9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	White
Odor:	Odorless
pH:	11.5
Specific Gravity @ 20 C (Water=1):	2.5
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	48- 62
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Partially soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	105.99

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Prolonged or repeated contact may cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 4220 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM24: 385 mg/l (Lepomis macrochirus)
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **STEELSEAL 100**

Revision Date: 12-Aug-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name:	STEELSEAL 100
Synonyms:	None
Chemical Family:	Graphite
Application:	Loss Circulation Material
Manufacturer/Supplier	Baroid Fluid Services Product Service Line of Halliburton P.O. Box 1675 Houston, TX 77251 Telephone: (281) 871-4000 Emergency Telephone: (281) 575-5000
Prepared By	Chemical Compliance Telephone: 1-580-251-4335 e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Graphite	7782-42-5	60 - 100%	2 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation. May cause delayed injury to lungs. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	> 673
Flash Point/Range (C):	> 356
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.07 - 0.12
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Not applicable.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust. Avoid dust accumulations. Wet activated carbon removes oxygen from air causing a severe hazard to workers inside carbon vessels and enclosed or confined spaces. Before entering such an area, sampling and dark procedures for low oxygen levels should be taken to ensure ample oxygen availability.

Storage Information Store away from oxidizers. Store in a dry location. Keep from heat, sparks, and open flames. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls A well ventilated area to control dust levels.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Dark gray
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.75
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	7592
Boiling Point/Range (C):	4200
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	1
Vapor Density (Air=1):	0.4
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong acids. Strong alkalis.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	May cause mild skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause mild gastric distress.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	Prolonged, excessive exposure to dust may cause pneumoconiosis, a lung disease caused by inhaling dust particles less than 0.5 micrometers into the lungs.
Other Information	None known.
Toxicity Tests	

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **STEELSEAL 400**

Revision Date: 12-Aug-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: STEELSEAL 400
Synonyms: None
Chemical Family: Graphite
Application: Loss Circulation Material

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Carbon	7440-44-0	60 - 100%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview
May cause eye and respiratory irritation. May cause delayed injury to lungs. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists.

Eyes
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion
Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician
Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	> 673
Flash Point/Range (C):	> 356
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.07 - 0.12
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Not applicable.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust. Avoid dust accumulations. Wet activated carbon removes oxygen from air causing a severe hazard to workers inside carbon vessels and enclosed or confined spaces. Before entering such an area, sampling and dark procedures for low oxygen levels should be taken to ensure ample oxygen availability.

Storage Information Store away from oxidizers. Store in a dry location. Keep from heat, sparks, and open flames. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls A well ventilated area to control dust levels.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Dark gray
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.75
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	38-45
Boiling Point/Range (F):	7592
Boiling Point/Range (C):	4200
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	1
Vapor Density (Air=1):	0.4
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong acids. Strong alkalis.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	May cause mild skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause mild gastric distress.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	Prolonged, excessive exposure to dust may cause pneumoconiosis, a lung disease caused by inhaling dust particles less than 0.5 micrometers into the lungs.
Other Information	None known.
Toxicity Tests	

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **SteelSeal 50**

Revision Date: 05-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: SteelSeal 50
Synonyms: None
Chemical Family: Graphite
Application: Loss Circulation Material

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Calcined petroleum coke	64743-05-1	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation. May cause delayed injury to lungs. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	> 673
Flash Point/Range (C):	> 356
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.07 - 0.12
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1, Flammability 0, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid creating or inhaling dust. Avoid dust accumulations. Wet activated carbon removes oxygen from air causing a severe hazard to workers inside carbon vessels and enclosed or confined spaces. Before entering such an area, sampling and dark procedures for low oxygen levels should be taken to ensure ample oxygen availability.
Storage Information	Store away from oxidizers. Store in a dry location. Keep from heat, sparks, and open flames. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	A well ventilated area to control dust levels.
Respiratory Protection	If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional. Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.

Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Granules
Color:	Dark gray
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.75
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	38-45
Boiling Point/Range (F):	7592
Boiling Point/Range (C):	4200
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	1
Vapor Density (Air=1):	0.4
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong acids. Strong alkalis.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	May cause mild skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause mild gastric distress.
Aggravated Medical Conditions	Skin disorders.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure to dust may cause pneumoconiosis, a lung disease caused by inhaling dust particles less than 0.5 micrometers into the lungs.

Other Information None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580 251 4335.

Disclaimer Statement

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*****END OF MSDS*****

MATERIAL SAFETY DATA SHEET

Product Trade Name: **VIS-PLUS®**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: VIS-PLUS®
Synonyms: None
Chemical Family: Organic acid
Application: Viscosifier

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fatty acid		30 - 60%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	356
Flash Point/Range (C):	180
Flash Point Method:	COC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Carbon Dioxide, Dry Chemicals, Foam.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 1, Reactivity 0
HMIS Ratings: Flammability 1, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use.

Storage Information Store away from alkalis. Store away from oxidizers. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls A well ventilated area to control dust levels.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Mild fatty
pH:	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	0.85
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	721
Boiling Point/Range (C):	383
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	9.8
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	> 3
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Keep away from heat, sparks and flame.
Incompatibility (Materials to Avoid)	Strong alkalis.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach. May act as obstruction if swallowed.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	LD50: > 2000 mg/kg (Rat)
Dermal Toxicity:	LD50: > 5000 mg/kg (Rabbit)
Inhalation Toxicity:	Not determined

Primary Irritation Effect: Not determined

Carcinogenicity Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Readily biodegradable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

APPENDIX 4: BASELINE SAMPLING METHODOLOGY

Introduction

International Environmental Management Co. Ltd. (IEM) conducted an offshore baseline sampling program in Apsara Petroleum Development Block A located in Cambodia in the central Gulf of Thailand.

Scope of Work

IEM collected seabed and water samples at representative locations from October 23rd to October 29th, 2010, and analyzed these for seawater quality, sediment quality, and biological resources. The biological resources collected were benthos, phytoplankton, zooplankton, and larvae, which are defined as follows:

- Benthos are organisms which live on, in, or near the seabed, also known as the benthic zone (http://www.caml.aq/benthos/index.html). They are usually found within or attached to the seabed sediment. Sediments provide a record of environmental conditions including the recent past; they also tend to accumulate pollutants over time. Benthos living in these sediments therefore could be an indicator of longer-term environmental conditions and the quality of the environment.
- Phytoplankton are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Phytoplankton are the main primary producer within the marine food chain and are abundantly present in the world's oceans (http://oceanworld.tamu.edu/resources/oceanography-book/marinefoodwebs.htm). Growth of phytoplankton depends on certain conditions such as temperature, light, the absolute and comparative concentration of micro-nutrients. Thus, phytoplankton is a good indicator of change in an offshore environment (www.pan-ol.lublin.pl/wydawnictwa/TOchr1/Zebek.pdf).
- Zooplankton are small protozoans or metazoans (e.g. crustaceans) that feed on other plankton. Zooplankton are important to the marine food chain as both primary and secondary consumers of not only phytoplankton but also other zooplankton.
- Larvae are a distinct juvenile form that many animals undergo before metamorphosis into adults. Marine larval dispersal is one of the most important topics in marine ecology because most marine larvae are capable of dispersing long distances from their release site and marine larvae are therefore an indicator of fisheries management, effective marine reserve design, and control of invasive species.

Together, these organisms represent a diverse biological marine community that are sensitive to changes in their environment and therefore good indicators of the overall health of the marine ecosystem.

The number of samples for each parameter is provided in **Table 1**. The detailed parameters and methodology used are provided in **Table 2**.

IEM collected QA/QC trip blanks and samples from a control station which was established well away from the potential influence of the development to determine a secure benchmark for the future. The control station for this sampling program is located 15 km southeast of the proposed development area. This distance and direction ensure that it is sufficiently located away from previous drilling locations in Block A.

Sampling station locations in the field were ascertained with the use of the GPS (Global Positioning Systems) both from hand held and the vessel's equipment. IEM also used GPS tracking software to assist in navigating the vessel to the precise position. The locations of the sampling stations are provided in **Figure 1**, and the coordinates are shown in **Table 3**.

Survey Vessel

Environmental sampling requires a stable working environment from which to deploy sampling equipment. The vessel must be able to withstand the sea conditions that can be expected in the central Gulf. Typically, the sampling vessel is a supply/tug ocean going vessel with ample deck space provided for working and placement of a 20 foot lab/office container.

The vessel contractor for this baseline survey was SC Management Co. Ltd. SC Management Co. Ltd. has a long history of successful sampling surveys in the Gulf of Thailand. All samples were collected over the side of a 32.4-m supply vessel KNO 102. The specifications of the KNO 102 suply vessel are shown in the Appendix.

Table 1: Number of Sampling Locations

Parameter	Number of Sampling Locations	Sampling Stations per Location	Control Station	QA/QC (Field Blank, Trip Blank, Duplicate)	Total Samples
Seawater	2	1 x 3 levels (3)	1 x 3 levels (3)	3	12
Sediment	11	1	1	1	13
Benthos	11	1	1	1	13
Phytoplankton	4	1	1	1	6
Zooplankton	4	1	1	1	6
Larvae	4	1	1	1	6

Table 2: Sampling Parameters and Methodology

Parameters	Detection Limit	Analytical Method	Preservation Method	Number of Samples
Seawater				
Total Metals:				
Arsenic	0.1 mg/L	USEPA 6020/on-line chelation-ICPMS	Plastic bottle, preserved with HNO_3 to pH< 2 and kept cool	12
Barium	10 µg/L			12
Cadmium	10 µg/L			12
Chromium	10 µg/L			12
Copper	10 µg/L			12
Lead	10 µg/L			12
Nickel	10 µg/L			12
Zinc	100 µg/L			12
Iron	0.5 mg/L	APHA 3500Fe:B/AAS		12
Manganese	0.5 mg/L	APHA 3500Mg:B/AAS		
Mercury	0.5 µg/L	USERA 7471/Cold-Vapour AAS		12
Hydrocarbons:				
TPH	C6-C9: 20µg/L; C10-C14: 50µg/L; C15-C28: 100µg/L; C29-C35: 50 µg/L	USEPA 8260 (Purge & Trap GCMS) + USEPA 8015 (GCFID)	1 litre glass+Two 40mL HCL preserved glass vial. Kept cool at 4°C	12
Physical Parameters				
Total Suspended Solids	2 mg/L	APHA 2540B	Kept cool at 4°C	12
TOC	5 mg/L	APHA 5310B	H_2SO_4 to pH <2, glass	12
Oil & Grease	5 mg/L	APHA 5520 E	H_2SO_4 to pH <2, glass	12
pH	0.1 pH unit	Troll 9000® Multiparameter probe	Measured in-situ	Continuous depth profiles
Conductivity	1 µS/cm	Troll 9000® Multiparameter probe	Measured in-situ	Continuous depth profiles
Temperature		Troll 9000® Multiparameter probe	Measured in-situ	Continuous depth profiles
Dissolved Oxygen		Troll 9000® Multiparameter probe	Measured in-situ	Continuous depth profiles
Turbidity	1 NTU	Troll 9000® Multiparameter probe	Measured in-situ	Continuous depth profiles
Sediment				
Total Metals:				
Arsenic	1 mg/kg	USEPA 6020/ICPMS	Glass bottle, Kept cool at 4°C	13
Barium	1 mg/kg			13

Parameters	Detection Limit	Analytical Method	Preservation Method	Number of Samples
Cadmium	0.02 mg/kg			13
Chromium	1 mg/kg			13
Copper	1 mg/kg			13
Lead	1 mg/kg			13
Nickel	1 mg/kg			13
Zinc	1 mg/kg			13
Iron	0.5 mg/kg	APHA 3500Fe:B/AAS	Glass bottle, Kept cool at 4°C	13
Mercury	0.02 mg/kg	USEPA 7471		13
Hydrocarbons:				
TPH	C6-C9: 2 mg/kg; C10-C14: 50 mg/kg; C15-C28: 100 mg/kg; C29-C35: 100 mg/kg	USEPA 8260 (Purge & Trap GCMS) + USEPA 8015 (GCFID)	Glass bottle, Kept cool at 4°C	13
TOC (include Moisture)	0.50%	APHA 5310B	Glass bottle, Kept cool at 4°C	13
Physical:				
particle size	0.10%	BS1377: Wet seiving (63um-2mm); Hydrometer (<63um)	500 gram in plastic bag	13
Biological				
Zooplankton (density/diversity)			Preserved in 4 percent formalin	6
Phytoplankton (density/diversity)			Preserved in 4 percent formalin	6
Larvae			Preserved in 4 percent formalin	6
Benthos (Density, Diversity, Biomass)			Samplers were relaxed in magnesium chloride for 30 minutes and fixed with 10 % formalin on board and replaced with 70% alcohol for storage in the laboratory. Remaining sediment on the sieves were collected and preserved with 10% formalin for further sorting in the laboratory.	13

Figure 1: Baseline Sampling Locations

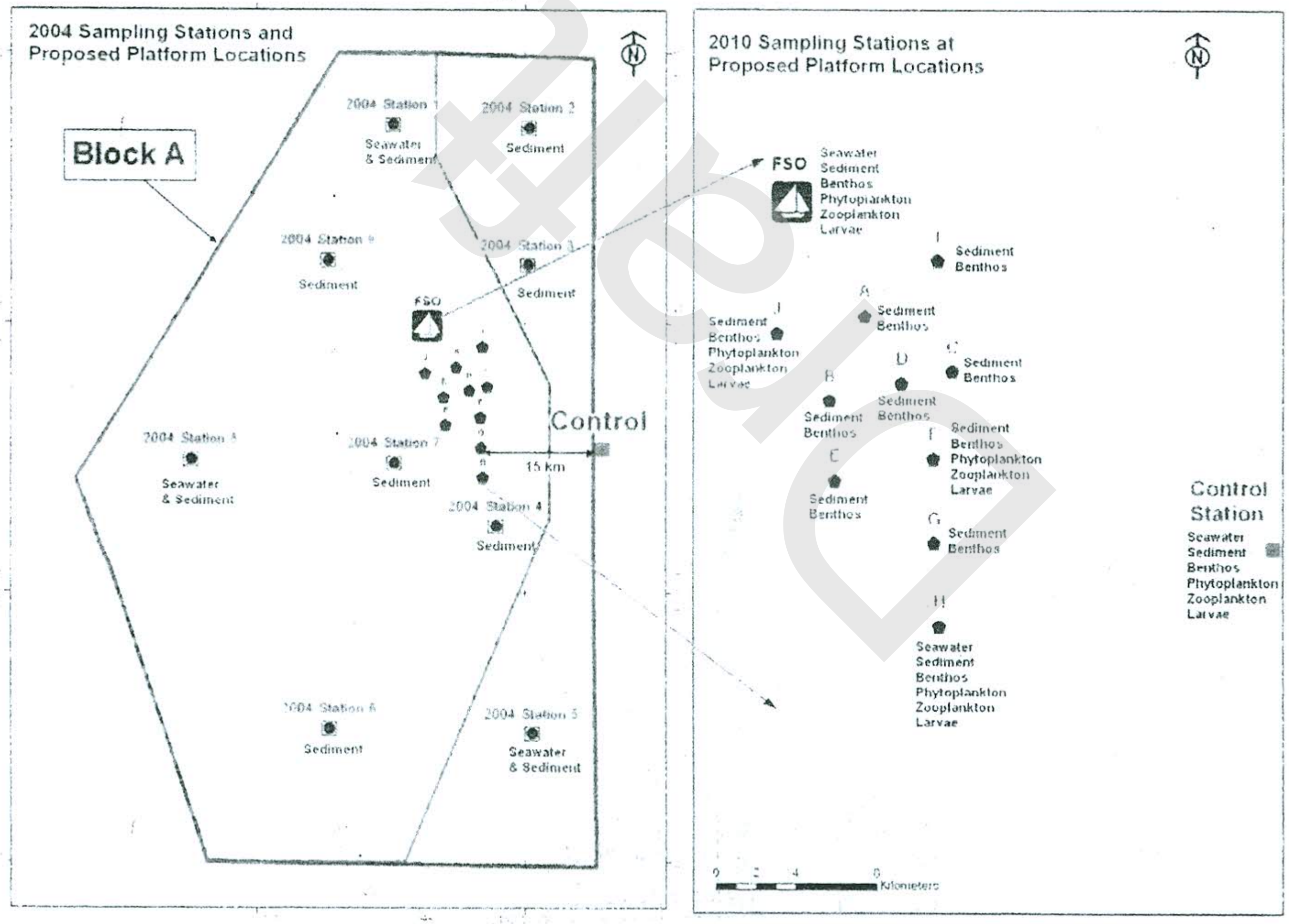


Table 3: Sampling Location Coordinates

PLATFORM	Coordinates(Indain1975)			
	EASTING	NORTHING	Lat	long
A	856150	1101150	102° 14'52.583"	9° 56' 47.217
B	854510	1097000	102° 13'57.475"	9° 54' 32.817
C	860501	1098506	102° 17'14.408"	9° 55' 19.867
D	858000	1097906	102° 15'52.205"	9° 55' 1.163
E	854800	1093100	102° 14' 5.743"	9° 52' 25.932
F	859629	1094200	102° 16'44.424"	9° 53' 0.161
G	859725	1090050	102° 16'46.235"	9° 50' 45.215
H	860000	1086000	102° 16'53.951"	9° 48' 33.463
I	859750	1103900	102° 16'51.534"	9° 58' 15.465
J	851878	1100253	102° 12'32.199"	9° 56' 19.407
FSO	852476	1106161	102° 12'53.694"	9° 59' 31.297
Control Point	876351	1089957	102° 25'51.212"	9° 50' 36.774

Data Sources

Information for the description of this environmental baseline comes from an environmental baseline survey conducted by IEM in Block A Cambodia between October 23rd and October 29th, 2010.

Seawater Collection Methodology

For seawater samples, some parameters were measured in-situ (continuously and near-instantaneously with a measurement probe), as specified in **Table 2**, while other parameters require offsite ex-situ laboratory analysis.

For parameters measured "in-situ" (pH, temperature, D.O., conductivity, turbidity), IEM measured profiles using a Troll 9000® Multi-parameter Sonde. The Sonde is equipped with a rugged 100 metre Teflon vented cable allowing depth profiles to be acquired anywhere in the Gulf of Thailand. The sonde was lowered from the seawater surface to the ocean floor (an approximate depth of 61 - 73 meters), and then brought back to the surface, taking measurements at 2 second intervals.

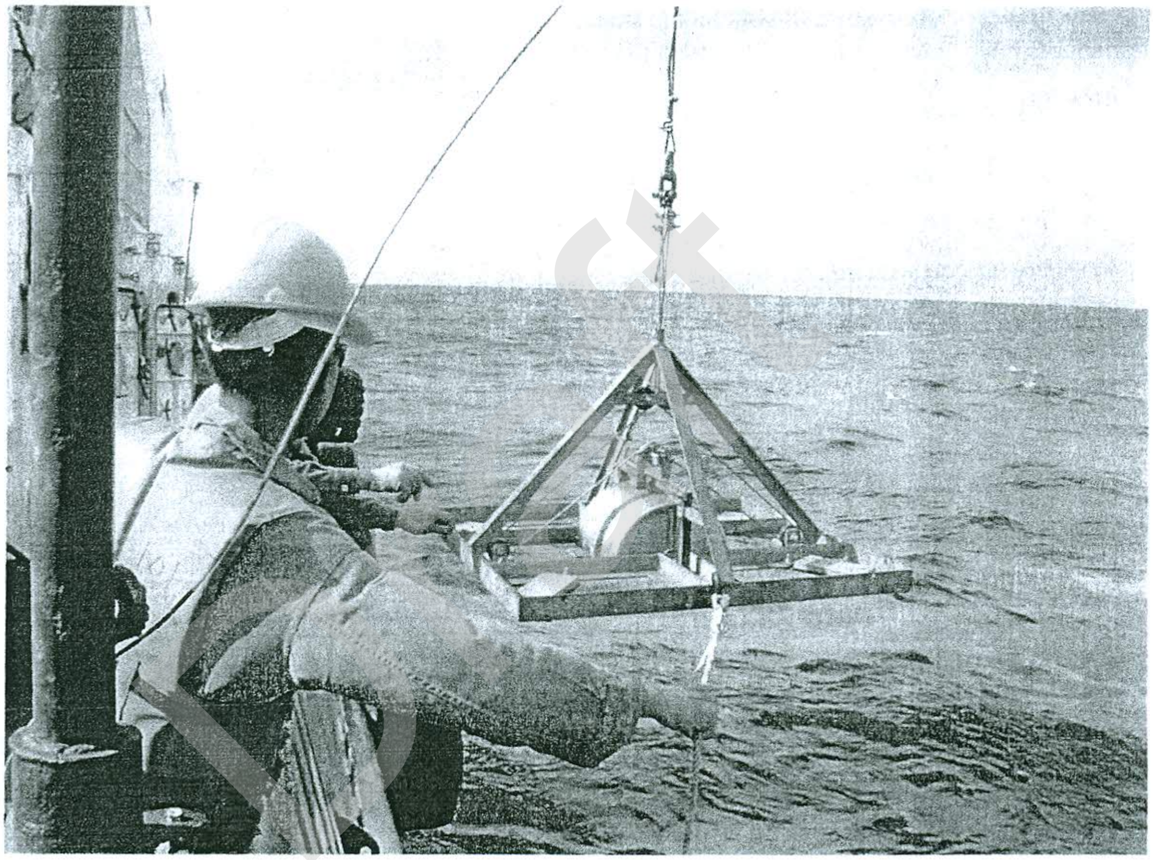
For parameters requiring offsite ex-situ laboratory analysis, samples were collected with the use of an Ocean Scientific Teflon Vertical Sampling Water Bottle with a 7.5-liter capacity, which was deployed on a metered, plastic-coated steel cable. Before deployment, the sampler was rinsed with distilled water and seawater at each sampling station 3-4 times. Water samplers were lowered into the sea to the desired depths, at 1 m and 30 m below the surface and 1 m above the seabed. The sampler was left in position for 30-60 seconds to allow equalization with the water at the specified depths. Once equalized, the closing mechanism was triggered to allow collection of a sample. The seawater was brought onboard and transferred to appropriate storage bottles, preserved as applicable, and stored according to the analytical requirement. The sample preservation methods are provided in **Table 2** above. All sample handling was done wearing nitrile gloves to avoid contamination. The samples were kept in a refrigerator.

Sediment Collection Methodology

Sediment samples were collected using a 0.1 m^2 "Day" grab sampler, equipped with stainless steel buckets, which was deployed on an un-greased cable wire. This "Day" grab sampler is especially designed for operation in deep seawater required for the collection of undisturbed sediment.

Each sediment grab was examined to ensure the water/sediment interface had not been disturbed. For chemical and physical tests, the top 2 – 3 cm of the sediment was carefully scooped off and transferred to the appropriate container according to the analysis prerequisite. Preservation requirements for sediment samples are provided in **Table 2** above. A photograph of the collection equipment is shown in **Figure 2**.

Figure 2: Sediment Sampling



Biological Resources Sampling Methodology

General Definitions

Diversity index

Diversity indices are commonly used to assess the state of an ecosystem (e.g., as a criterion for conservation evaluation), with high diversity generally being considered a desirable property in a community or ecosystem. Shannon's diversity index is one of the most commonly used diversity indices (http://www.tiem.utk.edu/~mbeals/shannonDI.html).

Richness

The "species richness" is simply the number of species present in an ecosystem. Margalef's richness index provides a measure of species richness that is roughly normalized for sample size without using more complex rarefaction techniques.

Evenness

The "species evenness" is the relative abundance or proportion of individuals among the species. Pielou's evenness is one mathematical method of representing the evenness of a community.

Benthos

Sediment samples were collected using a 0.1 m^2 "Day" grab sampler equipped with stainless steel buckets, which was deployed on a nylon rope using an A-frame crane and hydraulic winch. When the grab sampler reached the bottom it was raised up and brought back onboard. The contained sediment grab was examined to ensure the water/sediment interface was not disturbed.

The sediment was sieved through 2 mm, 1mm and 0.5mm to sort the benthos from the sediment (English et al., 1994). At each of the 12 stations (see **Figure 1**), three replicates of grab were collected and combined. Additional field duplicate samples at Station H were also collected and analyzed for QA/QC purposes to check the reproducibility of the laboratory's analytical results, as well as the environmental sample variability and to evaluate the precision of the methods. The samplers were relaxed in Magnesium chloride for 30 minute and fixed with 10 % formalin on board and replaced with 70% alcohol for storage in the laboratory (see **Figure 4**). Remained sediment on the sieves were collected and preserved with 10% formalin for further sorting in the laboratory.

The samples were sent to scientists at the Coral Reef and Benthos Research Unit, Center of Excellence for Biodiversity of Peninsular Thailand, Faculty of Science, Prince of Songkla University (**Figure 5** and **Figure 6**). Benthic fauna were identified at the lowest practical taxa and differentiated between species. Unidentified species were identified to genus level and organized in different species-like subgroups as genus sp.x. Therefore, the calculation of diversity index can be done at the species level. The benthic fauna were compared with previous benthos samples at the Coral Reef and Benthos Research Unit where data bases of benthos in the Gulf of Thailand were established (**Figure 7**).

The benthic density (individuals/m^2) was determined for each station with a mean and standard deviation for all stations. A diversity index was calculated for all sites to determine the evenness of the distribution.

The ***Shannon diversity index*** was calculated as:

$$H' = \sum_{i=1}^{S} Pi(\ln(Pi))$$

Where H = Diversity Index

P_i = Proportion of total sample belonging to species i^{th} was calculated as $Pi = \frac{ni}{N}$

N = the total number of individuals per site

n_i = the number of individuals in the ith family or taxa

S= Total number of species in each station

Pielou's evenness was calculated as

$$J = H' / (\ln S)$$

Margalef's richness index was calculated as:

$$(S-1)/\ln(n)$$

Where *H' is Shannon's diversity index, S* is total number of species in each station and *n* is number of individual in each station.

Figure 3: Sediment Sampling Protocol

Figure 4: Benthos Collection Protocol

Figure 5: Sediment Processing

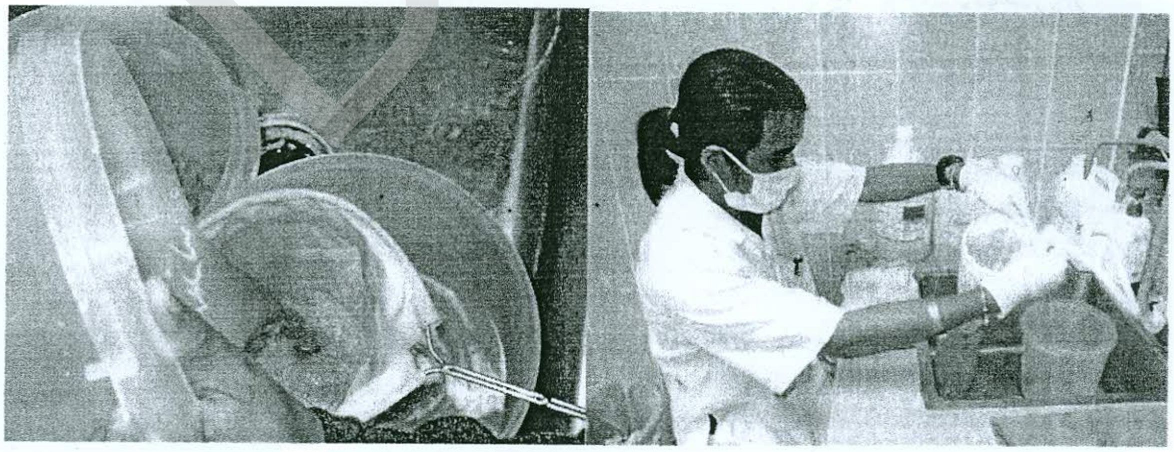


Figure 6: Recovering Benthos from Sediuments under Stereo Microscope

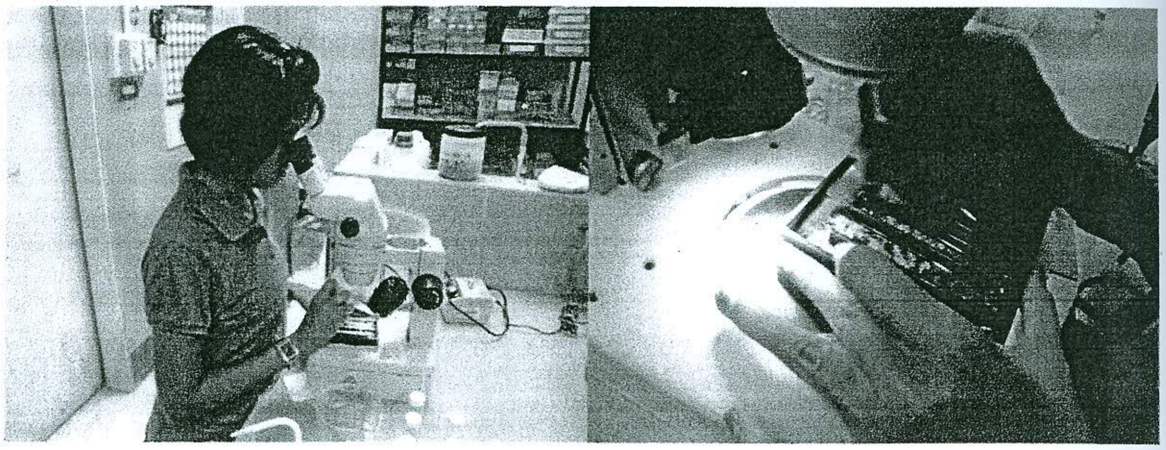
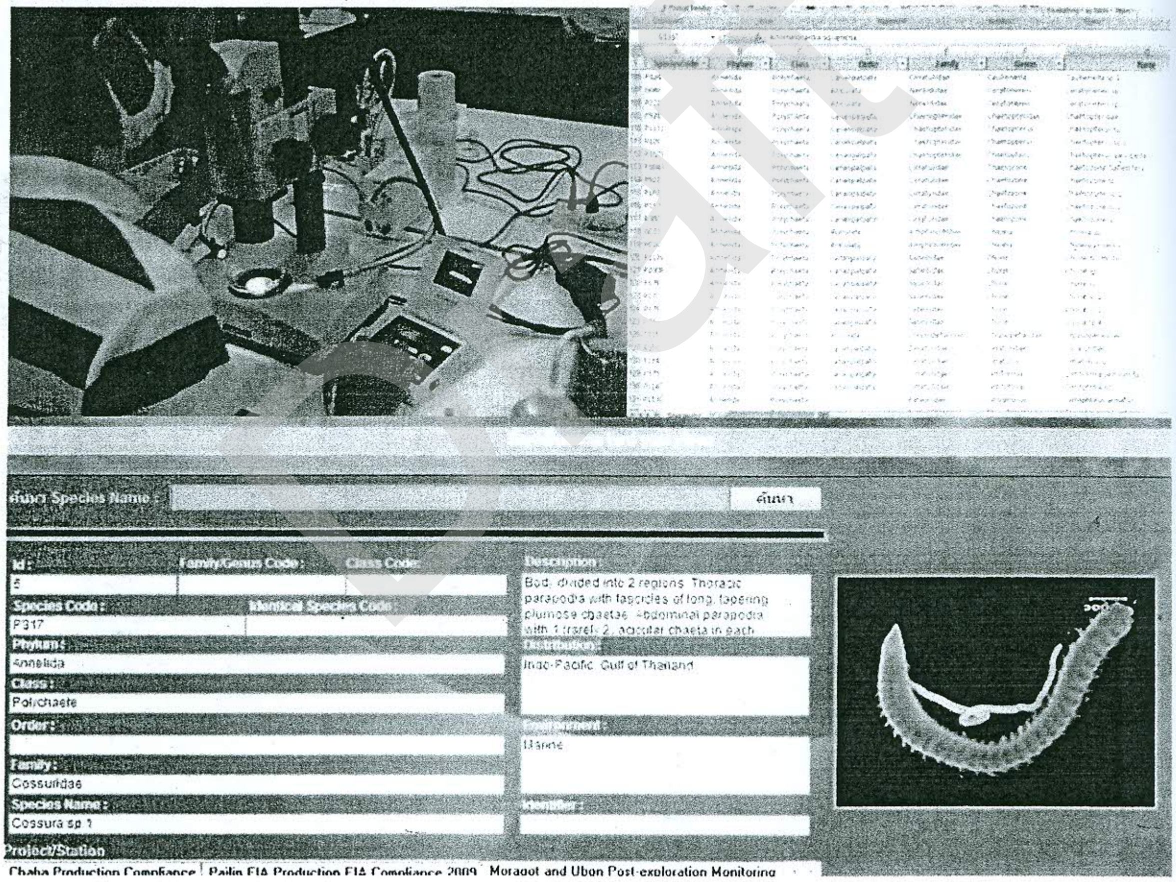


Figure 7: Analysis and Comparison of Benthos



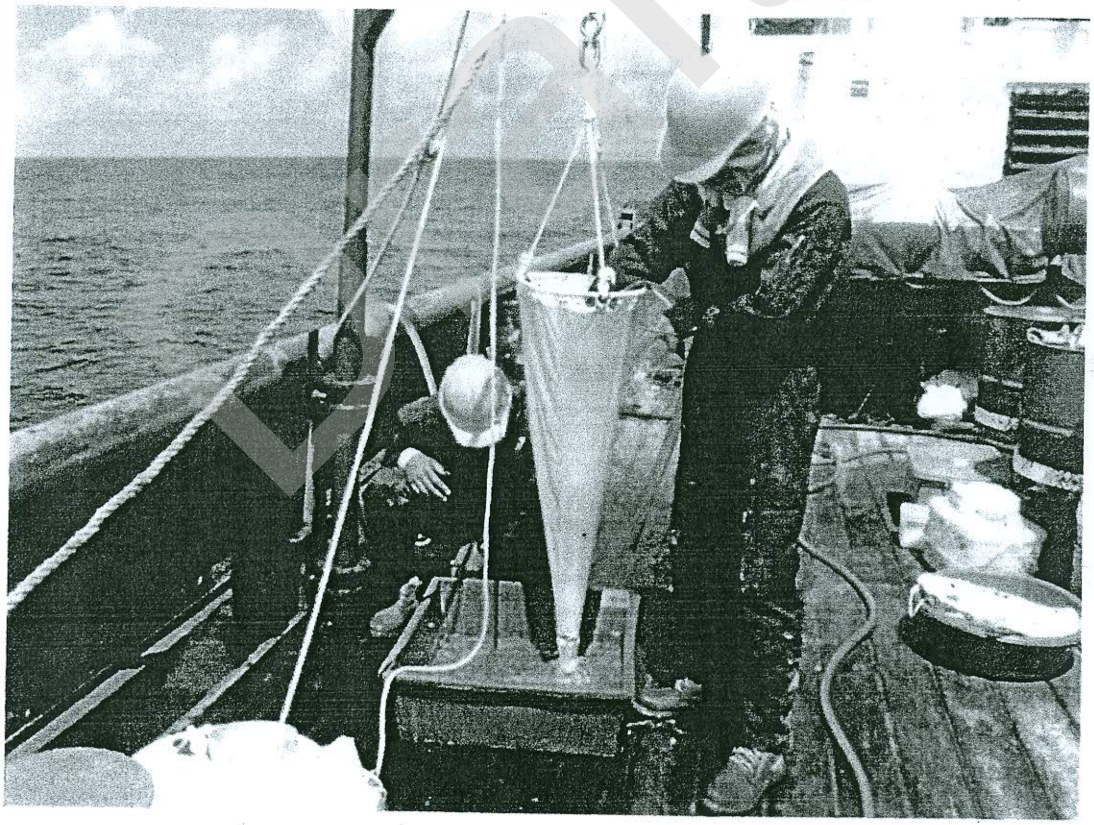
Phytoplankton

Two hundred liters of sea water at 1 meter depth was collected and pass through 22 micron phytoplankton net (**Figure 8**) at the 5 stations specified in **Figure 1** and **Table 1**. The plankton were preserved in 4 percent formalin in 250 ml bottle. At each station, two replicated samples were collected. The station name, date and time were recorded. Additional field duplicate samples at Station H were also collected and analyzed for QA/QC purposes to check the reproducibility of the laboratory's analytical results, as well as the environmental sample variability and to evaluate the precision of the methods.

The samples were sent to the Center of Excellence for Biodiversity of Peninsular Thailand, Faculty of Science, Prince of Songkla University for identification and counting. The plankton samples were counted in a Sedgwick-Rafter counting slide under the microscope. The identification of phytoplankton was done according to Wongrattana, (2544), Fujioka (1990), Tomas (1997) and Yamaji (1986).

The phytoplankton density was determined for each station with a mean and standard deviation for all stations. In addition, the Diversity index, Evenness Indexand Richness index of each station were calculated (as described above for benthos).

Figure 8: Phytoplankton Collection by Seawater Pumping



Zooplankton and Larvae

Zooplankton were collected with 330 micron plankton net (45 centimeter diameter, 1.5 meter long) at the 5 stations specified in **Figure 1** and **Table 1**. Additional field duplicate samples at Station H were also collected and analyzed for QA/QC purposes to check the reproducibility of the laboratory's analytical results, as well as the environmental sample variability and to evaluate the precision of the methods. A flow meter was attached to calculate the amount of sea water passing through the net. The 500 micron plankton net was used to collected fish larvae (see **Figure 9** and **Figure 10**).

The zooplankton from each tow was preserved with 4% formalin. The samples were visually identified according to the images and specifications described in Wongrattana (1998), Santhanam and Srinivasan (1994) and Yamaji (1986). The total amount of zooplankton of each tow was count and calculated to the number of zooplankton per $100m^3$. The actual density of each station was calculated from the average of 2 tows.

The diversity index was not calculated since zooplankton could not be identified completely to the species level due to the general difficulty of identification of zooplankton, larvae and fish larvae. In previous biological studies submitted to the Office of Environmental Policy and Planning (OEPP) in Thailand, the committee recommend not to calculate diversity indices for those samples which could not be identified down to the species level

Figure 9: Plankton Net with Flow Meter

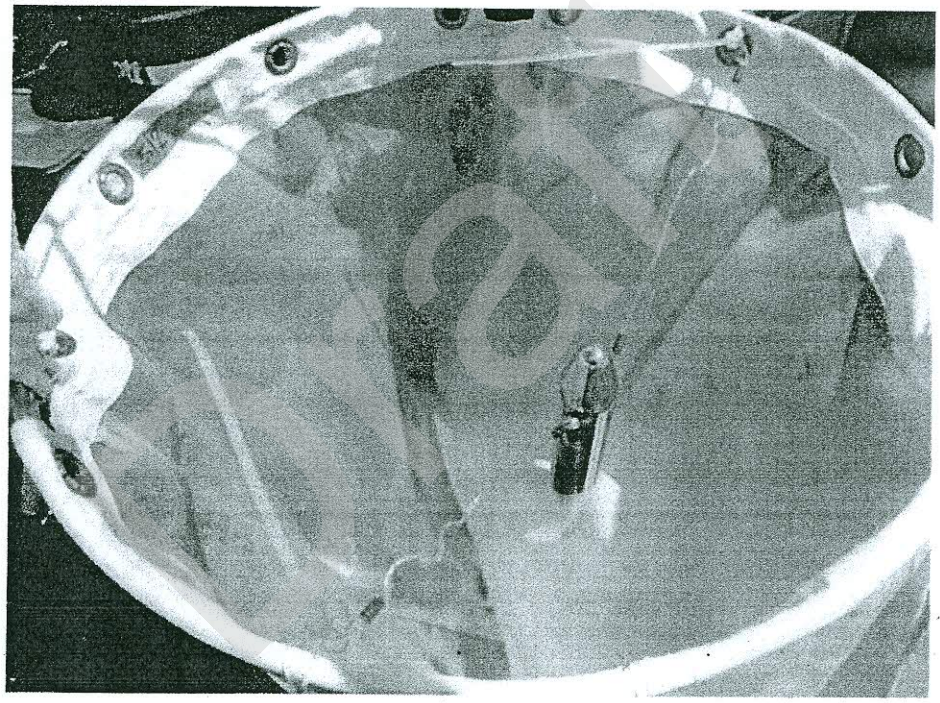
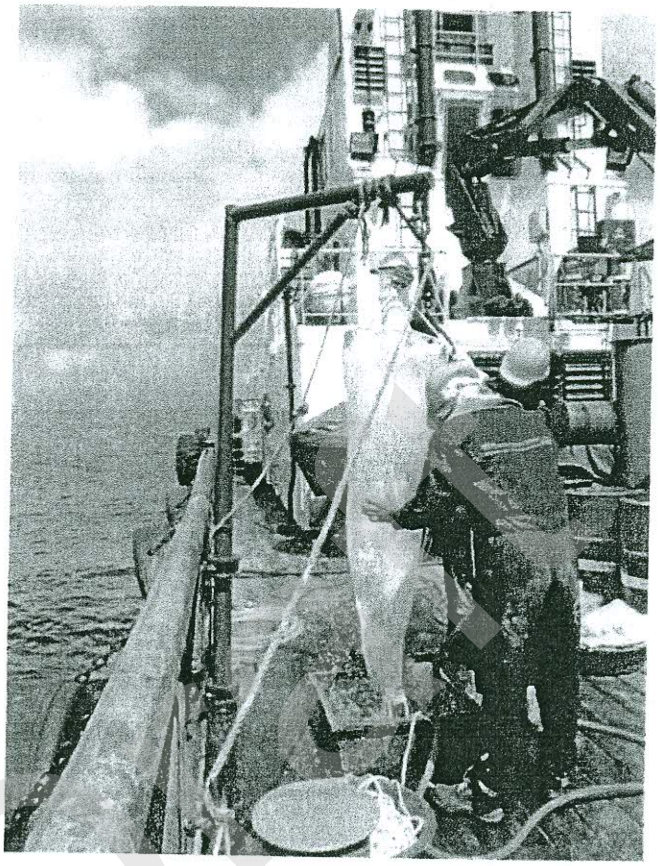


Figure 10: Plankton Net Being Cleaned



APPENDIX 5: PARTICLE SIZE DISTRIBUTION OF SEDIMENTS IN BLOCK A

ALS Technichem (HK) Pty Ltd

CERTIFICATE OF ANALYSIS

CONTACT:	MR THER AUNG	**WORK ORDER:**	HK1026334
CLIENT:	INTERNATIONAL ENVIRONMENTAL MANAGEMENT CO LTD	**SUB-BATCH:**	1
ADDRESS:	15th FLOOR, SITTHIVORAKIT BUILDING, 5 SOI PIPAT, SILOM ROAD, BANGRAK, BANGKOK, THAILAND 10500	**LABORATORY:** **DATE RECEIVED:** **DATE OF ISSUE:** **SAMPLE TYPE:**	HONG KONG 06/11/2010 27/11/2010 SEDIMENT
PROJECT:	CHEVRON BLOCK A	**No. of SAMPLES:**	13

COMMENTS

Sample(s) were received in a chilled condition.
Particle Size Distribution was subcontracted and tested by Geotechnics & Concrete Engineering (H.K.) Ltd (GCE)
GCE details report was attached. The attached report contains a total of 13 pages.

Sample Details

ALS Lab ID	*Sample ID*	*Date of Sampling*	*GCE Report no.*
HK1026334-001	A	25/10/2010	PSD10110071
HK1026334-002	B	26/10/2010	PSD10110072
HK1026334-003	C	26/10/2010	PSD10110073
HK1026334-004	D	26/10/2010	PSD10110074
HK1026334-005	E	26/10/2010	PSD10110075
HK1026334-006	F	27/10/2010	PSD10110076
HK1026334-007	G	27/10/2010	PSD10110077
HK1026334-008	H	28/10/2010	PSD10110078
HK1026334-009	I	24/10/2010	PSD10110079
HK1026334-010	J	25/10/2010	PSD10110080
HK1026334-011	FSO	25/10/2010	PSD10110081
HK1026334-012	CONTROL	27/10/2010	PSD10110082
HK1026334-024	DUPLICATE-SEDIMENT	01/11/2010	PSD10110083

ISSUING LABORATORY: HONG KONG

Address
ALS Technichem (HK) Pty Ltd
11/F Chung Shun Knitting Centre
1-3 Wing Yip Street
Kwai Chung
HONG KONG

Phone: 852-2610 1044
Fax: 852-2610 2021
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Mr Chan Kwok Fai, Godfrey
Laboratory Manager - Hong Kong

Abbreviations: *% SPK REC denotes percentage spike recovery*
CHK denotes duplicate check sample
LOR denotes limit of reporting
LCS % REC denotes Laboratory Control Sample percentage recovery

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

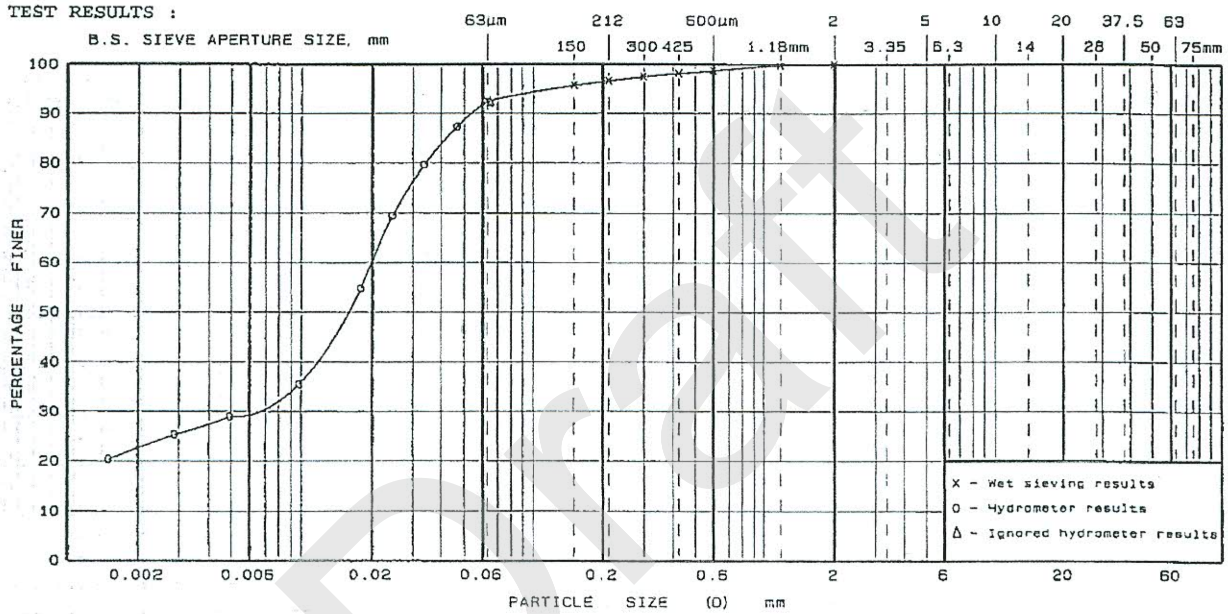
REPORT NO. : PSD10110071

CLIENT*	: ALS Technichem (HK) Pty Ltd			DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.				
SITE*	: --				
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON			DATE STARTED	: 13/11/2010
W.O. NO.*	: --	CONTRACT NO.*	: --	DATE COMPLETED	: 18/11/2010
JOB NO.	: GCE/10/164	TEST UNIT NO.	: S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: --	SAMPLE NO.*	: A	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --			SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



CLAY	SILT			SAND			GRAVEL			COB-BLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.016	mm
Uniformity Coefficient	($U = D_{60}/D_{10}$)	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	23	%
SILT	=	69	%
SAND	=	8	%
GRAVEL	=	0	%

Note : *Information provided by client
Remarks:HK1026334-001

TESTED BY	: C.H. CHOY	CHECKED BY	: W.K. Chan	CERTIFIED BY	: CHEUNG WING TAI
POST	: Lab. Technician	POST	: Reporting Officer	POST	: Lab. Manager
DATE	: 18/11/2010	DATE	: 24/11/2010	DATE	: 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

REPORT NO. : PSD10110072
DATE RECEIVED : 12/11/2010

CLIENT* : ALS Technichem (HK) Pty Ltd
ADDRESS* : 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.
SITE* : --
TEST LOCATION : GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON
W.O. NO.* : --
JOB NO. : GCE/10/164
HOLE NO.* : --
DESCRIPTION : --

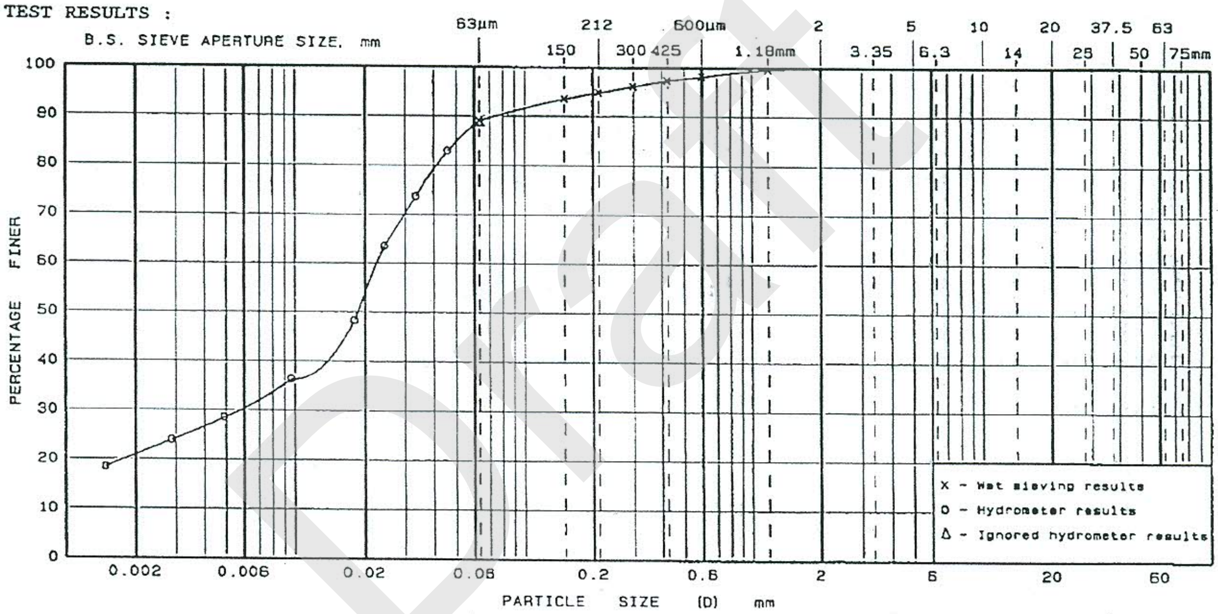
CONTRACT NO.* : --
TEST UNIT NO. : S 10132
SAMPLE NO.* : B

DATE STARTED : 13/11/2010
DATE COMPLETED: 17/11/2010
SAMPLE TYPE* : BULK
SAMPLE DEPTH* : -- m
SPEC. DEPTH : -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.019	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	21	%
SILT	=	67	%
SAND	=	12	%
GRAVEL	=	0	%

Note : *Information provided by client
Remarks:HK1026334-002

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 17/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

REPORT NO. : PSD10110073
DATE RECEIVED : 12/11/2010

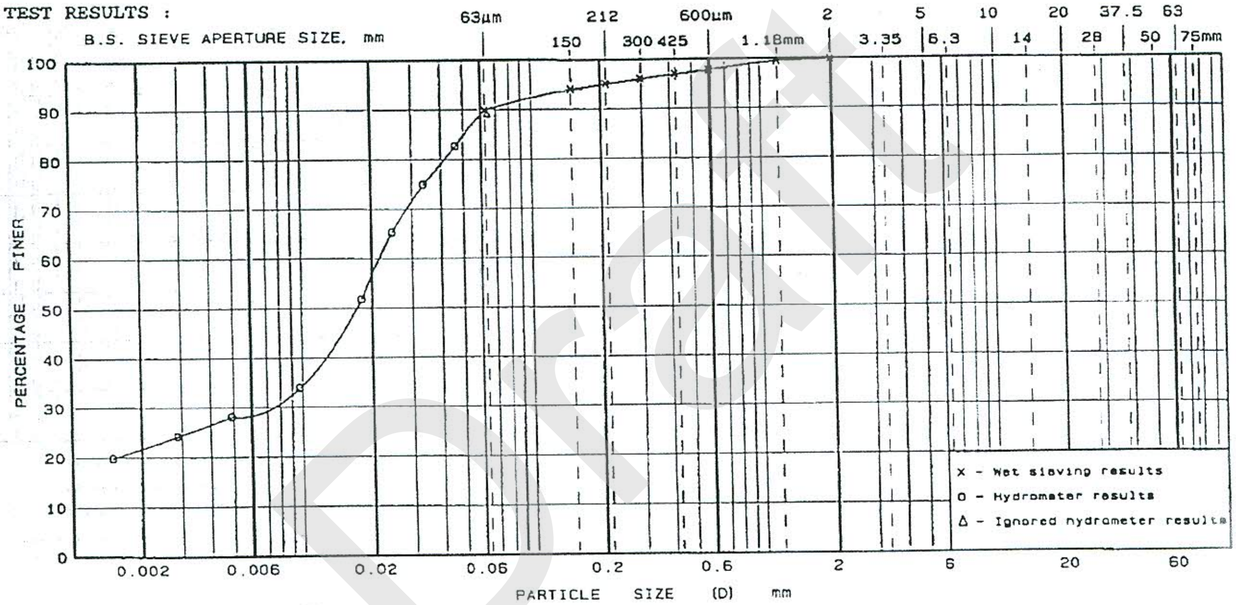
CLIENT* : ALS Technichem (HK) Pty Ltd
ADDRESS* : 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.
SITE* : --
TEST LOCATION : GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON
W.O. NO.* : --
JOB NO. : GCE/10/164
HOLE NO.* : --
DESCRIPTION : --

CONTRACT NO.* : --
TEST UNIT NO. : S 10132
SAMPLE NO.* : C

DATE STARTED : 13/11/2010
DATE COMPLETED: 17/11/2010
SAMPLE TYPE* : BULK
SAMPLE DEPTH* : -- m
SPEC. DEPTH : -- m

SAMPLE PREPARATION:
Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	— mm
Median Diameter	(D_{50})	=	0.018 mm
Uniformity Coefficient	($U = D_{60}/D_{10}$)	=	—

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	22 %
SILT	=	67 %
SAND	=	11 %
GRAVEL	=	0 %

Note : *Information provided by client
Remarks:HK1026334-003

TESTED BY : C.H. CHOY
POST : Lab. Technician
DATE : 17/11/2010

CHECKED BY : W.K. Chan
POST : Reporting Officer
DATE : 24/11/2010

CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Manager
DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

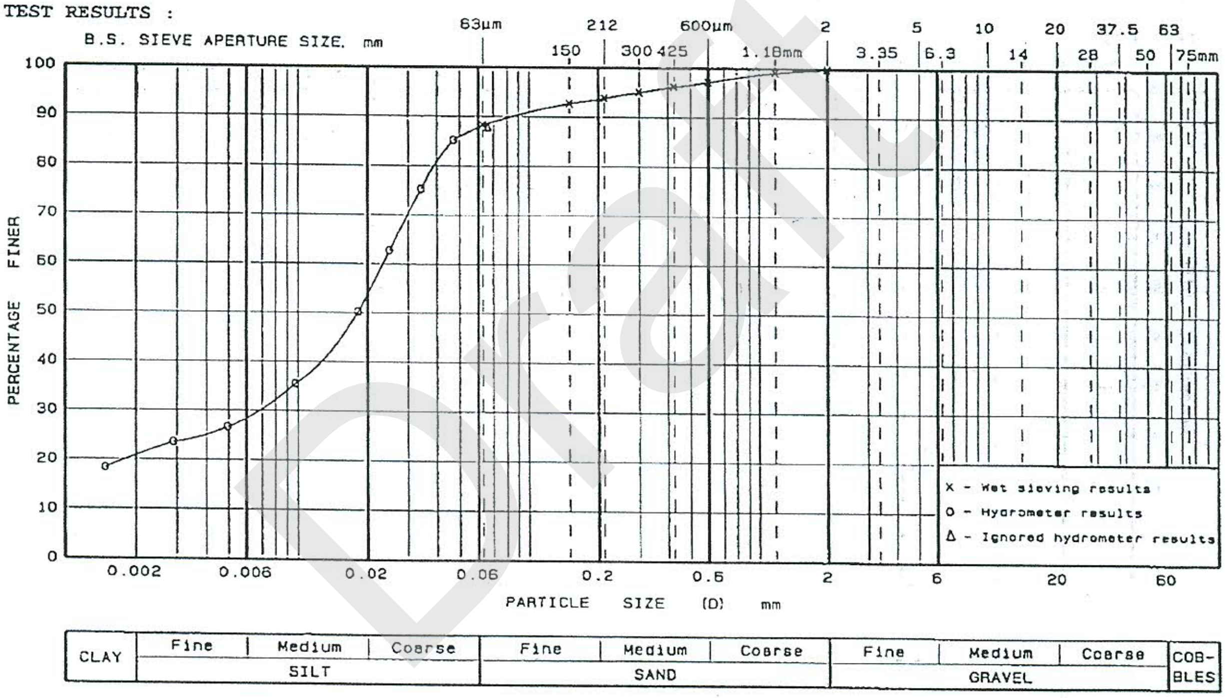
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

CLIENT*	: ALS Technichem (HK) Pty Ltd			REPORT NO.	: PSD10110074
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.			DATE RECEIVED	: 12/11/2010
SITE*	: --				
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON			DATE STARTED	: 13/11/2010
W.O. NO.*	: --	CONTRACT NO.*	: --	DATE COMPLETED	: 19/11/2010
JOB NO.	: GCE/10/164	TEST UNIT NO.	: S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: --	SAMPLE NO.*	: D	SAMPLE DEPTH*	: --
DESCRIPTION	: --			SPEC. DEPTH	: --

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	= —	mm
Median Diameter	(D_{50})	= 0.018	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	= —	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	21 %
SILT	=	67 %
SAND	=	12 %
GRAVEL	=	0 %

Note : *Information provided by client

Remarks:HK1026334-004

TESTED BY	: C.H. CHOY	CHECKED BY	: W.K. Chan	CERTIFIED BY	: CHEUNG WING TAI
POST	: Lab. Technician	POST	: Reporting Officer	POST	: Lab. Manager
DATE	: 19/11/2010	DATE	: 24/11/2010	DATE	: 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

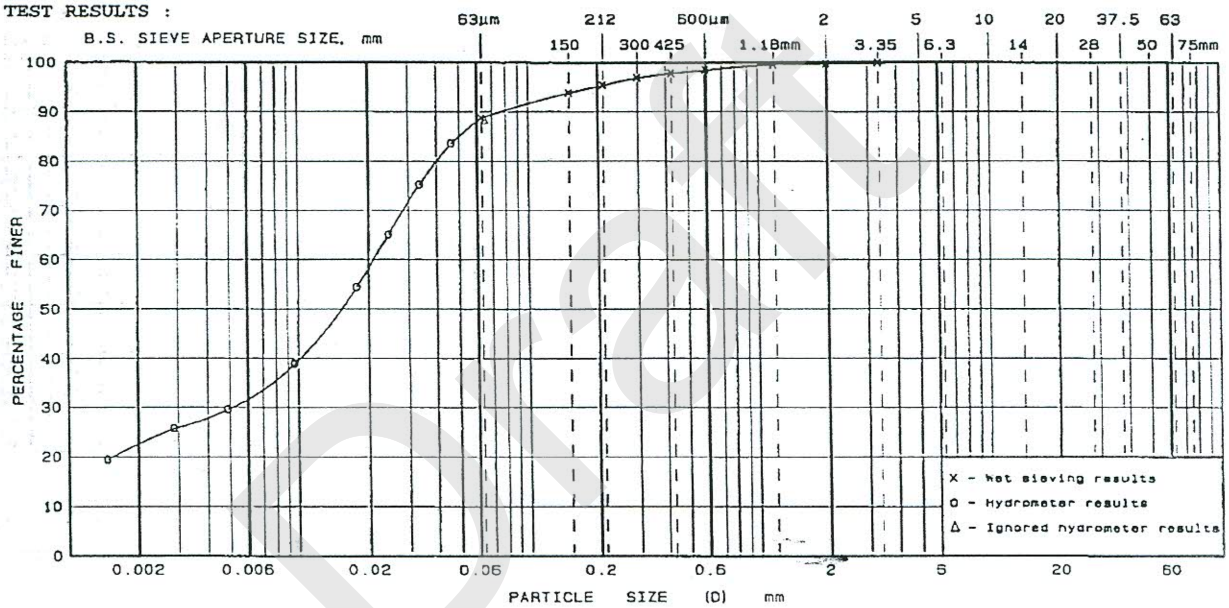
REPORT NO. : PSD10110075

CLIENT*	: ALS Technichem (HK) Pty Ltd	DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.		
SITE*	: --		
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON	DATE STARTED	: 13/11/2010
W.O. NO.*	: -- CONTRACT NO.* : --	DATE COMPLETED	: 18/11/2010
JOB NO.	: GCE/10/164 TEST UNIT NO. : S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: -- SAMPLE NO.* : E	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --	SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.016	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	23	%
SILT	=	65	%
SAND	=	12	%
GRAVEL	=	0	%

Note : *Information provided by client

Remarks:HK1026334-005

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 18/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

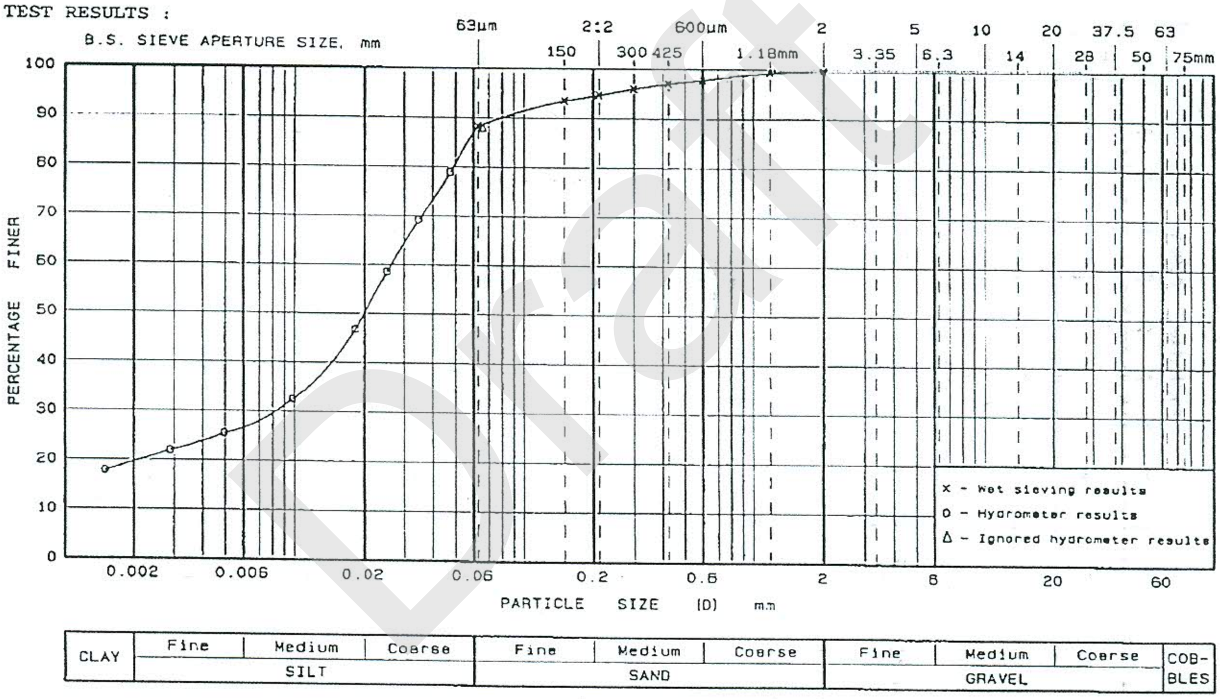
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

CLIENT*	: ALS Technichem (HK) Pty Ltd	REPORT NO.	: PSD10110076
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.	DATE RECEIVED	: 12/11/2010
SITE*	: --		
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON	DATE STARTED	: 13/11/2010
W.O. NO.*	: -- CONTRACT NO.* : --	DATE COMPLETED	: 17/11/2010
JOB NO.	: GCE/10/164 TEST UNIT NO. : S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: -- SAMPLE NO.* : F	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --	SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.020	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	20	%
SILT	=	67	%
SAND	=	13	%
GRAVEL	=	0	%

Note : *Information provided by client

Remarks:HK1026334-006

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 17/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

REPORT NO. : PSD10110077

DATE RECEIVED : 12/11/2010

CLIENT* : ALS Technichem (HK) Pty Ltd

ADDRESS* : 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.

SITE* : --

TEST LOCATION : GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON

DATE STARTED : 13/11/2010

W.O. NO.* : --

CONTRACT NO.* : --

DATE COMPLETED: 18/11/2010

JOB NO. : GCE/10/164

TEST UNIT NO. : S 10132

SAMPLE TYPE* : BULK

HOLE NO.* : --

SAMPLE NO.* : G

SAMPLE DEPTH* : -- m

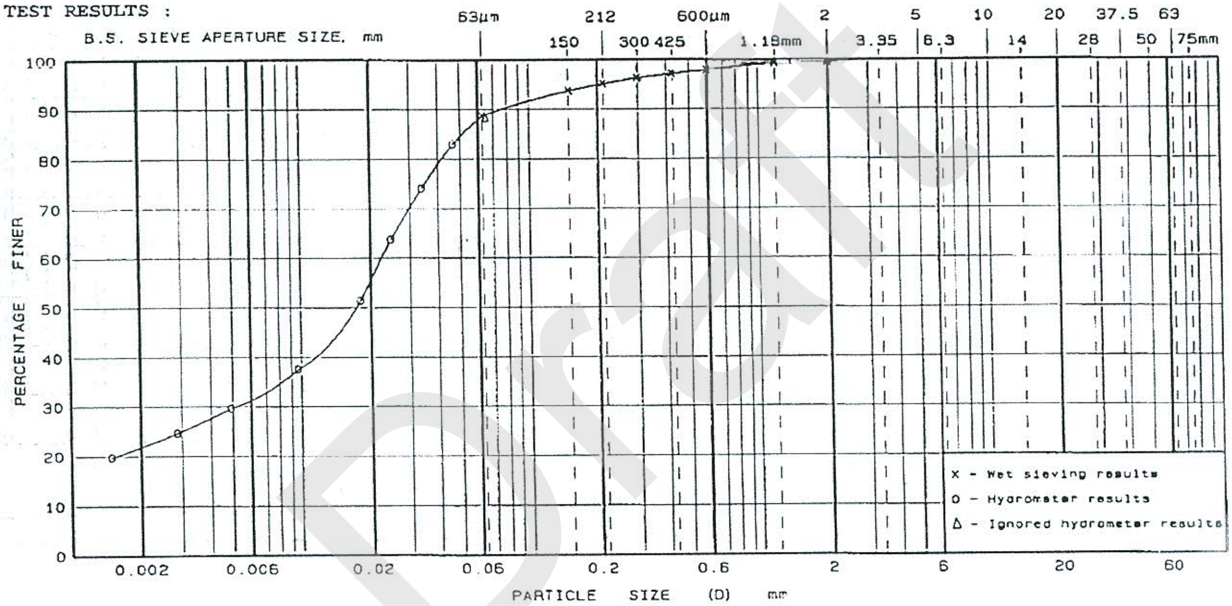
DESCRIPTION : --

SPEC. DEPTH : -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	— mm
Median Diameter	(D_{50})	=	0.018 mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	22 %
SILT	=	66 %
SAND	=	11 %
GRAVEL	=	1 %

Note : *Information provided by client

Remarks:HK1026334-007

TESTED BY : C.H. CHOY

POST : Lab. Technician

DATE : 18/11/2010

CHECKED BY : W.K. Chan

POST : Reporting Officer

DATE : 24/11/2010

CERTIFIED BY : CHEUNG WING TAI

POST : Lab. Manager

DATE : 24/11/2010

<u>REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL</u>

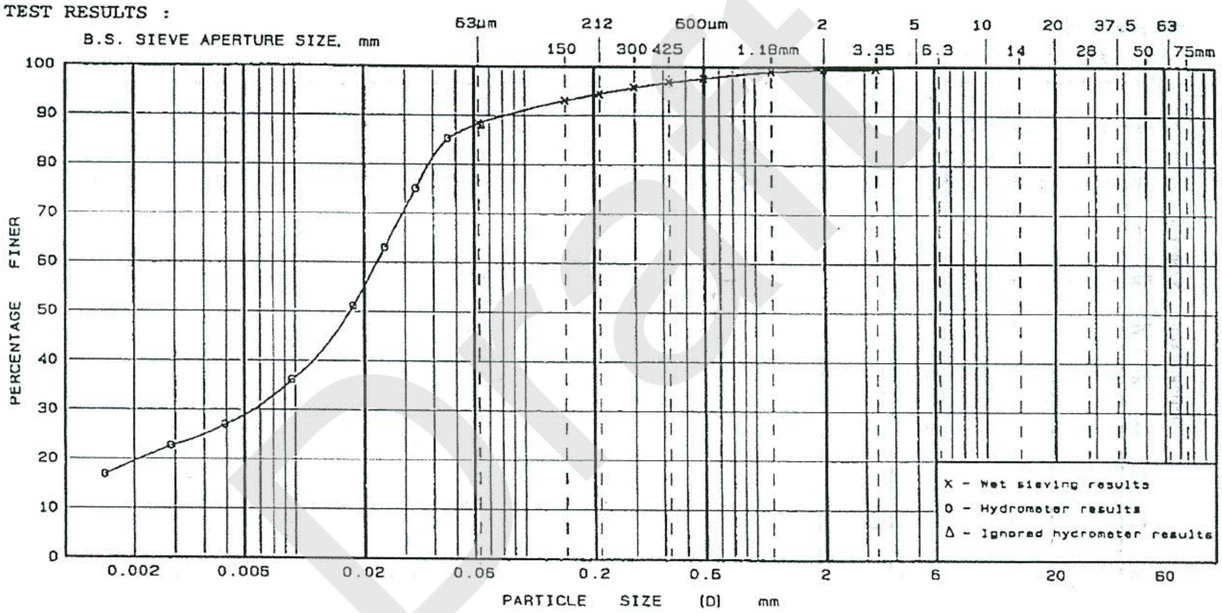
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

			REPORT NO.	: PSD10110078
CLIENT*	: ALS Technichem (HK) Pty Ltd		DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.			
SITE*	: --			
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON		DATE STARTED	: 13/11/2010
W.O. NO.*	: --	CONTRACT NO.* : --	DATE COMPLETED:	19/11/2010
JOB NO.	: GCE/10/164	TEST UNIT NO. : S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: --	SAMPLE NO.* : H	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --		SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

<u>ANALYSIS OF PARTICLE SIZE CURVE</u>

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.018	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

<u>FINAL SUMMARY</u>

CLAY	=	20	%
SILT	=	68	%
SAND	=	11	%
GRAVEL	=	1	%

Note : *Information provided by client

Remarks:HK1026334-008

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 19/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

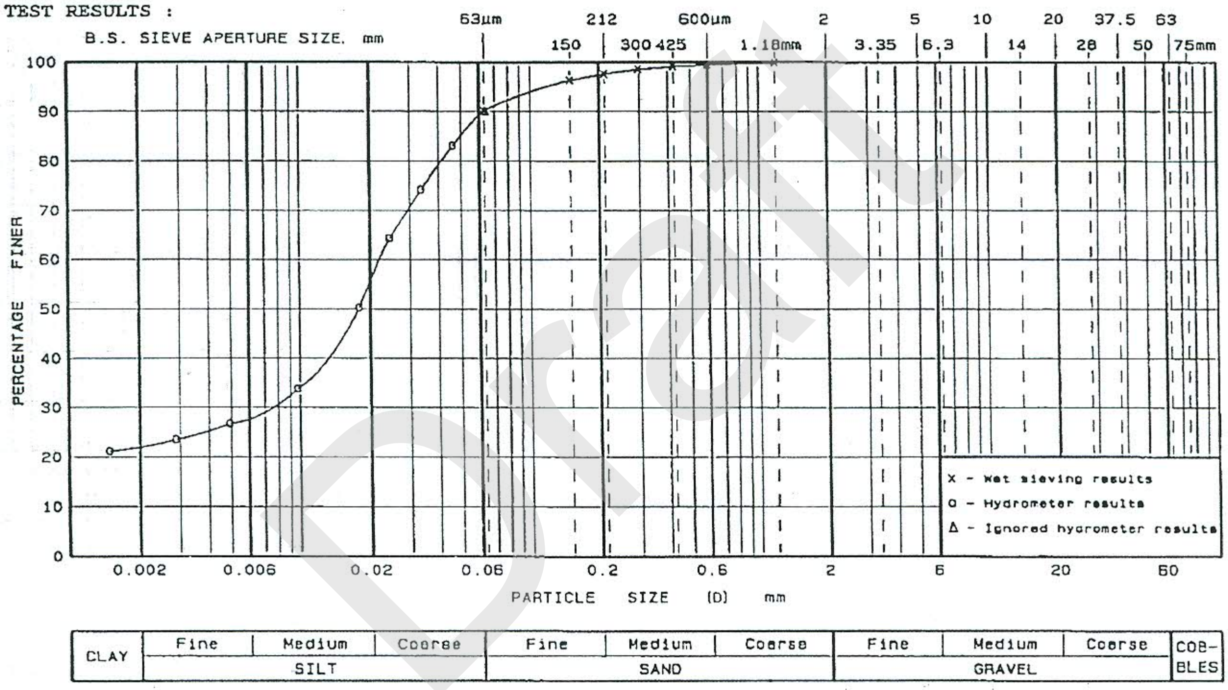
REPORT NO. : PSD10110079

CLIENT*	: ALS Technichem (HK) Pty Ltd	DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.		
SITE*	: --		
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON	DATE STARTED	: 13/11/2010
W.O. NO.*	: -- CONTRACT NO.* : --	DATE COMPLETED	: 17/11/2010
JOB NO.	: GCE/10/164 TEST UNIT NO. : S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: -- SAMPLE NO.* : I	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --	SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.018	mm
Uniformity Coefficient	($U = D_{60}/D_{10}$)	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	22	%
SILT	=	68	%
SAND	=	10	%
GRAVEL	=	0	%

Note : *Information provided by client
Remarks:HK1026334-009

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 17/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

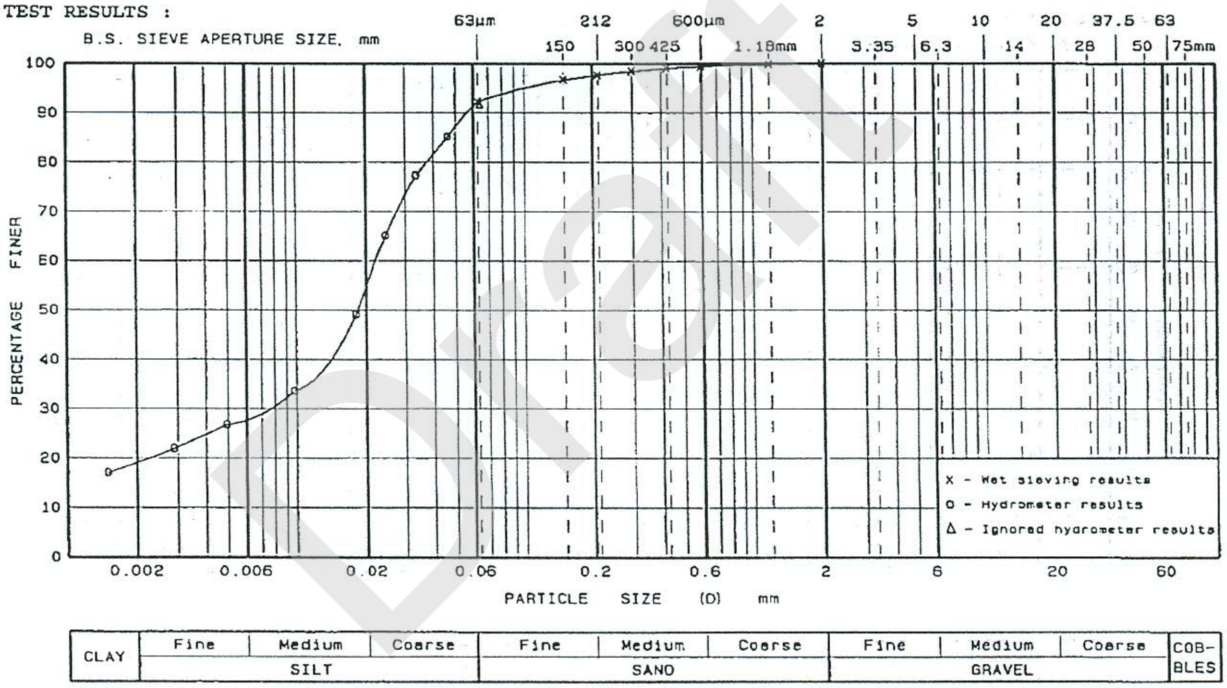
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

				REPORT NO.	: PSD10110080
CLIENT*	: ALS Technichem (HK) Pty Ltd			DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.				
SITE*	: --				
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON			DATE STARTED	: 13/11/2010
W.O. NO.*	: --	CONTRACT NO.*	: --	DATE COMPLETED	: 17/11/2010
JOB NO.	: GCE/10/164	TEST UNIT NO.	: S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: --	SAMPLE NO.*	: J	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --			SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	—	mm
Median Diameter	(D_{50})	=	0.019	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	19	%
SILT	=	73	%
SAND	=	8	%
GRAVEL	=	0	%

Note : *Information provided by client

Remarks:HK1026334-010

TESTED BY	: C.H. CHOY	CHECKED BY	: W.K. Chan	CERTIFIED BY	: CHEUNG WING TAI
POST	: Lab. Technician	POST	: Reporting Officer	POST	: Lab. Manager
DATE	: 17/11/2010	DATE	: 24/11/2010	DATE	: 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

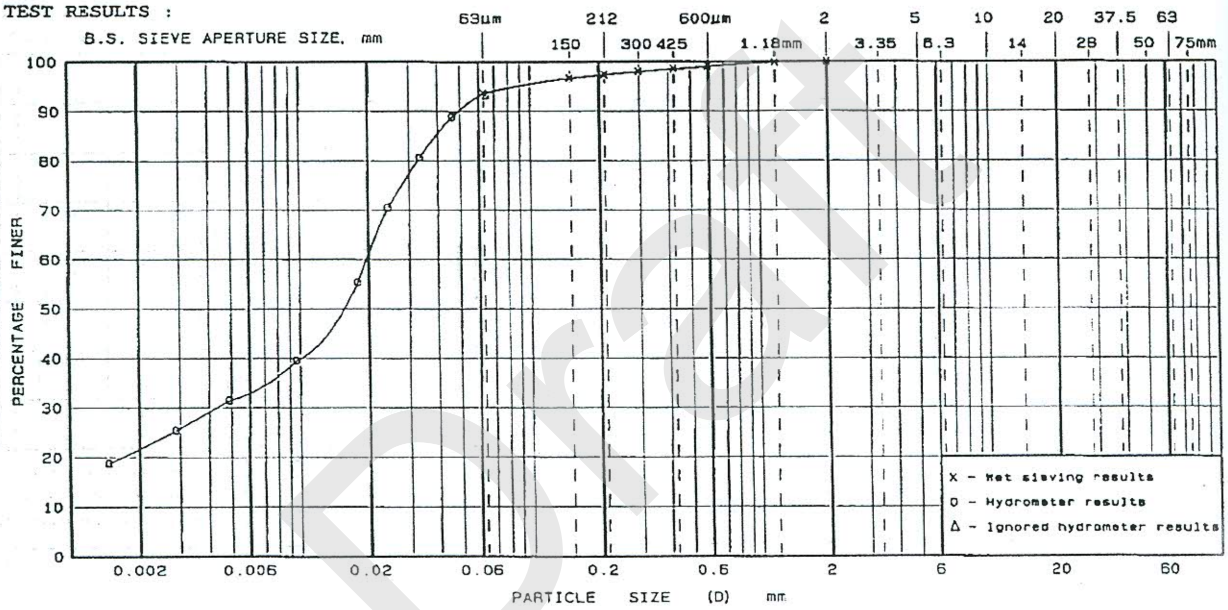
REPORT NO. : PSD10110081

CLIENT*	: ALS Technichem (HK) Pty Ltd	DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.		
SITE*	: --		
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON	DATE STARTED	: 13/11/2010
W.O. NO.*	: -- CONTRACT NO.* : --	DATE COMPLETED	: 17/11/2010
JOB NO.	: GCE/10/164 TEST UNIT NO. : S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: -- SAMPLE NO.* : FSO	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --	SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	= —	mm
Median Diameter	(D_{50})	= 0.016	mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	= —	

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	22 %
SILT	=	71 %
SAND	=	7 %
GRAVEL	=	0 %

Note : *Information provided by client

Remarks:HK1026334-011

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 17/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

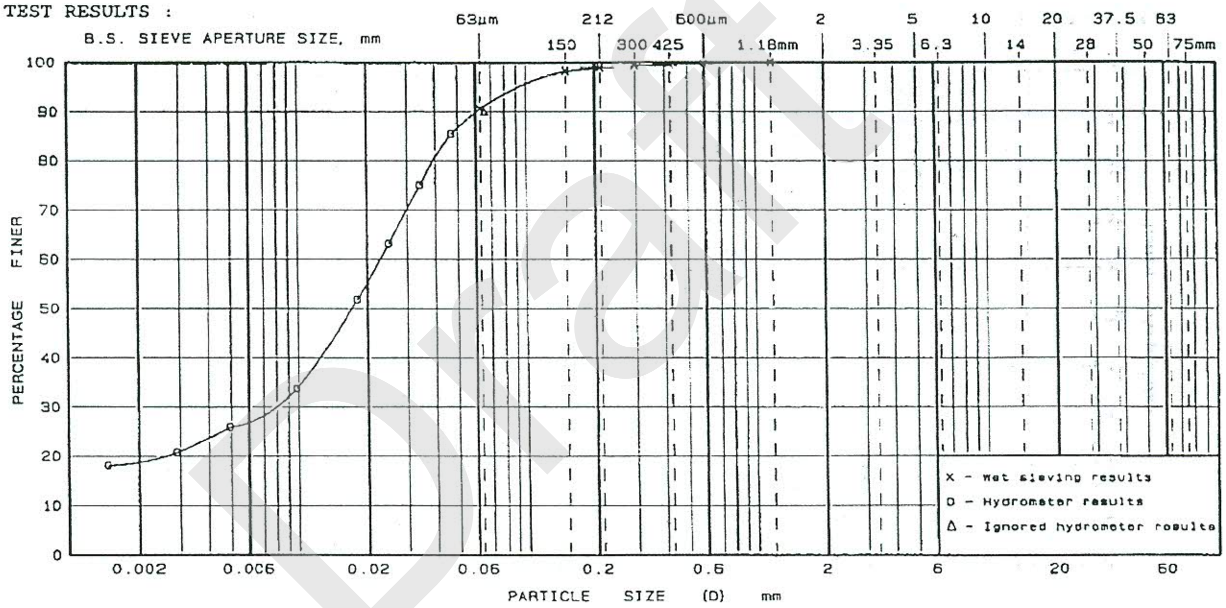
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

REPORT NO. : PSD10110082
DATE RECEIVED : 12/11/2010

CLIENT* : ALS Technichem (HK) Pty Ltd
ADDRESS* : 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.
SITE* : --
TEST LOCATION : GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON
DATE STARTED : 13/11/2010
W.O. NO.* : --
CONTRACT NO.* : --
DATE COMPLETED: 17/11/2010
JOB NO. : GCE/10/164
TEST UNIT NO. : S 10132
SAMPLE TYPE* : BULK
HOLE NO.* : --
SAMPLE NO.* : CONTROL
SAMPLE DEPTH* : -- m
DESCRIPTION : --
SPEC. DEPTH : -- m

SAMPLE PREPARATION:
Procedure for sieving test : Method A

TEST RESULTS :



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COB-BLES
	SILT			SAND			GRAVEL			

The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter (D_{10}) = — mm
Median Diameter (D_{50}) = 0.018 mm
Uniformity Coefficient ($U = D_{60}/D_{10}$) = —
(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY = 19 %
SILT = 71 %
SAND = 10 %
GRAVEL = 0 %

Note : *Information provided by client
Remarks:HK1026334-012

TESTED BY : C.H. CHOY
POST : Lab. Technician
DATE : 17/11/2010

CHECKED BY : W.K. Chan
POST : Reporting Officer
DATE : 24/11/2010

CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Manager
DATE : 24/11/2010

REPORT ON DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF SOIL

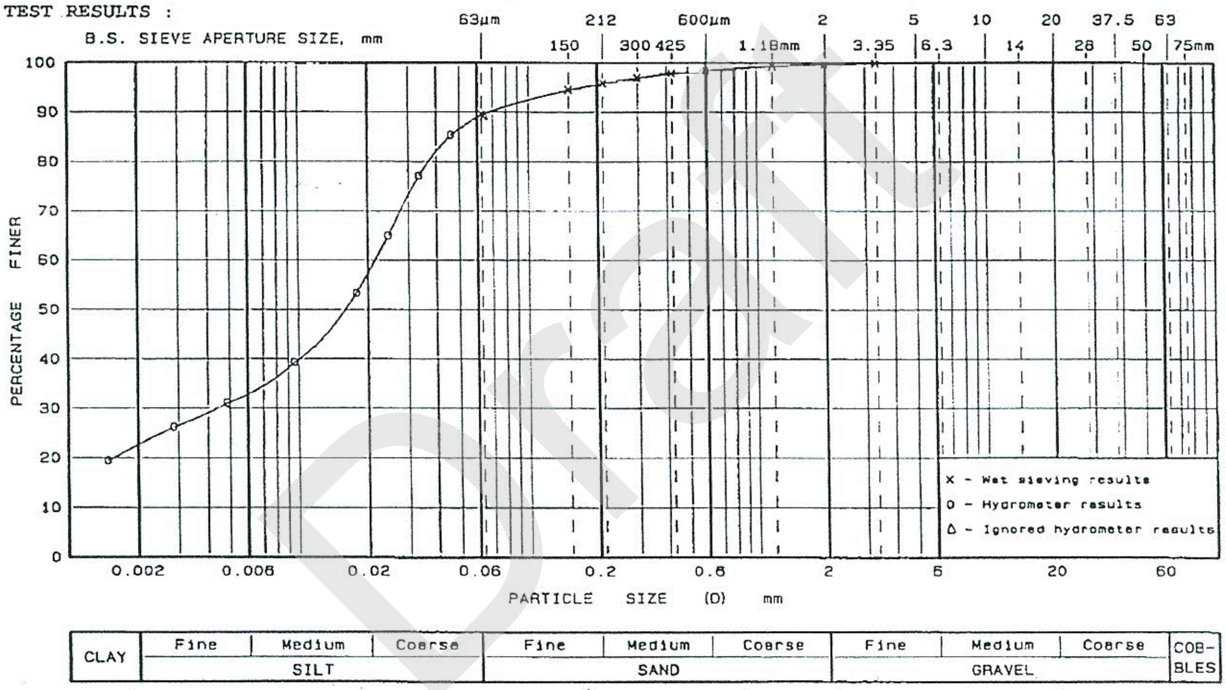
IN ACCORDANCE WITH GEOSPEC 3 : 2001 TEST(S) 8.1 / 8.5 / 8.7

		REPORT NO.	: PSD10110083
CLIENT*	: ALS Technichem (HK) Pty Ltd	DATE RECEIVED	: 12/11/2010
ADDRESS*	: 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip St, Kwai Chung, N.		
SITE*	: --		
TEST LOCATION	: GROUND FLOOR, 20 PAK KUNG STREET, HUNG HOM, KOWLOON	DATE STARTED	: 13/11/2010
W.O. NO.*	: -- CONTRACT NO.* : --	DATE COMPLETED	: 17/11/2010
JOB NO.	: GCE/10/164 TEST UNIT NO. : S 10132	SAMPLE TYPE*	: BULK
HOLE NO.*	: -- SAMPLE NO.* : --	SAMPLE DEPTH*	: -- m
DESCRIPTION	: --	SPEC. DEPTH	: -- m

SAMPLE PREPARATION:

Procedure for sieving test : Method A

TEST RESULTS :



The following information are only based on the opinion of the laboratory and are not under the scope of accreditation by HOKLAS :

ANALYSIS OF PARTICLE SIZE CURVE

Effective Diameter	(D_{10})	=	— mm
Median Diameter	(D_{50})	=	0.016 mm
Uniformity Coefficient	$(U = D_{60}/D_{10})$	=	—

(Ref. : Clause 6.59(4) of General Specification for Civil Engineering Works (1992))

FINAL SUMMARY

CLAY	=	23 %
SILT	=	66 %
SAND	=	11 %
GRAVEL	=	0 %

Note : *Information provided by client

Remarks:HK1026334-024, Sample ID : DUPLICATE - SEDIMENT

TESTED BY : C.H. CHOY	CHECKED BY : W.K. Chan	CERTIFIED BY : CHEUNG WING TAI
POST : Lab. Technician	POST : Reporting Officer	POST : Lab. Manager
DATE : 17/11/2010	DATE : 24/11/2010	DATE : 24/11/2010

APPENDIX 6: COMPLETE LIST OF BENTHOS SPECIES

Benthos Species Present in the Project Area

No.	Species of Benthos	No.	Species of Benthos
	Phylum Annelida		**Family Dorvilleidae**
	Class Polychaeta	20	*Dorvilleidae sp.1*
	Subclass Scolecida		**Family Eunicidae**
	Family Capitellidae	21	*Eunicidae sp.1*
1	*Capitellidae sp.1*	22	*Eunicidae sp.2*
2	*Capitellidae sp.2*		**Family Lumbrineridae**
3	*Capitellidae sp.3*	23	*Lumbrineridae sp.1*
4	*Capitellidae sp.4*	24	*Lumbrineridae sp.2*
5	*Capitellidae sp.5*	25	*Lumbrineridae sp.3*
6	*Capitellidae sp.6*		**Family Oenonidae**
7	*Capitellidae sp.7*	26	*Oenonidae sp.1*
8	*Capitellidae sp.8*	27	*Oenonidae sp.2*
9	*Capitellidae sp.9*		**Family Onuphidae**
10	*Capitellidae sp.10*	28	*Onuphidae sp.1*
	Family Maldanidae	29	*Onuphidae sp.2*
11	*Maldanidae sp.1*	30	*Onuphidae sp.3*
12	*Maldanidae sp.2*		**Suborder Amphinomida**
13	*Maldanidae sp.3*		**Family Amphinomidae**
14	*Maldanidae sp.4*	31	*Amphinomidae sp.1*
	Family Ophellidae		**Suborder Phyllodocida**
15	*Ophellidae sp.1*		**Family Glyceridae**
	Family Orbinidae	32	*Glyceridae sp.1*
16	*Orbinidae sp.1*	33	*Glyceridae sp.2*
17	*Orbinidae sp.2*		**Family Goniadidae**
18	*Orbinidae sp.3*	34	*Goniadidae sp.1*
	Family Paraonidae	35	*Goniadidae sp.2*
19	*Paraonidae sp.1*		**Family Nephtyidae**
	Subclass Palpata	36	*Nephtyidae sp.1*
	Order Aciculata	37	*Nephtyidae sp.2*
	Suborder Eunicida	38	*Nephtyidae sp.3*

No.	Species of Benthos	No.	Species of Benthos
39	*Nephtyidae sp.4*	62	*Spionidae sp.8*
	Family Nereididae		**Suborder Terebellida**
40	*Nereididae sp.1*		**Family Ampharetidae**
41	*Nereididae sp.2*	63	*Ampharetidae sp.1*
	Family Paralacydoniidae	64	*Ampharetidae sp.2*
42	*Paralacydoniidae sp.1*	65	*Ampharetidae sp.3*
	Family Phyllodocidae	66	*Ampharetidae sp.4*
43	*Phyllodocidae sp.1*		**Family Cirratulidae**
	Family Pilargidae	67	*Cirratulidae sp.1*
44	*Pilargidae sp.1*	68	*Cirratulidae sp.2*
45	*Pilargidae sp.2*	69	*Cirratulidae sp.3*
46	*Pilargidae sp.3*		**Family Flabelligeridae**
	Family Polynoidae	70	*Flabelligeridae sp.1*
47	*Polynoidae sp.1*		**Family Sternaspidae**
	Family Sigalionidae	71	*Sternaspidae sp.1*
48	*Sigalionidae sp.1*		**Family Terebellidae**
49	*Sigalionidae sp.2*	72	*Terebellidae sp.1*
	Family Syllidae		**Family Trichobranchidae**
50	*Syllidae sp.1*	73	*Trichobranchidae sp.1*
	Subclass Palpata		**Phylum Arthropoda**
	Order Canalipalpata		**Class Pycnogonida**
	Suborder Sabellida		**Order Pantopora**
	Family Sabellidae		**Family Pycnogonidae**
51	*Sabellidae sp.1*	74	*Pycnogonidae sp.1*
	Suborder Spionida		**Class Crustacea**
	Family Chaetopteridae		**Order Amphipoda**
52	*Chaetopteridae sp.1*		**Family Ampeliscidae**
	Family Magelonidae	75	*Ampelisca sp.*
53	*Magelonidae sp.1*	76	*Byblis sp.*
	Family Poecilochaetidae	77	*Ampeliscidae sp.1*
54	*Poecilochaetidae sp.1*	78	*Ampeliscidae sp.2*
	Family Spionidae	79	*Ampeliscidae sp.3*
55	*Spionidae sp.1*	80	*Ampeliscidae sp.4*
56	*Spionidae sp.2*	81	*Ampeliscidae sp.5*
57	*Spionidae sp.3*	82	*Ampeliscidae sp.6*
58	*Spionidae sp.4*	83	*Ampeliscidae sp.7*
59	*Spionidae sp.5*	84	*Ampeliscidae sp.8*
60	*Spionidae sp.6*	85	*Ampeliscidae sp.9*
61	*Spionidae sp.7*	86	*Ampeliscidae sp.10*

No.	Species of Benthos	No.	Species of Benthos
87	*Ampeliscidae sp.11*		**Family Alpheidae**
88	*Ampeliscidae sp.12*	113	*Alpheidae sp.*
89	*Ampeliscidae sp.13*	114	*Alpheidae sp.1*
90	*Ampeliscidae sp.14*	115	*Alpheidae sp.2*
91	*Ampeliscidae sp.15*	116	*Alpheidae sp.3*
	Family Haustoriidae	117	*Alpheidae sp.4*
92	*Haustoriidae sp.1*	118	*Alpheidae sp.5*
	Family Isaeidae		**Family Axiidae**
93	*Isaeidae sp.1*	119	*Axiidae sp.1*
94	*Isaeidae sp.2*	120	*Axiidae sp.2*
	Family Leucothoidae		**Family Eriphiidae**
95	*Leucothoidae sp.1*	121	*Eriphiidae sp.2*
96	*Leucothoidae sp.2*		**Family Goneplacidae**
	Family Lysianassidae	122	*Goneplacidae sp.1*
97	*Lysianassidae sp.1*	123	*Goneplacidae sp.2*
98	*Lysianassidae sp.2*		**Family Hippolytidae**
	Family Oedicerotidae	124	*Hippolytidae sp.1*
99	*Oedicerotidae sp.1*		**Family Leucosiidae**
	Order Cumacea	125	*Leucosiidae sp.1*
	Family Bodotriidae		**Family Palaemonidae**
100	*Bodotriidae sp.1*	126	*Palaemonidae sp.1*
101	*Bodotriidae sp.2*	127	*Palaemonidae sp.2*
	Family Diastylidae	128	*Palaemonidae sp.3*
102	*Diastylidae sp.1*		**Family Pandalidae**
103	*Diastylidae sp.2*	129	*Pandalidae sp.1*
	Family Gynodiastylidae		**Family Phasiphaeidae**
104	*Gynodiastylidae sp.1*	130	*Phasiphaeidae sp.1*
	Family Kalliapseudidae		**Family Pinnotheridae**
106	*Kalliapseudidae sp.1*	131	*Pinnotheridae sp.1*
107	*Kalliapseudidae sp.2*		**Family Portunidae**
	Family Leuconidae	132	*Portunidae sp.1*
108	*Leuconidae sp.1*	133	*Portunidae sp.2*
	Family Nannastacidae		**Family Processidae**
109	*Nannastacidae sp.1*	134	*Processidae sp.1*
	Order Decapoda		**Family Upogebiidae**
	Family Callianassidae	135	*Upogebiidae sp.1*
110	*Callianassidae sp.1*	136	*Upogebiidae sp.2*
111	*Callianassidae sp.2*		**Family Xanthidae**
112	*Callianassidae sp.3*	137	*Xanthidae sp.1*

No.	Species of Benthos	No.	Species of Benthos
138	*Xanthidae sp.2*	162	*Nemertea sp.*
139	*Xanthidae sp.3*	163	*Nemertea sp.1*
	Order Isopoda		**Class Anolpla**
	Family Anthuridae		**Order Palaeonemertea**
140	*Anthuridae sp.1*		**Family Tubulanidae**
141	*Anthuridae sp.2*	164	*Tubulanidae sp.1*
	Family Cirolanidae	165	*Tubulanidae sp.2*
142	*Cirolanidae sp.1*		**Order Heteronemertea**
	Family Gnathidae		**Family Lineidae**
143	*Gnathidae sp.1*	166	*Lineidae sp.1*
144	*Gnathidae sp.2*		**Phylum Sipuncula**
	Order Ostracoda		**Class Sipunculidea**
	Family Cypridinidae		**Order Golfingiformes**
145	*Cypridinidae sp.1*		**Family Themistidae**
146	*Cypridinidae sp.2*	167	*Themistidae sp.1*
	Order Mysidacea		**Family Phascolionidae**
147	*Mysidacea sp.1*	168	*Phascolionidae sp.1*
148	*Mysidacea sp.2*	169	*Phascolionidae sp.2*
149	*Mysidacea sp.3*	170	*Phascolionidae sp.3*
	Order Stomatopoda		**Class Phascolosomatidea**
	Family Nannosquillidae		**Order Phascolosomatiformes**
150	*Nannosquillidae sp.*		**Family Phascoosomatidae**
151	*Nannosquillidae sp.1*	171	*Phascolosomatidae sp.1*
152	*Nannosquillidae sp.2*	172	*Phascolosomatidae sp.2*
	Family Squillidae		**Order Aspidosiphoniformes**
153	*Squillidae sp.1*		**Family Aspidosiphonidae**
154	*Squillidae sp.2*	173	*Aspidosiphonidae sp.1*
155	*Squillidae sp.3*	174	*Aspidosiphonidae sp.2*
156	*Squillidae sp.4*		**Phylum Mollusca**
157	*Squillidae sp.5*		**Class Aplacophora**
	Order Tanaidacea		**Order Cavibelonia**
158	*Tanaidacea sp.*		**Family Simrothiellidae**
159	*Tanaidacea sp.1*	175	*Simrothiellidae sp.1*
	Phylum Cnidaria		**Class Bivalvia**
	Class Anthozoa	176	*Bivalvia sp.*
160	*Actinaria sp.*		**Order Limoida**
	Phylum Nematoda		**Family Limidae**
161	*Nematoda sp.1*	177	*Limidae sp.1*
	Phylum Nemertea		**Phylum Echinodermata**

No.	Species of Benthos	No.	Species of Benthos
	Class Ophiuroidea		
178	*Ophiuroidea sp.1*		
179	*Ophiuroidea sp.2*		
	Order Ophiurida		
	Family Amphiuridae		
180	*Amphiuridae sp.1*		
181	*Amphiuridae sp.2*		
182	*Amphiuridae sp.3*		
183	*Amphiuridae sp.4*		
184	*Amphiuridae sp.5*		
185	*Amphiuridae sp.6*		

APPENDIX 7: BROCHURE FROM PUBLIC PARTICIPATION ACTIVITIES

ឈេវរ៉ុន (Chevron) ជាក្រុមហ៊ុនមានការទទួលខុសត្រូវ

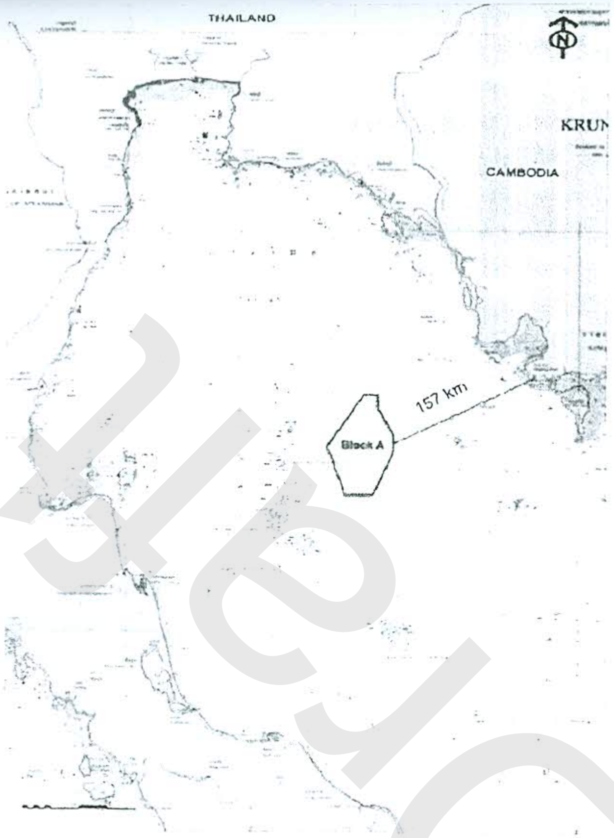
ការទទួលខុសត្រូវផ្នែកសង្គមរបស់ក្រុមហ៊ុន គឺជាមូលដ្ឋានគ្រឹះនៃដំណើរការអាជីវកម្មរបស់ក្រុមហ៊ុនឈេវរ៉ុន និងជាគុណតម្លៃមួយនៃគុណតម្លៃដ៏វិសេសវិសាលជាច្រើនទៀត។ នៅតាមបណ្តាសហគ្រាសរបស់យើងខ្ញុំនៅទូទាំងពិភពលោក យើងខ្ញុំមានជំនឿទុកចិត្ត ក្នុងការបង្កើនផលជាវិជ្ជមាននៃប្រតិបត្តិការរបស់យើងខ្ញុំ នៅជុំវិញទីកន្លែងដែលពួកយើងធ្វើការ ឱ្យបានក្នុងកម្រិតអតិបរមា សម្រាប់មនុស្សគ្រប់ជំនាន់ ទាំងនាពេលបច្ចុប្បន្ន និងទាំងពេលអនាគត។ ក្រុមហ៊ុនឈេវរ៉ុន បានចាប់ដៃគូជាមួយអង្គការផេក (Pact) ដែលជាអង្គការមិនមែនរដ្ឋាភិបាលអន្តរជាតិមួយ ដែលមានវត្តមាននៅក្នុងប្រទេសកម្ពុជា និងបានដាក់ចេញឱ្យប្រើប្រាស់នូវគម្រោង ចំនួន ៣ ក្នុងខេត្តព្រះសីហនុ។ កម្មវិធីការលើកកម្ពស់ការយល់ដឹង និងកម្មវិធីព្យាបាលអ្នកផ្ទុកមេរោគអេដស៍ និងជំងឺអេដស៍ បានចាប់ដំណើរការក្នុងឆ្នាំ២០០៩ ដោយមានការចូលរួមពីគ្រួសារអ្នកនេសាទចំនួន ៧០០គ្រួសារ។ នៅដើមឆ្នាំ២០១០ កម្មវិធីរយៈពេល២ឆ្នាំលើការលើកកម្ពស់សុខភាព អក្ខរកម្ម និងគំនិតផ្តួចផ្តើមបង្កើនប្រាក់ចំណូល ត្រូវបានអនុវត្តទៅលើក្រុមគ្រួសារកម្មករនេសាទដែលជួបការលំបាក ចំនួន ៤០០គ្រួសារ មកពីឃុំចំនួន ៩។ បន្ថែមពីលើនេះ ក្រុមហ៊ុនឈេវរ៉ុនក៏កំពុងសាងសង់បណ្ណាល័យថ្មីមួយសម្រាប់សិស្សអនុវិទ្យាល័យនៅមូលដ្ឋានមួយផងដែរ។

ក្រុមហ៊ុនឈេវរ៉ុនក៏បានចូលរួមក្នុងគម្រោងអភិរក្សសមុទ្រនៅឈូងសមុទ្រថៃផងដែរ។ សកម្មភាពនោះរួមមាន ការផ្សាំផ្កាថ្ម ការលែងសត្វសមុទ្រ ការសំអាតឆ្នេរ និងការលើកកម្ពស់ការយល់ដឹងជាសាធារណៈអំពីការអភិរក្សបរិស្ថាន។ ក្រុមហ៊ុនឈេវរ៉ុន ថែមទាំងបានគាំទ្រដល់កាកបាទក្រហមកម្ពុជាផងដែរ ។

អ្នកចូលរួមរបស់គម្រោងអភិវឌ្ឍន៍សហគមន៍ដែលដឹកនាំដោយអង្គការផេក (Pact)

សម្រាប់ពត៌មានបន្ថែម :

ក្រុមហ៊ុនឈេវរ៉ុន អូវើស៊ី ភេត្រូលៀម (ខេមបូឌា) លីមីធីត
លេខ ២៨ ផ្លូវ ៣១០ សង្កាត់បឹងកេងកង ១ ខណ្ឌចំការមន រាជធានីភ្នំពេញ
ប្រអប់សំបុត្រលេខ ១៦១៩ ប្រទេសកម្ពុជា
អ៊ីម៉ែល : InfoBlockA@chevron.com



ថាមពល និងការអភិវឌ្ឍន៍

ការអភិវឌ្ឍន៍ធនធានថាមពលនៅលើពិភពលោក បានលើកកម្ពស់យ៉ាងខ្លាំងនូវគុណភាពជីវិតប្រជាជននៅលើពិភពលោក។ ការអភិវឌ្ឍន៍នេះបានដើរតួនាទីយ៉ាងសំខាន់ក្នុងការធ្វើឱ្យមានកំណើន និងស្ថិរភាព នៃសេដ្ឋកិច្ចកើតថ្មី សេដ្ឋកិច្ចដែលទើបនឹងកើតមាន និងសេដ្ឋកិច្ចដែលបានចាក់ឫសយ៉ាងមាំ។ ការអភិវឌ្ឍន៍ថាមពលបានបង្កើតឱ្យមានការងារជំនាញ ជំរុញឱ្យមានឧស្សាហកម្មដោនស្ទ្រីមថ្មីៗ បង្កើតផលិតផល និងសេវាកាន់តែច្រើនសម្រាប់អតិថិជន បង្កើតឱ្យមានទីផ្សារនាំចេញ និងធ្វើឱ្យស្តង់ដារជីវភាពរស់នៅកាន់តែប្រសើរឡើង។ ក្រុមហ៊ុនឈេវរ៉ុន អូវើស៊ី ភេត្រូលៀម (ខេមបូឌា) លីមីធីត ទទួលបន្ទុកការអភិវឌ្ឍន៍ប្លុកអា (Block A) ដើម្បីជួយជំរុញឱ្យវិស័យថាមពលនៅប្រទេសកម្ពុជាកាន់តែប្រសើរឡើង។

Chevron

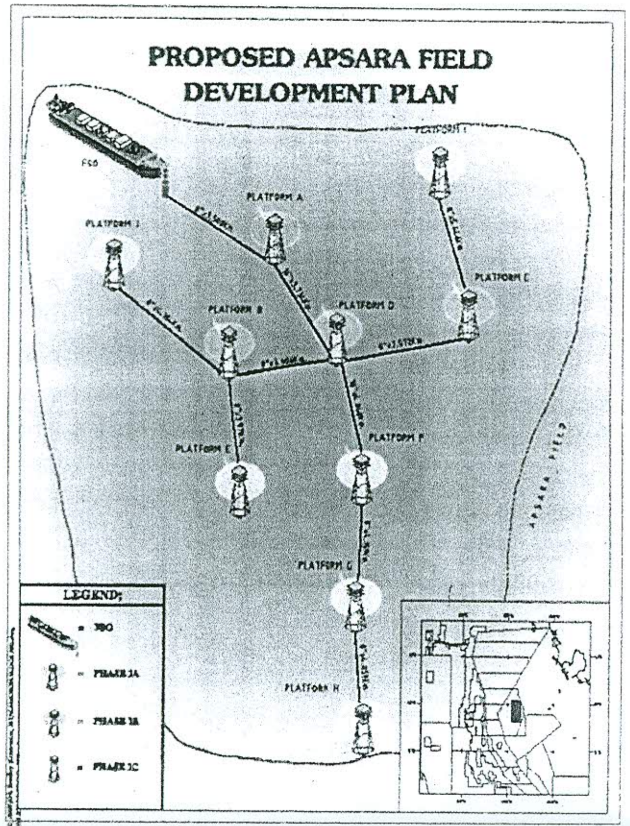
គម្រោងអភិវឌ្ឍន៍ ប្លុក A

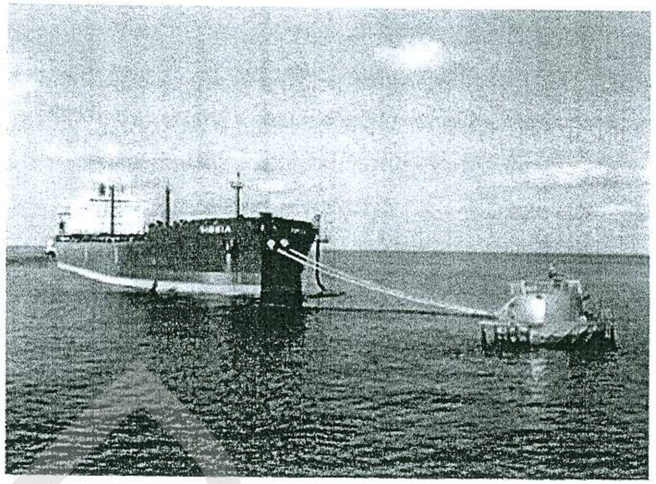
ក្រុមហ៊ុនឈេវរ៉ុន អូវើស៊ី ភេត្រូលៀម (ខេមបូឌា) លីមីធីត
Chevron Overseas Petroleum (Cambodia) Ltd.

ពត៌មានសង្ខេបអំពីក្រុមហ៊ុនឈេវរ៉ុន (Chevron)

ឈេវរ៉ុនគឺជាក្រុមហ៊ុនថាមពលបែបសមាហរណកម្មនាំមុខគេក្នុងពិភពលោក ដែលមានសាខាធ្វើអាជីវកម្មនៅពាសពេញពិភពលោក។ ជោគជ័យរបស់ក្រុមហ៊ុនបានមកដោយសារភាពស្ទាត់ជំនាញនិងការប្តេជ្ញាចិត្តនៃនិយោជិតរបស់ខ្លួន ជាមួយនឹងការអនុវត្តន៍នូវបច្ចេកវិជ្ជាដែលវិវត្តថ្មីៗបំផុតនៅក្នុងពិភពលោក។ ក្រុមហ៊ុនឈេវរ៉ុនជាប់ពាក់ព័ន្ធលើគ្រប់វិស័យសំខាន់ៗទាំងអស់ក្នុងឧស្សាហកម្មថាមពល។ ក្រុមហ៊ុនឈេវរ៉ុនធ្វើការខួងអណ្តូងស្វែងរុករក ផលិត ព្រមទាំងដឹកជញ្ជូនប្រេងឆៅ និងឧស្ម័នធម្មជាតិ ធ្វើការចំរាញ់ រកទីផ្សារលក់ និងចែកចាយការដឹកជញ្ជូនប្រេងឥន្ធនៈ និងផលិតផលថាមពលផ្សេងៗទៀត ធ្វើការផលិត និងលក់ផលិតផលគីមីសិលាគីមី បង្កើតថាមពល និងផលិតថាមពលដែលបានមកពីកំដៅផែនដី ផ្តល់នូវដំណោះស្រាយថាមពលយ៉ាងមានប្រសិទ្ធភាព ហើយនិងអភិវឌ្ឍន៍ធនធានថាមពលសំរាប់ពេលអនាគត រួមទាំងផលិតផលជីវៈឥន្ធនៈ។

ក្រុមហ៊ុនឈេវរ៉ុន បាននិងកំពុងធ្វើការប្រកបដោយសុវត្ថិភាព និងមានប្រសិទ្ធភាព នៅឈូងសមុទ្រថៃចាប់តាំងពីទសវត្សរ៍ទី ៦០ ហើយក្រុមហ៊ុនគឺជាប្រតិបត្តិករផ្នែកប្រេង និងឧស្ម័នធម្មជាតិដ៏ធំបំផុតនៅក្នុងតំបន់នេះ។ ក្រុមហ៊ុនឈេវរ៉ុនប្រតិបត្តិការប្រេងជាង ២៣៨ ផ្លាតហ្វម (platforms) និងបានធ្វើការខួងអណ្តូងប្រេងជាង ៤.២៨៥ អណ្តូងប្រេងកាត នៅក្នុងឈូងសមុទ្រថៃ ដែលមានផលិតកម្មប្រេងមធ្យមសរុបប្រមាណជា ៧៣.៥០០ ធុង នឹងប្រេងកំណក ៣៤.០០០ ធុង និងឧស្ម័នធម្មជាតិប្រមាណជា ១.១ កោដិហ្វីតគូប (1.1 billion gross cubic feet) ក្នុងមួយថ្ងៃ ១។





នាវាផ្ទុកប្រេងបណ្តែត (FSO)

ការពណ៌នាអំពីគម្រោង

ក្រុមហ៊ុនឈេវរ៉ុន មានផែនការអភិវឌ្ឍន៍តំបន់ប្លុកអា (Block A) នៅក្នុងសមុទ្រកម្ពុជាដើម្បីផលិតប្រេង។ តំបន់ប្លុកអា (Block A) ស្ថិតនៅប្រហែលជា ១៩៧ គីឡូម៉ែត្រ ខាងត្បូងឆៀងខាងលិច (ទិសនិរតី) នៃខេត្តព្រះសីហនុ និងជាតំបន់ដែលគ្របដណ្តប់លើផ្ទៃក្រឡាចំនួន ៤.៧០៩ គីឡូម៉ែត្រការ៉េ ។

ក្រុមហ៊ុនឈេវរ៉ុន ទទួលបានកិច្ចព្រមព្រៀងប្រេងកាតសម្រាប់ប្លុកអា តាំងពីឆ្នាំ ២០០២ ម្ល៉េះ។ ក្រុមហ៊ុនឈេវរ៉ុនគឺជាប្រតិបត្តិករនៃប្លុកអា ដែលត្រូវបានកាន់កាប់ផលប្រយោជន៍នៅក្រោមកិច្ចព្រមព្រៀងប្រេងកាត ជាមួយដៃគូរួមមាន : ក្រុមហ៊ុន Moeco Cambodia Co., Ltd., GS Caltex Corporation និង KrisEnergy (Cambodia) Limited។ ចាប់តាំងពីឆ្នាំ ២០០២ ក្រុមហ៊ុនឈេវរ៉ុន និងដៃគូរបស់ខ្លួនបានចំណាយប្រាក់ប្រមាណ ១៦០លានដុល្លារ ដើម្បីខួងអណ្តូងរុករក និងខួងអណ្តូងវាយតម្លៃ ចំនួន ១៨អណ្តូង និងធ្វើការវាយតម្លៃអំពីសក្តានុពលរបស់ប្លុកអា។ អណ្តូងទាំងនេះត្រូវបានខួងដោយជោគជ័យ និងប្រកបដោយប្រសិទ្ធិផល និងពុំមានឧប្បត្តិហេតុទាក់ទងនឹងបរិស្ថាន ឬ សុវត្ថិភាពអ្វីកើតឡើងឡើយ ។

គម្រោងនឹងត្រូវបានអភិវឌ្ឍន៍ជាបីដំណាក់កាល។ សម្រាប់ដំណាក់កាលដំបូងគឺដំណាក់កាល ១ក (Phase 1A) នឹងរួមមានផ្លាតហ្វមប្រព្រឹត្តកម្ម នាវាផ្ទុកប្រេងបណ្តែត (FSO) និងបំពង់បង្ហូរប្រេងរវាងផ្លាតហ្វមទៅនឹងនាវាផ្ទុកប្រេងបណ្តែត។ ផ្លាតហ្វមផលិតកម្មរហូតចំនួន៩ទៀតអាចនឹងត្រូវបានដំឡើងជាបន្តបន្ទាប់នៅក្នុងដំណាក់កាល ១ខ (Phase 1B) និង១គ (Phase 1C) ដែលការនេះគឺអាស្រ័យលើជោគជ័យពាណិជ្ជកម្មនៃដំណាក់កាល ១ក (Phase 1A)។

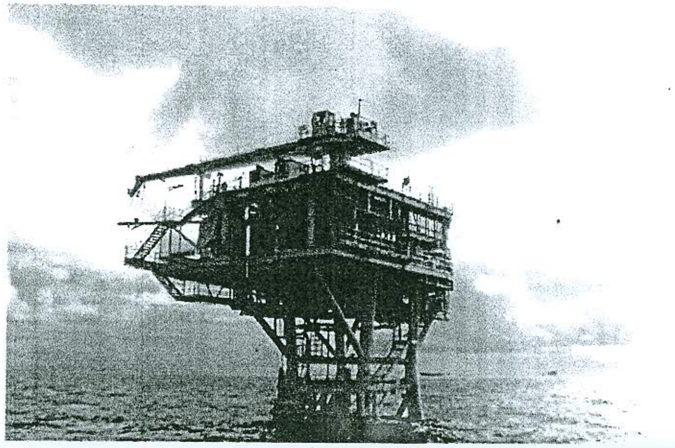
មូលដ្ឋានផ្គត់ផ្គង់សម្ភារៈលើដីគោកមួយដែលស្ថិតនៅក្នុងកំពង់ផែស្វយ័តក្រុងព្រះសីហនុនឹងត្រូវយកមកប្រើប្រាស់ដើម្បីជួយគាំទ្រដល់ប្រតិបត្តិការរបស់ប្លុកអា។ ក្រៅពីមានចរាចរដោយឧទ្ធម្ភាគចក្រពីខេត្តព្រះសីហនុមកកាន់នាវាផ្ទុកប្រេងបណ្តែត (FSO) ក៏នឹងមានចរាចរនាវាពីកំពង់ផែស្វយ័តក្រុងព្រះសីហនុ ជាកន្លែងដែលសំភារៈបរិក្ខារសម្រាប់គម្រោងនឹងត្រូវបានរក្សាទុក ទៅកាន់ទីតាំងប្រតិបត្តិការនៅឯនាយសមុទ្រផងដែរ។

គម្រោងនេះត្រូវបានរៀបចំបង្កើតឡើងដោយគោរពតាមបទបញ្ញត្តិ និងបទដ្ឋានពាក់ព័ន្ធទាំងអស់ដែលនៅជាធរមាន។

ផែនការសម្រាប់ដំណាក់កាល ១ ក (Phase 1A) នឹងរាប់បញ្ចូលអណ្តូងអភិវឌ្ឍន៍ចំនួន ២៤ ហើយអណ្តូងជាង ៣០០ទៀត អាចនឹងត្រូវបានខួងនៅក្នុងដំណាក់កាល ១ ក (Phase 1A) , ១ ខ (Phase 1B) , និង ១គ (Phase 1C)។

សុវត្ថិភាពមានសារៈសំខាន់ជាសារវន្ត

សុវត្ថិភាពគឺមានចង្អុលបង្ហាញក្នុងគ្រប់ទិដ្ឋភាពទាំងអស់នៃប្រតិបត្តិការរបស់ក្រុមហ៊ុនឈេវរ៉ុន ហើយយើងខ្ញុំគឺជាអ្នកនាំមុខគេផ្នែកឧស្សាហកម្មនៅក្នុងតំបន់ ចំពោះប្រតិបត្តិការប្រកបដោយសុវត្ថិភាព និង ការអនុវត្តប្រកបដោយការយកចិត្តទុកដាក់ចំពោះបរិស្ថាន។ យើងខ្ញុំជឿជាក់យ៉ាងមុតមាំថា គ្មានឧប្បត្តិហេតុណាមួយអាចកើតឡើងបានឡើយ (គឺមានន័យថាសូន្យឧប្បត្តិហេតុ) ហើយយើងខ្ញុំនៅតែបន្តប្រុងប្រយ័ត្នគ្រប់ពេលវេលាទាំងអស់ដោយបន្តខំតស៊ូឆ្ពោះទៅសម្រេចគោលដៅប្រតិបត្តិការនេះដោយគ្មានឧប្បត្តិហេតុ។



APPENDIX 8: AIR EMISSION CALCULATIONS

Greenhouse Gas Emissions

Methodology

Green house gas (GHG) emissions will occur from fossil fuel combustion over the project lifecycle and flaring during the operations phase. Emissions have been estimated using emission factors and global warming potentials for the three main GHG emitted by the project: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). GHG emissions from the project have been estimated following the Tier 1 approach of IPCC (2006) for stationary and mobile combustion and flaring. Note that values in tables have been converted from kg to metric tonnes.

$$CO_2\ Emission\ (kg) = Fuel\ Consumptio\ n\ (TJ)\ x\ Fuel\ Emission\ \ Factor\ (kgCO_2 / TJ) \quad \text{Eq.1}$$

Stationary Combustion (Diesel Fuel Use): Equation 1 is used to estimate GHG emissions from use of diesel fuel for stationary combustion with default fuel emission factors from

Fuel use must first be converted from Metric Tonnes (MT) to TJ. A net default calorific value for diesel of 43 TJ/Gg is used for this calculation, as provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This value is used for COPCL's use of medium diesel oil and intermediate fuel oil.

Diesel Fuel consumption (TJ) = diesel use (MT) x 10^{-3} (Gg/MT) x 43 (TJ/Gg)

CO_2 Emissions (MT) = 10^{-3} * Diesel Fuel Consumption (TJ) * Fuel Emission Factor (kg CO_2 / TJ)

Stationary Combustion (Associated Gas Use): Equation 1 is used to estimate GHG emissions from use of associated gas for stationary combustion with default fuel emission factors from **Table 1**.

Volumes of gas used must first be converted from MMSCFD to TJ. The maximum calorific value for natural gas of 50.4 TJ/Gg is used for this calculation, as provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This value is used as a worst case estimate because no specific information on wellhead gas characteristics is available. The density of the associated gas is assumed to be 0.717 kg/m^3, the density of methane at standard temperature and pressure.

Gas Use (TJ) = Gas Use (10^6 scf) x 0.0283 (m^3/scf) x 0.717 kg/m^3 x 10^{-6} Gg/kg x 50.4 (TJ/Gg)

CO_2 Emissions (MT) = 10^{-3} * Gas Use (TJ) * Fuel Emission Factor (kg CO_2 / TJ)

Mobile Combustion (Fuel Use from Vessels): Equation 1 is used to estimate GHG emissions from use of diesel fuel for marine transportation with default fuel emission factors from **Table 1**.

Fuel use must first be converted from Metric Tonnes (MT) to TJ. A net default calorific value for diesel of 43 TJ/Gg is used for this calculation, as provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This value is used for COPCL's use of medium diesel oil and intermediate fuel oil.

Diesel Fuel consumption (TJ) = diesel use (MT) x 10^{-3} (Gg/MT) x 43 (TJ/Gg)

CO_2 Emissions (MT) = 10^{-3} * Diesel Fuel Consumption (TJ) * Fuel Emission Factor (kg CO_2 / TJ)

Mobile Combustion (Helicopter Fuel Use): Equation 1 is used to estimate GHG emissions from jet gasoline use for helicopter transportation with default fuel emission factors from **Table 1**.

Fuel use must first be converted from Metric Tonnes (MT) to TJ. A net default calorific value for jet gasoline of 44.3 TJ/Gg is used for this calculation, as provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Helicopter Fuel consumption (TJ) = fuel use (MT) x 10^{-3} (Gg/MT) x 44.3 (TJ/Gg)

CO_2 Emissions (MT) = 10^{-3} * Fuel Consumption (TJ) * Fuel Emission Factor (kg CO_2 / TJ)

Flaring: The amount of gas flared will vary. Initially small volumes of associated gas will be generated (<2 mmscfd), which will be used as fuel gas and gas lift. The amount is expected to increase during years 2 and 3 to 2.5 and 3.5 mmscfd, respectively. The feasibility to inject gas will be investigated for Phase 1b and 1c: if injection takes place the amount of gas flared is expected to be 2 mmscfd.

GHG emissions from flaring are estimated using emission factors and global warming potentials for the three main greenhouse gases (CO_2, CH_4 and N_2O) as explained above for stationary combustion of associated gas. The only difference is that flaring will result in conversion of CH_4 to CO_2 at an efficiency of 98% and the stoichiometric mass conversion factor of 2.75 of CO_2 from CH_4 (2006 IPCC Guidelines for National Greenhouse Gas Inventories). The emission factors in **Table 1** have been adjusted.

The maximum calorific value for natural gas of 50.4 TJ/Gg is used for this calculation, as provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This value is used as a worst case estimate because no specific information on wellhead gas characteristics is available.

Table 1: Emission Factors for GHG Calculations

Types	Unit	CH_4	N_2O	CO_2	Total CO_2-eq
Diesel Use by Generators (Stationary Combustion)	kg/TJ	3	0.6	74,100	
	kg CO_2 eq/TJ	75	178.8	74,100	74,354
Associated Gas Use (Stationary Combustion)	Gg/TJ	1	0.1	56,100	
	Gg CO_2 eq/TJ*	25	29.8	56,100	56,155
Diesel Use for Water-Borne Navigation (Mobile Combustion)	kg/TJ	7	2	74,100	
	gCO_2 eq/TJ*	175	596	74,100	74,871
Helicopter Aviation Use (jet gasoline)	kg/TJ	0.5	2	70,000	
	gCO_2 eq/TJ*	12.5	596	70,000	70,609
Associated Gas Flaring	Gg/TJ	0.02	0.1	56,103	
	Gg CO_2 eq/TJ*	0.5	29.8	56,103	56,133

Source: IPCC (2007). Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2.html

* Global warming potentials (100 year time horizon): CO_2 = 1; CH_4 = 25; N_2O = 298

Other Gas Emissions

Methodology

Emission factors are based on the Revised 1996 IPPC Guidelines and are summarized for the different fuels in **Table 2**.

Table 2: Emission Factors of Gas Emissions

	NOx	CO	SO_2
Stationary	200 kg/TJ	15 kg/TJ	93.8 kg/TJ
Boats	67.5 g/kg fuel	21.3 g/kg fuel	0.3%
Helicopter	12.5 g/kg fuel	5.2 g/kg fuel	1 kg/t fuel
Flaring	150 kg/TJ	20 kg/TJ	negligible

Source: Revised 1996 IPPC Guidelines

APPENDIX 9: CUTTINGS MODELLING REPORT

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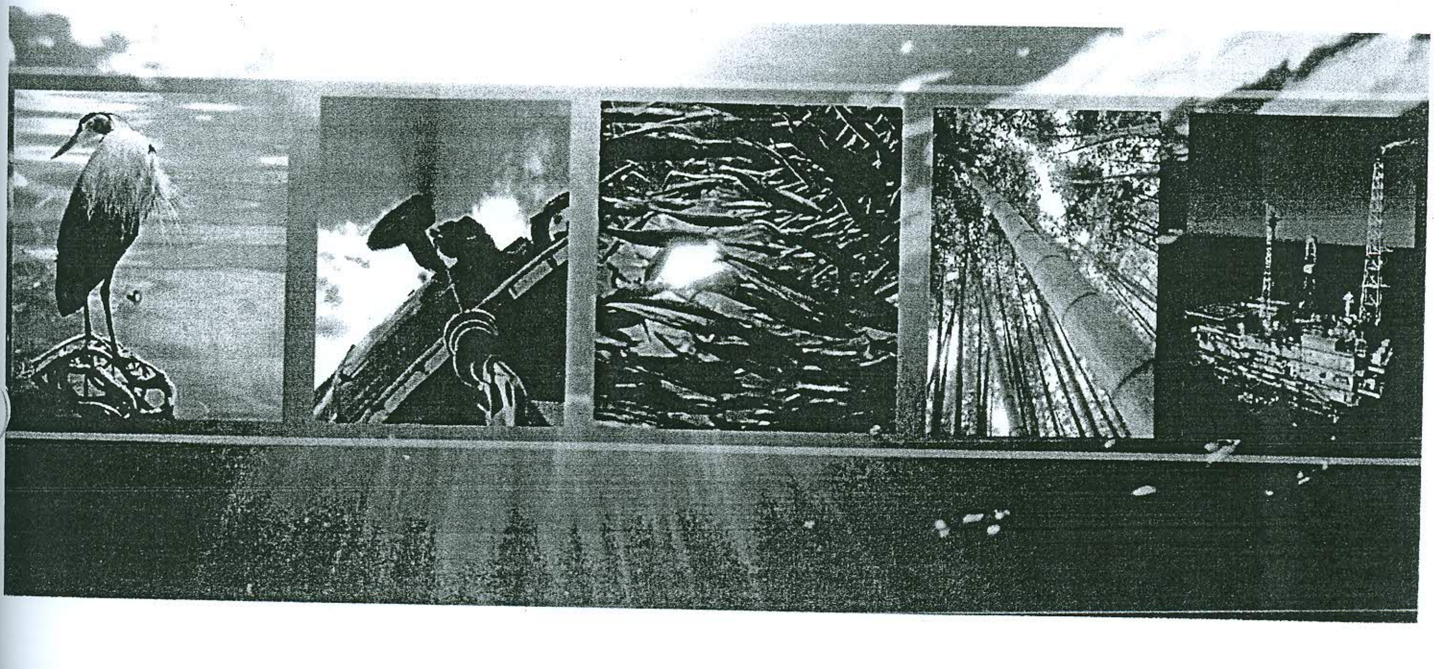
DRILL CUTTINGS AND DRILLING MUD DISPERSION MODELLING FOR BLOCK A DRILLING CAMPAIGN

25th July 2011

Prepared for:
IEM Co. Ltd., and Chevron Overseas Petroleum (Cambodia) Limited



Document control form

Document draft	Originated by	Edit & review	Authorized for release by	Date
Draft - Issued for internal review	Dr Sasha Zigic Alan Newnham	Dr Sasha Zigic Dr Brian King		20th December 2010
Draft - Issued for client review		Dr Sasha Zigic Dr Brian King	Dr Sasha Zigic	20th December 2010
Draft final - Issued for client review		Dr Ryan Dunn	Dr Sasha Zigic	22nd February 2011
Final Submitted		Dr Sasha Zigic	Dr Sasha Zigic	15th June 2011
Amended Final Submitted		Dr Ryan Dunn	Dr Sasha Zigic	25th July 2011

Document name: IEM_Chevron Cambodia Block A_CuttingsReport_Final_July2011.doc

APASA Project Number: G11042

APASA Project Manager: Dr Sasha Zigic

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EXECUTIVE SUMMARY

Chevron Overseas Petroleum (Cambodia) Limited (Chevron) proposes to conduct a drilling campaign in Block A, Cambodia, Gulf of Thailand, starting October 2012 as part of the Block A development project. The majority of the wells are to be drilled as three separate intervals (surface, intermediate and production), with the exception being a limited number of four string horizontal wells. The surface intervals (12.25" bore hole) will be drilled using seawater and Water Based Mud (WBM), with the extracted drill cuttings and WBMs being returned directly at the seabed. The intermediate interval (8.5" bore hole) will be drilled using sea water with WBM sweeps. Finally, the production interval (6.125" bore hole) will be drilled using Non-Aqueous Fluids (NAF). The cuttings and mud from the intermediate interval will be brought to the surface through the riser, upon which the sea water drilling fluid/cuttings are discarded. For the production hole NAF drilling fluid/ cuttings are brought to the surface through a riser and treated through solids control equipment with the drilling fluid being reused and the cuttings being discarded. The cuttings and residual mud will be discharged overboard 1 metre below mean sea level (~70 m above the seafloor). Well construction will take approximately 6.5 days of rig time per slim hole well (4 days of actual drilling) and 24 wells will be drilled from the Apsara-A platform.

The assumption for the modelling study is that the 24 wells are to be drilled as 3 separate batches, 8 wells will have their surface holes drilled, followed by 8 intermediate holes, followed by 8 production holes. This will be followed by Batch 2 and Batch 3, where the process is repeated. This assumption is used for modelling purposes and this might change during detailed design prior to drilling operations.

The drilling program should last ~6 months for a total of 24 wells.

To prepare the Environmental Impact assessment for the project, a dispersion modelling study was conducted to estimate the potential short-term (prior to any re-suspension) seabed sediment deposition generated from discharged drill cuttings and drilling mud. The main objectives of the study were to:

a) Simulate the near-seabed and sea surface discharges, for each batch (i.e. 3 simulations for near-seabed discharge, 3 simulations for sea surface discharge; and

b) Combine the results from all of the simulations to estimate the bottom thickness, seafloor coverage and minimum distance from adjacent sensitive receptors (i.e. Poulo Wai Island, Cambodia) to seabed minimum thickness threshold level above 0.07 mm.

The modelling study was carried out in stages. Firstly, the ocean/coastal hydrodynamic model (HYDROMAP) was validated extensively and then used to generate three-dimensional currents for the entire Gulf. Secondly, the generated currents and detailed discharge data was used as input into the far-field discharge model, MUDMAP, to predict the movement and settlement of the material. The near-seabed and near-surface releases were modelled separately for each batch.

Summary of Near Seabed Discharges

Due to the height of release (2 m above the seafloor) the modelling showed that the currents had little effect on the larger sediment (greater than 0.25 mm diameter) which rapidly settled within 50 m of the release site after discharge. In contrast, the modelling showed that the currents were able to carry and deposit the smaller sediment (less than 0.25 mm diameter) more than 3 km from the release site

Typically the sediment was deposited along a northwest to southeast line, which corresponds with the major tidal axis at the platform location. There were instances during which sediment had deposited to the northeast, which could be attributed to the change in current direction (i.e. flood to ebb).

The maximum thickness (or height of mound) ranged between 458 mm to 759 mm. The area of coverage on the seafloor varied from 1.28 km^2 during Batch 1 conditions to 1.57 km^2 during Batch 2 conditions. The maximum distance from the platform to the 0.07 mm threshold contour was 3.57 km. The minimum distance from Poulo Wai to the 0.07 mm threshold contour was 67.88 km.

Summary of Sea-Surface Discharges

Modelling showed that by releasing the material higher above the seabed (approximately 70 m above or 1 m below the sea surface at this location), the prevailing currents were able to carry the smaller sediments (less than 0.25 mm diameter) further from the release site and deposit it over a much larger area than the near seabed discharges. Although, similar to the near seabed discharges, the larger sediment (greater than 0.25 mm diameter) also rapidly settled within 50 m of the release site and overall the material settled in a predominately northwest to southeast direction.

The maximum thickness (or height of mound) ranged between 9.08 mm to 13.3 mm. The area of coverage on the seafloor varied from 3.77 km^2 during Batch 2 conditions to 4.01 km^2 during Batch 3 modelled conditions. The maximum distance from the platform to the 0.07 mm threshold contour was 4.25 km. The minimum distance from Poulo Wai to the 0.07 mm threshold contour was 67.63 km.

Total Accumulated Thickness

The seabed and sea surface discharges for all 3 batches were combined to assess what the outcome of the full 6 month production drilling campaign would be.

The total area affected by mud and cuttings deposition from drilling 24 wells at this site was 12.54 km^2. Of this area, 6.88 km^2 of the area (or 45% of the affected area) was calculated to be covered by less than 0.2 mm. Approximately, 0.95 km^2 (or 0.075%) of the seafloor coverage consisted of sediment greater than 1 mm. The distance from the nearest island Poulo Wai to the 0.07 mm thickness contour is 67.03 km east.

1 INTRODUCTION

Chevron Cambodia Ltd (Chevron) is proposing to conduct a drilling campaign in Block A, Gulf of Thailand (Gulf), Cambodia, starting October 2012. During the campaign, each well is to be drilled as three intervals (surface, intermediate and production). The surface intervals (12.25" bore hole) will be drilled using seawater and Water Based Mud (WBM), with the extracted drill cuttings and WBMs being returned directly at the seabed. The intermediate interval (8.5" bore hole) will be drilled using sea water with WBM sweeps and the production interval (6.125" bore hole) will be drilled using Non-Aqueous Fluids (NAF). The cuttings and mud from the intermediate and production intervals will be brought to the surface through a riser pipe for treatment on-board the drilling platform using solids control equipment. During processing most of the mud will be separated from the cuttings and re-used for drilling; a residual fraction of the mud will adhere onto to the cuttings. After processing, the cuttings and residual mud will be discharged overboard 1 metre below mean sea level (~70 m above the seafloor). Approximately, 6.5 days will be required to construct each well, with 4 days of actual drilling.

To gain an understanding of the potential short-term (no re-suspension) seafloor coverage resulting from the discharge operation, International Environmental Management (IEM), commissioned Asia-Pacific Applied Science Associates (APASA) to carry out a dispersion modelling study using the specifics of the planned drilling operation and the environmental conditions of the Gulf of Thailand.

The main aim of the study was to estimate the likely area of coverage and bottom thickness on the seafloor when the sediment is discharged from the Apsara A platform (Figure 1 and Table 1) for a drilling program lasting over six months (October – April). A total of twenty four wells will be drilled from the platform.

The findings from the assessment will assist IEM and Chevron to better understand the short-term (no re-suspension) seabed coverage from the discharge operation.

Table 1: Location of the Apsara A platform used as part of the Block A drill cuttings and mud dispersion modelling.

Wellhead Platform Name	***Latitude (North)***	***Longitude (East)***	***Water Depth (m)***
Apsara A platform	9° 56' 44.405"	102° 14' 50.969"	71

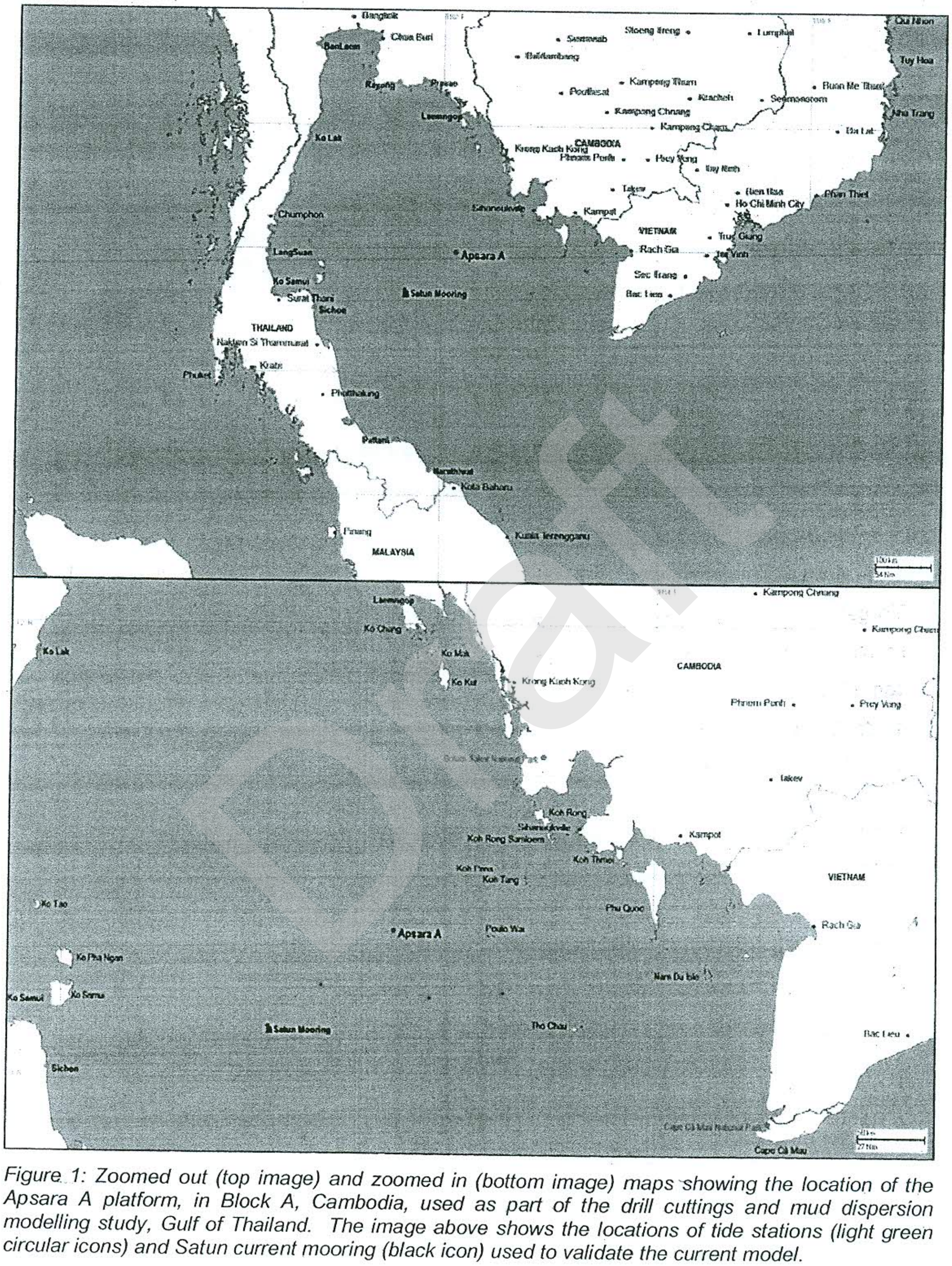

Figure 1: Zoomed out (top image) and zoomed in (bottom image) maps showing the location of the Apsara A platform, in Block A, Cambodia, used as part of the drill cuttings and mud dispersion modelling study, Gulf of Thailand. The image above shows the locations of tide stations (light green circular icons) and Satun current mooring (black icon) used to validate the current model.

2 SCOPE OF WORK

The scope of work included the following components:

- Generate three-dimensional (3D) currents for the entire Gulf, using a validated ocean/coastal model, HYDROMAP, for input into the sediment discharge model, MUDMAP;
- Model the transport and settlement for the near seabed and surface releases for the initial 8 wells (batch 1) starting October;
- Model the transport and settlement for the near seabed and surface releases for the following 8 wells (batch 2) starting end of November;
- Model the transport and settlement for the near seabed and surface releases for the remaining 8 wells (batch 3) starting early January; and
- Combine the results from the near seabed and sea surface simulations to determine the collective bottom thickness and seafloor coverage for the entire drilling program; above the natural sedimentation rate of 0.07 mm, during the drilling operation.

3 OCEAN-COASTAL CURRENT MODEL - HYDROMAP

The 3D current data was generated using Applied Science Associates (ASA's) advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world over the past 25 years (Isaji and Spaulding, 1984; Isaji *et al.*, 2001; Zigic *et al.*, 2003). In fact, the HYDROMAP tidal current data has been used as input to forecast (in the future) and hind cast (in the past) previous oil spills by the Pollution Control Department of Thailand and Chulalongkorn University (Thailand). Furthermore, the circulation data used by the Pollution Control Department of Thailand since 2003 has been validated as part of the Thai Resources and Environment Management Institute (TREMI) managed Southern Land Bridge Development Project.

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study. To simulate the ocean circulation over any area of interest, the model requires the following input data:

(1) The amplitude and phase of the important tidal constituents, which are used to calculate sea heights over time at the open boundaries of the model domain;

(2) Bathymetry for the area; and

(3) Wind data to define the wind shear at the sea surface.

The numerical solution methodology follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984).

3.1 Grid Setup

As the Topex-Poseidon database is more accurate in deeper waters (greater than 100 m), it was necessary to employ a nested-grid modeling scheme. Essentially, a regional hydrodynamic grid (see Figure 2) was initially setup and run to provide ocean boundary data for the local higher resolution grid (see Figure 2). This is a common hydrodynamic modeling approach to overcome the aforementioned depth restriction (Ye and Robinson, 1983 and Fang *et al.*, 1999).

The regional grid extended over the Gulf of Thailand, Andaman Sea, Malacca Strait, South China Sea, Java Sea and Makassar Strait. The grid was set up with a coarse resolution ranging from 25 km at the outer regions of the model grid to 6.3 km around the Gulf coastline.

The high resolution local grid consisted of 17,599 active computational water cells. The domain was subdivided horizontally into a grid with three levels of resolution. The resolution of the base cell was set at 9 km, which was reduced down to 2.25 km, to resolve detailed circulation and important coastal and island features.

A combination of datasets was used to describe the shape of the sea bed within the high resolution grid. For the Gulf, spot depths and contours were digitised from the most recent and highly resolved nautical charts released by the Thai Hydrographic office (February 2009). The data is the most recent and accurate available. Depths for the South China Sea were extracted from the SRTM dataset (Shuttle Radar Topographic Mission <http://www2.jpl.nasa.gov/srtm/>), which has a resolution of 1 km. The datasets were interpolated spatially to form a seamless, highly accurate representation of the depths (Figure 3).

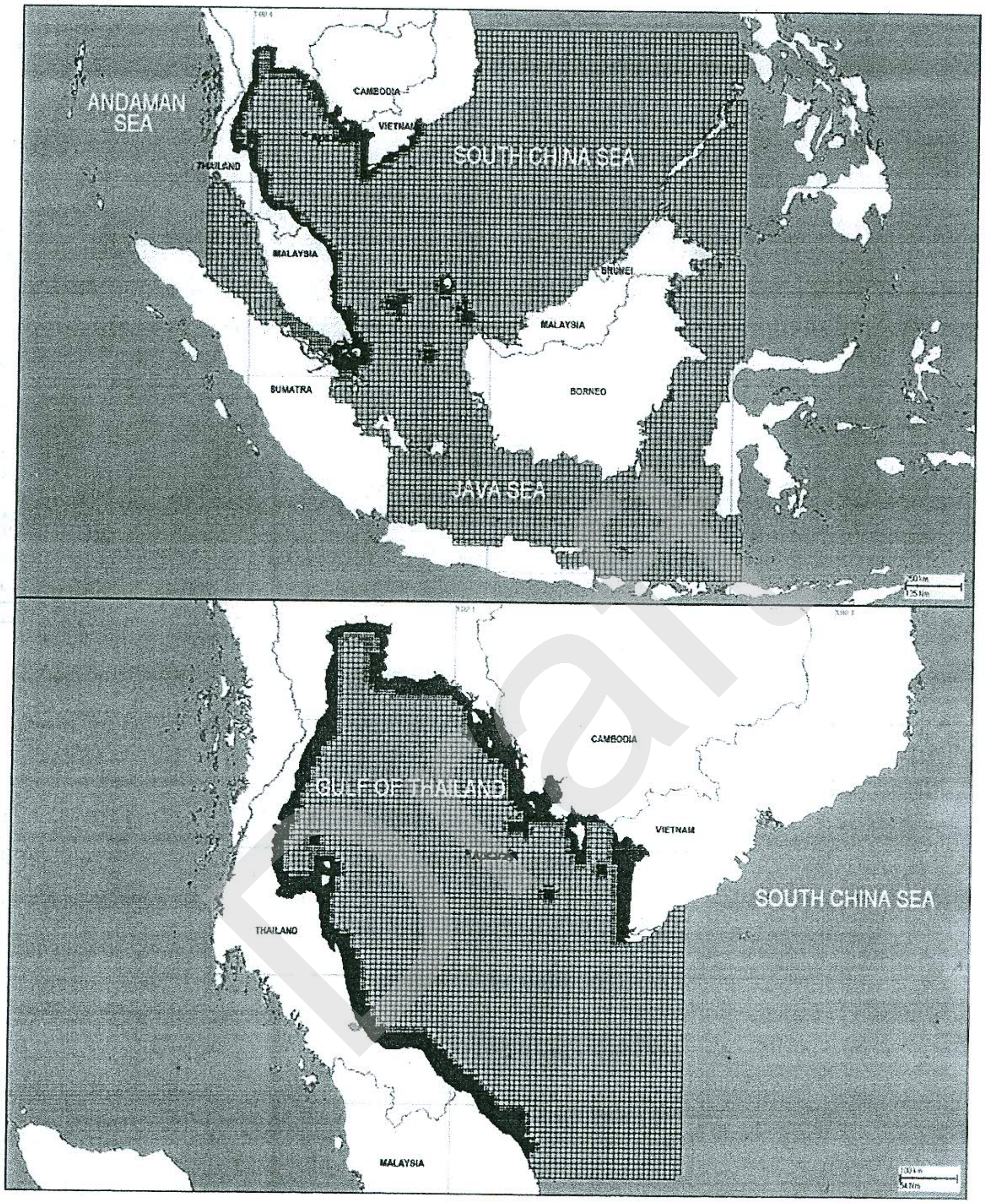

Figure 2: Extent of the large tidal model grid domain (top image) used to generate ocean boundary data for the higher resolution grid (bottom image).

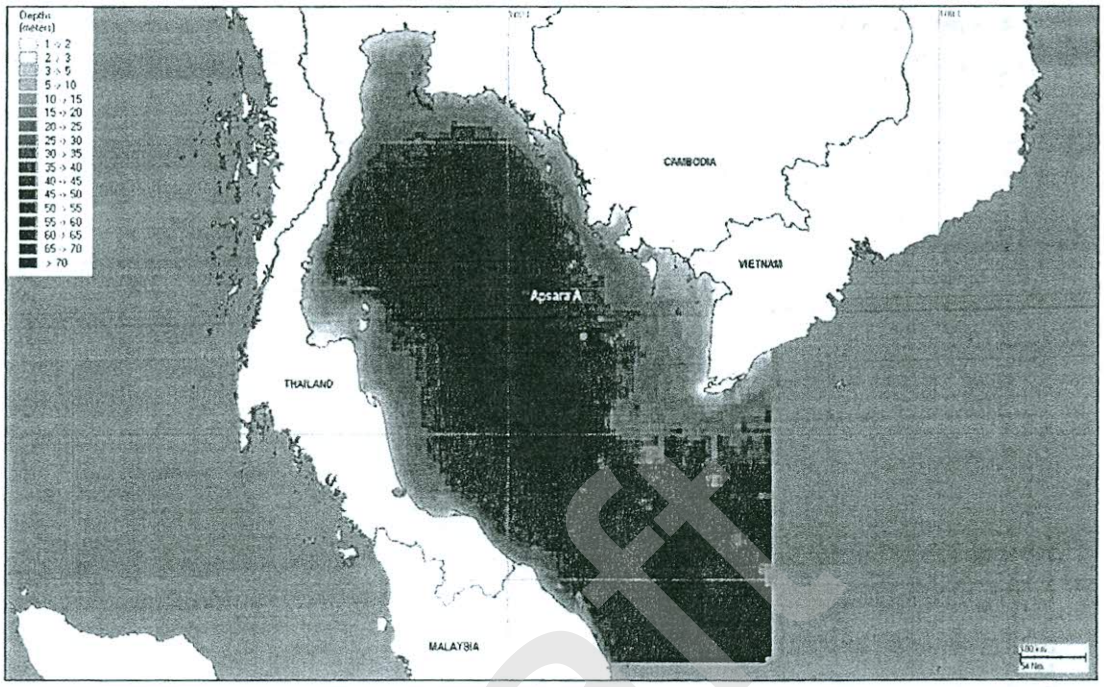

Figure 3: Bathymetric data used to define the shape of the seafloor within the tidal model.

3.2 Ocean Boundary Data

The tides at the entrance to the Gulf are mixed semi-diurnal (two high tides per day), with a clear spring-neap tidal cycle. The dominant tidal components in the Gulf are the S_2, M_2, K_1, and O_1 (Wolanski *et al.*, 1994). To account for the tidal forcing, the eight largest constituents (K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1) were selected. These are the same constituents as used by Yaiprasert *et al.* (2005) in a study of the tides within the Gulf. Typically these are the constituents specified in advanced hydrodynamic modelling applications, as they encompass a significant portion of the tidal signal and can accurately re-create the water levels and currents within the model domain (Militello and Zundel, 1999). Previous published modelling studies for the region by Cai *et al.* (2003) used only 4 tidal constituents. Employing twice as many tidal constituents greatly enhances the model prediction.

The tidal forcing along the ocean boundaries of the large grid was extracted from the Topex Poseidon global tidal database (TPX07.1; source: Oregon State University). The data was derived from long-term measurements taken by the Topex-Poseidon satellites since October 1992. The data has a resolution of 0.25 degrees (465 m) globally, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The satellites measured oceanic surface elevations (and the resultant tides) for over 13 years (1992-2005), during which they had carried out 62,000 orbits of the planet. The satellites were equipped with two highly accurate altimeters, capable of taking sea level measurements of less than ± 1 centimetre accuracy ("Ocean Surface Topography from Space" NASA/JPL). The Topex-Poseidon tidal data has been widely used amongst the oceanographic community (Vikebo *et al.*, 2005) and is the same dataset used by Yaiprasert *et al.* (2005) and Zu *et al.* (2008) to simulate the tidal influences in the Gulf of Thailand.

3.3 HYDROMAP Model Validation

The following sections provide a summary of an extensive study, which compared the accuracy of the modelling results to surface elevations and current data measured within the Gulf. Full details of the validation study are provided in APASA (2009).

Measured surface elevation validation

The first stage of the verification study involved comparing the model's accuracy with measured surface elevation data from nine stations, supplied by the Thai Hydrographic Department and Marine Department. The process involved running HYDROMAP for an entire year (2007), coinciding with the period of measured data.

The main objective of this phase was to ensure that the bathymetry, tidal constituents, winds (NCEP- see APPENDIX A) and bottom friction selected generated model results which compared well with all tidal stations. A Manning's bottom roughness coefficient of 0.025 was selected following testing that showed it produced the correct propagation of the tidal wave. Figure 4 shows time-series graphs of the model predicted and measured surface elevations for February 2007, for Narathiwat, Ko Samui, Ko Lak and Ban Laem stations (see Figure 1 for location of the tide stations). The four stations were selected to illustrate the model's accuracy along the entire coastline. The APASA (2009) report provides the results for all 9 stations for the entire year.

All four graphs show that the model accurately reproduced the magnitude (height) and timing of the tides (phase), even during sustained wind events during which the tidal levels did not drop. This demonstrates that the model was accurately replicating the natural variability in the measured tidal water levels and combined effects of wind, tide and bottom friction drag for the Gulf.

Considering the complexity of the water movement within the Gulf, the vast distances between the three stations, and that some of the stations are located adjacent to, or within estuaries, this is an exceptional achievement of the model formulations, settings and input data.

The Root Mean Square Error (RMSE) values were calculated for each site and are shown below in Table 2. The RMSE values for all four sites were equal to or below the recommended criterion of 14% (Sousa and Dias 2007).

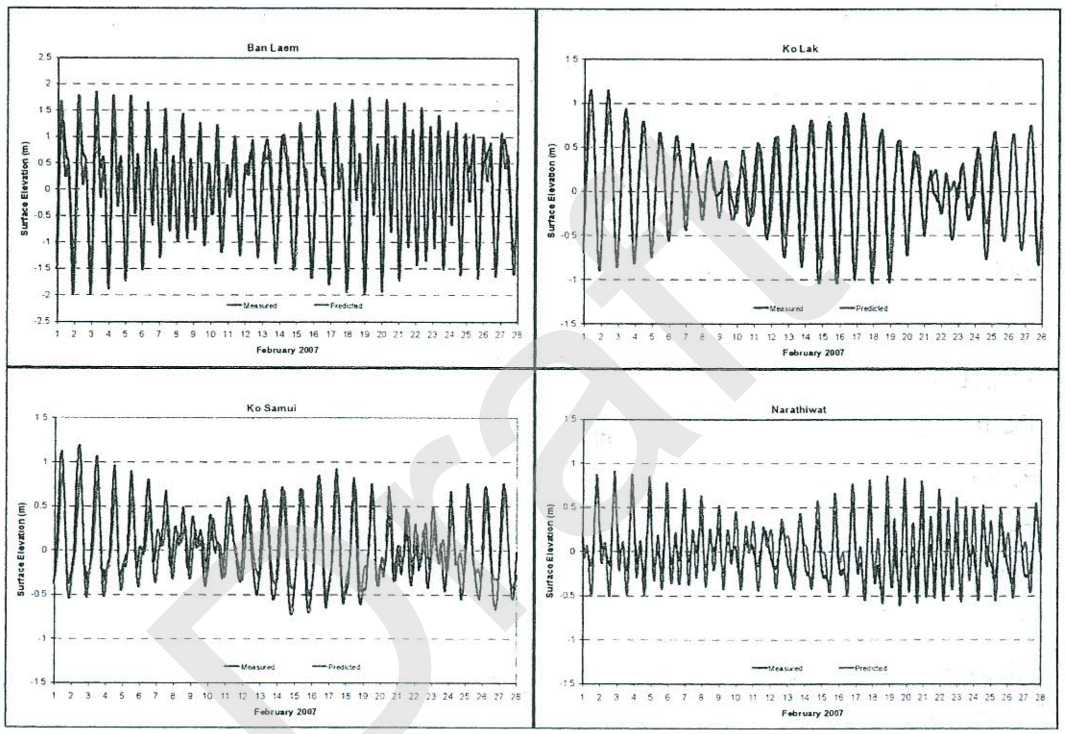

Figure 4: Time-series graphs of the predicted (red line) and measured (blue line) February 2007 surface elevations, at Narathiwat; Ko Samui, Ko Lak and Ban Laem.

Table 2: Statistical evaluation of the model performance for the four tide stations during February 2007.

Station	*Observed Range (m)*	*Predicted Range (m)*	*RMSE (m)*	*RMSE (%)*
Narathiwat	1.46	1.53	0.19	14
Ko Samui	1.92	1.40	0.22	11
Ko Lak	2.19	1.84	0.18	8
Ban Laem	3.26	3.85	0.33	10

Satun platform surface and bottom current validation

The second stage of the verification study involved comparing measured currents at the Satun production platform in the centre of the Gulf (see Figure 1 for location of platform) with the model predicted results. Two current meters were attached to a leg of the platform, one near the surface and the other near the bottom (Tetra Tech 2002). Data spanned from 1st January to 1st June 1999 (approximately 150 days) at 20 minute intervals. Wind data was also collected at the platform and was used as input into the model for the validation.

One of the main motives for this phase was to ensure that the model's wind shear factor and vertical eddy viscosity factor were generating accurate three-dimensional currents. The vertical eddy viscosity is used to control the amount of vertical shear (resistance) between the layers in the water column (Kowalik and Murty 1993) in a three-dimensional model. The value for vertical shear was tested between 10 cm^2/sec and 200 cm^2/sec against the Satun data and it revealed that the current speed and direction was sensitive to this parameter. A relatively low value of 20 cm^2/sec provided the best agreement the measured data at both depths.

Figure 5 shows time-series graphs of the predicted and measured surface and bottom current speeds. The graphs show that during the 150 day deployment, the model was capable of reproducing the varying current speeds very well at both depths. Figure 6 presents the currents speeds as north-south and east-west components at the two depths. The results highlight that the model accurately reproduced the change in direction as a function of time.

Figure 7 shows a scatter plot of the two datasets at the surface and bottom layers. The images demonstrate that the chosen model settings and input data (wind, tide and seabed drag) agree with the natural dynamics for the middle of the Gulf, including the north-westerly drift setup by the northeast monsoon winds.

Table 3 shows a statistical comparison between the measured surface and bottom currents at the Satun platform and model-predicted results. Statistically, the Relative Mean Error (RME) was on average below 15% for the surface layer and less than 10% for the bottom layer. All RME values were well below the value of 30% recommended for model calibration/validation by McCutcheon *et al.* (1990). These results provide further confirmation that the model is reproducing the currents within the Gulf with a high degree of accuracy.

Table 3: Statistical comparison between the measured surface and bottom currents at the Satun production platform and model predicted results from 1st January to 31st May 1999.

Depth of current meter	Maximum current speed (m/s)		Average current speed (m/s)		Relative Mean Error (%)		Root Mean Square Error (%)	
	Measured	**Predicted**	**Measured**	**Predicted**	**East-West**	**North-South**	**East-West**	**North-South**
Surface	0.80	1.04	0.26	0.18	14.8	14.0	18.2	16.5
Bottom	0.88	0.65	0.21	0.16	6.9	8.6	13.6	10.7

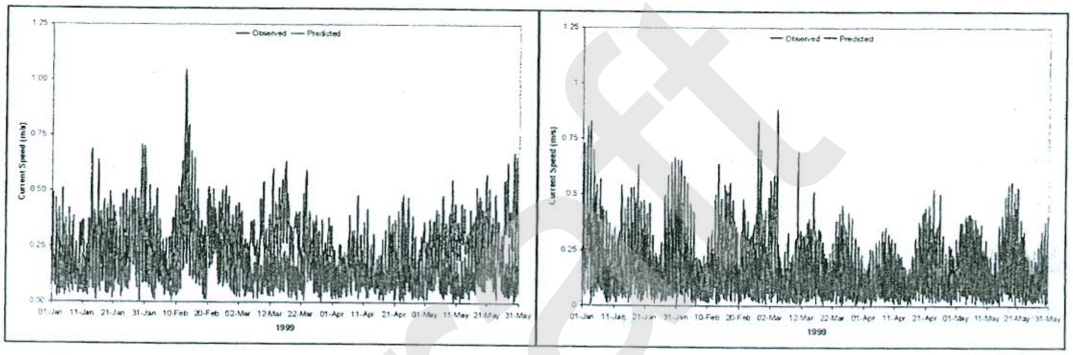

Figure 5: Time-series graphs showing the comparison between the Satun measured (blue) and predicted (red) current speeds. Left panel shows the surface current speeds and right panel shows the bottom current speeds.

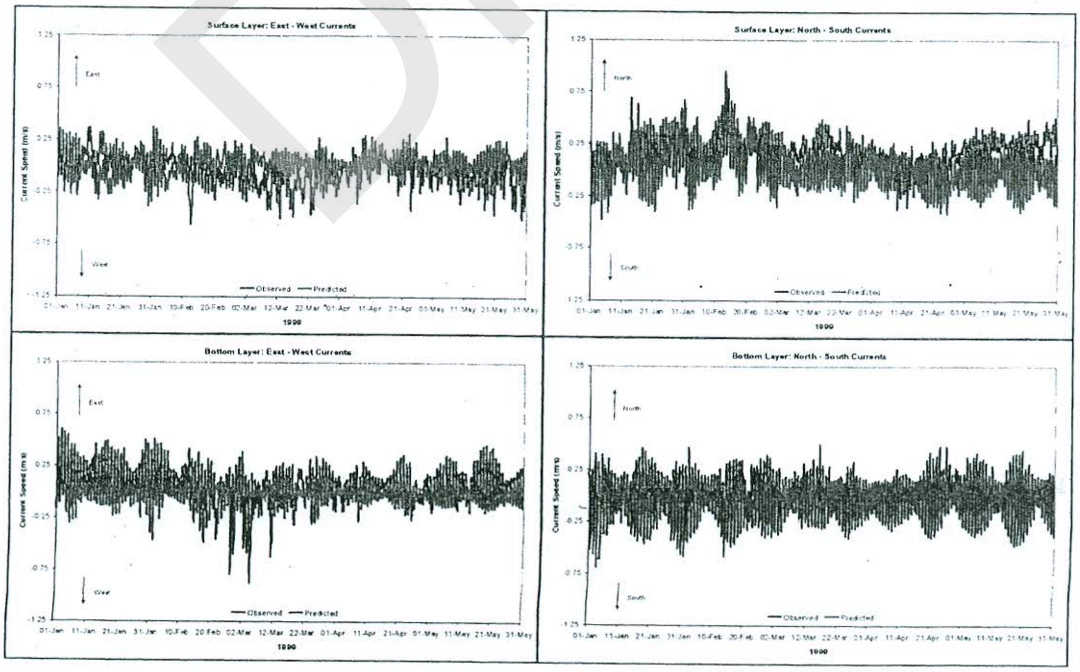

Figure 6: Time-series graphs showing the comparison between the Satun measured (blue) and predicted (red) east-west components current speeds (left panel) and north-south axis current speeds (right panel), for the surface and bottom layers. Note: north and east flows are positive axes.

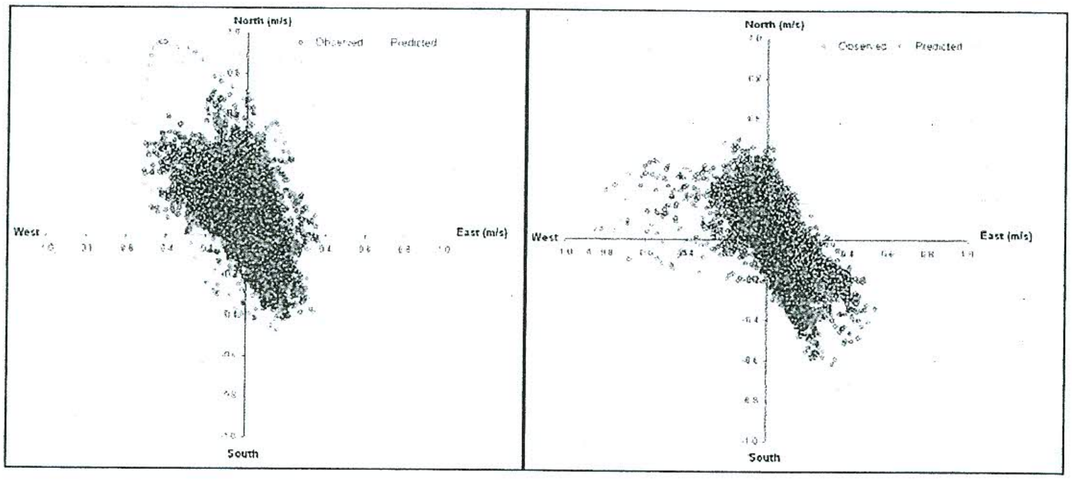

Figure 7: Scatter plots of the measured (blue circles) and predicted (red circles) surface currents (left panel) and bottom currents (right panel). Data covers the 1st January to 31st May 1999 period.

4 REGIONAL ENVIRONMENTAL DATA FOR APSARA A PLATFORM

4.1 Wind data

To generate current data as input into the sediment model for this study, HYDROMAP (model) was re-run from September 2012 to April 2013. To drive the model, historic wind data (September 2008 to April 2009) and future tidal conditions for 2012 – 2013 was used as input. This is a common hydrodynamic modeling approach, as the tides can be predicted well into the future and historic winds are representative of future winds.

The assumption that the wind data used to force the circulation model is considered representative of future years was confirmed by the Woods Hole Group (2004) report. The report presents 12 years of wind measurements at the Satun processing platform and found a high level of consistency between the years, due to the timing of the monsoons seasons and other climatic conditions.

Figure 8 shows the monthly and seasonal data (as wind roses) for the closest Global Forecast System (GFS) model station point to Apsara A platform (see location in Figure 1). Note the convention for defining current direction is the direction the wind blows **FROM**, which is used to reference wind direction throughout this report. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Eight directions are used. The branches are divided into segments of different thickness, which represent wind speed ranges from that direction. Speed ranges of 5 knots are used in these wind roses. The width of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction.

The data indicated that the winds at this station are relatively strong (mean 9.9 knots; maximum 28 knots) and vary seasonally.

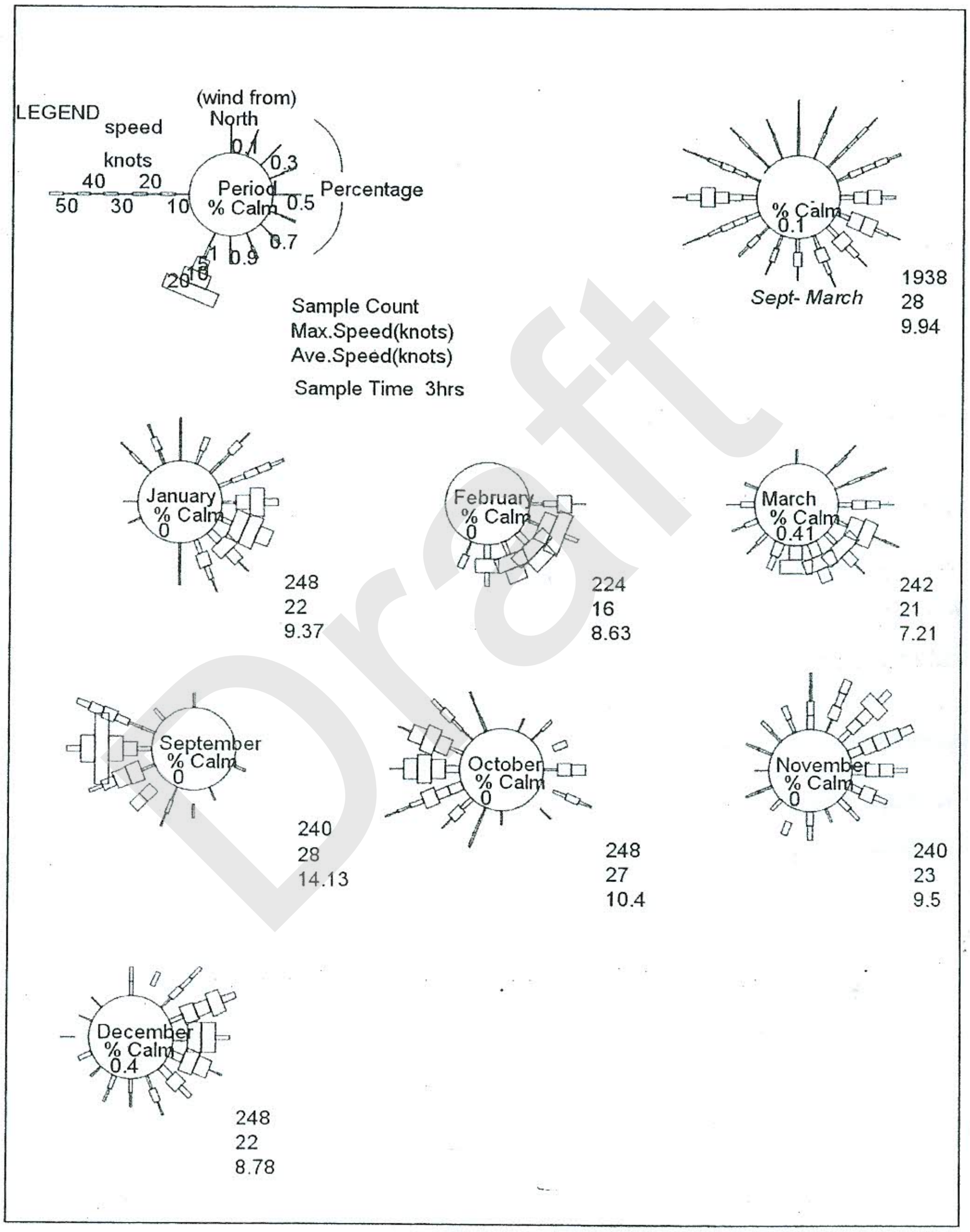

Figure 8: Monthly and seasonal wind rose distributions according the closest wind station from the Global Forecast System (GFS) model to the Apsara A platform. The wind data is based on September 2008 - March 2009.

Note the wind data is sourced from the National Centres for Environmental Predictions (NCEP) Global Forecast System (GFS) model. The data is the integration of extensive historic and observed atmospheric data into a state-of-the-art atmospheric model. This data product is recognized as one of the leading global wind forecast systems now available and has been shown to provide good forecast capabilities, especially for offshore regions (Zigic *et al.*, 2009).

4.2 Current data

Figure 9 shows the predicted monthly surface and bottom current roses at Apsara A platform. Note the convention for defining current direction is the direction the current flows **TO**, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Eight directions are used. The branches are divided into segments of different thicknesses, which represent current speed ranges for each direction. Speed intervals of 15 cm/s are used in these current roses. The width of each segment within a branch is proportional to the frequency of currents flowing within the corresponding range of speeds for that direction.

The data indicated that the currents at this site vary seasonally and with depth. The strongest surface currents speed was 137 cm/s in comparison to the bottom current speeds of 48 cm/s (see Figure 9). Surface currents demonstrated greater change in mean and maximum speeds due to the influence of the wind stress upon the water surface.

The major axes of the currents run in a northwest to southeast direction, which is in-line with the major tidal orientation. However, there are many episodes where the winds forced the surface currents in varying directions. In October the surface currents were predominately flowing to the south-southeast, signifying the influence of the south-westerly monsoon winds and the clockwise gyre. Alternatively, for the months of November to February the currents flowed predominately to the north and northwest, indicative of the northeast monsoon winds and the anti-clockwise gyre.

Figure 10 shows the predicted current speeds for the surface and bottom waters at Apsara A platform as time-series graphs between October 2012 to March 2013.

Figure 11 shows screenshots of predicted flood and ebb surface current vectors (or arrows) during February 2013 adjacent to the Apsara A platform. The proximity of the current vectors change with the grid resolution between and the coastal and offshore waters, with the highest resolution occurring along the coastline. The colour of the vectors represent current speed (i.e. a red vector represents a speed of 0.9-1.0 m/s).

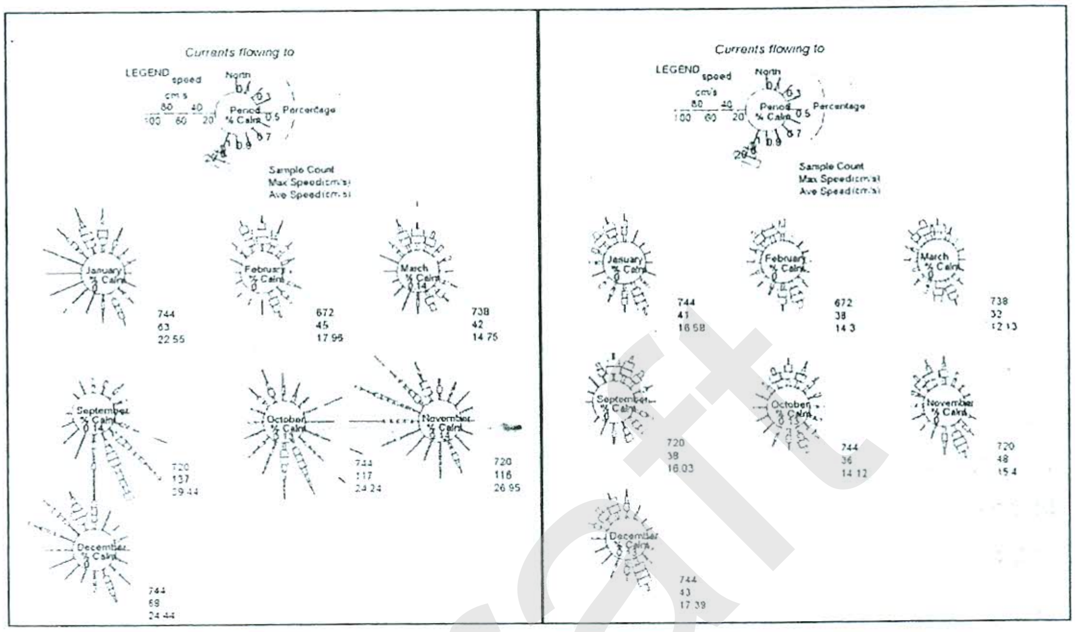

Figure 9: Monthly current roses for the surface waters (left image) and bottom waters (right image) adjacent to the Apsara A platform. The current roses are based on predicted currents between October 2012- March 2013.

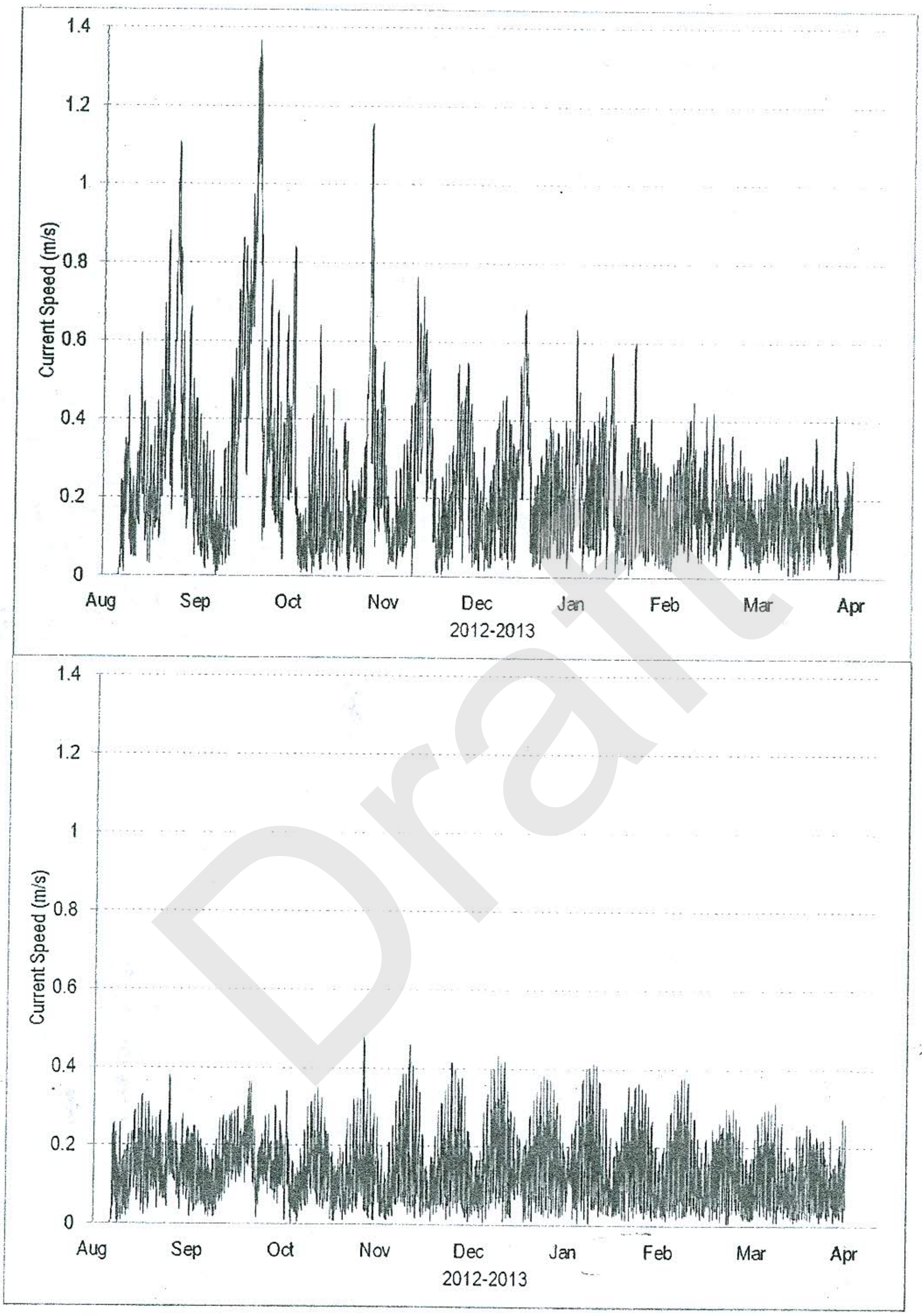

Figure 10: Predicted current speeds for the surface waters (upper image) and bottom waters (lower image) during October 2012 – March 2013, at Apsara A platform.

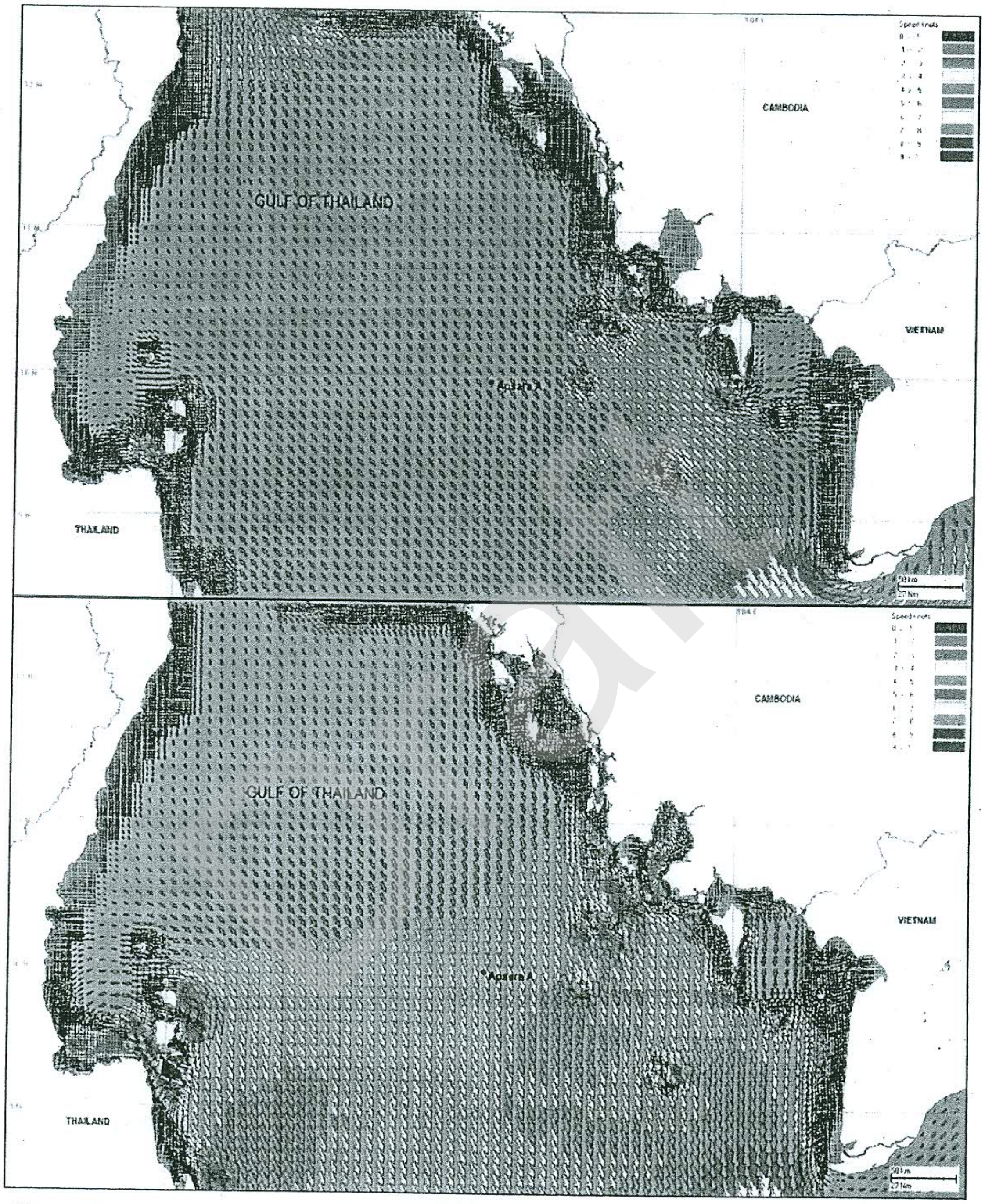

Figure 11: Sample screenshots of the predicted surface current vectors during a flood tide (top image) and ebb tide (bottom image) during February 2013. Note distance of the current vectors (or arrows) vary with grid resolution and the highest resolution occurs along the coastline.

Jet Phase	Densimetric Froude number Fr_o: $Fr_o = \frac{u_o}{\sqrt{g^{'} d_o}}$ where: u_o is the effluent exit velocity, d_o is the diameter of the discharge outlet and $g^{'}$ is the reduced gravitational acceleration.	Jet like (F>2) or plume like (F<2)
	Trajectory of a buoyant jet: $\frac{z}{L_b} = f\left(\frac{x}{L_b}, Fr_o, \frac{d_o}{L_b}\right)$ where: z is the vertical height of the plume centreline; Cross flow length scale $L_b = J_o/u_o^3$, where $J_o = u_o(d_o/2)^2 g$	Reference: Brandsma *et al.* (1992)
	Salinity: $\frac{d}{ds}(Q(S_d - S)) = E(S_d - S_a)$ Temperature: $\frac{d}{ds}(Q(T_d - T)) = E(T_d - T_a)$ where: Q is the total plume volume flux; T and S are the temperature and salinity of the fluid; T_d and S_d are the temperature and salinity of the discharged fluid; E is the rate of ambient fluid.	Reference: Brandsma *et al.* (1992)
	Separation of discharge fluid $G_i = 2C_i \lvert U - U_a \rvert rK$ where: G_i the rate the constituent leaves the plume; C_i - volume concentration; U plume centerline velocity vector; U_a ambient current vector; r plume radius and K is a coeffient.	Reference: Brandsma *et al.* (1992)
Dynamic	Magnitude of the collapse driving force $F_c = \frac{g}{6}\frac{d\rho_a}{dy}\left(1 - \frac{\lambda a_o}{a}\right)a^3$ where: F_c collapse driving force; g gravity; ρ_a density of ambient fluid; λ coefficient; and a is the radius attained in the initial descent; a_0 change in the radius attained in the initial descent.	Reference: Brandsma *et al.* (1992)

Collapse on the sea bed or sea surface	Plume collapsing on the sea bed $F_b = \frac{1}{2}(\rho - \rho_a) g a^2$ where: F_b collapse driving force; g gravity and ρ_a density of ambient fluid .	Reference: Brandsma *et al.* (1992)
Passive Dispersion	Concentration distribution $c(x,y,z) = \frac{q}{2\pi\sigma_y\sigma_z U}\exp\left(-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 - \frac{1}{2}\left(\frac{z-10}{\sigma_z}\right)^2\right)$ where $+\frac{q}{2\pi\sigma_y\sigma_z U}\exp\left(-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 - \frac{1}{2}\left(\frac{z+10}{\sigma_z}\right)^2\right)$ Where: q is the discharge rate; U is the current flow; σ_y and σ_z horizontal and vertical plume standard deviations and x, y and z are the coordinates along the direction of the plume movement, transverse to the direction of the plume movement and in the vertical respectively.	Dispersion of the particles would take on the form as described by Lewis (1997)
	Horizontal diffusion parameters $f_x = f_y = \sqrt{2K_h dt}$ where: K_h horizontal mixing coeffient; t is time and d is distance.	Reference: Bowden (1983); Webb (1982)
	Vertical diffusion parameters $f_z = \sqrt{2k_z dt}$ where: k_z is the vertical mixing coeffient; t is time and d is distance.	Reference: Bowden (1983); Webb (1982)

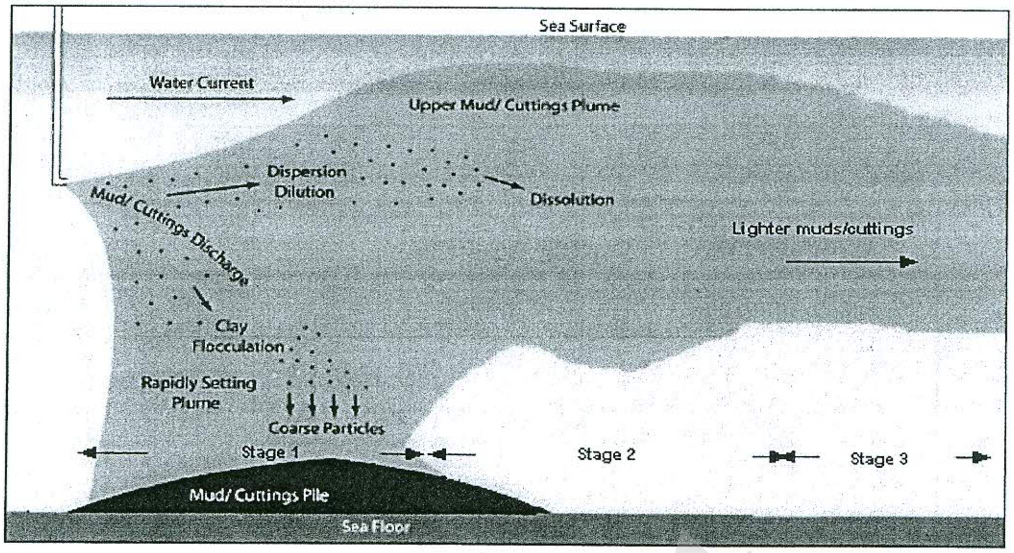

Figure 12: Conceptual diagram showing the general behaviour of cuttings and mud following the discharge to the ocean (Neff, 2005) and the idealised representation of the three discharge phases.

5.2 Drilling Program

The slim hole drilling method will be used for drilling the wells. As previously mentioned, the wells are to consist of surface, intermediate and production intervals. The surface holes (12.25" bore hole) will be drilled using WBMs, with the extracted drill cuttings and WBMs being returned directly to the seafloor from the annulus.

The intermediate intervals will be drilled using sea water with WBM sweeps. The production interval (6.125" bore hole) will be drilled using NAF. The cuttings and mud from the intermediate and production intervals will be brought to the surface through the riser for treatment using solids control equipment to recover mud. The cuttings and residual mud will be discharged overboard 1 metre below mean sea level (~70 m above the seafloor) from a vertically orientated 0.2 m discharge pipe.

Each well is to take 4 days to drill (6.5 days total well construction time), with 24 wells to be drilled from the Apsara A platform. As part of the modelling study it was assumed that the 24 wells will be drilled as 3 batches or 8 wells at a time. To begin with, the 8 wells will have their surface holes drilled, followed by 8 intermediate holes, followed by 8 production holes. This process is repeated then for the 8 wells of Batch 2 and the 8 wells of Batch 3. The drilling program should last approximately 6 months for the completion of all 24 wells. It should be made clear that this is simply an assumption made for the purpose of modelling. In reality, the batch size may change and there may be a few 4 string design wells depending on the results of previous batches.

Table 6 summarizes the estimated volume of cuttings and mud discharged for each well interval. Note the volume of residual NAFs is the estimated amount that adheres to the cuttings that is not removed by the solids control system.

Table 6: Estimate of the drill cuttings and spent drilling mud for each well.

Bore Diameter (inches)	***Well Interval***	***Discharge Method***	***Cuttings Volume Discharged (m^3)***	***Mud***		***Discharge Duration (Days)***
				Type	***Volume Discharged (m^3)***	
12 ¼ "	Surface Hole	WBM with cuttings returned directly to seafloor	20	WBM[a]	197	0.25
8 ½ "	Intermediate Hole	- Seawater with cuttings brought to a shale shaker on the drilling rig, then discharged to sea - WBM with cuttings brought to a shale shaker on the drilling rig, then discharged to sea	93	WBM	114*	0.75
6 1/8"	Production Hole	NAF and cuttings brought to a shale shaker and centrifuge on the drilling rig, then cuttings and residual mud discharged to sea	35	NAF[b]	90	3.0
	Total (for one well)		**148**		**401**	**4.0**

[a] *WBM – Water Based Mud*

[b] *NAF – Non-Aqueous Fluids*

* *Excludes sea water discharged.*

5.3 Discharge Input Data

The detailed input data used in the discharge model setup included:

- The density and particle size distribution;
- The relative temperatures, salinities and densities of the discharge and receiving waters;
- The rate of discharge of the whole cuttings and unrecoverable mud;
- The size and orientation of the discharge pipe;
- Discharge rate;
- The height of the discharge point relative to mean sea level; and
- Current and wind data to represent local physical forcing.

Table 7 shows a summary of the discharge configuration and the total estimated volume of cuttings and residual mud used as input into the model. The near seabed and sea surface discharges were modelled separately.

Table 8 shows the grain size distributions and associated settling velocities according to the type of mud used to drill each well interval. The detailed grain size data is based on cuttings samples analysed from an earlier Chevron drilling campaign (Moragot in 2007 and Maliwan in 2008, see APASA, 2008a; 2008b) in the Gulf of Thailand, using the same well design. For the intervals that will be drilled using WBM (surface and intermediate), the grain sizes are expected to vary between 0.00036 mm and 0.707 mm in diameter. The grain sizes of cuttings and residual NAF from the production interval are expected to range between 0.00036 mm to 1.41 mm in diameter. Fall velocities for the various size classes were derived from empirical data provided by Dyer (1986) in order to factor in the various sediments that will be produced from each operation.

Table 9 shows the composition of the sediment as a function of class for the well intervals drilled with water based mud and non-aqueous fluids. The table highlights that the material from the surface and intermediate intervals (cuttings and WBM) contained a greater portion of light and medium grain sizes, compared to the material from the production interval (cuttings and NAF). The reason is that the residual NAF attached to the cuttings causes the material to flocculate and aggregate after being discharged into the sea (Pivel *et al.*, 2009). WBM do not typically adhere to the cuttings after discharge (Terrens *et al.*, 1998).

A cuttings density of 2,600 kg/m^3 and a drilling mud (barite) density of approximately 4,200 kg/m^3 were specified as part of the model input parameters. It is important to note that grain size has a significantly greater influence on the rate of settling than density (Neff, 2005).

Table 7: Input data used for the drill cuttings and residual drilling mud dispersion modelling.

Total Wells to be drilled	24
Latitude	9° 56' 44.405" North
Longitude	102° 14' 50.969" East
Water depth (m)	71 m
Proposed Schedule (start date)	October 2012 (drilling program should last 6.2 months)
Drilling method	Slim Hole (see Table 8 for particle grain size)
Drill cuttings release amount near seabed	480 m^3
Drilling mud release amount near seabed	4,728 m^3
Drill cuttings release amount at sea surface (m^3)	3,072 m^3
Drilling mud release amount at sea surface (m^3)	4,896 m^3 (2,736 m^3 WBM; 2,160 m^3 NAF)
Discharge duration (days)	4 days per well (96 days for 24 wells) Not continuous discharge
Depth of discharge pipe below mean sea level (m)	1 m
Discharge pipe orientation	Vertical-downward
Diameter of discharge pipe (m)	0.2 m

Table 8: Grain size distribution and associated settling velocities according to the mud type used to drill the well interval.

Size Class	Grain size (mm)	Settling Velocity (cm/s)	Surface and intermediate well sections consisting of WBM and cuttings (composition %)	Production well section consisting of NAF and cuttings (composition %)
Very heavy	1.4100	20.05	0.00	0.20
	1.0000	14.6	0.00	0.74
	0.7071	11.03	0.10	4.37
	0.5000	7.70	1.20	13.06
	0.3536	5.20	2.40	19.31
	0.2500	3.40	3.80	12.84
Heavy	0.1768	2.10	5.10	6.73
	0.1250	1.30	6.60	6.92
	0.0884	0.70	8.10	11.45
	0.0625	0.40	9.10	5.70
	0.0442	0.20	9.20	3.29
	0.0313	0.10	8.60	3.29
Medium	0.0221	0.05	7.80	1.13
	0.0156	0.02	7.00	1.13
	0.0110	0.01	6.50	0.92
	0.0078	0.006	6.10	0.92
	0.0055	0.003	5.04	1.30
	0.0039	0.002	4.80	1.30
Light	0.0028	0.0007	3.80	0.65
	0.0020	0.0004	2.50	0.65
	0.0014	0.0002	0.90	0.82
	0.0010	0.0001	0.59	0.82
	0.0007	0.00005	0.46	0.82
Very Light	0.0005	0.000025	0.28	0.82
	0.00036	0.00001	0.03	0.82

Table 9: Portion (%) of sediment as a function of size class and mud type used to drill the well interval.

Sediment class ***(Size range in mm)***	***Surface and intermediate well sections consisting of WBM and cuttings (composition %)***	***Production well section consisting of NAF and cuttings (composition %)***
Very heavy (0.25 mm – 1.41 mm)	7.50	50.52
Heavy (0.0313 mm – 0.1768 mm)	46.70	37.38
Medium (0.0039 mm – 0.0221 mm)	37.24	6.70
Light (0.0007 mm – 0.0028 mm	8.25	3.76
Very light (0.00036 mm – 0.0005 mm)	0.31	1.64

5.4 MUDMAP Grid Configuration

MUDMAP uses a three-dimensional grid to represent the geographic region under study (water depth and bathymetric profiles). Due to the sediment travelling a much further distance when discharged at the sea surface, two varying grids extents were configured to compute the likely bottom thicknesses, and then combined soon after.

A 10 m x 10 m horizontal cell size was used to predict the concentrations from the near-seabed releases. The extent of the grid was 8.9 km (longitude, x-direction) by 10 km (latitude, y-direction) area.

A 15 m x 15 m horizontal cell size was used for the sea surface releases. The grid extent was 14.6 km (longitude or x-axis) by 14.6 m (latitude or y-axis).

5.5 MUDMAP Mixing Parameters

For the cuttings and mud discharged at the sea surface, the turbulence parameters used by the model were set to 0.1 m^2/s in the vertical and 0.25 m^2/s for the horizontal, based on previous studies by Copeland (1996). The vertical parameter is also used to account for the influence of wave-induced turbulence.

For the discharge of cuttings near the seabed, the horizontal parameter was kept at 0.25 m^2/sec, however, a very low vertical parameter was set (0.0001 m^2/sec), as it is considered insignificant 2 m above the seabed.

5.6 Natural Sedimentation Rate (Model Output)

An extensive field study by Srisuksawad *et al.* (1997) had found that the natural sedimentation rate for the Gulf varied between 0.56 mm/year to 1.96 mm/year. For this study the lower rate of 0.56 mm/year was used to calculate the thickness of the naturally occuring deposition layer during the each batch discharge operation. This equated to a thickness of 0.07 mm over the approximate 50-day period. Hence, a minimum threshold of 0.07 mm was set for the analysis presented below.

6 RESULTS

6.1 Near Seabed and Surface Discharges

Figure 13, Figure 15 and Figure 17 show the predicted thickness (greater than 0.07 mm threshold) and coverage on the seafloor from Batch 1 – 3 near seabed discharges. The results are based on a 9 day discharge after drilling 8 wells per batch.

The model results showed that due to the height of release (2 m above the seabed), the currents had little to no effect on the very heavy sediment (greater than 0.25 mm diameter) which raidly settled within 50 m from the release site. The currents did have an effect on the transport of the lighter sediment (less than 0.25 mm diameter), carrying and depositing the material greater than 3 km from the release site.

Typically the sediment was deposited along a northwest to southeast line, which corresponds with the major tidal axis at the exploration well. Interestingly, the results for Batch 1 (Figure 13) showed some of the material had deposited to the northeast of the well location, likely a result of the change in season and water circulation.

Table 10 presents the maximum bottom thickness, area of coverage (above 0.07 mm thickness threshold) and the maximum distances from the platform to the extent of the 0.07 mm threshold contour. The maximum thickness (or height of mound) ranged between 458 mm to 759 mm. The area of coverage on the seafloor varied from 1.28 km^2 during Batch 1 conditions to 1.57 km^2 during Batch 2 conditions. The maximum distance from the platform to the 0.07 mm threshold contour was 3.57 km. The minimum distance from the closest island Poulo Wai (Figure 1) to the 0.07 mm threshold contour was 67.88 km.

Figure 14, Figure 16, Figure 18 show the predicted thickness (greater than 0.07 mm threshold) and coverage on the seafloor from Batch 1 – 3 sea surface discharges. The results are based on a 41 day discharge after drilling 8 wells per batch.

Modelling showed that the higher release point (approximately 70 m above the seabed), permitted the prevailing currents to carry the slower settling material (<0.08 mm diameter) over a much larger area than the near seabed discharges. Similar to the seabed releases, the material settled in a predominately northwest to southeast direction, which corresponds with the major tidal axis.

Table 11 is a summary of the maximum bottom thickness, area of coverage (above 0.07 mm thickness threshold) and the maximum distances from the platform to the extent of the 0.07 mm threshold contour. The maximum thickness (or height of mound) ranged between 9.08 mm to 13.3 mm. The area of coverage on the seafloor varied from 3.77 km^2 during Batch 2 conditions to 4.01 km^2 during Batch 3 modelled conditions. The maximum distance from the platform to the 0.07 mm threshold contour was 4.25 km. The minimum distance from Poulo Wai (Figure 1) to the 0.07 mm threshold contour was 67.63 km.

*Table 10: Summary of the predicted maximum bottom thickness, area of coverage and maximum distance from the site to deposited sediment above 0.07 mm threshold from **near seabed discharges**. Results are based on a 9-day discharge of material from 8 wells per batch.*

Batch	***Maximum bottom thickness (mm)***	***Total area of coverage (km^2)***	***Maximum distance from the release site to the extent of the 0.07 mm threshold contour (km)***	***Distance from Poulo Wai Island to the 0.07 mm threshold contour (km)***
Batch 1	568	1.28	2.73	67.88
Batch 2	759	1.57	3.12	68.23
Batch 3	458	1.32	3.57	68.31

Table 11: Predicted maximum bottom thickness, area of coverage and maximum distance from the site to deposited sediment above 0.07 mm threshold from ***surface discharges****. Results are based on a 41-day discharge of material from 8 wells per batch.*

Batch	***Maximum bottom thickness (mm)***	***Total area of coverage (km^2)***	***Maximum distance from the release site to the extent of the 0.07 mm threshold contour (km)***	***Distance from Poulo Wai island to the 0.07 mm threshold contour (km)***
Batch 1	10.5	3.86	3.15	68.16
Batch 2	9.08	3.77	4.25	67.76
Batch 3	13.3	4.01	3.93	67.63

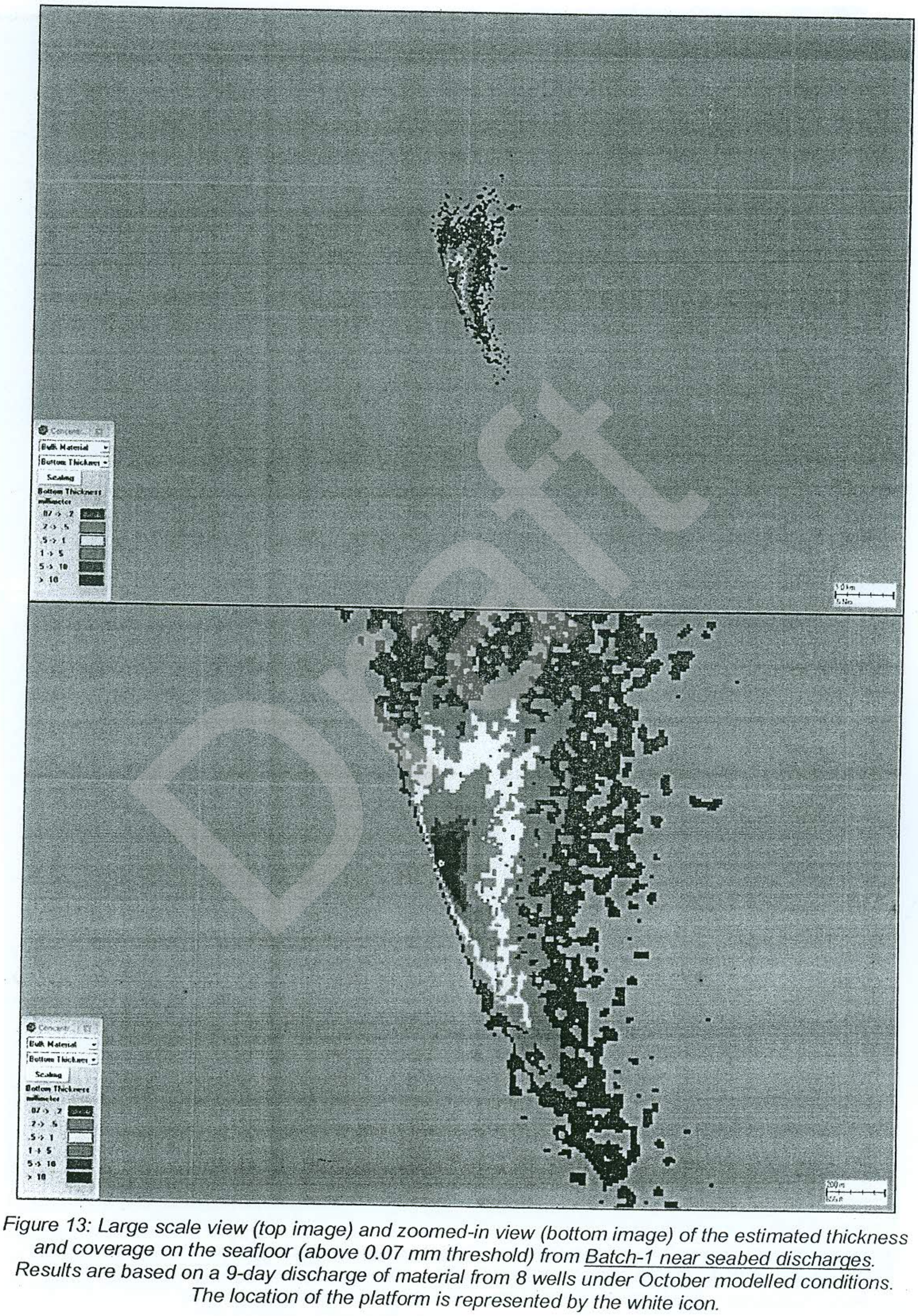

Figure 13: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from <u>Batch-1 near seabed discharges</u>. Results are based on a 9-day discharge of material from 8 wells under October modelled conditions. The location of the platform is represented by the white icon.

Figure 14: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from Batch-1 surface discharges. Results are based on a 41-day discharge of material from 8 wells under October - November modelled conditions.. The location of the platform is represented by the white icon.

Figure 15: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from Batch-2 near seabed discharges. Results are based on a 9-day discharge of material from 8 wells under November modelled conditions. The location of the platform is represented by the white icon.

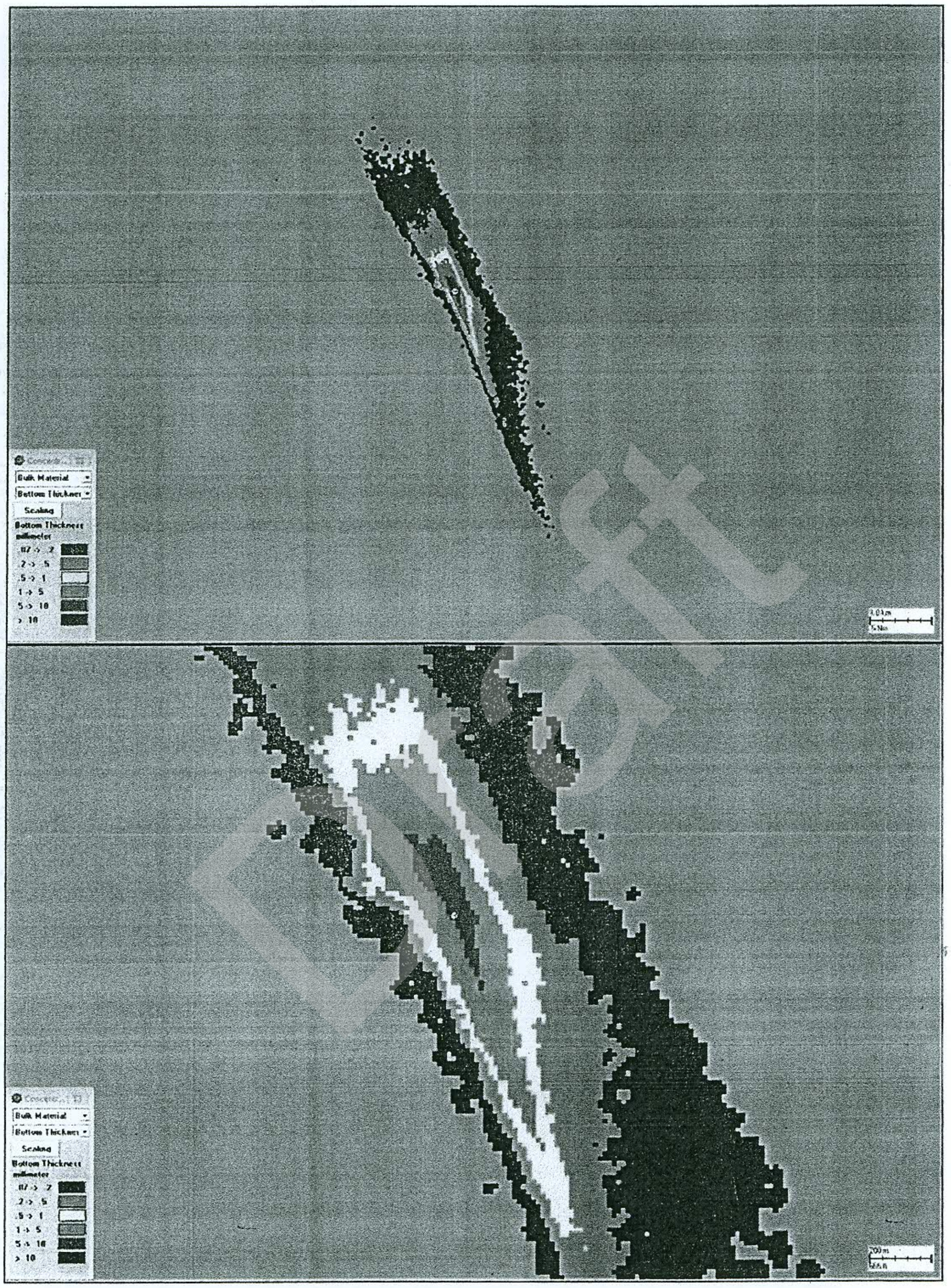

Figure 16: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from <u>Batch-2 surface discharges</u>. Results are based on a 41-day discharge of material from 8 wells under November to January modelled conditions. The location of the platform is represented by the white icon.

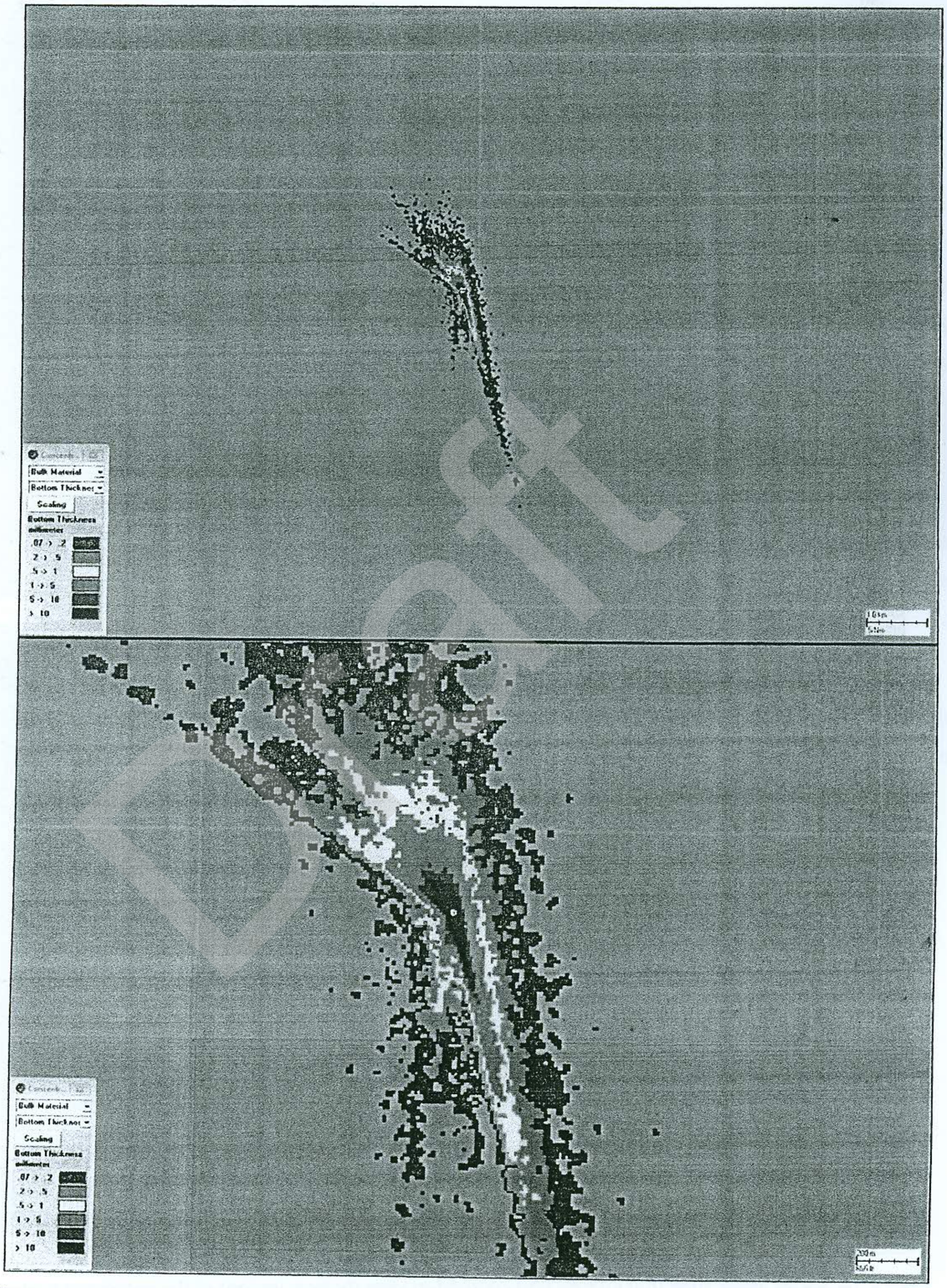

Figure 17: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from Batch 3 near seabed discharges. Results are based on a 9-day discharge of material from 8 wells under January modelled conditions. The location of the platform is represented by the white icon.

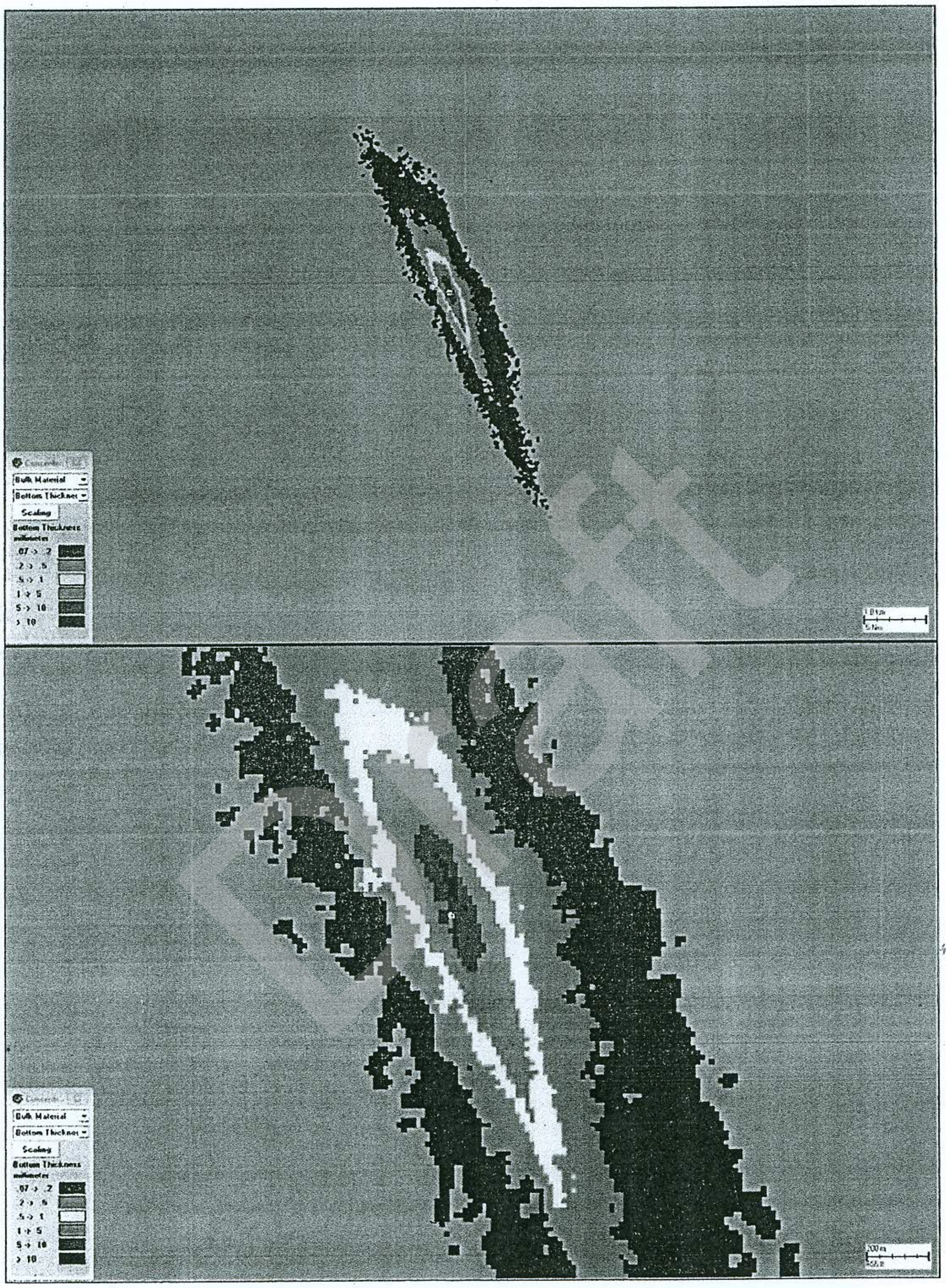

Figure 18: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from Batch 3 surface discharges. Results are based on a 41-day discharge of material from 8 wells under January to February modelled conditions. The location of the platform is represented by the white icon.

6.2 Total Accumulated Thickness

Figure 19 shows the estimated bottom thickness and seafloor coverage when the seabed and sea surface discharges from all 3 batches (each batch of 8 wells) are combined. The results are based on material discharged from 24 wells over the 6 month drilling campaign modelled.

Figure 20 shows the matching cross sectional view along the northwest to southeast axis, within 500m either side of the release site. Note the vertical scale is greatly exaggerated. The figure highlights the mounding adjacent to the release site and the exponential decline of the bottom thickness further away. The predicted maximum bottom thickness from the combined discharges was 1759.70 mm occurring immediately adjacent the well location (< 10 m). This is a worst case scenario, as further dispersion and resuspension of of settled material is likely.

Table 12 is the corresponding predicted area of coverage and percentage of coverage as a function of thickness. The total area of exposure was 12.54 km^2. About 6.68 km^2 of the area has a thickness between 0.07 mm – 0.2 mm or (45% of the seafloor coverage). Approximately, 0.95 km^2 (or 0.075%) of the seafloor coverage consists of sediment greater than 1 mm.

Table 13 shows the distance from the nearest sensitive receptor (Poulo Wai island) to the extent of the 0.07 mm and 1.0 mm thickness contour. As seen below, the 0.07 mm thickness contour is 67.03 km west from Poulo Wai.

No trans-boundary impacts are predicted to occur.

Table 12: Predicted area of coverage and percentage of coverage for each thickness range. Estimates are based on the entire 6 month, 24 well drilling campaign at Apsara A platform.

Thickness range (mm)	**Area of coverage (km^2)**	**Percentage of area covered**	**Maximum distance (km) from the release site to the contour extent**
0.07 - 0.2	6.88	54.84	5.70
0.2 - 0.5	3.57	28.46	3.92
0.5 - 1	1.14	9.05	2.40
1 - 5	0.75	6.01	1.56
5 - 10	0.09	0.73	0.60
>10	0.11	0.90	0.43
Total	**12.54**	**100**	

Table 13: Distance from the nearest sensitive receptor (Poulo Wai island) to the extent of the thickness contour. Estimates are based on the entire 6 month, 24 well drilling campaign at Apsara A platform.

Thickness contour (mm)	**Distance to Poulo Wai (km)**
0.07	67.03
1	68.71

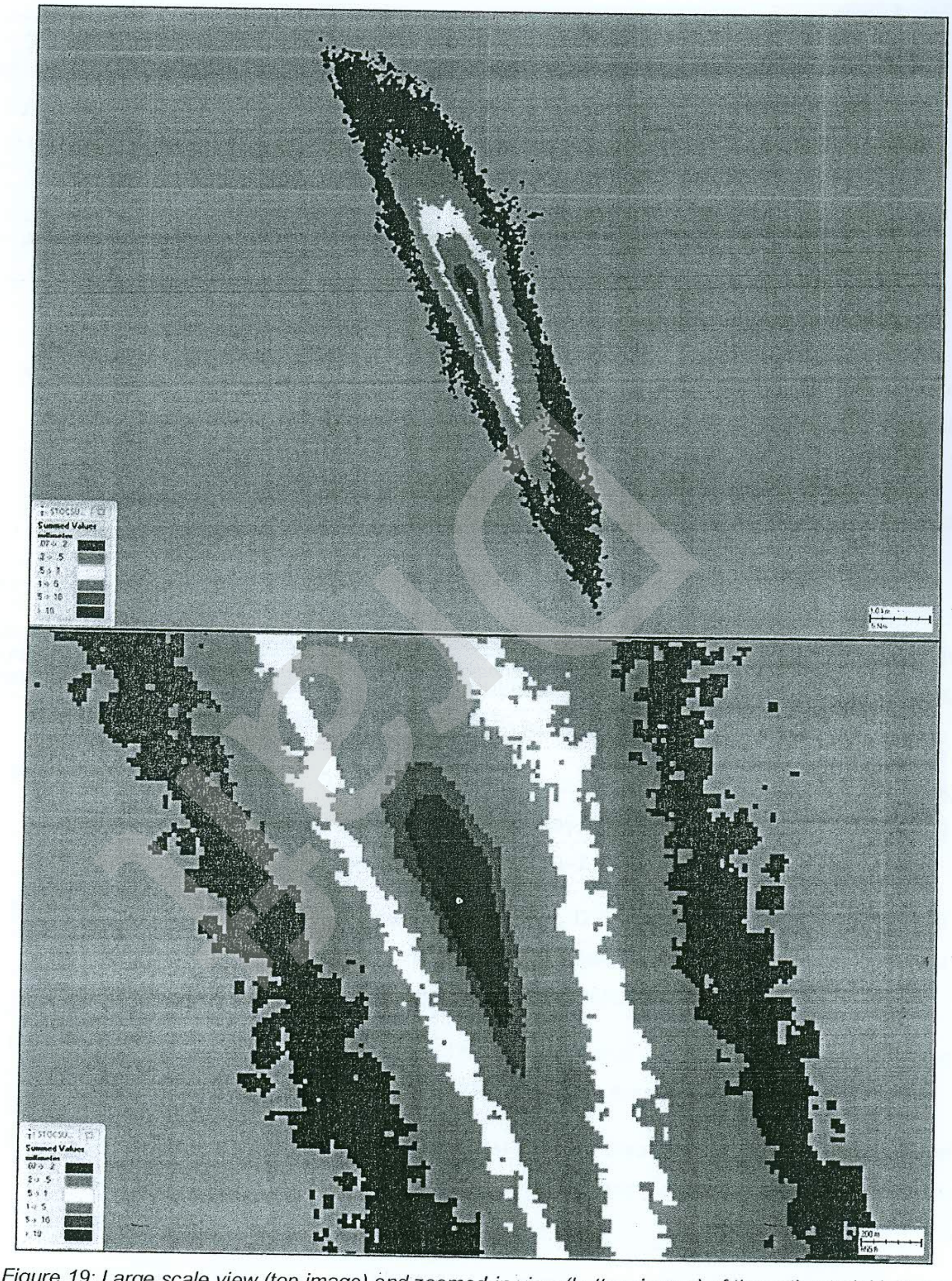

Figure 19: Large scale view (top image) and zoomed-in view (bottom image) of the estimated thickness and coverage on the seafloor (above 0.07 mm threshold) from near seabed and surface discharges for <u>all 3 drilling batches</u>. Results are based on material discharged from 24 wells over a 6 month drilling campaign modelled. The location of the well is represented by the white icon.

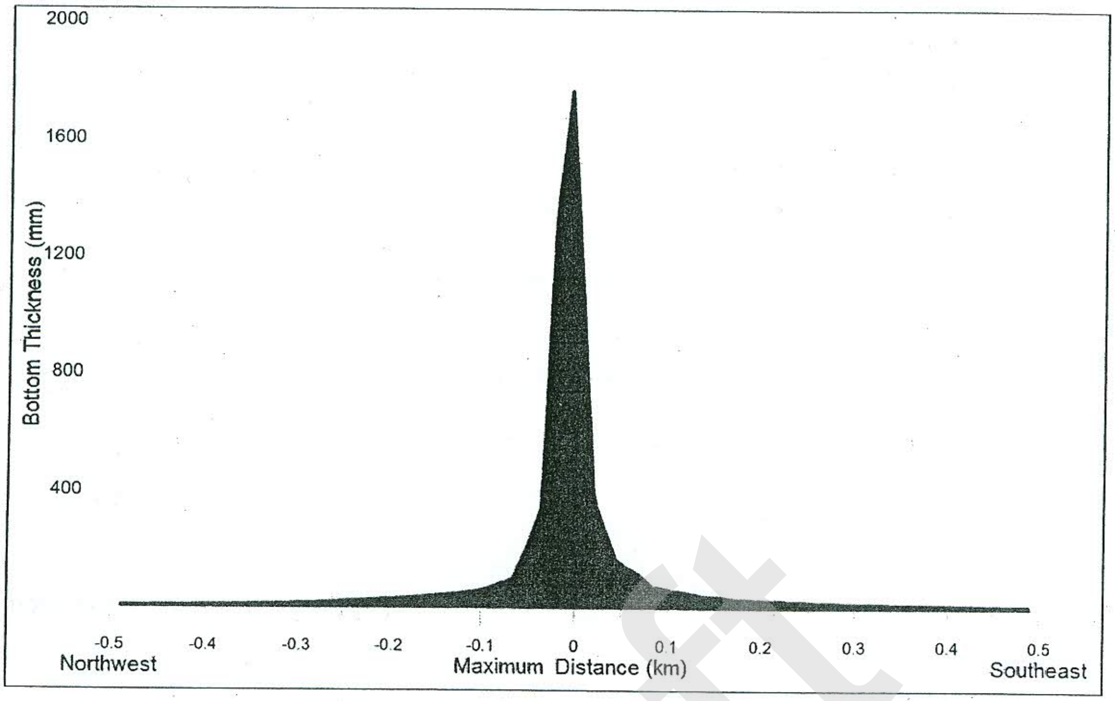

Figure 20: Cross section view of predicted thicknesses along the long axis (northwest to southeast) from near seabed and surface discharges for all 3 batches. Results are based on material discharged from 24 wells over the 6 month drilling campaign modelled. Note the vertical scale is exaggerated.

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8 APPENDIX A

8.1 Wind Data for the Model Validation – Study 1

The historic wind data for the hydrodynamic model validation study were sourced from the National Centers for Environmental Predictions (NCEP), NOAA-CIRES Climate Diagnostics Center in Boulder, Colorado. The NCEP wind data is the integration of extensive historic and observed atmospheric data into a state-of-the-art atmospheric model with global coverage predictions at 6-hourly intervals. The model includes parameterizations of all major physical processes, including convection, large-scale precipitation, shallow convection, gravity-wave drag, radiation with diurnal cycle and interaction with clouds, boundary layer physics, an interactive surface hydrology, and vertical and horizontal diffusion processes. Near-real time observations are used to self-correct the model predictions to provide an archive of corrected weather data (Cox *et al.,* 1998). The archived re-analysed data have proven to be a highly reliable descriptor of wind-fields over the Gulf region (Chotamonsak and Kreasuwun, 2008).

Furthermore, the NCEP wind data for 2004 was validated and accepted by TREMI as input for the land-bridge oil spill project. The validation process involved comparing the NCEP historic wind speeds and directions to measured data by the Thai Meteorological Department.

Table 14: Comparison of the NCEP historic wind speeds (knots) to measured data by the Thai Meteorological Department (TMD).

Location	March-April		May-August		September-October		November-February	
	TMD	NCEP	TMD	NCEP	TMD	NCEP	TMD	NCEP
Upper Gulf	5.2	5.4	6.5	6.7	6.4	4.4	8.5	9.4
Lower Gulf Nearshore	8.9	8.0	8.4	9.8	9.9	8.6	10.2	12.0
Lower Gulf Offshore	9.6	10.4	9.4	11.7	10.6	8.6	10.8	12.2