PART 2

PILOT PROJECT

CHAPTER 7 OBJECTIVES OF PILOT PROJECT

7.1 Objectives of Pilot Project

This chapter and the next two chapters (Chapters 8 and 9) describe the pilot project activities implemented in the fall of 2006. The focus of the pilot project was capacity development for environmental monitoring.

The pilot project of this study has two components, which are (i) examination of the environmental monitoring plan, trial sampling and analysis, and (ii) remote sensing and GIS technologies in environmental management. The objectives of the pilot project are:

- To implement activities contributing to future development of monitoring activities by Atyrau MoEP and the Atyrau HYDROMET Centre, which is the parent body of the Regional Environmental Monitoring Centre, and
- To support the introduction of remote sensing and GIS technologies for environmental monitoring in the northern Caspian Sea.

7.2 Design of the Pilot Project

Based on the objectives, activities suitable as pilot project and also address the existing monitoring activity issues described in Section 5.5 and 5.6, were selected as shown in Table 7.2.1.

Table 7.2.1(1/2) Activities Implemented in Pilot Project to Tackle Existing Issues

<table>
<tr><th rowspan="2">Existing Issues</th><th colspan="2">Possible Actions through the Pilot Project</th></tr>
<tr><th>Examination of Environmental Monitoring Plan, Trial Sampling and Analysis</th><th>Remote Sensing and GIS Technologies in Environmental Management</th></tr>
<tr><td colspan="3">Monitoring of Ambient Environment (Organizational Aspects)</td></tr>
<tr><td>Clarification of demarcation of monitoring on the Caspian Sea among relevant organizations</td><td>- Examination of environmental monitoring plan for the Regional Monitoring Centre and Atyrau MoEP.</td><td>-</td></tr>
<tr><td>Examination for the purposes of adding monitoring parameters regarding oil derived pollutants</td><td>- Implement hydrocarbon analysis in air quality monitoring.
- Implement analysis of TPH and PAHs in Japan.</td><td>-</td></tr>
<tr><td>Renovation of monitoring plans for development of oil fields off-shore and petroleum relevant facilities on-shore</td><td rowspan="3">- Prepare proposal on environmental monitoring plan for the Regional Monitoring Centre and Atyrau MoEP.
- Water and sediment quality monitoring considering existing and expected main pollution sources in the near future.</td><td>-</td></tr>
<tr><td>Setting of representative sampling points in the northern Caspian Sea</td><td>-</td></tr>
<tr><td>Fixing of sediment sampling points</td><td>-</td></tr>
<tr><td>Setting of air quality monitoring points outside Atyrau city</td><td>- Examination of environmental monitoring plan for the Regional Monitoring Centre and Atyrau MoEP.
- Air quality monitoring outside Atyrau city.</td><td>-</td></tr>
<tr><td colspan="3">Monitoring of Ambient Environment (Technical Aspects)</td></tr>
<tr><td>Securing of technical measures to collect regional information from areas where access is difficult.</td><td>-</td><td>- Provision of training regarding satellite image analysis to identify soil pollution area.</td></tr>
</table>

Table 7.2.1(2/2) Activities Implemented in Pilot Project to Tackle Existing Issues

<table>
<tr><th rowspan="2">Existing Issues</th><th colspan="2">Possible Actions through the Pilot Project</th></tr>
<tr><th>Examination of Environmental Monitoring Plan, Trial Sampling and Analysis</th><th>Remote Sensing and GIS Technologies in Environmental Management</th></tr>
<tr><td colspan="3">Monitoring of Ambient Environment (Technical Aspects)</td></tr>
<tr><td>Improving the technical expertise for monitoring of petroleum derived pollutants</td><td>- Provide a lecture related to analysis of petroleum derived pollutants.</td><td>-</td></tr>
<tr><td>Assuring the reliability of the analytical laboratory</td><td>- Analysis of heavy metals with certified material</td><td></td></tr>
<tr><td colspan="3">Monitoring of pollution source (Organizational Aspects)</td></tr>
<tr><td>Formulation of pollution source monitoring plans depending on the condition of relevant petroleum industry facilities</td><td>- Examination of environmental monitoring plan for the Regional Monitoring Centre and Atyrau MoEP.</td><td>-</td></tr>
<tr><td>Set important monitoring parameters for pollution source monitoring</td><td>- Examination of pollution monitoring plan for Atyrau MoEP.</td><td>-</td></tr>
<tr><td colspan="3">Monitoring of pollution source (Technical Aspects)</td></tr>
<tr><td>Improving technical expertise for monitoring of petroleum derived pollutants</td><td rowspan="2">- Provide a lecture related to analysis of petroleum derived pollutants and constituents of petroleum.
- Soil pollution monitoring</td><td>-</td></tr>
<tr><td>Improving technical expertise for analysis of constituents of petroleum and interpretation of analytical results</td><td>-</td></tr>
<tr><td colspan="3">Monitoring after oil spill cases (Technical Aspects)</td></tr>
<tr><td>Introduction of technical measures to implement rapid and continuous monitoring after oil spill cases</td><td>-</td><td>- Provision of training regarding satellite image analysis to monitor oil spill conditions.</td></tr>
<tr><td colspan="3">Dissemination of monitoring information to various stakeholders (Organizational aspects)</td></tr>
<tr><td>Securing of tools to disseminate monitoring information from the Regional Environmental Monitoring Centre</td><td>- Securing of tools to disseminate monitoring information from the Regional Environmental Monitoring Centre</td><td>- Securing of tools to disseminate monitoring information from the Regional Environmental Monitoring Centre</td></tr>
<tr><td>Providing knowledge of database for the Atyrau Hyderomet Centre and Atyrau MoEP</td><td>-</td><td>- Holding of mini-workshop to provide knowledge of GIS database in Atyrau</td></tr>
<tr><td colspan="3">Dissemination of monitoring information to various stakeholders (Technical aspects)</td></tr>
<tr><td>Examination of the development for the GIS database to combine the various monitoring information.</td><td>-</td><td>- Preparation of GIS database to store and distribute the combined information on existing petroleum related facilities and resources, natural environmental conditions, and environmental monitoring.</td></tr>
</table>

Source : JICA Study Team

7.3 Main Joint Work through Pilot Project

As mentioned in Section 7.1, the pilot project has the following two components:

- Examination of the environmental monitoring plan and trial sampling and analysis
- Remote sensing and GIS technologies in environmental management

The component of examination of the environmental monitoring plan and trial sampling and analysis included joint planning of trial sampling and analysis, sampling, field measurements, laboratory analysis, lectures and mini-workshops. The results of the monitoring activities were incorporated into the GIS database, which is stored at KAZHYDROMET in Almaty and Information and Analytical Centre of MoEP in Astana. The information was disseminated to stakeholders through the study's newsletter. The read-only version of the electronic database was handed to Atyrau MoEP, Atyrau HYDROMET Centre and the central MoEP so that they can assimilate them into their environmental management activities, and it is expected that they will disseminate the data to wider audience through official channels, such as the annual environmental report prepared by Ayurau MoEP.

The pilot project also introduced remote sensing technologies to analyze environmental conditions and transport of oil slicks using high-resolution satellite images. This was carried out through a series of technical training sessions for the staff of KAZHYDROMET. In addition, an environmental GIS database was developed based on available information provided by MoEP and other relevant organizations.

With respect to remote sensing and GIS technologies in environmental management, there is still a large information and technological gap between the central organizations and organizations involved in daily monitoring and pollution control activities. Therefore, two mini-workshops were organized in Atyrau in order to close this gap by presenting general information on the technologies used and outputs obtained through the pilot project.

The main joint-works implemented through the pilot project activities are summarized in Table 7.3.1.

Table 7.3.1 Main Joint-work Implemented through the Pilot Project

Component	Work Item	Period	Participants for Joint-work	Measures
1.Environmental Monitoring Activity	(1) Water and sediment quality monitoring	Oct. to Nov. 2006 Sampling : 14th, 16th, and 20th to 21st Oct.	Atyrau MoEP Atyrau HYDROMET	Planning and sampling: Joint-work Analysis: Sub-contract work named "Environmental Monitoring (off-shore) Survey"
	(2) Air quality monitoring	Oct. to Nov. 2006 Sampling : 26th to 27th Oct.	Atyrau MoEP Atyrau HYDROMET	Planning and sampling: Joint-work Analysis: Sub-contract work named "Environmental Monitoring (on-shore) Survey"
	(3) Soil quality monitoring	Oct. to Nov. 2006 Sampling : 19th to 29th Oct.	Atyrau MoEP	Planning and sampling: Joint-work Analysis: Sub-contract work named "Environmental Monitoring (on-shore) Survey"
	(4) Lecture on petroleum derived pollutants analysis	24th Oct. 2006	Atyrau HYDROMET	Lecture
	(5) Mini-workshop for discussion on needs of Regional Monitoring Centre	27 Oct. 2006	Atyrau MoEP KAZGYDROMET Atyrau HYDROMET Atyrau AKIMAT Fishery Department Emergency Response Department	Presentation and discussion in mini-workshop
	(6) Analytical training with certified reference material	1st to 3rd Nov.2006	Atyrau MoEP Atyrau HYDROMET	Lecture and practical training in laboratory
2. Remote sensing and GIS technologies in environmental management	(1) Technical transfer training on satellite image analysis	18th Oct. to 17th Nov.2006	Atyrau HYDROMET	Lecture and practical training with ArcGIS 9
	(2) GIS database formulation	Oct. to Nov. 2006	MoEP (provision of information for GIS database)	Sub-contract work named "GIS Database Formulation"
	(3) Mini-workshop for introduction of remote sensing and GIS technologies in environmental management	8th and 9th Nov. 2006	Atyrau MoEP Atyrau HYDROMET Private petroleum industries	Presentation and discussion in mini-workshop

Source : JICA Study Team

CHAPTER 8 EXAMINATION OF ENVIRONMENTAL MONITORING PLAN AND TRIAL SAMPLING AND ANALYSIS

8.1 Activity Plan

The technical, organizational and institutional issues associated with environmental monitoring were discussed in Chapters 5 and 7. In order to develop capacity to tackle these issues, the following activities were planned and implemented from September to November 2006:

- Examination of the environmental and pollution source monitoring plan for the Regional Environmental Monitoring Centre and Atyrau MoEP
- Water and sediment quality monitoring
- Air quality monitoring
- Soil pollution monitoring
- Arrange a lecture about analysis of petroleum derived pollutants and constituents of petroleum
- Heavy metal analysis with certified materials

These activities were planned as summarized in Section 8.1. The details of the activities are explained from Chapter 8.2

8.1.1 Examination of the Environmental and Pollution Source Monitoring Plan for the Regional Environmental Monitoring Centre and Atyrau MoEP

In regard to the environmental monitoring, the following issues have been confirmed:

- Relevant organizations do not cooperate to improve the environmental monitoring in accordance with progress in the development of offshore oil fields and construction plans for related land-based petroleum facilities.
- Demarcation between relevant organizations for monitoring activities in the northern Caspian Sea is not clear.

To facilitate discussion about these issues and garner the opinions of relevant organizations on the environmental monitoring plan formulated, the following activities were planned:

- Daily discussion with the Atyrau HYDROMET Centre and Atyrau MoEP.
- Holding a mini-workshop to discuss the monitoring activities required of the Regional Environmental Monitoring Centre and cooperation among relevant organizations.

In regard to the mini-workshop, Atyrau MoEP invited the Department of Use and Control of Environment and Natural Resources (DUCER) of Atyrau Oblast, Fishery Department, and Emergency Response Department to join the discussion. The JICA Study Team also invited the central MoEP and the Atyrau HYDROMET Centre to the mini-workshop.

8.1.2 Water and Sediment Quality Monitoring Considerations for the Main Pollution Sources

(1) Water/Sediment Quality Monitoring

Water/sediment quality monitoring under the pilot project was planned and implemented considering the existing and future main pollution sources. The monitoring plan was designed based on discussions involving Atyrau HYDROMET Center, Atyrau MoEP and the JICA Study Team. The outline of the water/sediment quality monitoring plan is shown in Table 8.1.1.

Figure 8.1.1 Discussion for Planning of Water/Sediment Monitoring

Table 8.1.1 Plan for Water and Sediment Sampling and Analysis in the Northern Caspian Sea

Items	Monitoring Plan
Sampling Points	- The following items were considered when the sampling points were set. (a) Important areas to be monitored, such as the estuary of Ural River, which is the entrance point of the pollution load to the northern Caspian sea, and the Kashagan oil field, which may become one of major pollution sources in near future. (b) Regional Pollution Monitoring Program (RPMP) which should be implemented for international cooperation under CEP (c) Existing and past sampling points set by KAZHYDROMET and CEP to compare analytical results with past monitored data - Based on the examination, 10 sampling points were set.
Sampling Frequency	- Once in October 2006.
Analysed parameters	- Main targets were oil products, heavy metals (Pb, Cd, Cr, Ag, Cu, Zn), and nutrients (N, P).
Sampling and Field Analysis	- A vessel for sampling was hired from a transportation company due to difficulty in using Atyrau MoEP's vessel - Newly purchased field measurement equipment was used. - A new format for the recording of sampling and field analysis was prepared. - Pre-treatment measures followed GOST, based on internationally accredited measures.
Analysis	- The analytical laboratory of the regional monitoring centre and Atyrau MoEP had not been established prior to the pilot activity period, so laboratory analysis was sub-contracted. - Analytical methods followed GOST, based on internationally accredited measures.

Source: JICA Study Team

(2) Air Quality Monitoring

In regard to air quality monitoring, it was confirmed that outside Atyrau city there is no ambient environmental sampling point, which is required to monitor petroleum related pollutants. To gather air quality information in a wider area, an air quality monitoring activity was planned and implemented. The JICA Study Team had discussions with the Atyrau HYDROMET Centre and Atyrau MoEP to formulate a monitoring plan. The outline of the air quality monitoring plan is shown in Table 8.1.2.

Table 8.1.2 Air Monitoring Plan

Items	Formulated Monitoring Plan
Sampling Points	- The following items were considered when the sampling points were set: (a) Existing oil facilities to be monitored, such as Tengiz oil processing facility, and on-shore oil fields (b) Necessity to gauge the background concentration of air pollutants around Atyrau city (c) Future plan to construct an oil processing plant in the eastern area of Atyrau city by Agip KCO - Considering such items, 5 sampling points were set. Additionally 4 sampling points were set for NMHC monitoring.
Sampling Frequency	- Monitoring on three days in October 2006 (For NMHC, monitoring on one day in October 2006)
Analysed parameters	- SO_2, NOx, CO, PM and NMHC.
Sampling and Field Analysis	- Air sampling was done with a mobile air sampling pump. Sampling method followed GOST.
Analysis	- The analytical laboratory of the regional monitoring centre and Atyrau MoEP had not been established prior to the pilot activity period, so laboratory analysis was sub-contracted. - Analytical methods followed GOST.

Note : Non-methane hydrocarbons are constituents of petroleum. The hydrocarbons generate secondary pollutants and cause photochemical smog.

Source: JICA Study Team

(3) Soil Pollution Monitoring

After establishment of the analytical laboratory in Atyrau MoEP, the laboratory will implement pollution source monitoring of the discharge conditions of pollutants from petroleum related facilities. Under the pilot project, after discussions with Atyrau MoEP, soil pollution monitoring was implemented on the oil field and its surrounding area as a trial activity for future pollution source monitoring. The target oil fields were selected, and the permission to enter the fields and take samples was arranged by Atyrau MoEP. The outline of the soil pollution monitoring plan is shown in Table 8.1.3.

Table 8.1.3 Plan for Soil Pollution Monitoring in and around Oil Fields

Items	Formulated Monitoring Plan
Sampling Points	- The following were set as targets for soil sampling. (a) Old well in the on-shore oil field near the coast of Caspian Sea (b) Coastal area near on-shore oil field - Based on the examination, 3 sampling points were set.
Sampling Frequency	- Once in September 2006
Analysed parameters	- Oil products, heavy metals (Pb, Cd, Cr, Ag, Cu, Zn)
Sampling and Field Analysis	- Japanese soil sampling method was adopted.
Analysis	- The analytical laboratory of the regional monitoring centre and Atyrau MoEP had not been established prior to the pilot activity period, so laboratory analysis was sub-contracted. - Analytical methods followed GOST.

Source: JICA Study Team

(4) Lecture about Analysis of Petroleum Derived Pollutants and Constituents of Petroleum

The Regional Environmental Monitoring Centre/Atyrau HYDROMET Centre and Atyrau MoEP will be required to have a capacity to analyse petroleum-derived pollutants and constituents of petroleum to implement future monitoring activities for pollution control of the petroleum industry. A lecture about analysis of substances mentioned above is seen as a first step to develop such a capacity. Contents of the lecture were as follows:

- Explanation of constituents of petroleum
- Regulation to control petroleum pollution
- Analytical method for total petroleum hydrocarbon (TPH) using GC-FID[1]
- Measurement of tar balls

(5) Heavy Metal Analysis with Certified Material

During the period of the pilot project, the laboratories of the Regional Environmental Monitoring Centre/Atyrau HYDROMET Centre and Atyrau MoEP were under construction, and the possible analytical work was limited. Both organizations had plans to operate their laboratories with already purchased analytical equipment. To recognize the importance of quality assurance/quality control (QA/QC), training in heavy metal analysis with the certified materials was implemented as shown in Table 8.1.4. For the analytical training, the laboratory of the sub-contractor for water/sediment quality monitoring was utilized. The junior experts of the Atyrau HYDROMET Centre and Atyrau MoEP participated in the training.

Table 8.1.4 Program to Introduce Analysis with Certified Materials

Date	Contents
1st Day	- Lecture about how to use certified materials and examples of factors causing analytical errors in heavy metal analysis with atomic absorption spectrophotometer (AAS) - Exercise of how to operate AAS - Lecture about pre-treatment of sediment samples in the laboratory
2nd Day	- Exercise on heavy metal analysis with certified materials by electrothermal type of AAS
3rd Day	- Exercise on heavy metal analysis with certified materials by flame AAS

Source: JICA Study Team

8.2 Examination of the Environmental and Pollution Source Monitoring Plan for the Regional Environmental Monitoring Centre and Atyrau MoEP

(1) Mini-Worksop

A mini-workshop to discuss the needs of the newly established Regional Environmental Monitoring Centre was held with 17 participants from the Atyrau HYDROMET Centre, Atyrau MoEP, Natural Resource Control Department of Atyrau Oblast, Fishery Department and Department of Safety Control on Off-shore Oil Field Development. In the mini-workshop, discussions were held after the following presentations:

Figure 8.2.1 Mini-workshop

[1] Gas chromatograph – Flame Ionization Detector

Table 8.2.1 Presentation at Mini-workshop

No.	Name	Organization/Position	Presentation
1	Stroeva Tatiana Pavlovna	Caspian Sea Research Department, KAZHYDROMET	Monitoring of water level in Caspian Sea
2	Zatsepina Tatiana Stanislavovna	Chief of Laboratory, Atyrau HYDROMET Centre	Current activities and future plan of the Atyrau HYDROMENT Centre
3	Satvelieva Olga	Manager, Atyrau MoEP	Current activities and future plan of Atyrau MoEP
4	Kengo Naganuma, Shinsuke Sato	JICA Study Team	Introduction to the Japanese Environmental Monitoring System

Source: JICA Study Team

Table 8.2.2 Participants of Mini-workshop

No.	Name	Organization
1	Akatieva Tatiana Vladimirovna	Director of the Atyrau HYDROMENT Centre
2	Ignatchenko Ljudmila Nikolaevna	Meteorological Department, KAZHYDROMET
3	Stroeva Tatiana Pavlovna	Caspian Sea Research Department, KAZHYDROMET
4	Zatsepina Tatiana Stanislavovna	Chief of Laboratory, the Atyrau HYDROMETCentre
5	Amurova Gulzhan Utenbergenovna	First class chemical analytical expert, the Atyrau HYDROMENT Centre
6	Dzhambatyrov Murad Tursungelievich	Vice-director of Department of Fishery Control in Ural River and Caspian Sea
7	Shankieva Kuralai Kabdabaevna	Vice-director of Atyrau MoEP
8	Il'yasov Eleman Kauanuly	Department of Natural Resource Control
9	Abdrahan Marat Ginajatulu	Director of Atyrau MoEP
10	Tambavtseva Inga	Manager of Department of Fishery Control in Ural River and Caspian Sea
11	Satvelieva Olga	Manager, Atyrau MoEP
12	Bushanova Venera	Manager, Atyrau MoEP
13	Galimov Nurolla	Vice-director of Department of Safety Control on Off-shore Oil Field Development
14	Uralova Ardan	Assistant expert of laboratory, Natural Resource Control Department in Atyrau Oblast
15	Telagisov Zholdaskali	Natural Resource Control Department in Atyrau Oblast
16	Umtalieva Raihan	Natural Resource Control Department in Atyrau Oblast
17	Gutsina Larisa	Natural Resource Control Department in Atyrau Oblast

Note : From MoEP, Mr. Bekniyazov, manager of monitoring department, was invited for the mini-workshop, but the manager was absent because of his commitments to revision of the Kazakhstan Environmental Code.

Source: JICA Study Team

(2) Opinions of Participants of the Mini-Workshop

The following opinions were raised at the mini-workshop:

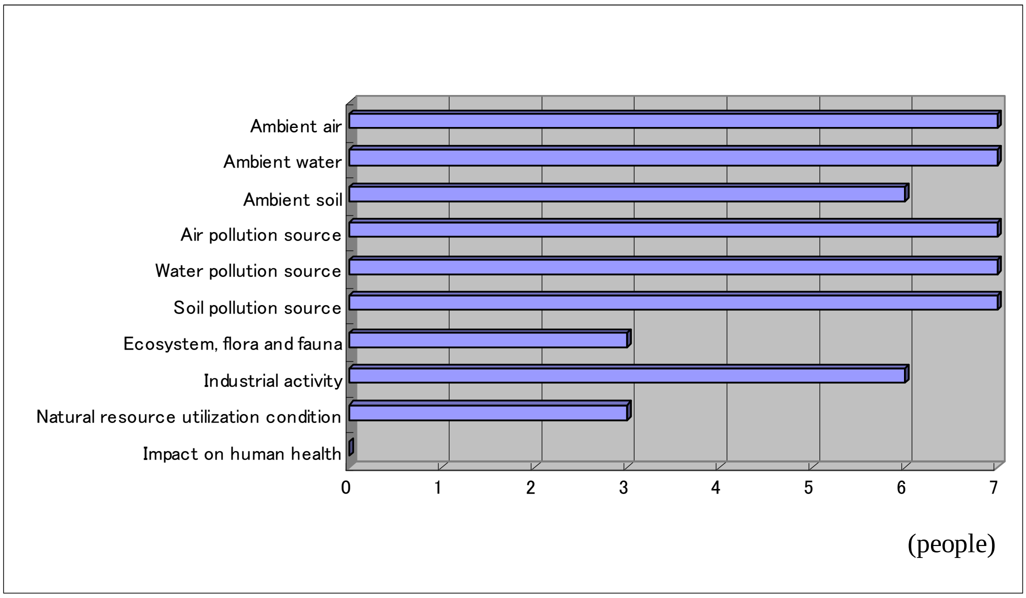
- The need to formulate a system for cooperation between relevant organizations engaged in environmental monitoring.
- For implementation of useful activities by the Regional Environmental Monitoring Centre, there need to be clear objectives and also a secure budget and necessary human resources.
- The need for suitable equipment and facilities, such as a special large vessel for monitoring of the Caspian Sea and introduction of modern system for air quality monitoring.
- An improvement in efficiency of environmental conservation activities would be expected

if the Regional Environmental Monitoring Centre unifies all the environmental monitoring information and data collected by various relevant organizations.

- The need for an exchange of information between the Regional Environmental Monitoring Centre and relevant organizations, in the future.
- It is desirable to disseminate monitoring information to the general public in the future.
- The Master Plan prepared by the JICA Study Team will be reviewed to examine its effectiveness two or three years after it has begun to be implemented.
- Cooperation with the countries around the Caspian Sea is essential.
- The need to continuously monitor the characteristics and amount of pollutants discharged from the enterprises.
- It is important to inspect the petroleum relevant facilities, such as off-shore oil fields, Tengiz oil processing facility, petrochemical industry planned for construction in Karabutan, and it is recommended that the Regional Environmental Monitoring Centre should have branch offices around the facilities.

In the mini-workshop, the participants actively exchanged opinions about the sharing of monitoring information, in particular, about the idea of unifying environmental information at the Regional Environmental Monitoring Centre and the exchange of information between the Regional Environmental Monitoring Centre and other organizations, as well as other opinions above. Through the mini-workshop, it was found that the local relevant organizations are serious about getting the information required for their activities.

The JICA Study Team also requested participants to provide their opinions, by questionnaire, about the future activities required from the Regional Environmental Monitoring Centre. The opinions collected are shown in Figure 8.2.2. The participants expected the Regional Environmental Monitoring Centre to implement not only ambient environmental monitoring but also pollution source inspection on air, water and soil. It suggested that the Regional Environmental Monitoring Centre should be required to plan their monitoring activities to get information about impact of discharged pollutants from the pollutant sources in the northern Caspian Sea and its surrounding area.



Note : Results of questionnaire on proposed activities required of the Regional Environmental Monitoring Centre, which was distributed to the participants of the mini-workshop. The participants could select multi-choices in the questionnaire. Among 17 participants of the mini-workshop, the questionnaires were collected from 16 participants.

Figure 8.2.2 Required Activities of the Regional Environmental Monitoring Centre

8.3 Trial Sampling and Analysis

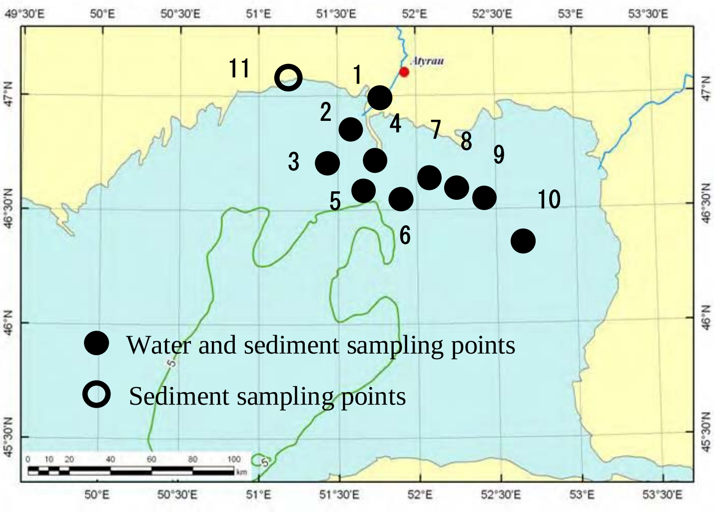
8.3.1 Water Quality/Sediment Quality Monitoring in Northern Caspian Sea

Water and sediment quality monitoring was implemented with one expert from the Atyrau HYDROMENT Centre and another expert from Atyrau MoEP. The outline of activities is as follows:

Table 8.3.1 Outline of Water/Sediment Quality Monitoring

Item	Contents
Survey Period	14, 16 and 20 to 21 October 2006
Monitoring points	10 sampling points around estuary of Ural River and Kashagan oil field (The water samples were taken from surface and bottom layers. Sediment samples were taken from surface of sediments.) Additionally one sediment sample was taken at a coastal area.
Analysed parameter	Water quality: water temperature, pH, EC, salinity, DO, BOD_5, COD, SS, turbidity, nitrogen (NH_4, NO_2, NO_3), phosphorous (T-P), oil products, heavy metals (Cu, Zn, Cr^{6+}, Pb, Hg) Sediment quality: oil products, phosphorous, heavy metals（Cu, Zn, Cr^{+6}, Pb, Hg）

Source: JICA Study Team



Field Measurement

Source: JICA Study Team

Figure 8.3.1 Water and Sediment Monitoring Points

(1) Water Quality Analytical Results

1) Heavy Metals

Analytical results for heavy metals in seawater are shown in Table 8.3.2. In comparing these results with Japanese water quality standards, it was found that there is no significant pollution.

On the other hand, the results suggest that attention should to be given to the ecological risk. Comparing the analytical results with Kazakh standards for fishery, US EPA ecological toxic thresholds [2] and Canadian guideline values [3], suggests that attention should be given to concentrations of hexavalent chromium, copper, and cadmium. There are various guideline values for considering ecological risk, so it is not easy to identify if there is a problem even though the analytical results satisfied certain guideline values. However, continuous monitoring on ecological risk should be implemented.

[2] Eco Update vol.3, No.2 (1996) US EPA
[3] Summary table of Canadian environmental guideline (2002)

Table 8.3.2 Analytical Results for Heavy Metals

Unit:mg/L

Monitoring Points	Coordination	Chromium	Copper	Zinc	Lead	Cadmium	Mercury
No.1	N 46º56'01" E 51º41'43"	0.0017	0.0113	<0.05	<0.0005	0.0003	0.00008
		0.0021	0.0079	<0.05	<0.0005	0.0002	0.0001
No.2	N 46º50'33" E 51º33' 07"	0.0089	0.0126	<0.05	<0.0005	0.0002	0.00015
		0.0102	0.0441	<0.05	<0.0005	0.0004	0.00022
No.3	N 46º 47'09" E 51º28'42"	0.0096	0.0318	<0.05	<0.0005	0.0002	0.00033
		0.0122	0.0289	<0.05	<0.0005	0.0002	0.00028
No.4	N 46º40'00" E 51º40'03"	0.0014	0.0091	<0.05	<0.0005	0.0009	0.00048
		0.0095	0.0168	<0.05	<0.0005	0.0008	0.00049
No.5	N 46º 34'57" E 51º 37'12"	0.0082	0.0026	<0.05	<0.0005	0.0009	0.00038
		0.0024	0.0036	<0.05	<0.0005	0.0008	0.0005
No.6	N 46º35'59" E 52º06'07"	0.0015	0.0032	<0.05	<0.0005	0.0008	0.00025
		0.0077	0.0085	<0.05	<0.0005	0.0009	0.00028
No.7	N 46º31'58" E 52º26'03"	0.0022	0.0039	<0.05	<0.0005	0.0009	0.00014
		0.0019	0.0032	<0.05	<0.0005	0.0010	0.00012
No.8	N 46º33'00" E 52º17'12"	0.0007	0.0036	<0.05	<0.0005	0.0011	0.00019
		0.0118	0.0038	<0.05	<0.0005	0.0009	0.00008
No.9	N 46º28' 22" E 52º38' 12"	0.0011	0.0036	<0.05	<0.0005	0.0007	0.00023
		0.0009	0.0041	<0.05	<0.0005	0.0007	0.00025
No.10	N 47º 04'16" E 51º 01'59"	0.0018	0.0071	<0.05	<0.0005	0.0009	0.00008
		0.0029	0.0047	<0.05	<0.0005	0.0008	0.0005
Minimum		0.0007	0.0026	-	-	0.0002	0.00008
Average		0.0049	0.0107	-	-	0.0007	0.0003
Maximum		0.0122	0.0441	-	-	0.0011	0.0005
Japanese standard		0.05	—	—	0.01	0.01	0.0005
Kazakh standard (sea water)		0.001	0.005	0.05	0.01	0.01	less than detective limit
US EPA ecological toxic threshold		0.05	0.0024	0.081	0.0081	0.0093	0.0011
Canadian guideline (aquatic life)		0.0015	—	—	—	0.00012	—
Analytical method		M 01-37-2000 Analyzed by AAS	M 01-29-98 Analyzed by AAS	ISO 8288-88 Analyzed by AAS	M 01-29-98 Analyzed by AAS	M 01-29-98 Analyzed by AAS	PND F 14.1:2:4.160-2000 Analyzed by mercury analyzer
Detective limit		0.0005	0.0005	0.05	0.0005	0.0001	0.00005

Note : AAS means Atomic absorption spectrophotometer.

Source: JICA Study Team

2) Total phosphorous, Total Nitrogen and COD

Analytical results for total phosphorous, total nitrogen, and COD are shown below. Comparing analytical results with the Japanese water quality standards, the concentration level of total nitrogen was almost the same as fishery class 1[4], the concentration level of total phosphorous was the same as Fishery Class 2 water[5]. For reference, the concentration of total nitrogen and phosphorous at environmentally representative points in Tokyo Bay were 0.29-3.95 mg/L, and 0.063-0.379mg/L, respectively in 2005.

4 At the level, various aquatic resources including benthic animals can be caught stably.
5 At the level, aquatic resources, which are mainly fishes excluding benthic animals, can be caught.

Table 8.3.3 Analytical Results for Total Phosphorous, Total Nitrogen, and COD

Monitoring Points		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
Total nitrogen	Surface layer	0.24	0.29	0.24	0.23	0.13	0.15	0.19	0.15	0.19	0.23
(mg/L)	Bottom layer	0.21	0.32	0.24	0.22	0.18	0.17	0.28	0.17	0.20	0.19
Total Phosphorous	Surface layer	0.083	0.050	0.008	0.079	0.052	0.031	0.059	0.031	0.017	0.027
(mg/L)	Bottom layer	0.101	0.050	0.050	0.17	0.066	0.100	0.040	0.050	0.072	0.029
COD	Surface layer	2.4	3.4	4.0	2.5	3.0	2.2	2.6	3.0	2.3	2.8
(mg/L)	Bottom layer	2.4	3.1	4.8	2.7	3.6	2.1	2.4	2.2	2.22	2.2

Note: Amount of total nitrogen was calculated with analytical results of nitrate, nitrite, and ammonium by spectrophotometer (PND F 14.1:2:4.157-99). Total phosphorous was analyzed by Molybdenum blue absorption absorptiometry. Chemical Oxygen Demand (COD) was analyzed by potassium permanganate (PND F 14.1:2:4.190-03).
Source: JICA Study Team

3) Oil Products

Analytical results for oil products are shown below. There is no significant difference between their concentration in the surface layer and those in the bottom layer. All of analytical values were less than Kazakh standard values.

Table 8.3.4 Analytical Results of Oil Products

Monitoring Points		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	MPC
Oil Products	Surface layer	0.031	0.015	0.014	0.027	0.012	0.016	0.029	0.02	0.017	0.023	0.05
(mg/L)	Bottom layer	0.028	0.011	0.017	0.022	0.015	0.018	0.024	0.018	0.015	0.027	

Note 1 : Oil products was analyzed by fluorometer with hexan extraction (PND F 14.1:2:4.128-98). Detective limit is 0.005mg/L。
Note 2 : MPC means Maximum Permissible Concentration.
Source: JICA Study Team

(2) Sediment Analytical Results

1) Heavy Metals

Analytical results for heavy metals in the sediment are shown in Table 8.3.5. The concentrations of heavy metals were higher in the estuary of the Ural River (No.1 and No.3 monitoring points) and at the north coast (No.11 sampling point).

In comparing the analytical results with international standards, significant heavy metal pollution was not observed. Comparison of the results with past analytical results under CEP in 2001 generally showed the concentration of total heavy metals in the sediment at the same level, excluding the result at the north coast (No.11 sampling point).

Table 8.3.5 Analytical Results for Heavy Metals

Unit: mg/kg

Monitoring Points	Coordination	Chromium	Copper	Zinc	Lead	Cadmium	Mercury
No.1	N 46º56'01" E 51º41'43"	34.5	17.0	29.6	11.8	0.20	0.0133
No.2	N 46º50'33" E 51º33' 07"	38.5	18.9	32.7	19.7	0.26	0.0112
No.3	N 46º 47'09" E 51º28'42"	29.2	16.2	28.3	17.2	0.48	0.0112
No.4	N 46º40' 00" E 51º40' 03"	16.5	3.28	4.90	13.3	0.56	0.0101
No.6	N 46º 34'57" E 51º 37'12"	17.7	4.24	6.24	21.2	0.96	0.0089
No.7	N 46º35'59" E 52º06'07"	22.0	5.23	9.24	8.80	0.25	0.0106
No.8	N 46º31'58" E 52º26'03"	18.8	4.40	8.94	7.37	0.08	0.0076
No.9	N 46º33'00" E 52º17'12"	16.4	2.72	5.73	9.60	0.08	0.0079
No.10	N 46º28' 22" E 52º38' 12"	21.6	6.92	11.7	9.42	0.28	0.013
No.11	N 47º 04'16" E 51º 01'59"	27.3	33.4	44.4	26.2	0.58	0.0121
Maximum		16.4	2.72	4.9	7.37	0.08	0.076
Average		24.3	11.2	18.2	14.5	0.37	0.011
Minimum		38.5	33.4	44.4	26.2	0.96	0.133
Probable Effect Level in sediment (Note 1)		160	108	271	112	4.2	0.696
Analytical results under CEP in 2001 at adjacent area of monitoring points in this study		3.8-103	1.7-19.2	-	1.4-14.6	-	0.001-0.04

Note 1 : Source "Screening Quick Reference Table" (Office of Response and Restoration, NOAA)

Note 2 : At No.5 of the sampling points, the sample taken comprised of pieces of shells, so analysis were not carried out.

Note 3: The samples were decomposed with nitrogen acid. Chromium, copper, zinc, and cadmium were analyzed by atomic absorption spectrophotometer (RD 52.18.191-89). Mercury was analyzed by mercury analyzer (PND F 14.1:2:4.160-2000).

Source: JICA Study Team

2) Oil Products and Constituents of Petroleum

Analytical results of oil products in the sediment are shown in Table 8.3.6 and Table 8.3.7. Table 8.3.7 shows the analytical results for total petroleum hydrocarbons by a Japanese analytical laboratory. It should be noted that analytical methods Kazakhstan and Japan are different, so the analytical results are also different.

Comparing the analytical results of the Caspian Sea with the concentration of oil products in heavily polluted seas in the world, it can be said that the sediment in the northern Caspian Sea has not been significantly affected by pollutants. For example, 58 samples of analytical results in Havana Bay, an area seriously affected by oil, showed that the sediment had 31-1,436 mg/kg of oil product (GEF/RLA/93/G41 Project (GEF, 1998)).

Table 8.3.6 Analytical Results for Oil Products

Monitoring Point	No.1	No.2	No.3	No.4	No.6	No.7	No.8	No.9	No.10	No.11
Oil Products (mg/kg)	3.82	2.73	2.59	4.89	3.41	3.32	2.39	3.95	2.11	1.32

Note 1: At No.5 of the sampling points, the sample taken comprised of pieces of shells, so analysis were not carried out.
Note 2: Outline of analytical method is as follows. 0.5 to 1g of sample was added to 10ml of tetra chloro-hydrocarbon, and filtrate solution after 15 minutes shaken was analysed by fluorospectrophotometer.[6]

Source: JICA Study Team

Table 8.3.7 Analytical Results for Total Petroleum Hydrocarbons Analyzed by Japanese Analytical Laboratory

Monitoring Points	No.1	No.2	No.3	No.4	No.6	No.7	No.8	No.9	No.10	No.11
TPH (mg/kg)	100	74	78	58	62	75	57	59	55	61

Note 1: At No.5 of the sampling points, the sample taken comprised of pieces of shells, so analysis were not carried out.
Note 2: Outline of analytical method is as follows. 10g of sample was added to 50ml of tetra chloro-hydrocarbon, and filtrate solution after 30 minutes shaken was analysed by infrared spectrophotometer. Reference material is hexadecane.[7]

Source: JICA Study Team

Ten sediment samples were analyzed in a Japanese laboratory for 16 polycyclic aromatic hydrocarbons (PAHs) that are specified as priorities by the USEPA. The concentrations of all PAHs in all sediment samples were less than the detection limit, as shown in Table 8.3.8. The guideline values for these organic chemicals for ecological risk are 88.9–1,493.54 μg/kg, and no pollution by PAHs was detected.

Table 8.3.8 Analytical Results of Polycyclic Aromatic Hydrocarbons (PAHs) by Japanese Certified Laboratory [8]

Unit : μg /kg

Chemical	No.1	No.2	No.3	No.4	No.6	No.7	No.8	No.9	No.10	No.11	Guideline Value
acenapthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	88.9
acenapthylene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	127.87
anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	245
indenopyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-
chrysene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	845.98
dibenz[ah]anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	134.61
napthalene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	390.64
pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1,397.6
fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1,493.54
fluorine	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	144.35
phenanthrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	543.53
benz[a]anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	692.53
benzo[b]fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-
benzo[k]fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-
benzo[a]pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	763.22

Note 1: N.D. means "Not Detected". Detection limit is 10μg /kg.
Note 2: Adopted analytical method followed EPA 8270, and PAHs were analyzed by gas chromatograph – flame ionization detector (GC-FID).
Note 3: Source of the guideline values is "Screening Quick Reference Table" (Office of Response and Restoration, NOAA).
Source : JICA Study Team

[6] PND F 14.1:2:4.128-98 in GOST.
[7] "Draft Guideline of Measures on Oil Pollution". (2006) Geo-environmental Protection Centre, Japan
[8] Nihon Environmental Service Co., Ltd.

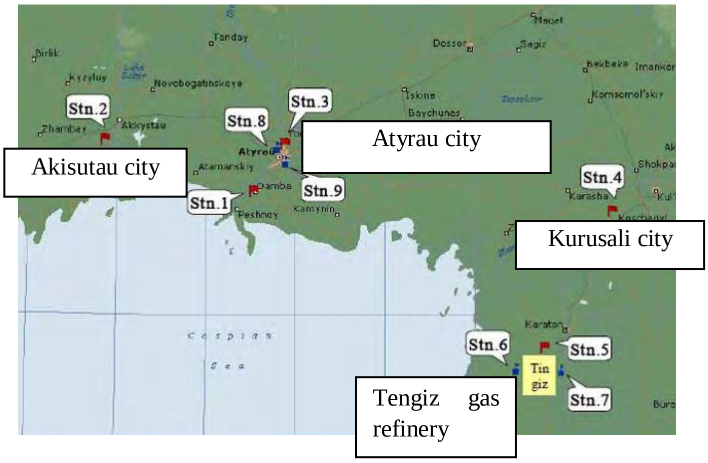
8.3.2 Air Quality Monitoring

Although the Atyrau HYDROMET Centre does not implement regional air quality monitoring at present, they plan to do such monitoring in the future. Under this study, air quality monitoring was carried out, with one expert from the Atyrau HYDROMET Centre and another expert from Atyrau MoEP, to get experience and information to be utilized for setting monitoring points for regional air quality monitoring.

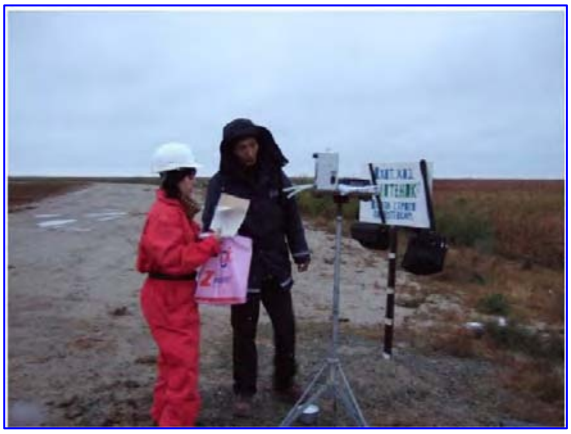
Table 8.3.9 Outline of Air Quality Monitoring

Item	Contents
Survey period	19 to 29 Oct 2006
Survey points	Three points in Atyrau city and two points around Tengiz oil processing facility (Note: Additionally, NMHC was measured at four points.)
Analytical parameters	SO_2 , NO_2 , CO, PM[9], meteorological parameter (wind direction, winds peed, temperature) (Note: NMHC was analysed at a part of sampling points)
Frequency	Three times per day of sampling during three days

Source: JICA Study Team



Source: JICA Study Team



Air quality sampling

Figure 8.3.2 Air Quality Monitoring Points

Air quality monitoring results are shown in Table 8.3.10. It is difficult to judge the overall air quality condition because the survey period was limited to three days, but there was no significant air pollution detected during the survey period.

Comparing the analytical results at each sampling point, the analytical results for sulphur dioxide and carbon monoxide were not so different between sampling points in city areas (Atyrau city and Akistau city) and those in local areas (southern suburb of Atyrau city and adjacent area of Akistau city). On the other hand, the analytical results of nitrogen dioxide in the city areas were higher than those in the local areas, which were 0.031-0.045 mg/m^3 and 0.015-0.034 mg/m^3, respectively. It suggested that vehicles are the main air pollution source in the city area in existing conditions.

Comparing of the analytical results around Tengiz oil processing facility with those at other monitoring points, there is no significant difference in sulphur dioxide, nitrogen dioxide, and carbon monoxide.

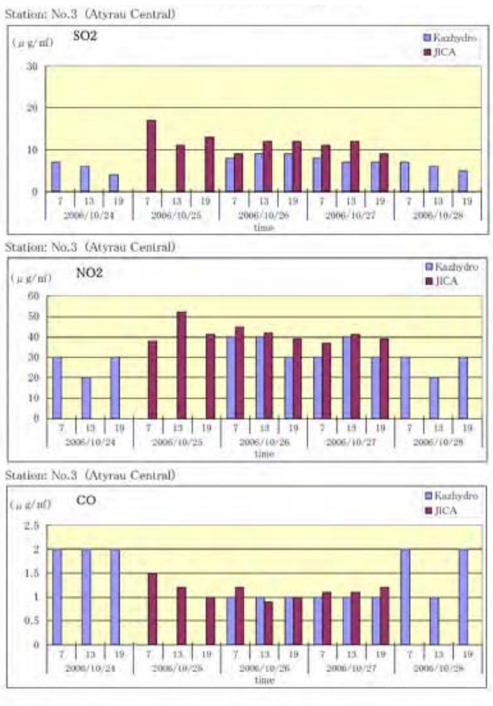
[9] Particulate matter was determined with PND 52.04.186-89 in GOST

Table 8.3.10 Air Quality Monitoring Results

Sampling Points	Coordination	Survey Period	Sulphur dioxide	Nitrogen dioxide	Carbon monoxide
			mg/m³	mg/m³	mg/m³
1.Southern suburb of Atyrau city	N 46° 56'32" E 51° 44'07"	10/19-10/21	0.009 - 0.021	0.015 - 0.034	0.3 - 0.5
2. Adjacent area of Akistau city	N 47° 10'25" E 50° 55'33"	10/22-10/24	0.008 - 0.016	0.017 - 0.034	0.2 - 0.9
3. Atyrau city	N 47° 06'12" E 51° 53'39"	10/25-10/27	0.009 - 0.017	0.038 - 0.045	0.9 – 1.5
4. Kurusari city	N 46° 51'39" E 53° 48'00"	10/20-10/22	0.007 - 0.012	0.031 - 0.045	0.1 – 0.9
5Tengiz oil processing facility	N 46° 08'11" E 53° 24'26"	10/23-10/25	0.006 - 0.015	0.018 - 0.038	0.1 – 0.2
Kazakh standard (mg/kg)		-	0.5	0.085	5.0
WB guideline figure (mg/kg) [10]		-	0.125	0.15	-
Analytical Method		-	PND 52.04.186-89 g.5.2.7.2	PND 52.04.186-89 g.5.2.1.3.	PND 52.04.186-89 g.6.5.
Detection Limit		-	0.001	0.001	0.75

Source: JICA Study Team

Figure 8.3.3 shows a comparison of the results in this study with the results obtained by the Atyrau HYDROMET Centre in Atyrau city during the period of the pilot project. For each analytical parameter there is no significant difference shown between the results under the pilot project and those obtained by the Atyrau HYDROMET Centre.



Source: JICA Study Team

Figure 8.3.3 Comparison of Air Quality Monitoring Results

Analytical results of non-methane hydrocarbons (NMHC) are shown below. From the monitoring results of the one-day measurement it is not expected that the detected concentration

10 "Pollution Prevention and Abatement Handbook" (1998) World Bank

would have any significant impacts. Comparing the results around Tengiz oil processing facility with those in Atyrau city, it was confirmed that the concentration of non-methane hydrocarbons around Tengiz oil processing facility tended to show higher concentration than those in Atyrau city. It is suggested that, in future, the impacts of the emission of hydrocarbons from petroleum related facilities should be examined.

Table 8.3.11 Hydrocarbon Monitoring Results

Sampling Points	Sampling date	Non-methane hydrocarbons mg/m^3						Total
		6:00	8:00	10:00	12:00	15:00	18:00	
Stn.1 Atyrau city	28 Oct	3.91	4.34	4.35	3.30	2.68	3.48	3.68
Stn.2 Atyrau city	29 Oct	3.50	3.24	4.61	3.26	4.14	3.30	3.68
Stn.3 East of Tengiz gas refinery (200m far from the facility)	26 Oct	4.92	4.81	5.01	5.24	5.43	5.03	5.07
Stn.4 West of Tengiz gas refinery (200m far from facility)	27 Oct	3.63	3.81	4.24	4.56	4.73	4.62	4.27

Note : Analytical method adopted was PND 50-90-84 in GOST. Detection limit is 0.5 mg/m^3.
Source: JICA Study Team

8.3.3 Soil Pollution Monitoring

As a result of discussions with Atyrau MoEP, the oil fields belonging to Kazmanaigaz company, and the adjacent area along the coasts of the northern Caspian Sea were selected as soil pollution monitoring sites. On 26 and 27 September 2006, soil sampling was carried out with one expert from Atyrau MoEP. When soil sampling was implemented, the JICA expert demonstrated the method for taking soil samples for oil component analysis, described in "Draft Guideline of Measures on Soil Pollution (2006)", and for heavy metal analysis.

Figure 8.3.4 Soil Sampling

Analytical results of samples taken are shown below. Comparing the analytical results with international standards or guideline values, no significant heavy metal pollution was detected.

The analytical results of oil products showed high concentrations. As the number of sampling points was limited and it is difficult to judge regional soil pollution conditions, it is considered that information about the concentration of oil products needs to be collected hereafter.

Table 8.3.12 Soil Pollution Monitoring Results

Sampling Point	Coordination	Cadmium	Copper	Lead	Chromium	pH	Oil products
		mg/kg	mg/kg	mg/kg	mg/kg	-	g/kg
Embamonaigaz oil field	N 46° 45’46” E 56° 11’54”	0.080	3.75	2.15	1.89	7.4	2.080
Embamonaigaz oil field	N 46° 45’59” E 50° 10’21”	0.075	3.25	1.80	2.38	7.5	0.310
Botanahan oil field	N 46° 55’56” E 53° 09’14”	0.071	6.07	5.10	2.54	7.4	3.210
Kazakh standard (mg/kg)		0.5	3.0	6.0	6.0	-	0.1
Dutch standard (mg/kg)		0.8	36	85	100	-	-
EU directive 86/278(mg/kg)		0.5	45	55	55	-	-
Reference figure of total amount in soil in Japan (mg/kg)		9	-	600	-	-	-
TPH cleanup standard in Oklahoma (g/kg)							Residential area 0.05 Industrial area 0.5

Note : The samples were decomposed with nitrogen acid. Cadmium, copper, lead, and chromium were analyzed by atomic absorption spectrophotometer (GOST 17.2.6.01-86).

Source: JICA Study Team

8.4 Lecture on Analysis of Constituents of Petroleum

A lecture about analysis of constituents of petroleum and monitoring of relevant pollutants was provided, and there was discussion with the Atyrau HYDROMET Centre. Among the equipment purchased by the Atyrau HYDROMET Centre, there is a gas chromatograph (with flame ionization detector and capillary column) and a FT-IR which are for the analysis of oil and other organic components. So it is possible to implement environmental monitoring, not only for the evaluation of petroleum pollution using concentration of total hydrocarbons, but also to detect pollution sources by analysis of the constituents of the petroleum. However, they were not utilized during the period of the pilot project because the laboratory was under renovation. Hereafter, continuous training needs to be provided to utilize this equipment effectively. The following section describes the items to be considered for petroleum analysis.

(1) Analysis of Petroleum Components

In order to grasp the conditions of petroleum in water/soil, a variety of methods are available according to the measurement objectives. The following shows the major measuring or observation methods:

- Observation under microscope,
- Measurement of particle size distribution,
- Analysis by nephelometer,
- Determination of oil content,
- Measurement of the content of total petroleum hydrocarbons (TPHs),
- Analysis of oil component (qualitative and quantitative)

For example, “measurement of particle size distribution” is used to design oil separators such as API or CPI. For the monitoring of oil in water and soil, the “determination of oil content” is generally adopted. The following shows the major methods for the determination of oil content:

- Partition-gravimetric method,
- Partition-infrared method,
- Partition-fluorescence method.

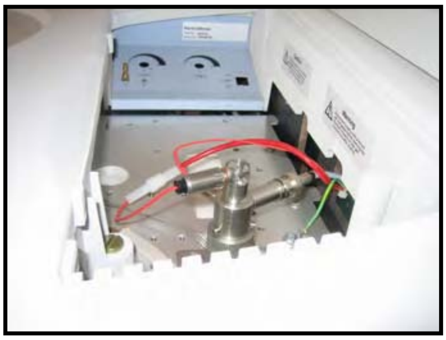
It should be noted that the results obtained from these methods are only the concentration values of total hydrocarbons and not the concentrations of specific constituents. The concentration of total petroleum hydrocarbons represents overall quantitative information on oil contamination. However, in some cases, qualitative or quantitative information concerning the composition of petroleum is required. In order to know the composition of oil or petroleum, analytical methods using gas chromatograph – flame ionization detector (GC-FID) are required.

1) Total Petroleum Hydrocarbon (TPH)

When total petroleum hydrocarbons (TPH) are analysed, the constituent hydrocarbons in water or soil are extracted by various solvents.

The hydrocarbons extracted by solvents are measured using the methods mentioned above such as the gravimetric method. If the partition-infrared method or the partition-fluorescence method is applied, the results are expressed as a value converted into an equivalent of the reference material such as chrysene.

As mentioned, petroleum is composed of various kinds of hydrocarbons. Information on the constituents is necessary to properly manage and control the environmental pollution caused by petroleum. The hydrocarbons that form the constituents of petroleum can be separated and measured by utilizing a Gas Chromatograph – Flame Ionization Detector (GC-FID). A GC can separate the hydrocarbons in order of the number of carbons in the molecule by the difference in affinity of each hydrocarbon for the coating substances in the packed column or capillary column. FID has a high sensitivity for hydrocarbons. The Atyrau HYDROMET Centre and Atyrau MoEP have procured a GC-FID. In the future, it will be desirable to improve the capacity to implement petroleum analysis with the GC-FID.



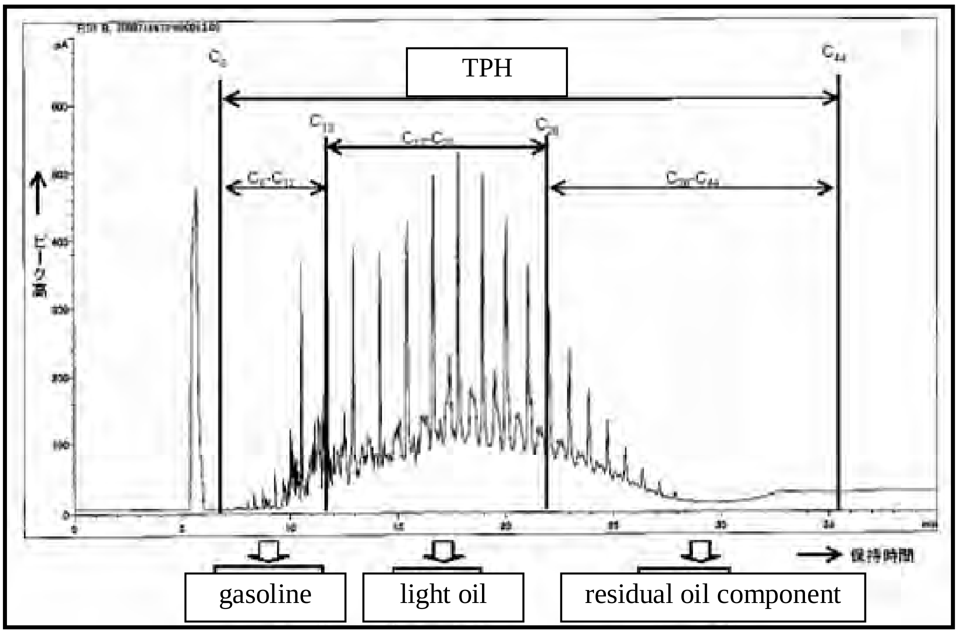
Flame Ionization Detector

Capillary Column

Figure 8.4.1 Flame Ionization Detector and Capillary Column of GC-FID in Atyrau Hydromet Center

Identification of each hydrocarbon is carried out with analysis of a chromatogram obtained by analysis using the GC-FID. An example of a chromatogram is shown in Figure 8.4.2. Comparing the pattern of a chromatogram with that of reference hydrocarbons, the particular hydrocarbons present can be identified. Basically, the constituents of petroleum are identified according to the number of carbons in the hydrocarbons. The range of number of carbons identified by GC is from six (C6) to 44 (C44) in general. Petroleum components by the number of carbons are as follows:

- $C_6 - C_{12}$ (Gasoline component)
- $C_{12} - C_{28}$ (Gas oil component)
- $C_{28} - C_{44}$ (Residual oil component)



Source : Draft Guideline of Measures on Petroleum Pollution (2005) Japanese Ministry of Environment

Figure 8.4.2 Example of Chromatogram of GC-FID

8.5 Analytical Training with Certified Reference Materials

Heavy metal analytical training was carried out with certified materials brought from Japan. Two analytical experts from the Atyrau HYDROMET Centre and one expert from Atrau MoEP joined in the training. The outline of the training is shown below. On the questionnaire distributed after the training, the three trainees answered that their knowledge on theory and operation procedure of AAS was improved, and further training for operation of analytical equipment including AAS would be required.

Figure 8.5.1 Analytical Training

Table 8.5.1 Outline of Analytical Training with Certified Materials

Date	Program
1 Nov 2006	- Lecture on how to use certified materials, and factors causing analytical errors in AAS analysis - Introduction of AAS in the laboratory of the sub-contractor - Lecture on pre-treatment method for sediment in the laboratory of the sub-contractor
2 Nov 2006	- Training on operation of electrical thermal type of AAS with the certified material and water samples in the laboratory of the sub-contractor)
3 Nov 2006	- Training on operation of AAS with the certified material and extraction of sediment samples - Supplemental lecture on soil sampling and analysis

Source: JICA Study Team

CHAPTER 9 TECHNICAL TRANSFER REGARDING SATELLITE IMAGE ANALYSIS AND GIS DATABASE CONSTRUCTION

9.1 Activity Plan

To tackle existing issues of pollution monitoring in the petroleum industry, the following activities were planned and implemented from September to November 2006 and April to May 2007.

- Technical transfer regarding application of satellite image analysis for environmental management
- Technical transfer regarding GIS database formulation and its utilization
- Holding mini-workshop regarding satellite image analysis and GIS techniques in Atyrau

9.1.1 Technical Transfer regarding Application of Satellite Image Analysis for Environmental Management

KAZHYDROMET has been forecasting oceanographic-phenomena and freezing of the Caspian Sea since 2002. However, there is no experience of full-fledged satellite image analysis by using software for satellite image processing and they do not have a suitable system with the required capacity. Considering the existing situation, it was decided that there should be technical transfer regarding the application of satellite image analysis for environmental management.

The target group of the technical transfer was the staff of the Information Technology Department of KAZHYDROMET's headquarters in Almaty. First, a satellite image processing and analysis system (personal computer, ERDAS IMAGINE 9.0 of Leica Geosystems as satellite image processing and analysis software, and satellite image data) was installed at the Information Technology Department. Technical transfer regarding satellite image analysis was carried out using this system. Oil pollution and environmental information of the study area were also extracted by satellite image analysis in the case study. The outline for the technical transfer is shown in Table 9.1.1.

Table 9.1.1 Technical Transfer regarding Application of Satellite Image Analysis for Environmental Management

Item	Contents
Utilized Satellite Image	- TERRA/ASTER data: 20 scenes - ENVISAT/ASAR data: 3 scenes
Training Period	- Middle of October to middle of November 2006 (three weeks) - Early of May 2007 (one week)
Contents of Technical Transfer	- Installation of satellite image processing and analysis system - Lecture on fundamentals of satellite image processing and analysis - Introduction of case examples in the field of environmental management - Lecture about searching methods and purchasing satellite image data - Exercises of software operation - Lecture on case study for the extraction of oil pollution and environmental information

Source: JICA Study Team

9.1.2 Technical Transfer regarding GIS Database Formulation and Its Utilization

The Information Technology Department of the headquarters of KAZHYDROMET has been developing the environmental monitoring database of the whole Kazakhstan since the 2004 fiscal year. However, the number of experts who have knowledge and capacities regarding GIS are limited. Considering the existing situation, it was planed to implement technical transfer regarding GIS database formulation and its utilization.

The target group was the staff of the Information Technology Department of KAZHYDROMET's headquarters in Almaty. However, considering the need to share GIS database between Almaty and Atyrau, brief training for the staff of Atyrau HYDROMET Centre and Atyrau MoEP was also carried out. The outline of the technical transfer is shown in Table 9.1.2.

Table 9.1.2 Technical Transfer regarding GIS Database Formulation and Its Utilization

Item	Contents
Training Period	- Early of May 2007 (one week)
Installed GIS System	- Personal computer and ArcGIS 9.1 of ESRI as GIS software for Information Technology Department of KAZHYDROMET - ArcExplorer 2.0 of ESRI, a free GIS database viewer, for Atyrau HYDROMET Centre and Atyrau MoEP
Contents of Technical Transfer	- Installation of GIS system - Construction of GIS database - Exercises of software operation - Lecture on fundamentals of GIS and its utilization

Source: JICA Study Team

9.1.3 Holding Mini-workshop regarding Satellite Image Analysis and GIS Technique in Atyrau

In order to deepen the understanding regarding environmental monitoring by satellite image analysis and GIS database, a series of mini-workshops were held in Atyrau for the staff of the Atyrau HYDROMET Centre, Atyrau MoEP, and relevant stakeholders. The contents of mini-workshop were as follows:

- The fundamentals of satellite image processing and analysis.
- Results of the case study.
- The fundamentals of GIS technique.
- GIS database construction and its utilization.
- Discussion.

9.2 Result of Technical Transfer

The activities of the technical transfer were carried out in a total of 15 days, between 18th October and 17th November 2006 and a total of 6 days, between 2nd May and 11th May 2007. The schedule and activities are shown in Table 9.2.1.

Table 9.2.1 Schedule and Scope of Technical Transfer

KAZHYDROMET (Headquarters)

	Day	Activity
1	18/OCT/06	The fundamentals of satellite image processing and analysis.
2	19/OCT/06	Applications in the field of environmental management.
3	20/OCT/06	Searching and purchasing satellite image data.
4	23/OCT/06	Exercise-1: Import of TERRA/ASTER data
5	24/OCT/06	Exircise-2: Geocoding of TERRA/ASTER data
6	26/OCT/06	Exercise-3: Mosaicking of TERRA/ASTER data
7	27/OCT/06	Exercise-4: Image enhancement of TERRA/ASTER data
8	30/OCT/06	Exercise-5: Import of ENVISAT/ASAR data
9	31/OCT/06	Exercise-6: Geocoding of ENVISAT/ASAR data
10	1/NOV/06	Exercise-7: Image enhancement of ENVISAT/ASAR data
11	13/NOV/06	Case Study-1: Extraction of environmental information from satellite image
12	14/NOV/06	Case Study-2: Extraction of environmental information from satellite image
13	15/NOV/06	Case Study-3: Extraction of environmental information from satellite image
14	16/NOV/06	Case Study-4: Extraction of oil pollution from satellite image
15	17/NOV/06	Case Study-5: Extraction of oil pollution from satellite image

KAZHYDROMET (Headquarters)

	Day	Activity
1	02/MAY/07	Review of satellite image analysis (ASTER)
2	03/MAY/07	Review of satellite image analysis (ENVISAT) Case Study: Extraction of oil pollution from satellite image
3	07/MAY/07	Introduction of GIS database
4	08/MAY/07	Exercise: Management and utilization of GIS database

Atyrau HYDROMET Center

	Day	Activity
1	10/MAY/07	Introduction to GIS database and exercise of software

Atyrau MoEP

	Day	Activity
1	11/MAY/07	Introduction to GIS database and exercise of software

9.2.1 Satellite Image Analysis

(1) Outline of Technical Transfer on Satellite Image Analysis

The technical transfer on satellite image analysis for the staff of the Information Technology Department of KAZHYDROMET's headquarters in Almaty was carried out as a part of the pilot project to develop environmental management capacity. The activities were as follows:

- Installation of a satellite image processing and analysis system
- Introduction to the fundamentals of satellite image processing and analysis
- Applications in the field of environmental management
- Training on searching and purchasing of satellite image data
- Training on software operation
- Case study for extraction of oil pollution and environmental information

(2) Installation of Satellite Image Processing and Analysis

1) Personal computer

A personal computer (hereafter PC) was installed for satellite image processing and analysis. Main specifications of the PC are as follows:

- CPU: Pentium-4 3.9GHz
- Main Memory: 2.0GB
- Hard Disk Drive: 80GB + 300GB
- Operating System: Windows XP Professional SP2
- Monitor: 19 inch LCD

2) Software for satellite image processing and analysis

EREDAS IMAGINE 9.0 (hereafter ERDAS IMAGINE) of Leica Geosystems was installed as the satellite image processing and analysis software. The main functions of ERDAS IMAGINE are as follows:

- Image display
- Data format conversion
- Geometric correction
- Mosaicking
- Data interpolation
- Image enhancement
- Radar image processing
- Image classification
- Programming

3) Satellite image data

The satellite image data used in the activities are TERRA/ASTER and ENVISAT/ASAR data.

ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer) is the high-performance optical sensor developed by the Ministry of Economy, Trade and Industry of Japan (hereafter METI). ASTER is mounted on the earth observation satellite TERRA of the National Aeronautics and Space Administration (NASA). ASTER has 14 observation wavebands in the spectral region from visible ray to thermal infrared and can acquire information about various phenomena on the Earth's surface (geology, vegetation, atmosphere, ocean, volcano, etc.) on a local or a regional scale.

ENVISAT/ASAR is the radar sensor developed by European Space Agency (hereafter ESA). ASAR is of the Synthetic Aperture Radar (SAR) type and can observe various phenomena on the Earth's surface by C band microwave (5.331GHz or 5.62cm) which is radiated from ASAR. The specifications of both sensors are shown in Table 9.2.2 and 9.2.3.

Twenty scenes of TERRA/ASTER and 5 scenes of ENVISAT/ASAR were purchased and utilized in the activities. The index maps of both sensors are shown in Figure 9.2.1 and 9.2.2 and the lists of the data used are shown in Tables 9.2.4 and 9.2.5.

Table 9.2.2 Specification of TERRA/ASTER

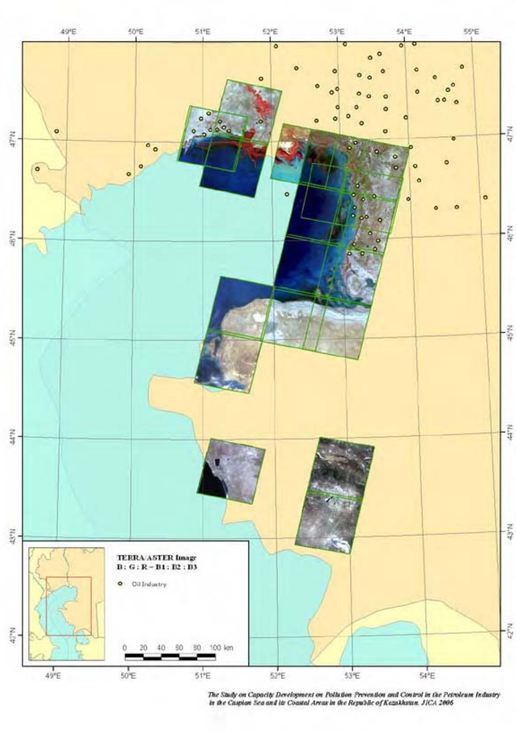
Altitude	705km
Orbit	Sun-Synchronous Descending
Repeat Cycle	16 days
Lunch	1999
Type	Optical Sensor (Passive Sensor)
Sensor	ASTER（Advanced Spaceborne Thermal Emission and Reflection Radiometer） Visible – Near Infrared Radiometer (VNIR) Ground Resolution: 15m Band 1：0.52 – 0.60 micrometer Band 2：0.63 – 0.69 micrometer Band 3：0.78 – 0.86 micrometer Short Wave Infrared Radiometer (SWIR) Ground Resolution: 30m Band 4：1.600 – 1.700 micrometer Band 5：2.145 – 2.185 micrometer Band 6：2.185 – 2.225 micrometer Band 7：2.235 – 2.285 micrometer Band 8：2.295 – 2.365 micrometer Band 9：2.360 – 2.430 micrometer Thermal Infrared Radiometer (TIR) Ground Resolution: 90m Band 10：8,125 – 8.475 micrometer Band 11：8.475 – 8.825 micrometer Band 12：8.925 – 9.275 micrometer Band 13：10.25 – 10.95 micrometer Band 14：10.95 – 11.65 micrometer

Source: Documents of TERRA/ASTER

Table 9.2.3 Specification of ENVISAT/ASAR

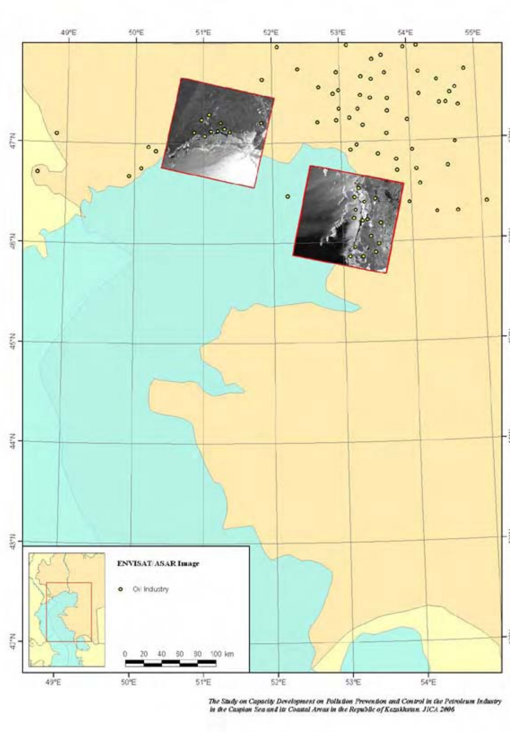
Altitude	800km
Orbit	Sun-Synchronous Descending
Repeat Cycle	35 days
Lunch	2002
Type	Radar Sensor (Active Sensor)
Sensor	ASAR Ground Resolution: 12.5m ～ 25m （Image or Multi-Polarization Mode） 150m（Wide Swath Mode） C band Synthetic Aperture Radar (SAR): 5.331GHz（5.62cm）

Source: Documents of TERRA/ASTER



Source: JICA Study Team

Figure 9.2.1 Index Map of TERRA/ASTER



Source: JICA Study Team

Figure 9.2.2 Index Map of ENVISAT/ASAR

Table 9.2.4 List of TERRA/ASTER Data Used

No.	Granule ID	Date	Level
1	ASTL1B 030927073502061002004 9	2003/09/27	1B
2	ASTL1B 0309270734530610020050	2003/09/27	1B
3	ASTL1B 0309270734440610020062	2003/09/27	1B
4	ASTL1B 0309270734350610020063	2003/09/27	1B
5	ASTL1B 0209240736170610020064	2002/09/24	1B
6	ASTL1B 0109210741270610020065	2001/09/21	1B
7	ASTL1B 0109210741180610020066	2001/09/21	1B
8	ASTL1B 0109210741090610020061	2001/09/21	1B
9	ASTL1B 0109210741000610020067	2001/09/21	1B
10	ASTL1B 0411160734110610020068	2004/11/16	1B
11	ASTL1B 0411160734020610020051	2004/11/16	1B
12	ASTL1B 0508220740190610020052	2005/08/22	1B
13	ASTL1B 0508220740100610020053	2005/08/22	1B
14	ASTL1B 0407110734370610020054	2004/07/11	1B
15	ASTL1B 0304200735180610020055	2003/04/20	1B
16	ASTL1B 0408210729080610020056	2004/08/21	1B
17	ASTL1B 0408210728590610020057	2004/08/21	1B
18	ASTL1B 0207310730270610020058	2002/07/31	1B
19	ASTL1B 0205120730200610020059	2002/05/12	1B
20	ASTL1B 0406250735270610020060	2004/06/25	1B

Source: JICA Study Team

Table 9.2.5 List of ENVISAT/ASAR Data Used

	Granule ID	Date	Level
1	ASA_IMP_1PNUPA20060504_065641_000000 152047_00235_21832_0163.N1	2006/05/04	PRI
2	ASA_IMP_1PNUPA20060517_064819_000000 152047_00421_22018_0162.N1	2006/05/17	PRI
3	ASA_IMP_1PNUPA20060830_064821_000000 152050_00421_23521_0161.N1	2006/08/30	PRI
4	ASA_IMG_1PNDPA20061004_064822_000000 152051_00421_24022_1754.N1	2006/10/04	GEC
5	ASA_IMG_1PNDPA20061108_064823_000000 152052_00421_24022_1743.N1	2006/11/08	GEC

Source: JICA Study Team

(3) Introduction to Fundamentals of Satellite Image Processing and Analysis

An introductory lecture was given on the principle of remote sensing technology. Remote sensing technology is the basis of satellite image processing and analysis. The following topics were covered:

- Principle of remote sensing technology.
- Type and characteristic of electromagnetic waves.
- Passive sensor (optical sensor).
- Active sensor (radar sensor).
- Characteristic of satellite image data.

(4) Applications in the Field of Environmental Monitoring

The application of satellite image analysis in the fields of environment management and disaster prevention were explained using the following variables:

- Sea temperature, turbidity and chlorophyll monitoring
- Bottom index (for coral reef monitoring)
- Vegetation – soil – water index
- Forest classification
- Sulphur oxide and temperature monitoring in a volcano
- Forest fire monitoring
- Flood and debris avalanche monitoring
- Earthquake damage monitoring
- Oil leak monitoring
- Extraction and classification of polluted soil in an oil field
- Application of satellite image processing and analysis for water resources development

(5) Training on Searching and Purchasing Satellite Image Data

The methods of searching and purchasing TERRA/ASTER and ENVISAT/ASAR data on the Internet were introduced.

TERRA/ASTER data is distributed from the Earth Remote Sensing Data Analysis Centre (hereafter ERSDAC), which is a non-profit organization under jurisdiction of METI. Users can search and purchase directly on the website of ASTER Ground Data System (hereafter ASTER GDS) of ERSDAC.

ENVISAT/ASAR data is distributed from ESA. Users can search and purchase directly on EOLI-WEB, the website for searching of satellite image data.

The addresses of both websites are as follows:

- ASTER GDS of ERSDAC

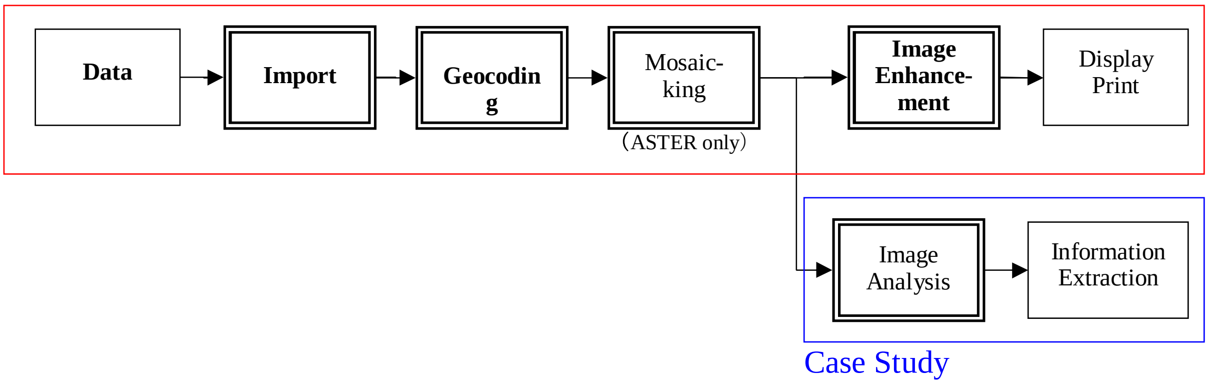
http://imsweb.aster.ersdac.or.jp/ims/html/MainMenu/MainMenu.html

- EOLI-WEB of ESA

http://eoli.esa.int/servlets/template/welcome/entryPage2.vm

(6) Training on Software Operation

The staff practised operation of the satellite image processing software using the system installed at KAZHYDROMET. The training covered import, geocoding (to add positional information to satellite image data), mosaicking (to stitch neighbouring plural images together and to create a larger image), and image enhancement as the most basic procedure of satellite image processing. The flowchart of satellite image processing and analysis is shown in Figure 9.2.3.



Source: JICA Study Team

Figure 9.2.3 Flowchart of Satellite Image Processing and Analysis

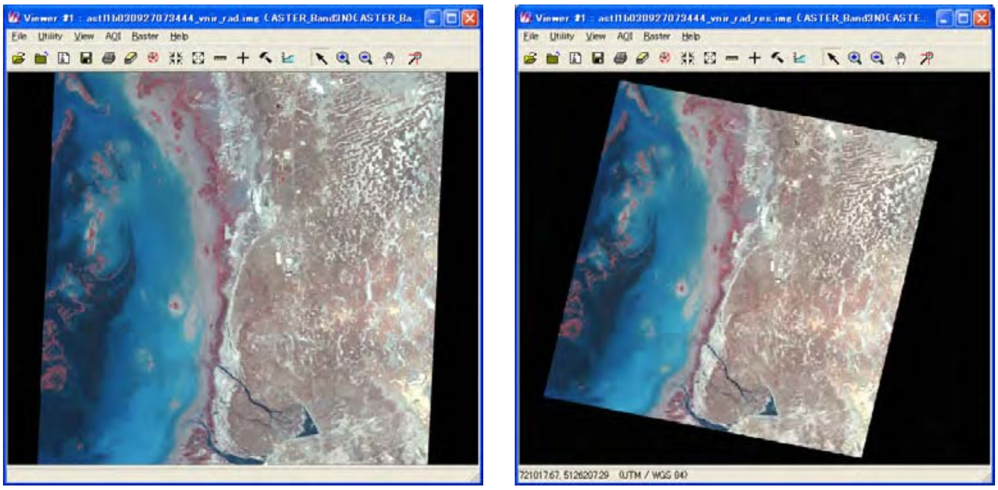
1) Import of TERRA/ASTER data

TERRA/ASTER is distributed as HDF (hierarchical data format) format from ERSDAC. HDF format presents a hierarchical structure as its name implies with header files and the image data stored in each hierarchy.

The import tool of ERDAS IMAGINE can read HDF files directly and convert image data, which is stored as 8 bit or 12 bit binary data with the HDF files, to ERDAS IMAGINE – specific image format. This tool can also read positional information (latitude and longitude at about 120 points on the image data), which is stored with its header file, and convert it to a ground control point file (hereafter GCP file).

2) Geocoding of TERRA/ASTER data

Geometric correction tool of ERDAS IMAGINE can add positional information to the satellite image data automatically by using the GCP file. ERDAS IMAGINE offers various geometric correction models and resampling methods. In the technical transfer, the process of geocoding was applied using “polynomial” as the geometric correction model and “nearest neighbour” as the resampling method (Figure 9.2.4).



Imported TERRA/ASTER Image (non coordinate information) | Geocoded Image

Source: JICA Study Team

Figure 9.2.4 Result of Geocoding

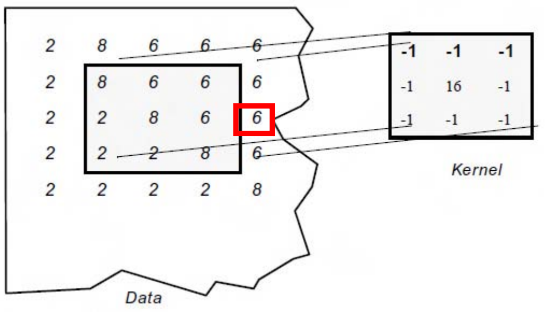
The process of projection has already been applied to TERRA/ASTER Level 1B data and the user can specify the projection and reference ellipsoid when purchasing data. The TERRA/ASTER data used in this technical transfer were projected to Universal Transverse Mercator (hereafter UTM) as projection and World Geodetic System 1984 (hereafter WGS 84) as reference ellipsoid.

3) Mosaicking of TERRA/ASTER data

ERDAS IMAGINE can stitch neighbouring plural images together by digital image processing. Data acquired on the same day (acquired successively) can be easily stitched together because the conditions of the surface and atmosphere were more or less the same at the time of acquiring the data. On the other hand, if data acquired on different days are stitched, it is necessary to execute a color adjustment process (ex. histogram matching, color balancing, etc.) between these data because the conditions of surface and atmosphere are distinct.

4) Image enhancement of TERRA/ASTER data

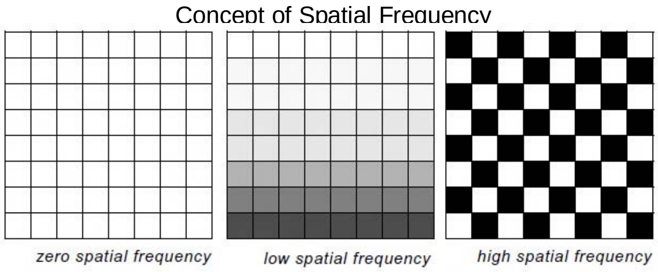
ERDAS IMAGINE can support various methods of spatial frequency filtering. Spatial frequency filtering is a method used to change the spatial frequency of satellite image data by using convolution matrices. The most popular filtering method is “edge enhancement” (Figure 9.2.5) and this method is suited to extracting information.



Output value of the centre of data (frame in red)

$$= ((-1\times8)+(-1\times6)+(-1\times6)+(-1\times2)+(16\times8)+(-1\times6)+(-1\times2)+(-1\times2)+(-1\times8)) \div ((-1)+(-1)+(-1)+(-1)+16+(-1)+(-1)+(-1)+(-1))$$

$$= 88/8 = 11$$



Source: ERDAS IMAGINE Field Guide

Figure 9.2.5 Spatial Frequency Filtering using Convolution Matrix

5) Import of ENVISAT/ASAR data

ENVISAT/ASAR data is distributed as MPH/SPH (main product header / specific product header) format from ESA. The MPH/SPH file is temporarily converted to TIFF format file by BEST 4.03 (hereafter BEST) because ERDAS IMAGINE cannot directly import MPH/SPH files. After this process, the TIFF file is converted to ERDAS IMAGINE – specific image format by the import tool of ERDAS IMAGINE.

6) Geocoding of ENVISAT/ASAR data

BEST can analyze the MPH/SPH header file and extract positional information (latitude and longitude at the four corners of an image data) from the header file. The geometric correction tool of ERDAS IMAGINE can add positional information to satellite image data manually on the basis of extracted positional information.

The TERRA/ENVISAT PRI data had already undergone the process of projection and the data used in this technical transfer were projected to UTM as projection and WGS 84 as reference ellipsoid.

7) Image enhancement of ENVISAT/ASAR

ENVISAT/ASAR and other radar data include random "salt-and-pepper" noise which is called "speckle noise". ERDAS IMAGINE offers various spatial frequency filtering methods to reduce speckle noise. In this technical transfer a median filter, the simplest of various filtering methods, was applied to ENVISAT/ASAR data.

(7) Case Study

In the case study, image analyses using TERRA/ASTER and ENVISAT/ASAR data were performed to extract information regarding oil pollution and the environment in the northern

Caspian Sea and its coastal area. The image analysis methods applied in the case study were as follows:

TERRA/ASTER

- Color composite image
- Normalized difference vegetation index
- Vegetation – soil – water index
- Multi channel sea surface temperature

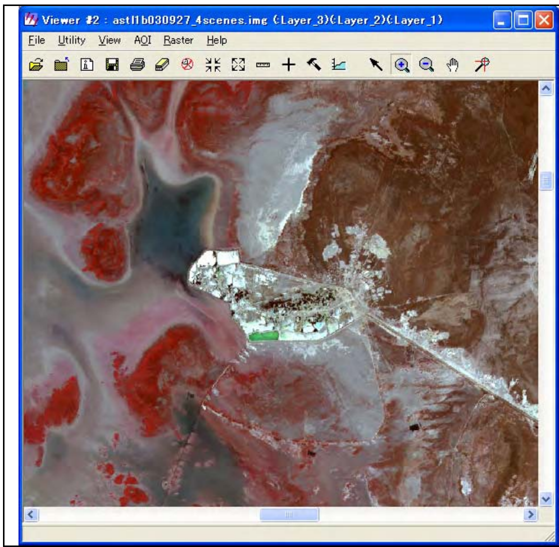
ENVISAT/ASAR

- Oil leak monitoring in submerged oil fields

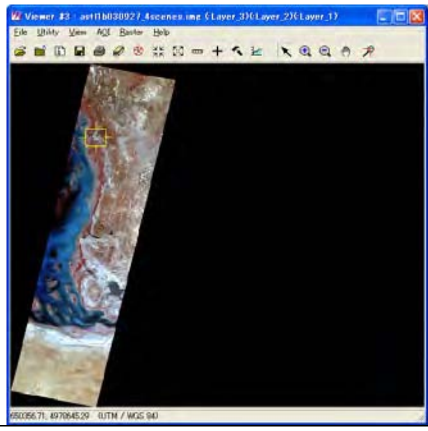
The results of image analyses are described as follows:

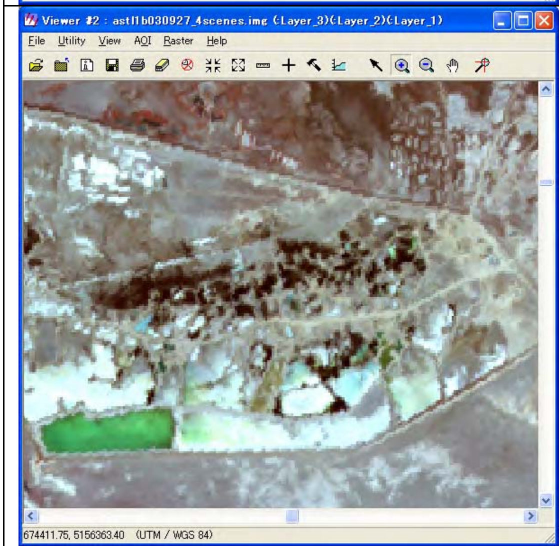
1) Color composite image

Color composite image is a method to create a pseudo color image by assigning primary colors (RGB) to radiance histograms of three optional bands. In the case study, color composite images were created by assigning blue to band 1, green to band 2, and red to band 3. A color composite image that is created by this color combination is called a “false color image”. In a false color image, the pixels that correspond to vegetation show as a reddish color. Equally, water is a blackish – bluish color, soil is a brownish to bright color, and man-made structures are a light bluish to white color. The characteristic images in the study area are shown in Figure 9.2.6 and the results of the image interpretation are shown as follows:

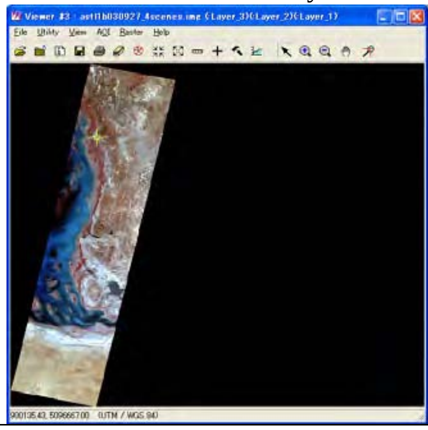


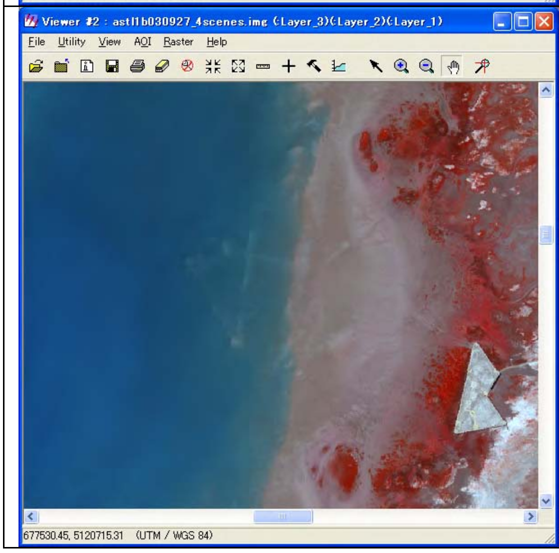
1. West Teren'uzyuk oil field



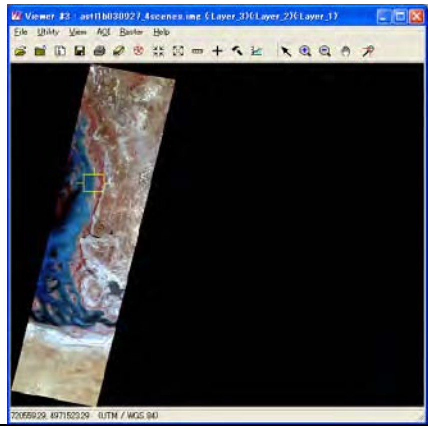


2. Polluted soil or pond for oil evaporation in West Teren'uzyuk oil field (enlarged)



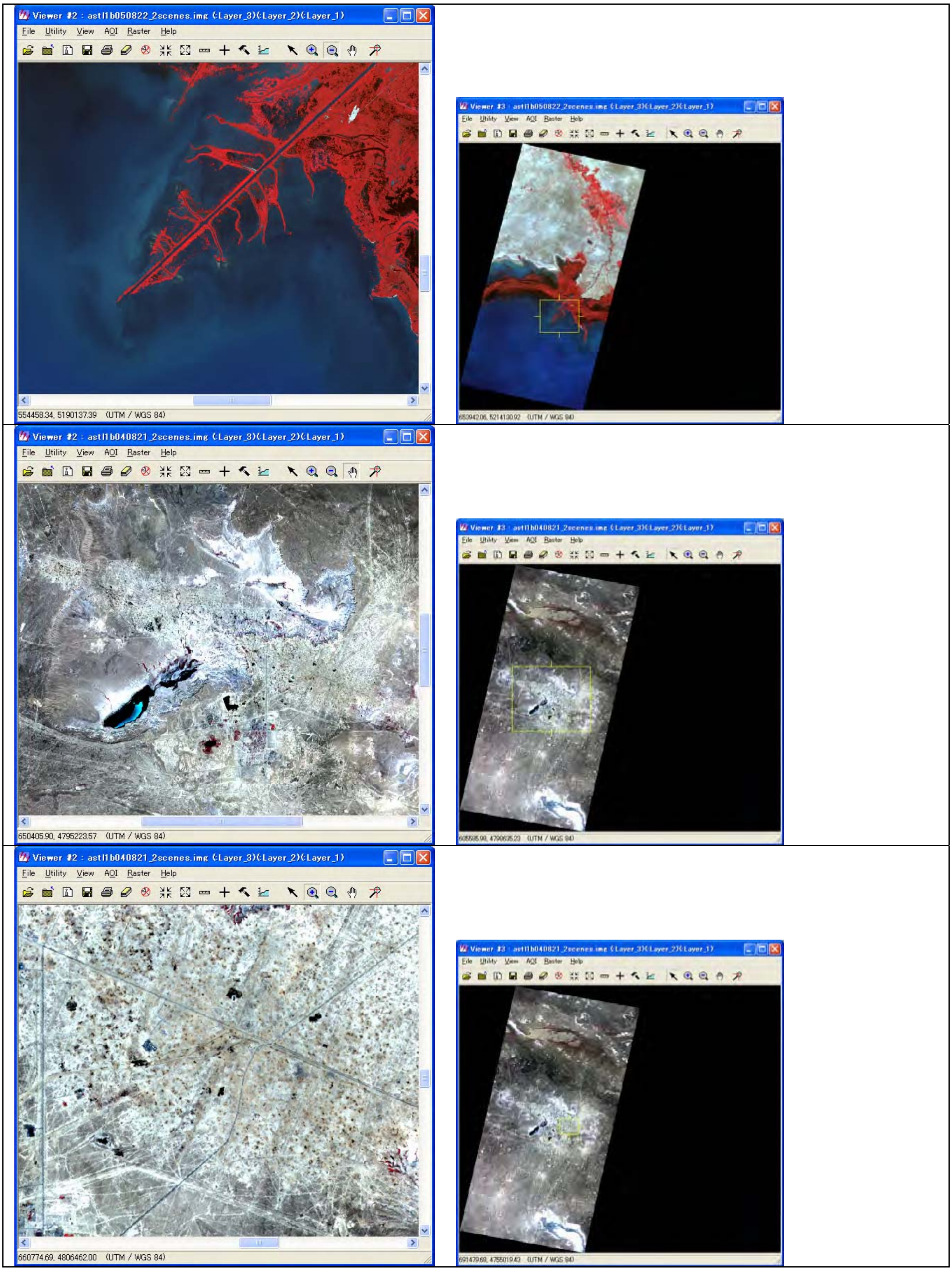


3. Submerged oil field in Pribrezhnoye



Source : JICA Study Team

Figure 9.2.6 (1/2) Color Composite Image of TERRA/ASTER Data



Source : JICA Study Team

Figure 9.2.6 (2/2) Color Composite Image of TERRA/ASTER Data

1. and 2. West Teren'uzyuk oil field

In the images it is possible to observe embankments for protecting the oil field and its surrounding area from the rise of sea level. Many dark to brown colored pixels also can be recognized inside the embankment and it is probable that these pixels show the polluted soil or ponds for oil evaporation. The Director of Atyrau MoEP and the Information-Analytical Centre of the Environmental Protection, MoEP has made some comments about the soil of this oil field being quite polluted.

3. Submerged oil field in Pribrezhnoye

Linear or circle mounding and access roads related to the submerged oil field can be recognized in the shallows. Although oil leak accidents have often occurred in this area, an oil slick cannot be observed in this image.

4. Alteration of sea color in Ural delta

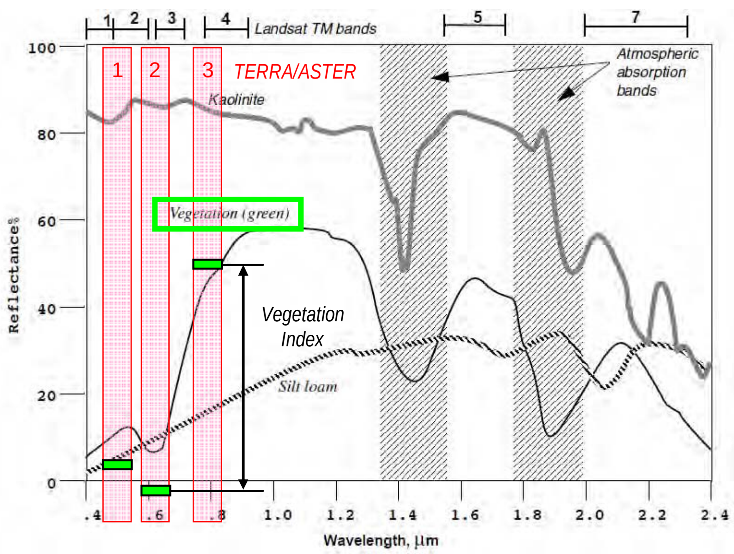
Reeds, which are distributed widely in the mouth of the Ural River, show as a reddish color in this image. The sea surface shows as a gradation of color from dark-blue to milky and it is probable that this gradation represents a change of turbidity or depth of water.

5. and 6. Uzen oil field

Numerous facilities and ponds for oil evaporation can be recognized in these images. In the enlarged image, brown colored pixels, which are distributed widely, can be observed and it is conceivable that these pixels represent polluted soil. In fact, according to the results of a field survey, conducted by ERSDAC, it became evident that these brown colored pixels corresponded exactly to the distribution of polluted soil.

2) Normalized difference vegetation index

Vegetation displays a characteristic spectral signature; absorption in band 2 and strong reflection in band 3 (Figure 9.2.7). Vegetation index is a method to determine the variation of volume and activity of vegetation by the ratio of band 2 and 3.



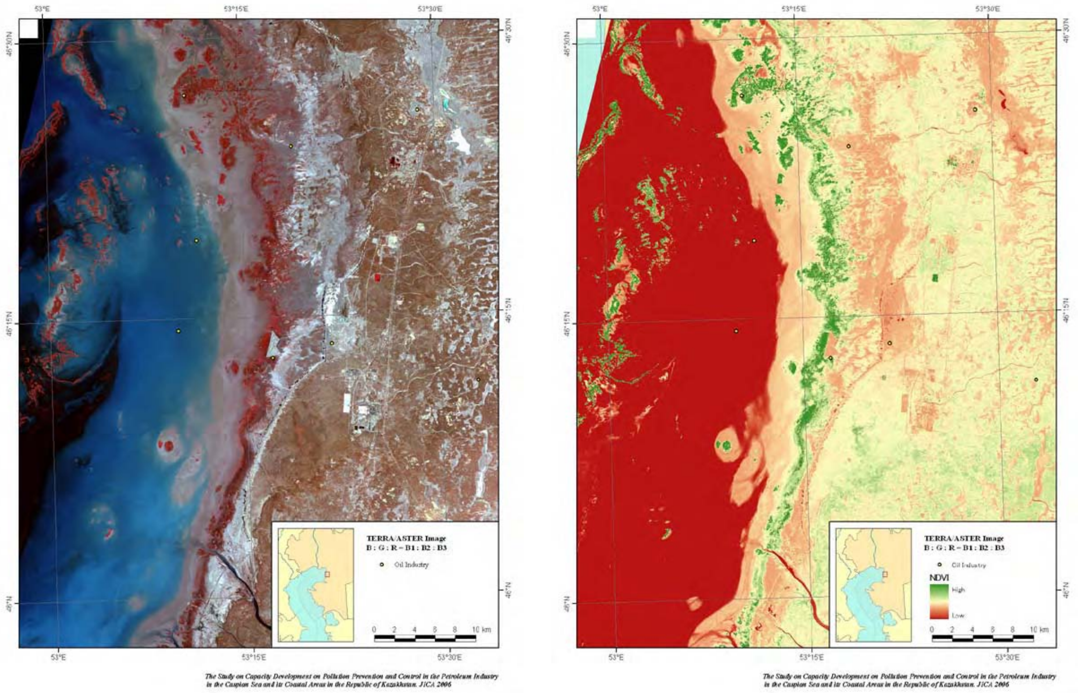
Source: ERDAS IMAGINE Field Guide

Figure 9.2.7 Principle of Vegetation Index

Normalized difference vegetation index (hereafter NDVI) is the most popular vegetation index. NDVI is calculated by the following formula:

$$NDVI = \frac{R_{band3} - R_{band2}}{R_{band3} + R_{band2}}$$

with Rband3 for radiance value of band 3, and Rband2 for radiance value of band 2. The NDVI image of Tengiz oil field is shown in Figure 9.2.8 color-coded with the pixels of dense or high activity area shown in green and the pixels of sparse or low activity area shown in yellow to brown. The green colored pixels, which are distributed along the coast, indicate the reed community. There is generally sparse vegetation in the inland area but vegetation communities can be observed along a river.



False Color Image NDVI Image

Source: JICA Study Team

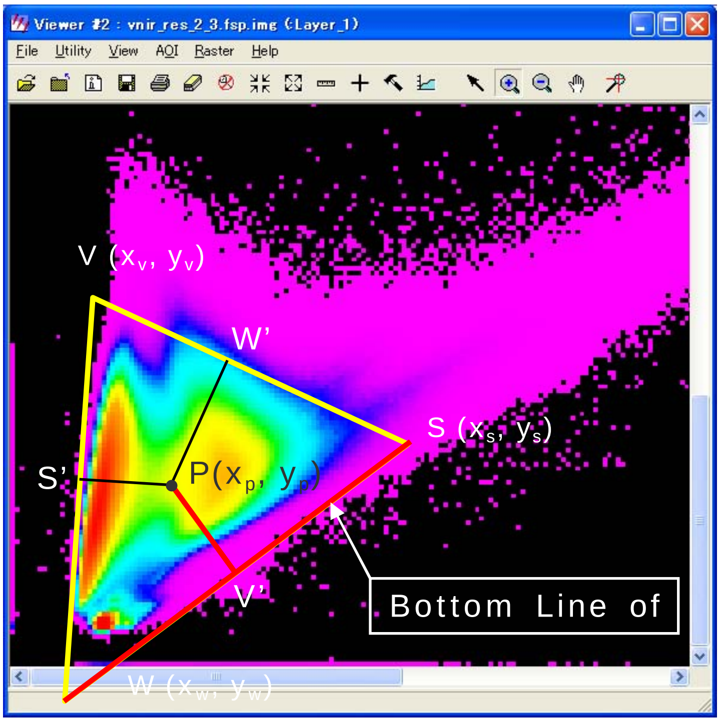
Figure 9.2.8 NDVI Image of Tengiz Oil Field

3) Vegetation – soil – water index

The vegetation – soil – water index (hereafter VSW index) is an advanced technique to calculate the ratio between vegetation, soil, and water at a particular pixel by using the radiance value of band 2 and 3.

Generally, a pixel of satellite image data consists of elements such as vegetation, soil, rock, moisture, water, manmade structure, and so on, because the ground resolution of satellite data is 15m to 30m. Such a condition, which consists of heterogeneous elements in the same pixel, is called a “mixel” and each element is called an “end member”. The VSW index is a method to calculate the ratio of three end members, vegetation, soil, and water. Such a technique is generally called “unmixing”.

When plotting radiance values of band 2 and 3 to a scatter diagram, most radiance values are distributed over the area in the shape of a triangle (Figure 9.2.9). The apexes of this triangle represent end members of vegetation, soil, and water. In other words, end member values are for pixels that consist of only one end member (vegetation, soil, or water) and pixel values that are distributed within the triangle correspond to a mixel. Therefore, the ratio of the three end members of a pixel (P in Figure 9.2.9) can be calculated by determining the ratio of distance between that pixel and each end member (PV', PS', and PW' in Figure 9.2.9). The VSW index image that was calculated from TERRA/ASTER data of the mouth of the Ural River is shown in Figure 9.2.10.



Bottom Line of Vegetation (S-W): $ax + by + c = 0$

$a: y_s - y_w \quad b: x_w - x_s \quad c: y_s * (x_s - x_w) + x_s * (y_w - y_s)$

Bottom Line of Soil (V-W): $ax + by + c = 0$

$a: y_v - y_w \quad b: x_w - x_v \quad c: y_v * (x_v - x_w) + x_v * (y_w - y_v)$

Bottom Line of Water (V-S): $ax + by + c = 0$

$a: y_v - y_s \quad b: x_s - x_v \quad c: y_v * (x_v - x_s) + x_v * (y_s - y_v)$

Distance between P (x_p, y_p) and Bottom Line of X

$= PX' = \mathrm{sqrt}\,[(a * x_p + b * y_p + c)^2 / (a + b)^2]$

VSW Index of P (x_p, y_p)

Band 1: PW' / (PV' + PS' + PW') * 100

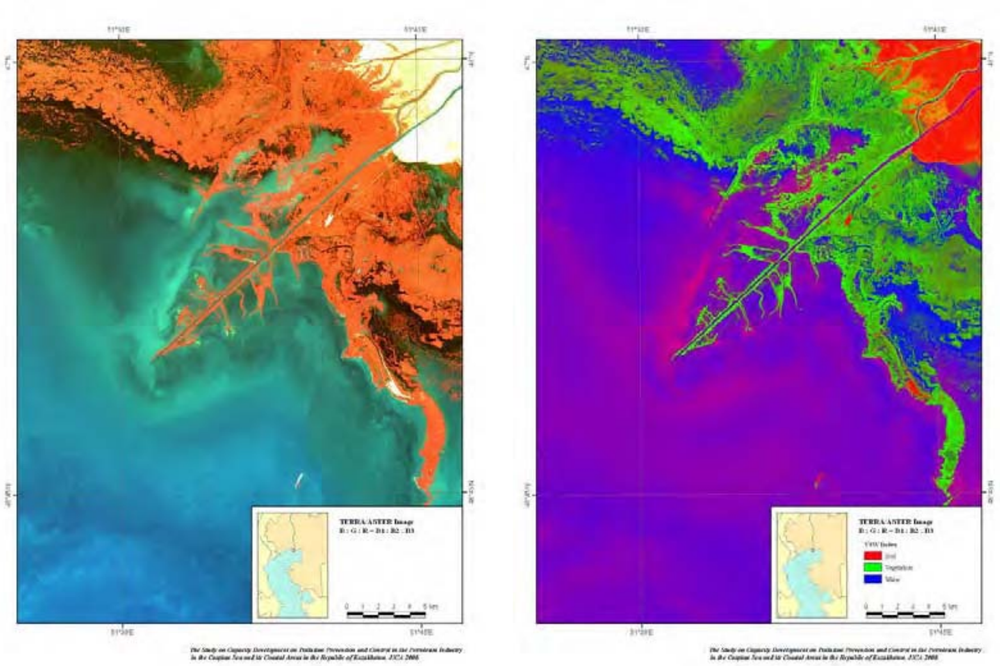
Band 2: PV' / (PV' + PS' + PW') * 100

Band 3: PS' / (PV' + PS' + PW') * 100

Band 1 + Band 2 + Band 3 = 100%

Source : JICA Study Team

Figure 9.2.9 Principle of VSW Index



False Color Image VSW Index Image

Source: JICA Study Team

Figure 9.2.10 VSW Index Image of the Mouth of the Ural River

In a VSW index image, a red colored pixel shows an end member of soil. Equally, green is vegetation and blue is water. The gradation of color from blue, purple to magenta can be observed in waters. This variation in color results from the increase of the soil component in the sea and it indicates suspended materials from rivers or sediments. In the reed community, the gradation of color from green to bluish green can also be observed and this variation in color indicates the difference of vegetation coverage. That is to say, a pixel of dense reed area shows green in color, but the water component, which is shown as blue, increases with decreasing vegetation coverage.

4) Multi channel sea surface temperature

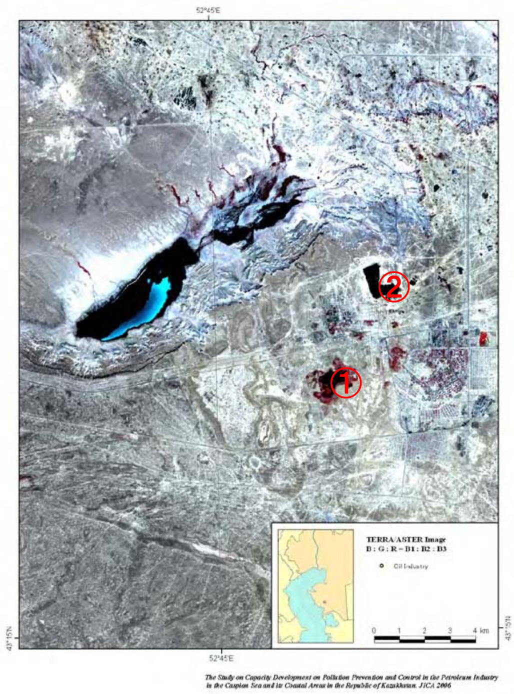
The multi channel sea surface temperature (hereafter MCSST) is a method to estimate sea temperature simply by using thermal infrared data. In calculation of MCSST, the atmospheric effect can be reduced by using radiance temperature data of multi thermal infrared channels (bands). Radiance temperature is calculated by the following formula:

$$RT_x = \frac{C_2}{\lambda \ln\left(\frac{C_1}{\lambda^5 \times R_x} + 1\right)}$$

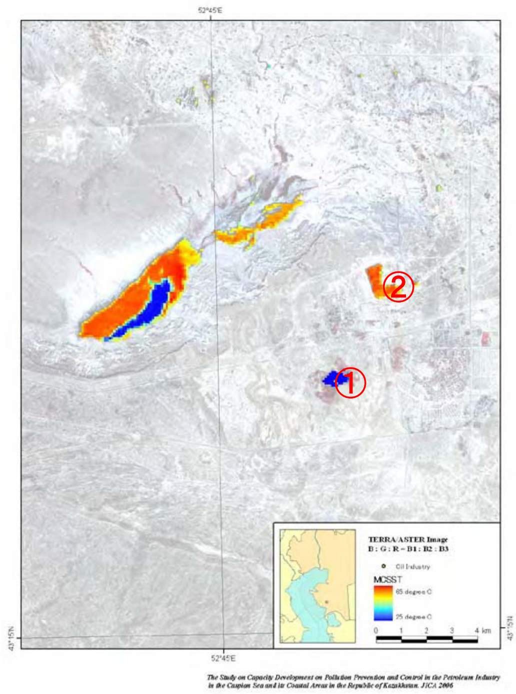
with RTx for radiance temperature of band x, Rx for radiance value of band x, lx for momentum centre of band x, and C1 and C2 for coefficients. By using thermal infrared data from TERRA/ASTER, the MCSST can be estimated by the following formula:

$$MCSST_{ASTER} = 1.16 - 1.07 \times RT_{10} + 0.49 \times RT_{11} + 1.13 \times RT_{12} + 0.78 \times RT_{13} + 0.32 \times RT_{14}$$

with MCSSTASTER for estimated sea temperature. The MCSST of the Uzen oil field is shown in Figure 9.2.11, color-coded with high temperature shown in red to yellow and low temperature shown in blue.



False Color Image



MCSST Image

Source: JICA Study Team

Figure 9.2.11 MCSST Image of Uzen Oil Field

The variation of temperature in water areas (ponds for oil evaporation) is quite wide. At first glance, color of Pond 1 (P1) and Pond 2 (P2) are the same in the false color image, however, P1 shows low temperature and P2 shows high in the MCSST image. It became evident that P1 consists of clear water and P2 is covered by a layer of oil.

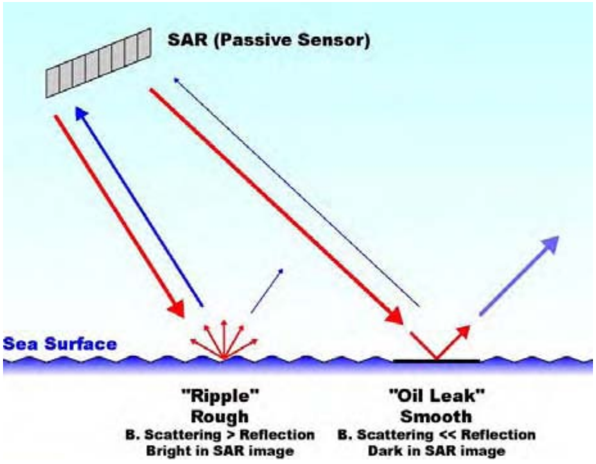
5) Oil leak monitoring in submerged oil fields

The radar sensor (active sensor) radiates microwaves toward targets (usually the Earth's surface) and observes microwaves that return to the sensor including scattered and reflected microwaves from targets. This process of microwave propagation is called "back scattering". Backscattering has a dependence on "roughness" of target because backscattering increases on a rough target and decreases on a smooth target.

The principle of oil leak monitoring by ENVISAT/ASAR and other radar sensors is given in Figure 9.2.12. Rippling sea surface is defined as "rough" and shows a bright pixel in the ENVISAT/ASAR image. On the other hand, calm is defined as "smooth" and is represented as a dark pixel in the ENVISAT image.

When an oil slick occurs in a rippling sea surface (air velocity: 0.5 to 5.0 m/s), the oil leak minimizes occurrence of ripple and smoothes the sea surface. Therefore, in images of ENVISAT/ASAR and other radar sensors an oil slick shows as dark pixels compared with surrounding bright pixels of water with ripple.

Incidentally, in an area of gale conditions, it is impossible to detect an oil slick because the strong wind affects the surface and makes the oil slick indistinguishable. Moreover, in an area of calm conditions, it is difficult to distinguish an oil slick from the sea surface because the backscattering of the oil slick and sea surface are both low.



Source: JICA Study Team

Figure 9.2.12 Principle of Oil Leak Monitoring by Radar Sensor

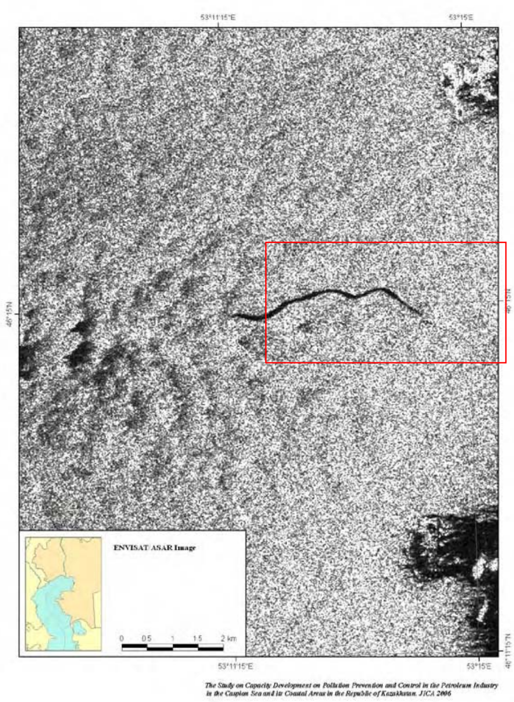
Oil leak detection was performed in the submerged oil field of Pribrezhnoye where an oil leak accident occurred on May, 2006. The ENVISAT/ASAR data used for the exercise were acquired at four times from May to November, 2006. The acquisition date of used data and items of monitoring are shown in Table 9.2.6.

Table 9.2.6 Acquisition Date of Used ENVISAT/ASAR Data and Items of Monitoring

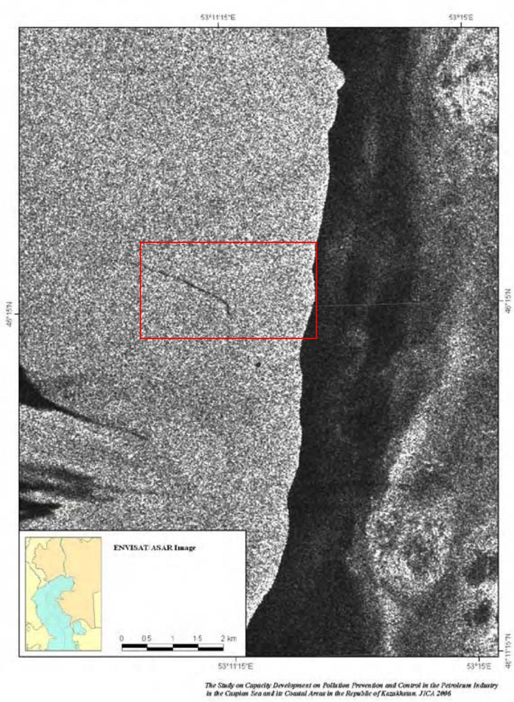
Acquisition date	Items of monitoring and events regarding the oil leak accident in Pribrezhnoye oil field	
	MAY 2006 (?)	Occurrence of the oil leak accident To start operations for liquidation
	12/MAY/2006	To announce news release of the oil leak accident by Ministry of Emergencies
① 17/MAY/2006	→→→	（Monitoring: Extent of oil leak, Pollutant）
	June or July 2006	To complete operations for liquidation
② 30/AUG/2006	→→→	（Monitoring: Conditions of surface after operations）
③ 06/OCT?2006	→→→	（Monitoring: Conditions of surface after operations）
④ 08/NOV/2006	→→→	（Monitoring: Conditions of surface after operations）
	10/NOV/2006	Ground truth by JICA Study Team

Source: JICA Study Team

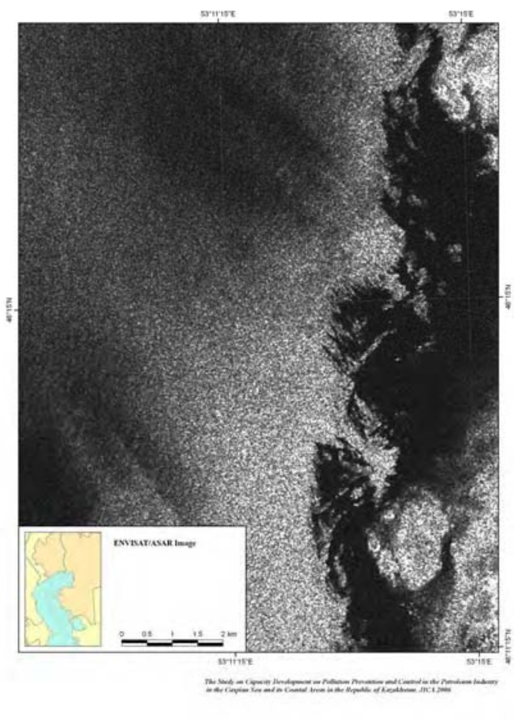
The ENVISAT/ASAR images are shown in Figure 9.2.13. Dark pixels, which spread in an east-west direction, can be observed in the centre of 17th May and 30th August images, but it can not be observed in 6th October image. In 8th November image, waters are shown as dark pixels because surface condition of this time is calm. Therefore the image of 8th November cannot be utilized for the monitoring.



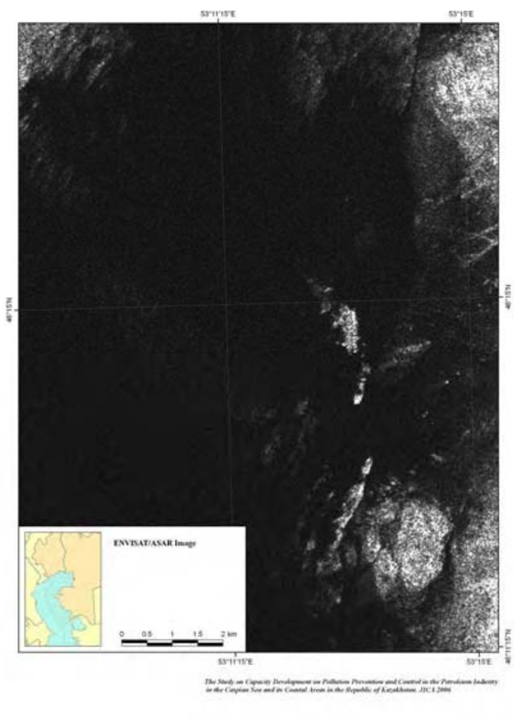
ENVISAT/ASAR Image（17/MAY/2006）



ENVISAT/ASAR Image（30/AUG/2006）



ENVISAT/ASAR Image（06/OCT/2006）



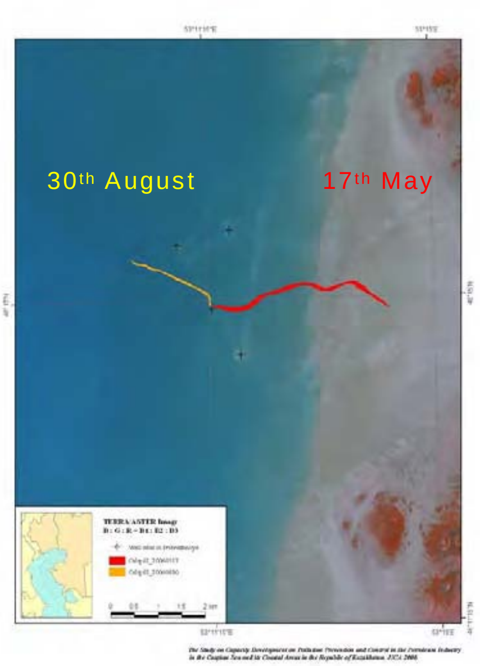
ENVISAT/ASAR Image（08/NOV/2006）

Source: JICA Study Team

Figure 9.2.13 ENVISAT/ASAR Image of the Submerged Oil Field in Pribrezhnoye

Comparison of these dark pixels with the location of the submerged oil field was performed. The overlaid images of the dark pixels detected from ENVISAT/ASAR images (red and yellow polygon; red from 17th May and yellow from 30th August), the location of the submerged oil field detected from TERRA/ASTER image (black cross), and TERRA/ASTER false color image, are shown in Figure 9.2.14.

It is clear that the dark pixels of both images are spread in an east-west direction from the same starting point, which seems to be the submerged oil field. Therefore, there is a high possibility that the dark pixels indicate the oil slick of the oil leak accident. The oil slick observed on 17th May is spread out by the wind to the east over a length of 4.1 km and a width of 70 m at its maximum. The oil slick observed on 30th August is spread out by the wind to the east over a length of 2.4 km and a width of 30 m at its maximum. These results suggest that the range and volume of the oil slick decreased in time, but the oil leak accident continued for more than 3 months.



TERRA/ASTER Image (27th September, 2006)

Source: JICA Study Team

Figure 9.2.14 Result of Oil Leak Monitoring

In 6th October image, dark pixels, which indicate an oil slick, cannot be observed. In addition, an oil leak cannot be observed in Pribrezhnoye oil field by JICA Study Team's ground verification on 10th November, 2006. Therefore the oil leak accident came to an end by the process of liquidation.

Source: JICA Study Team

Figure 9.2.15 Result of Ground Truth (Photos of Pribrezhnoye oil field)

(8) Evaluation of Technical Transfer

An evaluation of the technical transfer was carried out by questionnaires at the mid-point and the termination of the technical transfer. All participants answered “understood completely” or “understood practically” regarding the fundamentals of satellite image processing and analysis. Regarding use of the software, all participants answered, “can execute completely” or “can execute completely with the manual”. Furthermore, the participants worked on the assignments very diligently, often practised their skills after the lecture hours, and their attitude was serious. Therefore, it is concluded that all participants understood practically all material prepared. However, it is important for participants to gain more experience through OJT in order to master these techniques completely. In addition, there is a need to purchase books and literature regarding remote sensing technology so the participants can obtain a deeper understanding of the principles of processing and analysis.

Box 1: Utilization of Satellite Image Analysis for Spilled Oil Monitoring

Oil leak accidents from submerged oil fields have often occurred in the northern Caspian Sea. However, characterization of the present conditions of the accident location and surroundings were not performed because access to the accident location is difficult and possible only by helicopter. The repeat cycle (the number of days to return to the same orbit) of ENVISAT is 35 days so it can take images of the target area once per month. It takes two or three weeks from data capture to obtain satellite image data because the data has to be transmitted from ENVISAT to the ground base-station and initial data processing carried out. Therefore monitoring using ENVISAT/ASAR data cannot commence until one or two months after an oil leak accident. The observational range of an ENVISAT/ASAR data is 100 km square and the monitoring of the accident location and its surroundings requires one or two ENVISAT/ASAR data. The per-scene cost is 400 Euro (if purchasing it from the dealerships of ENVISAT data in EU, transportation charges are not include).
The Advanced Land Observing Satellite (ALOS) which was launched by Japan Aerospace Exploration Agency (JAXA) at 24th January, 2006 carries PALSAR as L-band Synthetic Aperture Radar (SAR). ALOS/PALSAR data can be applied to the oil leak monitoring as ENVISAT/ASAR. The repeat cycle of ALOS is 46 days and it enables to monitor the target area once every one and half month. The observational range of an ALOS/PALSAR data is 40 to 70 km square and the monitoring in the accident location and its surroundings requires one or two ALOS/PALSAR data. The per-scene cost is 25,000 yen (if purchasing it from the dealerships of ALOS data in Japan, transportation charges are not included).

Specification of ALOS/PALSAR

Altitude	700 km
Orbit	Sun-Synchronous Descending
Repeat Cycle	46 days
Launch	2006
Type	Radar Sensor (Active Sensor)
Sensor	PALSAR Ground Resolution: 7m～44m (High Resolution Mode) 24m～89m (Multi-Polarization Mode) 100m (Wide Swath Mode) L band Synthetic Aperture Radar (SAR): 1.270GHz (23.6cm)

Source : ALOS/PALSAR

9.2.2 GIS Database Construction

(1) Outline of GIS Database Construction and Technical Transfer

GIS software was installed on a personal computer at KAZHYDROMET. Then, an environmental information database was constructed, and technical transfer regarding the maintenance, management, and utilization of database was carried out.

The target group of the technical transfer was the staff of the Information Technology Department of KAZHYDROMET's headquarters in Almaty, as was the technical transfer of satellite image analysis. However, considering the importance of information sharing of the GIS database between Almaty and Atyrau, a short technical transfer to the staff of Atyrau HYDROMET Center and Atyrau MoEP was also carried out. The contents of technical transfer were as follows:

- Installation of GIS system
- Environmental information database construction
- Use of software
- Lecture on the fundamentals of GIS and its utilization

(2) Installation of GIS System

1) Personal computer

For the specification of installed personal computer, see "Section 9.2.1 Satellite Image Analysis".

2) GIS Software

In KAZHYDROMET headquarters, ArcGIS 9.1 of ESRI (hereafter ArcGIS) was installed as GIS software. Main functions of ArcGIS are as follows:

- Display of vector and raster data.
- Vector data generation
- Geo processing (Analysis)
- Layout and output

In Atyrau HYDROMET Center and Atyrau MoEP, ArcExplorer 2.0 of ESRI (hereafter ArcExplorer) was installed as GIS software. ArcExplorer is free software for browsing of GIS database. Its functions are limited to display of vector and raster data, simple search, and output. ArcExplorer cannot support sophisticated functions, for examples, vector data generation, geo processing (analysis), and so on.

(3) Environmental Information Database Construction

1) Configuration of database

This database consists of four sub-database; base map, environmental monitoring, environmental resource, and pollution source.

The base map consists of the map information of KAZHYDROMET on a scale of 1:1,000,000 and information of the city, river, shoreline, and depth of water by Caspian Environment

Programme (CEP). The environmental monitoring is made up of the results of environmental monitoring by KAZHYDROMET and the pilot project. The pollution source consists of information on oil and gas fields, submerged oil and gas fields, and related facilities. The environmental resource is made up of information on the distribution of the flora and fauna, conservation area, and environmental sensitivity.

In addition, the satellite image data and the results of satellite image processing and analysis were incorporated into the database as the information about present condition and the base map.

The configuration of the environmental information database is shown as follows and details of database are shown in Table 9.2.7.

- ASTER： Image and processed image of TERRA/ASTER
- Base： Base map from CEP，ESRI and Global Mapping Project
- ETM+ Image and processed image of LANDSAT/ETM+
- ENVISAT： Image and processed image of ENVISAT/ASAR
- GDB： Database
- Basemap”： Base map sub-database of Atyrau Oblast
- Basemap02： Base map sub-database of Atyrau and Mangistaus Oblast
- Monitoring： Environmental monitoring sub-database
- PollutionSource： Pollution source sub-database
- Resource： Environmental resource sub-database
- Layer File： “Layer File” format (specific file format of ArcGIS includes information on legends)
- Project： “Project File” format (specific file format of ArcGIS includes information on layout)
- Shapes： Database after projection conversion from DD to UTM

Table 9.2.7(1/4) Configuration of Database

Folder and GDB	Description	Data Type	Pro-jection
ASTER (AST_[path][row][view]_[acq. data]_[sensor]_[process].img)			
/mcsst	Multi Channel Sea Surface Temperature image	image	UTM
/mosaic	Mosaic image (band 1, 2, 3)	image	UTM
/ndvi	Normalized Differential Vegetation Index (NDVI) Image	image	UTM
/orig	Full scene image (band 1, 2, 3)	image	UTM
/shape	Shapefile of image coverage	image	UTM
/vsw	Vegetation – Soil – Water (VSW) Index image	image	UTM
Base			
/Caspian	Vector files of CEP	vector	DD
/EsriWorldMap	World vector and raster maps by ESRI	vector raster	DD
/GlobalMap	Global Mapping Project data	vector	DD
ETM (L7_[path][row]_[acq. data]_[process].img)			
/mosaic	Mosaic image of all full scenes (band 1, 2, 3, 4, 5, 7).	image	UTM
/orig	Full scene image (band 1, 2, 3, 4, 5, 7)	image	UTM
/shape	Shapefile of image coverage	polygon	UTM
/thermal	Thermal image (band 6)	image	UTM
ENVISAT (ENVI_[track][frame]_[acq. data]_[process].img)			
/orig	Full scene image	image	UTM
/shape	Shapefile of image coverage	polygon	UTM
GDB (Personal Geo Database)			
Basemap.mdb (from 1:1,000,000 Topographic map of Atyrau region, CEP and JICA)			
airport	Airport	point	DD
border_regional	Political boundary (country)	line	DD
border_oblast	Political boundary (oblast)	line	DD
cities	Cities	point	DD
city_poly	City area (polygon)	polygon	DD
coastline	Caspian Sea coastline	line	DD
depth_contour	Caspian Sea depth contour	line	DD
island	Island in Caspian Sea	line	DD
island_poly	Island in Caspian Sea (polygon)	polygon	DD
political_bound	Political boundary	line	DD
railway	Railway	line	DD
river	River	line	DD
road	Road	line	DD
study_area	Study area of this project	polygon	DD

DD: Decimal Degree, UTM: Universal Transverse Mercator projection
Source: JICA Study Team

Table 9.2.7(2/4) Configuration of Database

Folder and GDB	Description	Data Type	Pro-jection
GDB (Personal Geo Database)			
Basemap02.mdb (from 1:1,000,000 Topographic Map of Atyrau and Mangistaus region)			
borders	Political boundary (all)	line	DD
caspian_sea	Area of Caspian Sea	polygon	DD
cities_pointt	Small cities	point	DD
cities_poly	Main cities	polygon	DD
coastline	Coastline of Caspian Sea	line	DD
railways	Railway	line	DD
rivers	River	line	DD
roads	Road	line	DD
transaquatic_zone	Transaquatic zone near coastline	polygon	DD
Monitoring.mdb (from analysis data of KAZHYDROMET, JICA and CEP)			
air_kzhydro	Analysis result of air samples by KAZHYDROMET	point	DD
air_pp	Analysis result of air samples by pilot project	point	DD
deposit_kzhydro	Analysis result of deposit samples by KAZHYDROMET	point	DD
deposit_pp	Analysis result of deposit samples by pilot project	point	DD
soil_CEP_2001	Analysis result of soil samples by CEP (2001)	point	DD
soil_kzhydro	Analysis result of soil samples by KAZHYDROMET	point	DD
soil_pp	Analysis result of soil samples by pilot project	point	DD
water_kzhydro	Analysis result of water samples by KAZHYDROMET	point	DD
water_pp	Analysis result of water samples by pilot project	point	DD
PollutionSource.mdb (from Resource Map of Atyrau and Mangistaus region, CEP and AgipKCO)			
build_material	Mines and quarries of construction materials	point	DD
kashagan_claim	Claim of AgipKCO Kashagan area	polygon	DD
kashagan_pipline_ corridor	Proposed corridor of pipeline from Kashagan to onshore	polygon	DD
oil_gas_field	Oil and gas fields in Atyrau and Mangistaus region	point	DD
oil_gas_field_ claim	Claims of oil and gas fields in Atyrau and Mangistaus region	polygon	DD
oil_gas_field_ flooded	Submerged oil and gas fields in Atyrau and Mangistaus region	point	DD
pipeline_gas	Routes of gas pipelines in Atyrau and Mangistaus region	line	DD
pipeline_oil	Routes of oil pipelines in Atyrau and Mangistaus region	line	DD
pollutant	Distribution of pollutant facilities in Atyrau and Mangistaus region	point	DD
waste	Distribution of waste sites in Atyrau and Mangistaus region	point	DD

DD: Decimal Degree, UTM: Universal Transverse Mercator projection
Source: JICA Study Team

Table 9.2.7(3/4) Configuration of Database

Folder and PGDB	Description	Data Type	Pro-jection
GDB (Personal Geo Database)			
Resource.mdb (from reports of AgipKCO, KAAE and AgipKCO)			
animal_habitat	Distribution of animal habitat	point	DD
bird_habitat_point	Distribution of bird habitat	point	DD
bird_habitat_poly	Distribution of bird habitat	polygon	DD
bird_migration_ route	Migration route of bird	line	DD
bird_waterfowl_ quantity_autumn	Quantity of waterfowl per 1 sq. km in autumn	polygon	DD
bird_waterfowl_ quantity_summer	Quantity of waterfowl per 1 sq. km in summer	polygon	DD
bird_waterfowl_ quantity_winter	Quantity of waterfowl per 1 sq. km in winter	polygon	DD
coastline_1977	Position and type of coastline in 1977	line	DD
coastline_1997	Position and type of coastline in 1997	line	DD
coastline_type	Type of coastline	line	DD
es_coastal_habitat	Coastal habitat in Environmental Sensitivity report	polygon	DD
es_inland_habitat	Inland habitat in Environmental Sensitivity report	polygon	DD
fish_habitat	Distribution of fish habitat	point	DD
fish_metal_ concentration	Distribution of metal concentration in fish organs and tissues	polygon	DD
protected_area	Specially protected natural territories	polygon	DD
seal_habitat_ summer_autumn	Seasonal distribution of seal habitat in summer and autumn	polygon	DD
seal_habitat_ winter_spring	Seasonal distribution of seal habitat in winter and spring	polygon	DD
seal _pupping	Distribution of seal pupping area in winter	polygon	DD
sturgeon_ migration_autumn	Migration route of sturgeon in autumn	line	DD
sturgeon_ migration_spring	Migration route of sturgeon in spring	line	DD
sturgeon_ migration_summer	Migration route of sturgeon in summer	line	DD
sturgeon_ quantity_autumn	Quantity of sturgeon per 30 minutes trawl in autumn	polygon	DD
sturgeon_ quantity_spring	Quantity of sturgeon per 30 minutes trawl in spring	polygon	DD
sturgeon_ quantity_summer	Quantity of sturgeon per 30 minutes trawl in summer	polygon	DD
vegetation	Type and distribution of vegetation	polygon	DD
vegetation_flora	Distribution of flora	point	DD
vegetation_reed	Distribution of reed	polygon	DD
/Resource	Environmental Sensitivity in the northern Caspian Sea	point	DD

DD: Decimal Degree, UTM: Universal Transverse Mercator projection

Source: JICA Study Team

Table 9.2.7(4/4) Configuration of Database

Folder and GDB	Description	Data Type	Pro-jection
Layer File			
/Basemap	Layer file of ArcGIS for Basemap.mdb	-	-
/Basemap02	Layer file of ArcGIS for Basemap02.mdb	-	-
/Monitoring	Layer file of ArcGIS for Monitoring.mdb	-	-
/PollutionSource	Layer file of ArcGIS for PollutionSource.mdb	-	-
/Resource	Layer file of ArcGIS for Resource.mdb	-	-
Project			
	Project file of ArcGIS	-	-
Shape			
/Basemap	All vector data of Basemap.mdb in UTM projection	vector	UTM
/Basemap02	All vector data of Basemap02.mdb in UTM projection	vector	UTM
/Monitoring	All vector data of Monitoring.mdb in UTM projection	vector	UTM
/PollutionSource	All vector data of PollutionSource.mdb in UTM projection	vector	UTM
/Resource	All vector data of Resource.mdb in UTM projection	vector	UTM

DD: Decimal Degree, UTM: Universal Transverse Mercator projection
Source: JICA Study Team

2) Format of database

The personal geo database (hereafter PGD), which was developed to interface ArcGIS with MS-Access, was used as the base format for the database. By using the PGD, it will be easier to upgrade the database to a larger one in the future. PGDs were made for four sub-databases and various vector data were stored in each PGD.

3) Design of database

KAZHYDROMET had already been constructing an environmental monitoring database system, and consistency with the existing system was taken into consideration. Since the database information was originally owned by different organizations, the database was designed to integrate such information. An outline of database design is as follows:

The coordinate system of the database is decimal degree (reference ellipsoid: WGS84) for vector data, and is UTM (Zone 39, reference ellipsoid: WGS84) for raster data (mainly image data).

The information owned by KAZHYDROMET and other organizations is converted to a data format suitable for use by ArcGIS (hereafter shapefile). For examples, the environmental concentration data are currently managed as MapInfo format data of the national environmental monitoring system. In such cases, the data were converted to shapefile format, after being converted into the MIF exchange format.

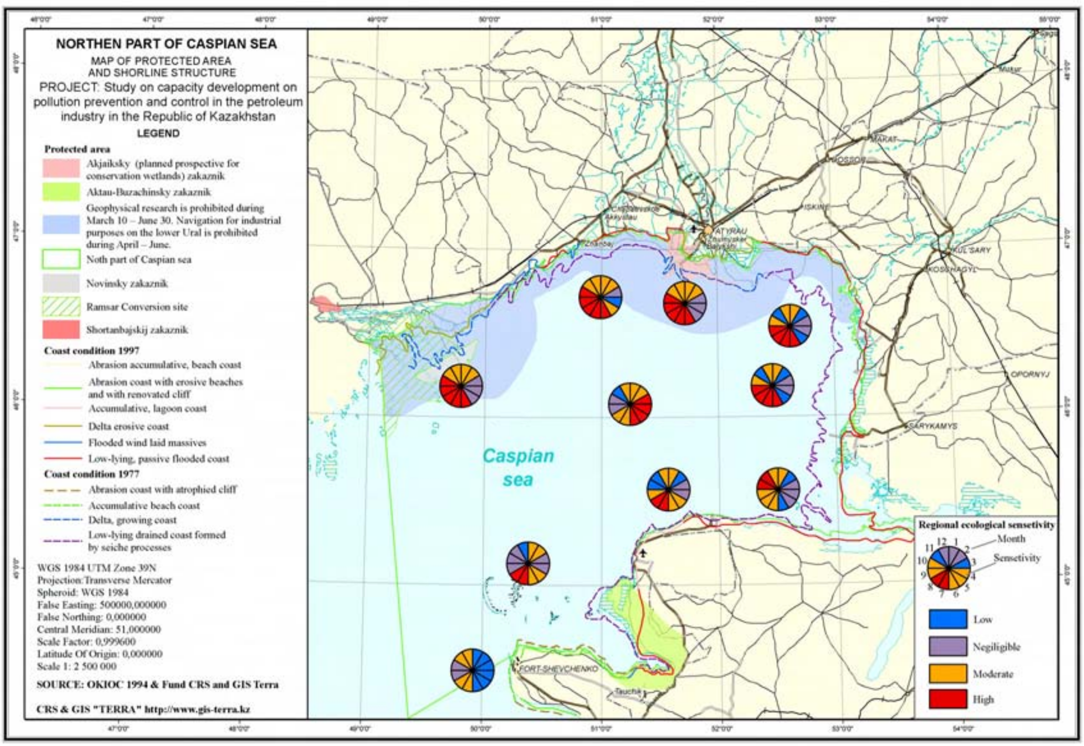
The environmental concentration data of KAZHYDROMET are the core of the environment information database. The items in the database correspond to the environmental parameters monitored by KAZHYDROMET. The parameters currently analyzed and recorded by KAZHYDROMET are as follows:

- Water: Site, Date, Time, Depth, Water temperature, pH, Color, Transparency, Floating matters, Carbon dioxide, Hydrogen sulphide, Dissolved oxygen, Ammonia, NO_2-N, NO_3-N, Total nitrogen, Chloride, Sulphate, Hardness, Calcium, Magnesium, Carbonate, Orthophosphate, Iron (II), Iron (III),Total iron, Surface-active agent, Phenol, Oil, Manganese, Mercury,Chromium, Chromium (VI), Chromium (III), Copper, Zinc, Lead, Cadmium, Nickel, Sodium, Potassium, Total ion, BOD, Sulphuric acid, Fluorine,Fluoride, Silicon, Boron, Vanadium, Molybdenum, Cobalt, Silver, Tin, Arsenic, Cyanide, Thiocyanic acid

- Sediment: Site, Date, Time, Depth, Water temperature, pH, Oil, Cadmium, Lead, Copper, Nickel, Zinc.
- Air: Site, Date, Time, Floating materials, Sulphur dioxide, Dissolved sulphate, Carbon monoxide, Nitrogen dioxide, Hydrogen sulphide, Ammonia.
- Soil: Site, Date, Time, Depth, Water temperarute, Sampling depth, T-S, THC, Cadmium, Lead, Copper, Chromium, Zinc.

4) Layout and output

The subject maps were created by overlaying necessary information by using the display and layout functions of ArcGIS. Examples of subject maps are shown in Figure 9.2.16.



Source: JICA Study Team

Figure 9.2.16 Examples of Subject Map by ArcGIS

(4) Exercise to Practice Use of Software

A series of lectures and hands-on training sessions on maintenance, management, and utilization of the GIS database were provided for the staff of the Information Technology Department of KAZHYDROMET. The contents of the technical transfer were as follows:

1) New shapefile creation

The shapefile format is an ArcGIS – specific format for vector data and is classified into "point", "line", and "polygon (area)" depending on its shape. New shapefiles for the oil slick and the submerged oil field detected from the satellite image were created by the editing function of ArcGIS. Incidentally, the shapefiles of the oil leak were created as polygon data and the shapefiles of the submerged oil field were created as point data.

2) Import of table data

"Table" means a set of data elements arranged in rows and columns. Each row represents an individual entity and each column represents an attribute value. Usually, the results of environmental monitoring are saved as table data, and the position (x, y coordinate data), result, and description are stored as attribute values. ArcGIS can read table data which has x, y coordinate data and convert it to shapefile (point) format.

3) Layout of subject map

Subject maps were created by overlaying necessary information using the display and layout functions of ArcGIS. ArcGIS can configure an optional output size and scale, and easily create annotations (grid coordinates, legend, north allow, scale bar, label, and so on).

(5) Lecture on the Fundamentals and Utilization of GIS

Under present circumstances, the awareness of Atyrau HYDROMET Center regarding "data management" and "data analysis" is low because their task is only to collect monitoring data and to send it to headquarters. On the other hand, Atyrau MoEP has a desire to use GIS to manage various data, but they have not achieved this goal because of a lack of budget and technical capacity.

In order to raise the awareness of monitoring in the organizations of Atyrau, a lecture on the fundamentals of GIS and its utilization was delivered to the staff of Atyrau HYDROMET Center and Atyrau MoEP. In addition, an installation and exercise of ArcExplorer for browsing of GIS database was carried out in these organizations. The contents of the lecture were as follows.

1) The fundamentals of GIS

An introduction to the definition of GIS, data model, and data type was carried out. Instruction material on the GIS, which was produced by JICA-Net, was distributed.

2) Utilization of GIS

Atyrau HYDROMET Center only conducts environmental monitoring and then sends the data to its headquarters. As the data are managed at the headquarters, the local staff cannot review the environmental data. This problem was taken into account when designing the activity.

GIS is an effective tool for the integration of various data on the basis of "positional information" and GIS can support the decision making of the user by analysing, evaluating, and sharing integrated data. With installation of the GIS database, it will be possible to not only integrate various data (results of monitoring activities, existing information, satellite image, and so on) into one database, but also to share this database in Atyrau and other branch offices. The information sharing by GIS will enable the results of monitoring activities to be fed back to the staff of branch offices.

3) Browsing of GIS database by ArcExplorer

Exercises regarding display of vector and raster data and generation of a theme map were provided to the staffs of Atyrau HYDROMET Center and Atyrau MoEP.

(6) Evaluation of Technical Transfer

The effectiveness of the technical transfer was evaluated upon completion using a questionnaire. Regarding the fundamentals of GIS, all participants answered “understood completely” or “understood practically”. Regarding the exercise for the use of software, all participants answered “can execute completely” or “can execute completely with the manual”. Overall, it was concluded that all participants understood practically all components of the technical transfer.

9.2.3 Mini-Workshop in Atyrau

(1) Outline of the Mini-Workshop

In order to deepen the understanding of performing environmental monitoring with satellite image analysis and GIS database, a mini-workshop titled “Application of Satellite Image Analysis to Environmental Monitoring” was held for the staff of Atyrau HYDROMET Center and Atyrau MoEP. The agenda of the mini-workshop was as follows:

- The fundamentals of satellite image processing and analysis.
- Result of the case study.
- The fundamentals of GIS technique.
- GIS database construction and its utilization.
- Discussion.

(2) Result

There were about ten participants from Atyrau HYDROMET Center and Atyrau MoEP, and the session resulted in many questions and discussion. The participants expressed particular interest in oil leak monitoring by ENVISAT/ASAR imagery and there was a proposal from participants to monitor the current state of the accident location by ENVISAT/ASAR. In addition, the Director of Atyrau MoEP made the comment that MoEP should actively use satellite imagery and GIS technology for environmental monitoring.

After this mini-workshop, another technical seminar on the same theme was quickly organized for engineers of petroleum companies at the request of the Director of Atyrau MoEP. This technical seminar for engineers of petroleum companies was held under the sponsorship of Atyrau MoEP. There were 35 participants consisting of 26 engineers from petroleum companies and 9 staff members from Atyrau MoEP. Most participants from the petroleum companies were engineers in charge of environment management. Most participants mentioned that the seminar was very useful and they learned the effectiveness and importance of satellite image analysis for environmental monitoring.