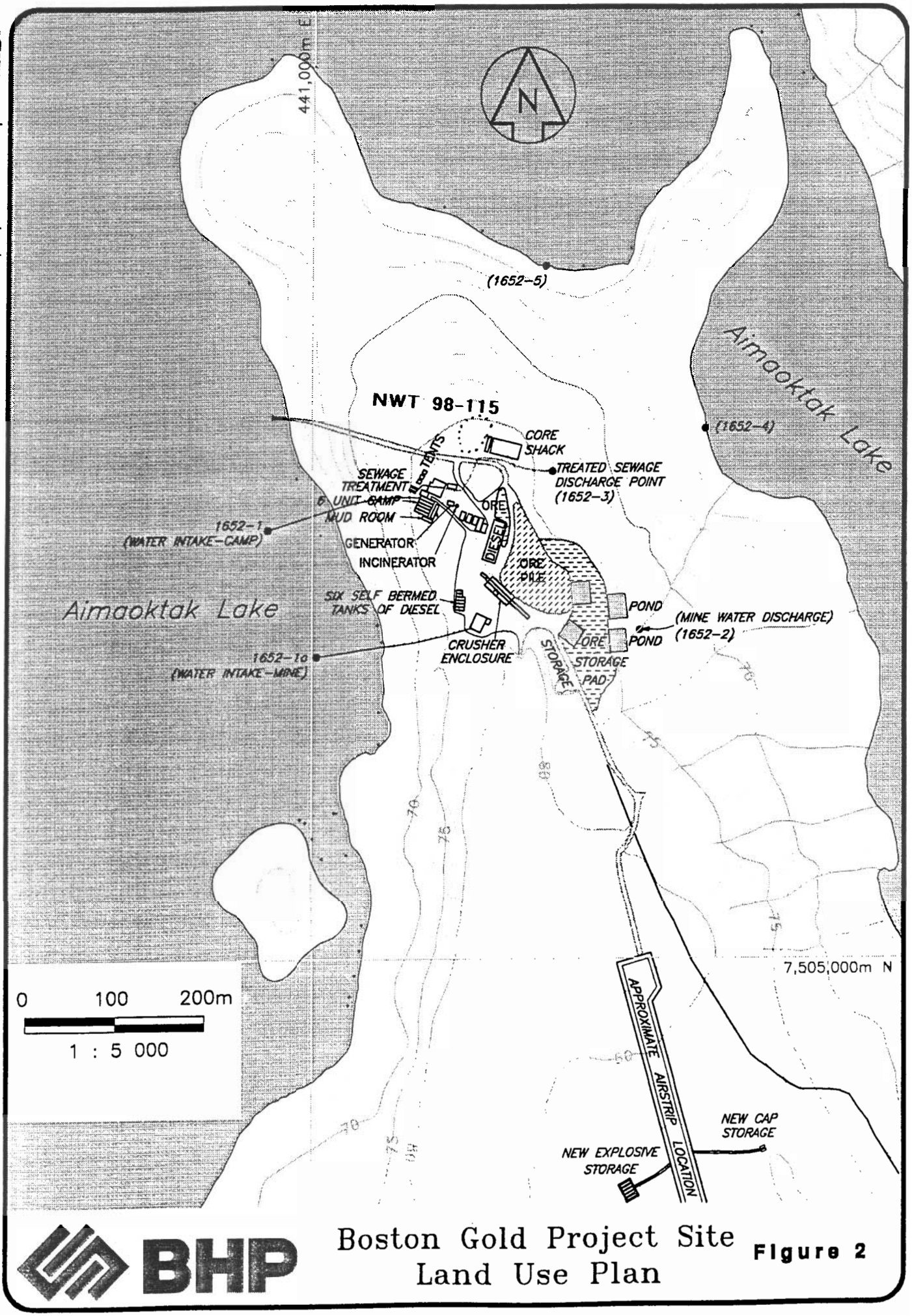
Lead Agency

Spill significance

Lead Agency contact and time

Is this file now closed? ☐ yes ☐ no

Reported by	Position, Employer, Location	Telephone
J. PARSONS	ENVIRONMENTAL FIELD MANAGER, BHP MINERALS	(604) 520-3412
Reported to	**Position, Employer, Location**	**Telephone**
C. HANKS	SR. ENVIRONMENTAL MANAGER, BHP	(867) 669-6145



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Boston Gold Project Site Land Use Plan

Figure 2

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BOSTON PROJECT SITE
Aerial Photo 1998

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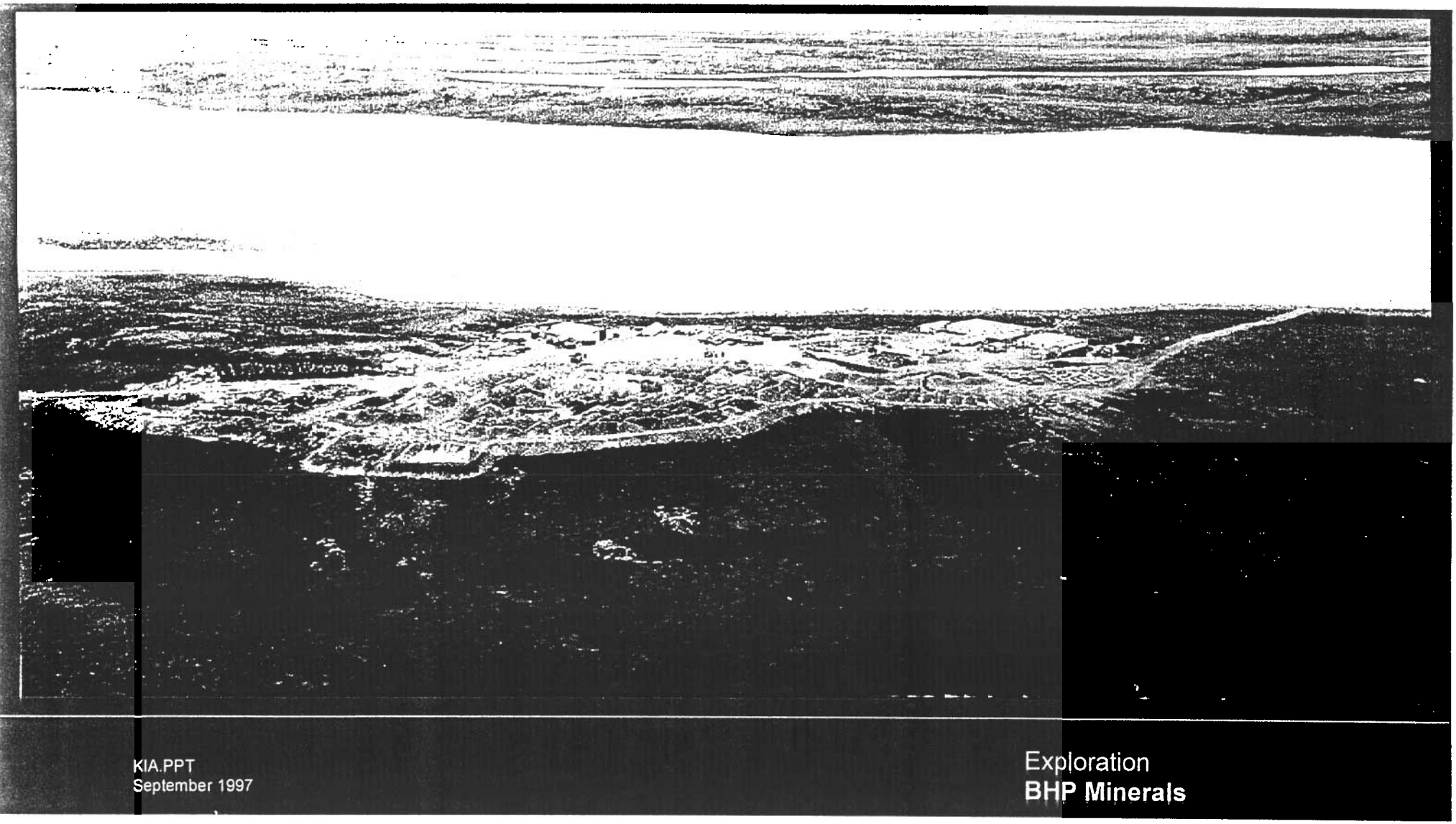

FIGURE 1